Republic of Fiji

Third National Communication

Report to the United Nations Framework Convention on Climate Change

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UN environment

United Nations Environment Programme

Republic of Fiji

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Report to the United Nations Framework Convention on Climate Change

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ACRONYMS & ABBREVIATIONS

ACP	Africa, Caribbean and Pacific
ADB	Asian Development Bank
ADO	Automotive Diesel Oil
AFOLU	Agriculture, Forestry and Other Land Use
AWS	Automatic Weather Stations
BOD	Biological Oxygen Demand
BoM	Australian Bureau of Meteorology
CC	Climate change
CCA	Climate change adaptation
CCAM	Conformal Cubic Atmospheric Model
CCDRM	climate change and disaster risk management
CDM	Clean Development Mechanism
CCU	Climate Change Unit
CH_4	Methane
CIMP5	Coupled Model Intercomparison Project (phase 5)
CO_2	Carbon dioxide
COP	Conference of the Parties
CPA	CDM Programme Activity
CROP	Council of Regional Organisations of the Pacific
CSDs	Climate Sensitive Diseases
CSIRO	Commonwealth Scientific and Industrial Research Organization
CTBT	Comprehensive Nuclear-Test-Ban Treaty
CVA	Climate Vulnerability Assessment
Dm	Dry Matter
DoE	Department of Environment (Fiji)
DRR	Disaster Risk Reduction
EbA	Ecosystem-based Adaptation
ECAL	Environment and Climate Adaptation Levy
EEZ	Exclusive Economic Zone
EFL	Electricity Fiji Ltd
EIA	Environmental Impact Assessment
EMA	Environment Management Act 2005
ENSO	El Niño Southern Oscillation
eq.	equivalent
EU	European Union
EWS	Early Warning System
FAO	Food & Agriculture Organisation
FDoE	Fiji Department of Energy
FFHCOP	Fiji Forest Harvesting Code of Practice
FMS	Fiji Meteorological Services
FNU	Fiji National University
FNPF	Fiji National Provident Fund
FOD	First Order Decay
FOLU	Forestry and other Land Use
FRCS	Fiji Revenue and Customs Services
FSC	Fiji Sugar Cooperation
GCMs	Global Climate Models
GCPV	grid-connected PV
GDP	Gross Domestic Product
GEF	Global Environment Facility
GFDRR	Global Facility for Disaster Reduction and Recovery
Gg	Gigagram (10^9 grams or 1 kilotonne)
GGF	Green Growth Framework
GHGs	Green House Gases
GHGI	Greenhouse gas inventory
GIZ	Deutsche Gesellschaft fur Internationale Zusammenarbeit
Gt	Giga ton
GWh	Gigawatts per hour
GWP	Global Warming Potential
Ha	Hectare(s)
HFC	Hydrofluorocarbon(s)
HFO	Heavy Fuel Oil
HIES	Household Income and Expenditure Survey
ICM	Integrated Coastal Management
ICT	Information and communications technology
IDO	Industrial Diesel Oil
JICA	Japanese International Cooperation Agency
IMO	International Maritime Organisation
INC	Initial National Communication
iNDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
IUCN	International Union for Conservation of Nature

Kg	Kilogram
kW	Kilo watts
kWh	kilo watts hour
LEDS	Low Emission Development Strategy
LPG	Liquefied Petroleum Gas
LTA	Land Transport Authority (Fiji)
LUCF	Land use change & Forestry
LULUCF	Land Use, land use Change and Forestry
M	Million (prefix)
MDGs	Millennium Development Goals
MFO	Marine Fuel Oil
MJO	Madden-Julian Oscillation
MOBIE	Ministry of Business, Innovation and Enterprise, NZ Government
MRV	Measurement Reporting and Verification
MSMEs	small and medium enterprises
Mt	million tonnes
MWh	Mega Watts per hour
N_2O	Nitrous oxide
NAP	National Adaptation PLan
NBSAP	National Biodiversity Strategic and Action Plan
NCCP	National Climate Change Policy
NCCAS	National Climate Change Adaptation Strategy
NCD	Non-communicable diseases
NCMNUP	National Climate Monitoring Upgrade Project
NDC	Nationally Determined Contribution
NDMO	National Disaster Management Office
NEP	National Energy Policy
NGO	Non-Government Organisation
NZ	New Zealand
p.a.	per annum
PACC	Pacific Adaptation to Climate Change
PACCSAP	Pacific-Australia Climate Change Science and Adaptation Planning Program
PACE-SD	Pacific Centre for Environment and Sustainable Development
PBS	Poverty Benefit Scheme
PCCSP	Pacific Climate Change Science Program
PCRAFI	Pacific Catastrophe Risk Assessment and Financing Initiative
PDNA	Post Disaster Needs Assessment
PIEP	Pacific Islands Energy Policy
PMT	Project Management Team
PV	Photovoltaic
RBSN	Regional Basic Synoptic Network
RCP	Representative Concentration Pathway's
RE	Renewable energy
REDD+	Reducing Emission from Deforestation and Forest Degradation
RRA	Renewable Energy Readiness Assessment
RTCs	Rural Training Centres
SE4all	Sustainable Energy for All
SLM	Sustainable Land Management
SNC	Second National Communication
SPC	Pacific Community
SPCZ	South Pacific Convergence Zone
SPREP	Secretariat of the Pacific Regional Environment Programme
SST	sea-surface temperatures
SWD	Solid Waste Disposal
TCs	Tropical cyclones
TNA	Technology needs Assessments
TNC	Third National Communication
ULP	Unleaded Petrol
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency
USP	University of the South Pacific
V&A	Vulnerability and Adaptation
VA	Vulnerability Assessment
WAF	Water Authority of Fiji
WASH	Water Sanitation and Hygiene
WMO	World Meteorological Organization

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FOREWORD

Climate change is possibily the most challenging crisis of our time, and its adverse impacts pose significant threats to the sustainable livelihoods, security and well-being of Fijians. It is against this backdrop that Fiji advocates urgent action to tackle the impacts of climate change and implores the global community to strengthen its response by supporting the Paris Agreement and limiting global temperature rise to 1.5^{0}C above the pre-industrial level.

Fiji's Third National Communication is an important report that helps Fiji fulfil its reporting obligation as a Party to the UNFCCC. This report shows how Fiji is progressing in meeting our international commitments on climate change. It also, lays out the level of vulnerability and risks we are facing to the current impacts of climate change, how we are coping with these impacts, and what the future might look like as the climate rapidly changes. Additionally, it describes Fiji's greenhouse gas emissions and documents the mitigation actions the nation is taking in the pursuit of low-carbon and climate-resilient development.

It is our hope that Fiji's commitment and action on climate change will encourage and inspire other nations to take aggressive action. Fiji's Presidency of COP23 triggered action on many fronts that not only accelerated the momentum on climate negotiations and climate action but also achieved tangible outcomes of COP24 and the finalising of the Paris Rulebook. Fiji's continued support to the UNFCCC and the Paris Agreement is also evident in the major socio-economic policy and institutional shifts and reforms Fiji has undertaken in recent years. Fiji's newly launched Low Emission Development Strategy to achieve net-zero emissions by 2050, the National Adaptation Plan and the Planned Relocation Guidelines for increasing resilience and adaptive capacity are integral parts of Fiji's efforts to blunt the impact of climate change in a resolute and coordinated manner. These instrumental documents were launched at COP24 in Poland last year and highlight the major current undertakings. Moreover, Fiji has been partnering and working with international expertise in the assessment and resourcing of various sectors in order to climate-proof the economy and secure a sustainable future for the country.

I express my sincere gratitude to the many stakeholders for their efforts and contributions to make this national report as comprehensive as possible so that we may inform the global community of the seriousness of the issue of climate change in our country and the urgent need for their support and action to mitigate the adverse impacts. I believe that our commitment, demonstrated through this reporting and the other adopted initiatives, amplifies our strong push towards achieving the core objective of the UN Climate Convention and its Paris Agreement.

Makereta Konrote
Permanent Secretary for Economy

EXECUTIVE SUMMARY

Introduction

In 1993, the Republic of Fiji joined the majority of countries in the international community in ratifying the United Nations Framework Convention on Climate Change (UNFCCC). This Third National Communication (TNC) to the UNFCCC follows and builds on the Second National Communication (SNC) submitted in 2014, and has been prepared in fulfilment of Fiji's obligations to the UNFCCC under Articles 4 and 12. The TNC follows the UNFCCC guidelines and includes information on Fiji's Greenhouse Gas Inventory for the 2006 to 2011 reporting period. The document also reports on the country's vulnerability to climate change and measures to address and adapt to these vulnerabilities, alongside options for climate change mitigation.

The TNC project was implemented by the Climate Change and International Cooperation Division under the Ministry of Economy, with the support of the United Nations Environment Programme and funded by the Global Environment Facility (GEF).

National Circumstances

Geography, Geology and Climate

The Republic of Fiji lies in the heart of the Southwest Pacific Ocean and comprises approximately 332 islands, of which about 110 are inhabited. The Exclusive Economic Zone (EEZ) covers about 1.3 million square kilometres. The group includes numerous small volcanic islands, low-lying atolls and elevated reefs. The two largest islands are Viti Levu and Vanua Levu, where majority of the 884,887 population live (2017 census). The islands have a diverse range of terrestrial ecosystems, including extensive areas of indigenous forest. Both larger islands also have distinct wet and dry sides due to prevailing wind patterns. Fiji's coastal ecosystems consist of mangroves, algae and sea-grass beds in shallow reef and lagoon areas. There are various pristine reef types such as barrier, fringing platform and atoll or patch reefs that house most of Fiji's aquatic biodiversity.

The weather in Fiji is characteristic of a mild tropical climate. The South Pacific Convergence Zone is a key climate feature which brings in abundant rain under the prevailing southeast trade winds. Due to its geographical location, it is highly exposed to potentially catastrophic weather events such as cyclones and floods, which have major implications for the economy. The predicted climate change and sea-level rise could also have profound consequences for the country considering the high concentration of economic activities and settlements in coastal areas. Following the devastation of TC Winston, the country has been classified as the 14th most exposed country to natural disasters and one of the most vulnerable countries to climate change.[1]

Population

The country's population grew by 0.6 per cent from 2007 to 2017. The urban population has also grown by 16.3 per cent with a subsequent decrease in rural population by 5.5 per cent. Majority of Fiji's population is concentrated in major urban areas, with about 44 per cent spread across rural communities around the country. This has implications for the carrying capacity of the urban infrastructure to accommodate the high inflow of rural migrants and is a major factor contributing to the rapid growth of urban squatter settlements. Incidentally, these people are highly vulnerable to natural disaster risks due to the poor housing stocks within these settlements.

Economy

The Fijian economy has grown successively for nine years since 2010, with 2019 forecasted to be the 10th year for consecutive growth. On average, the economy expanded by 4.2 per cent during this period. Excluding the lower growth in 2016 as a result of TC Winston, the average growth was almost 5.0 per cent.

Strong growth in the economy is attributed to the robust performance of the tourism, construction, manufacturing, wholesale and retail trade, information and communication, transport and finance sectors. In 2019, growth was expected to be moderate in line with the projected slowdown in the global economy, domestic private sector credit and the Government's fiscal consolidation effort after the reconstruction and rehabilitation post Tropical Cyclone Winston. The cyclone was the strongest recorded in history with estimated damage amounting to US$0.9 billion, including US$0.6 billion in damage and US$0.3 billion in losses.

1 World Risk Report Analysis and prospects, 2017

National Greenhouse Gas Inventory

Fiji's first national Greenhouse Gas (GHG) inventory was reported in the Initial National Communication in 2005 using 1994 data. In the SNC, emissions were reported for the 2004 inventory year published in 2013, which was developed using the 1996 IPCC Guidelines for National Greenhouse Gas Inventories. This report details GHG emissions for the period 2006-2011 using the 2006 IPCC Guidelines for Greenhouse Gas Inventories.

Fiji's main GHG emissions consist mostly of carbon dioxide (CO2) from the energy sector with smaller amounts of methane (CH4) and nitrous oxide (N_2O) from agriculture and waste. Forestry emissions were understood to be slightly positive at around 380 Gg per annum but with a good deal of uncertainty. Overall emissions were estimated to be around 2500 Gg per annum (2.5 million tons per annum), which remained reasonably constant throughout the reporting period.

Fiji's per capita emissions are 2.8 tons or around 40 per cent of the world average during the reporting period.

In absolute terms, Fiji's total CO2 equivalent emissions were around 0.006 per cent of world emissions.

The 2006 to 2011 GHG emissions results revealed a reasonably constant trend over the reporting period with the annual variation dominated by logging volumes. The compilation of the GHG inventory continues to be a challenge, especially with regards to the availability of activity data for computation of GHG emissions. The Energy sector in Fiji continued to be the main contributor of GHG emissions contributing 58% to the National total emissions, with Land transportation making up the largest share of the Energy sector emissions (60%).

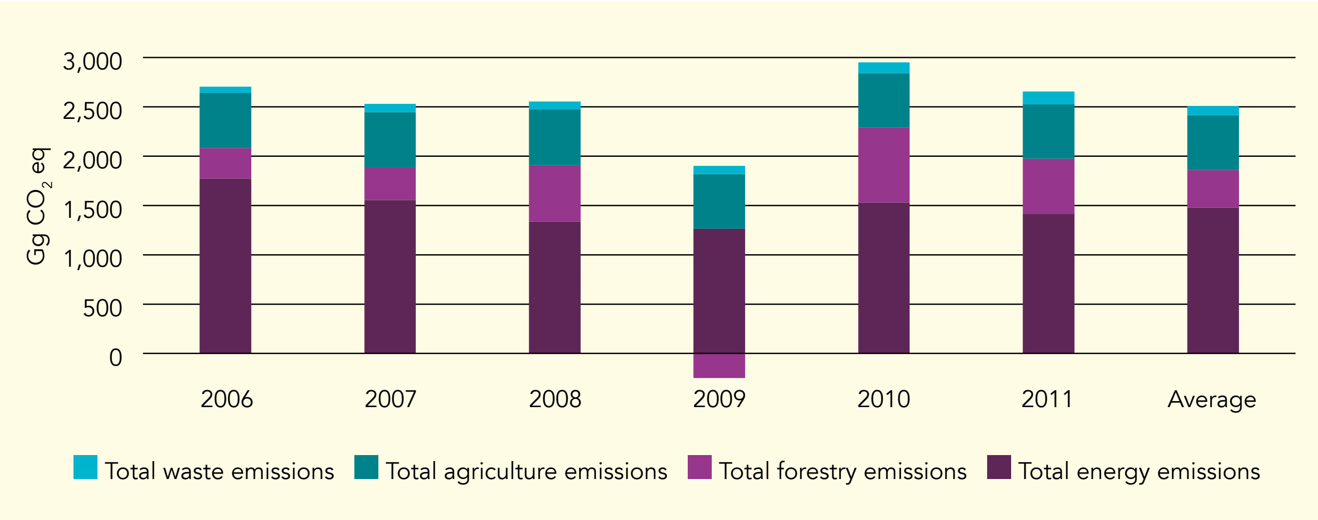


Figure 1: Fiji's Total GHG emission by sector

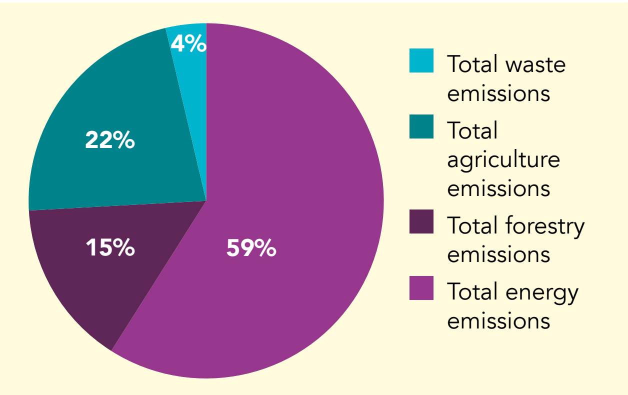


Figure 2: Fiji's GHG emissions by sector (average (2006-2011)

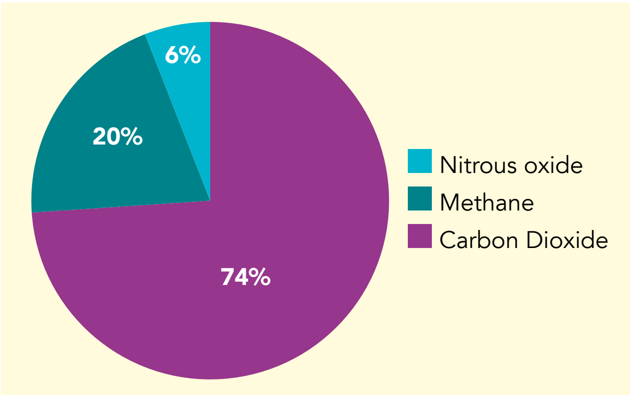


Figure 3: Fiji's GHG emissions by type of gas (average 2006-2011)

Key Category Analysis

The key category level assessment shows the contribution of each source or sink category to the total national inventory level.

Table 1: Approach 1 level Assessment for the Fiji GHG Inventory for 2011 (with key categories in bold).

IPCC code	Category	Greenhouse Gas	Emissions Estimate (Gg CO_2 Eq.)	Level Assessment	Commulative %
1.A.3.b	**Land transport**	**CO_2**	**905**	**0.350**	**35%**
3.B.1	**Forestry**	**CO_2**	**380**	**0.147**	**50%**
3.A.1	**Enteric Fermentation**	**CH_4**	**314**	**0.121**	**62%**
1.A.1.a.1	**Grid diesel use (electricity)**	**CO_2**	**223**	**0.086**	**70%**
1.A.4.C	**Industrial consumption**	**CO_2**	**153**	**0.059**	**76%**
3.C.7	**Rice cultivation**	**CH_4**	**92**	**0.036**	**80%**
3.A.2	**Manure Management**	**CH_4**	**81**	**0.031**	**83%**
1.A.4.b	**Domestic consumption**	**CO_2**	**76**	**0.029**	**86%**
4.A	**Solid Waste Disposal**	**CH_4**	**65**	**0.025**	**88%**
1.A.4.a	**Commercial consumption**	**CO_2**	**61**	**0.024**	**91%**
3.C.6	**Indirect N_2O Emissions from Manure Management**	**N_2O**	**61**	**0.024**	**93%**
4.D.1	**Domestic Waste-Water treatment and discharge**	**CH_4**	**58**	**0.022**	**95%**
1.A.3.d.2	Marine transport	CO_2	55	0.021	97%
1.A.5.a	Off grid diesel use (electricity)	CO_2	22	0.008	98%
1.A.3.a.2	Air transport	CO_2	18	0.007	99%
3.C.5	Indirect N_2O Emissions from Managed Soils	N_2O	14	0.005	100%
3.C.4.f	Direct N_2O Emissions from Managed Soils	N_2O	11	0.004	100%

In terms of development objectives, agriculture, forestry and land transport are considered high-priority areas. Land transport is one of the highest rated key categories for 2011. Other key emission sources include Forest Land, Enteric Fermentation, Electricity Generation, Industrial Consumption of energy, Rice Cultivation, Manure Management, Domestic consumption of energy, Solid Waste disposal, Commercial Consumption of Energy, Indirect Nitrous Oxide Emissions from Manure Management and Domestic Waste-Water treatment and discharge.

Completeness and uncertainty assessment

The level of completeness in inventory compilation represents the extent to which all sources and sinks as well as gases are covered by the inventory. There are instances where full coverage is not possible due to data unavailability or methodological issues.

Energy

For land transport, a model was developed from the number and type of vehicles registered annually to ascertain fuel consumption from estimated vehicle usage (km per annum) and efficiency values. This approach was used since fuel sale data was not provided by fuel companies.

Good data was available for different vehicle classes from the Land Transport authority and specific fuel consumption for each class gave good agreement with total fuel consumption from the Fiji Revenue and Customs Services. An uncertainty of around ± 10 per cent is associated with the emissions results from this source category.

For the whole Energy sector reference approach, there were uncertainties in the data from the Fiji Revenue and Customs Services (FRCS) that needs to be addressed in future reports as well as instituting some level of quality control and independent assurance of data integrity. For the sectoral approach, it is recognised that there are considerable gaps in information in the Energy sector that needs to be addressed by obtaining data directly from the fuel supply companies.

Forestry

Forestry data in Fiji was difficult to access in complete form for both natural and plantation forests. There were several national reports on the carbon content of Fiji's Forests, but with considerable uncertainty about the totals. In addition, the degradation levels in various historical reports differed considerably (around a factor of 10), making any assessment of emissions from this sector inherently uncertain and therefore yielding an uncertainty of around ± 30 per cent.

Agriculture

Uncertainties in the agricultural sector are inherent due to the lack of detailed census data in animal numbers, land areas under cultivation, fertiliser application quantities and crop yields on an annual basis. The uncertainties are suggested to be higher than the energy sector and amount to around ± 30 per cent.

Establishing a national manure management system and broadening knowledge in this area will be crucial in improving methane emission estimates, which is also one of the key categories, especially considering the high potential of this gas to contribute to global warming. Moreover, to enable more robust emissions calculation from rice cultivation, there is a need that country specific data on hectares of rice farms per different water regime system that is the farms that are irrigated, rain-fed or upland be reported. This information is crucial because irrigated farms produce more methane whereas the emission factor for upland farms is zero.

The major source of nitrous oxide emissions is N-fertilizer used in sugarcane fields. Therefore, research should be undertaken to derive national emission factor from sugarcane farming. There is a need to undertake efforts to generate a database for the amount of plant or crop residue that is incorporated into the soil, alongside the amount of fertilizer applied to flooded plains like rice farms. This is a missing source of nitrous oxide emissions in Fiji's current GHG Inventory.

Waste

There were a number of limitations in the data quality for the waste sector noting that emission estimates from both the solid waste and wastewater sources were largely computed using default values suggested in the IPCC 2006 guidelines, which could lead to large margins of error. To improve data capture on the quantities of waste disposed, it is recommended that weighbridges be installed at all solid waste disposal sites. There is also a need to undertake research in waste characterisation to determine the waste composition for Fiji which could vary significantly from the defaults values for Australia and New Zealand.

Impacts, Vulnerability and Adaptation

Fiji's first-ever Climate Vulnerability Assessment (CVA) was launched at COP23 in November 2017 which encompasses the climate risks Fiji faces due to its high exposure to natural hazards such as cyclones, storm surge, severe storms, flooding, landslide, drought and extreme temperature. The CVA report was prepared by the Fijian Government with the support of the World Bank and Global Facility for Disaster Reduction and Recovery (GFDRR). It outlines the impending impacts of climate change in the coming decades, unveiling the threats on Fiji's economy which includes livelihoods, poverty levels, health, food security and infrastructure. Recognising these potential risks, the analysis also identifies interventions in key priority areas to reduce vulnerability and build resilience. These key areas to increase adaptive capacity include: building inclusive and resilient towns and cities; improving infrastructure services; climate-smart agriculture and fisheries; and conserving ecosystems and building socioeconomic resilience. The report provides a quantitative basis for understanding the physical threats to the country, created by natural hazards and climate change and the development needs and opportunities of the country as identified in the 5-Year & 20-Year National Development Plan.

In response to national needs to build resilience of all Fijians and international commitments, the Fijian Government has prepared a National Adaptation Plan (NAP) 2018. The Fiji NAP will serve to implement the adaptation component of the National Development Plan, the CVA and the National Climate Change Policy. Moreover, the NAP will provide the basis to comprehensively address climate change through integrating adaptation options into national development planning.

Key findings from the Climate Vulnerability assessment- economy wide vulnerability

- The average annual asset losses from natural disasters are estimated at FJ$500 million (more than 5 per cent of GDP).
- A 100-year fluvial flood could cause asset losses of over FJ$2 billion.
- Asset losses are highest for the transport and building sectors (46 per cent and 44 per cent of the total, excluding agricultural losses).
- The fraction of GDP lost every year due to cyclones and floods could increase by up to 50 per cent by 2050 (reaching more than 6.5 per cent of GDP); in this scenario average asset loss would increase by more than 50 per cent.
- Investments needed to address floods (including from sea level rise) are estimated at FJ$500 million for pluvial and fluvial floods and FJ$1.6 billion for coastal flooding.
- FJ$9.3 billion (almost 100 per cent of GDP) in investment over the next 10 years is required to strengthen resilience. Transport requires FJ$469 million/year (92 per cent of the transport sector budget), water FJ$113 million/year (49 per cent of the water sector budget), housing FJ$22 million/year (86 per cent of housing sector budget), environment FJ$8 million (77 per cent of the environment sector budget).
- The number of cyclones/year is not expected to increase, but the proportion of high-intensity events is expected to increase. Fiji experiences an average of 1 cyclone/year; while this is unlikely to increase, the likelihood of any cyclone being a category 4 or 5 storm is increasing.

Food security and nutrition

In the last 16 years the agriculture sector has suffered damages and losses from cyclones and floods amounting to about FJ$791 million. Cyclones cause destruction to crops, trees, farming and fishing equipment and related infrastructure; the death of livestock and destruction of the reef ecosystems that support fisheries. Floods also have detrimental effects, causing crop damage due to inundation. These damages lead to negative impacts on productivity, which also have serious implications for food security and economic loss. There is imminent need to strengthen Fiji's disaster preparedness efforts in the agriculture sector by establishing means to safeguard, protect and enhance the resilience of supply systems and promoting breeding and cultivation of indigenous and improved seed varieties. Moreover, effective on-the–ground implementation capacity and conservation of coastal ecosystems such as mangroves, sea grasses and coral reefs are proactive approaches towards safeguarding of coastal fish habitats and buffering the impacts of storm surges. The cost of adaptation intervention in the agriculture and fisheries sector to safeguard food security, nutrition and sustain livelihood is expected to amount to $F34 million.

Health

Climate change affects the social and environmental determinants of health, so ensuring clean air and water, sufficient food and adequate shelter are key priorities in building resilience and adaptive capacity and mitigating risks. Changes in the state of the environment as a result of climate change increases human exposure to contaminated food and water, with potential health effects from climate-sensitive vector-borne diseases such as dengue fever, leptospirosis and typhoid fever, along with diarrhoea, which become widespread post floods and cyclones. Moreover, climate-sensitive diseases are projected to increase over time.[2] Adaptive measures include construction of Green Health Facility with improved medical equipment, strengthening capability of early detection of climate-change-sensitive disease, enhancing the public health response to climate-sensitive diseases and enhancing collaboration with the communities vulnerable to the impacts of climate change.

Human settlements

Housing backlog in Fiji increases by 600 units per year. This as a result leads to increasing informal settlements, which consist of housing stock of poor quality. Strengthening housing and ensuring that housing settlements are located in safer areas are priorities to reduce Fiji's vulnerability. The evaluated cost of improving land-use planning, supporting resilient housing and strengthening informal settlements stands at FJ$202 million, which includes FJ$130 million for additional new interventions.

2 Hallegatte et al. 2016.

Infrastructure

The energy sector is at risk from rainfall variability which is highly likely especially for the high emissions scenario. Reduced average annual rainfall could affect energy supply as 55-65 per cent of energy is hydropower. To increase resilience and adaptive capacity, the estimated investment required is FJ$446 million, FJ$175 million of which is for new activities. These investment needs are to cater for the diversification of energy distribution and generation options and opportunities to enhance the protection of key energy assets.

Similarly, the transport infrastructure accounts for 46 per cent of annual asset losses from disasters. Upgrading work is essential in order to incorporate current and future environmental and climate risks into infrastructure designing. Investment to increase sector resilience is estimated at FJ$4.3 billion, FJ$3.1 billion of which has already been planned for.

The risks imposed by the onset of climatic events include infrastructural damage, service disruption and environmental and health hazards. Longer-term threats to the sector as a result of climate change include salt water intrusion and drying up of ground water and surface water sources. There is thus a need to upgrade, repair, relocate and build new water and sanitation infrastructure that is protected against flooding and other climatic events. Resilience in the water sector is estimated to cost FJ$1.1 billion.

Tourism

The vulnerability assessment predicts a decrease in tourism revenues by 18 per cent in 2030, with key impacts including increased natural hazard events resulting in temporary decreases in tourist numbers, as occurred post TC Evan in 2012, when tourist arrivals decreased by 2.5 per cent. Effects on environmental quality and ecosystems, public health risks and weakened infrastructure are other factors which can deter tourists from choosing Fiji as a travel destination. Considering that tourism is the backbone of the economy, it is most important that these risks are reduced and managed so that they do not negatively impact Fiji as a choice of holiday destination.

Biodiversity and natural environment

Fiji's natural environment and biodiversity, from terrestrial, freshwater to coastal and marine ecosystems, is mainly impacted by anthropogenic activities including over-exploitation, habitat loss and coastal development, as well as urban, agricultural and industrial pollution. The detrimental impacts of these activities are aggravated with climate change. It is suggested that such impacts could potentially change entire coastal and marine ecosystems, significantly affecting livelihoods. Conserving ecosystems (native forests, coral reefs and mangroves) is vital to increasing resilience and sustaining livelihood. These measures are expected to cost Government FJ$77 million in the short and medium term.

Table 2: Estimated costs of planned and proposed projects in priority areas to increase adaptive capacity and increase resilience.

<table>
<tr><th rowspan="2">Sector</th><th colspan="3">Investment Needs (FJ$ million)</th><th colspan="3">Recurrent Costs (FJ$ million)</th></tr>
<tr><th>Planned</th><th>New</th><th>Total</th><th>Planned</th><th>New</th><th>Total</th></tr>
<tr><td>Housing/land use</td><td>63</td><td>152</td><td>215</td><td colspan="3" rowspan="9">175-440</td></tr>
<tr><td>Hazard management</td><td>n.a</td><td>2,106</td><td>2,106</td></tr>
<tr><td>Transport</td><td>3,098</td><td>1,591</td><td>4,689</td></tr>
<tr><td>Energy</td><td>271</td><td>175</td><td>446</td></tr>
<tr><td>Water</td><td>685</td><td>447</td><td>1,132</td></tr>
<tr><td>Health/education</td><td>5</td><td>568</td><td>573</td></tr>
<tr><td>Environment</td><td>55</td><td>22</td><td>77</td></tr>
<tr><td>Agriculture</td><td>11</td><td>3</td><td>14</td></tr>
<tr><td>Fisheries</td><td>6</td><td>14</td><td>20</td></tr>
<tr><td>Social Protection</td><td></td><td></td><td></td><td>47</td><td>4</td><td>51</td></tr>
<tr><td>Grand Total</td><td>4,194</td><td>5,078</td><td>9,272</td><td></td><td></td><td>226-491</td></tr>
</table>

Mitigation

Despite the fact that the country contributes a mere 0.006 per cent of global emissions, Fiji has shown its commitment to the Paris Agreement with an ambitious Nationally Determined Contributions (NDC) of 30 per cent reduction in energy-sector emissions by 2030. Fiji's current Nationally Determined Contribution (NDC) is specific to the energy sector. The overall mitigation target in the NDC is to reduce CO2 emissions by 30% from a BAU (Business As Usual) baseline scenario in 2013, 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 US$ 500 million in 2015. The 30% emission target will be achieved by striving to reach 100% renewable-energy power generation and through economy-wide energy efficiency. Fiji has also developed the NDC Implementation Roadmap with the support of the Global Green Growth Institute (GGGI) to operationalise Fiji's NDC commitment and is working with GGGI to develop bankable investment plans and project pipelines.

Recognising its promising renewable energy potential and ambitious renewable energy target, Fiji launched the Fiji Rural Electrification Fund (FREF) program in cooperation with the Leonardo DiCaprio Foundation, the solar-energy company Sunergise, the Fiji Locally Managed Marine Area Network and Energy Fiji Limited. The fund is a non-profit and charitable organisation aimed at facilitating investments in renewable-energy-based power generation in Fiji, which will support the socio-economic development of the country and reduce greenhouse gas emissions in Fiji. At present the fund has provided upfront capital to bring in clean and renewable energy to off-grid communities. Vio Island, just off the coast of Fiji's mainland Viti Levu, is the first community to be electrified under the FREF program.

Furthermore, in compliance with Article 4, paragraph 19, of the Paris Agreement Fiji has developed a mid-century, long-term low emission development strategy. The overall aim of Fiji's Low Emission Development Strategy is to enhance Fiji's ability to plan for decarbonisation of its economy in the long- term. It provides a framework and a pathway for a progressive revision and enhancement of targets under its NDC to reduce CO2 emissions and achieve net zero by 2050.

Barriers to Climate Change Mitigation and Adaptation

There are many barriers for effective mitigation and adaptation options in Fiji, many of which are common to developing countries in general and some of which are country-specific.

- **Capital:** Access to capital is limited. The capital costs of renewable energy technologies are generally higher than those of conventional technologies. Also, owing to the risks perceived for new technologies, financing costs tend to be higher.

- **Trade Barriers:** Although many countries are revising their trade policies in order to liberalise markets, substantial tariff barriers remain in many cases for imports of (emission reducing) foreign technologies, including energy supply equipment.

- **Institutional and Administrative Difficulties:** Such difficulties exist in terms of developing technology-transfer contracts, which can be a necessity to qualify regional construction companies as potential partners.

- **Regional Cooperation:** There is a need for greater regional cooperation among developing countries, both in R&D work and in the international commercial contracting network.

- **Access to Information:** Developing countries have in general poor access to information. It is one thing to recognise that the information and technology desired are available, but is quite another issue to gain access to them.

- **Differing Needs:** The needs of the developing countries are quite different to those of the developed countries. Developing countries are generally still focused on large capacities of cheap, reliable power with low technical risk, and have new technologies as a lower priority. In addition, most developing countries rate development as a higher priority than reducing emissions.

- **Economic Incentives:** Incentives for donors are weak mainly when energy demand is scarce and scattered. This barrier can be minimised by the additional potential value gained through JI/CDM schemes.

Constraints and Gaps and Related Financial, Technical and Capacity Needs

Fiji has taken a number of initiatives to ensure that climate change is mainstreamed into national development through the formulation of key policy frameworks, setting the basis for climate change adaptation and mitigation activities. This includes the formulation of the Green Growth Framework (2014), the 5-Year and 20-Year National Development Plan (2017), National Adaptation Framework (2017), Fiji's Climate Vulnerability Assessment (2017), the Planned Relocation Guidelines (2018), National Adaptation Plan (2018). Whilst adaptation is a key priority, Fiji has also shown commitment in mainstreaming climate change mitigation by developing a sector-wide Low Emission Development Strategy (2018). In retrospect the SNC had identified gaps and constraints in terms of the lack of existing frameworks and financial resources to address climate change.

While much progress has been made in terms of policy frameworks, lack of financial resources still remains a major roadblock to cater for the technical and capacity needs for adaptation and mitigation activities and long-term investments in climate change research and development. However, initiatives such as the Environment and Climate Change Adaptation Levy (ECAL) is a small window of opportunity for the country to fund climate change adaptation and mitigation projects. The country has demonstrated self-sufficiency through this initiative and the need for immediate action to address some of the impacts of climate change the country is already facing. Private sector contributions can be proven useful; however, their involvement towards climate finance is lacking, and thus a major challenge for the Government is to provide a conducive and enabling commercial environment in order to make a good business case for adaptation and mitigation projects.

Apart from the financial constraints, to implement the interventions in the climate action plans and strategies requires building appropriate implementing capacity. The consideration to conduct a proper assessment of Fiji's capacity and technology needs for climate actions, identifying gaps, and take steps to carry out capacity building and technology transfer for climate actions will be important in bridging the gap between policy and implementation on the ground.

While the National Development Plan serves to mainstream climate change in all areas of development planning and identifies the relevance of different Government programmes to climate change and disaster management, there still exists opportunities to further strengthen monitoring, evaluation and tracking of on-the-ground implementation. This requires stronger inter-institutional coordination and technical capacity across all relevant stakeholders, which includes staff knowledge, training and experience, along with relevant systems required to operationalise climate change policies and strategies.

Effectively improving institutional arrangements and technical capacity in relevant ministries and agencies will also improve data integrity, with key planning and development agencies having quality and reliable data readily available for informed decision making, disaster preparedness, and policy and strategy development alongside meeting the reporting obligations under UNFCCC and its Paris Agreement. This further needs to be aligned to a robust and transparent bottom-up monitoring, reporting and verification system that evaluates whether national and international support provided for climate action in the country is adequate, identifying where more efforts are concentrated and where efforts are still lacking, and learning how to direct them appropriately.

In summary, climate change presents new developmental complications that require drawing cross-sectorial links and strengthening institutional arrangements with all key players, who in turn require relevant technical knowledge and understanding, technology transfer, finance and adequate systems in place to better address and implement solutions to climate change at all levels of governance.

CHAPTER 1
NATIONAL CIRCUMSTANCES

Geography, Geology and Climate

Table 3: Country Profile

Location	It is located between latitudes of 15⁰ and 22⁰ south and between longitude 175⁰ east and 178⁰ west.
Area	Fiji is a large archipelago consisting of more than 300 islands covering around 18,300 square kilometres of land area, scattered over 1.3 million square kilometres of the Southern Pacific Ocean.
Population	884,887 population (2017 census)
GDP	FJ$4.63 billion
GDP per capita	FJ$7,685.9 per capita

Fiji comprises numerous small volcanic islands, low-lying atolls and elevated reefs. The largest islands have a diverse range of terrestrial ecosystems, including extensive areas of indigenous forest. Both larger islands also have distinct wet and dry sides due to prevailing wind patterns. Fiji's coastal ecosystems consist of mangroves, algae and sea-grass beds in shallow reef and lagoon areas. There are various pristine reef types such as barrier, fringing platform and atoll or patch reefs that house most of Fiji's aquatic biodiversity.

The climate in Fiji is characteristic of an oceanic tropical climate. Average daily temperatures remain relatively constant year-round at 25°C (77°F) only becoming a few degrees higher during the rainy season. Annual rainfall distribution on the main island of Viti Levu is affected by the island's central mountain range. As a result, the eastern half of the island receives 3-5 meters of annual rainfall, while the western half receives 2-3 meters. The rainy season lasts from November to April, and Fiji is frequently affected by tropical cyclones during this period. El Niño events are associated with reduced rainfall on the islands, in part due to shifts in the typical path of tropical cyclones away from Fiji. The 1997-1998 El Niño events contributed to bringing about one of the worst droughts on record. (Climate variables and projections are further detailed in the Impact, Vulnerability and Adaptation Chapter).

Population and Economy

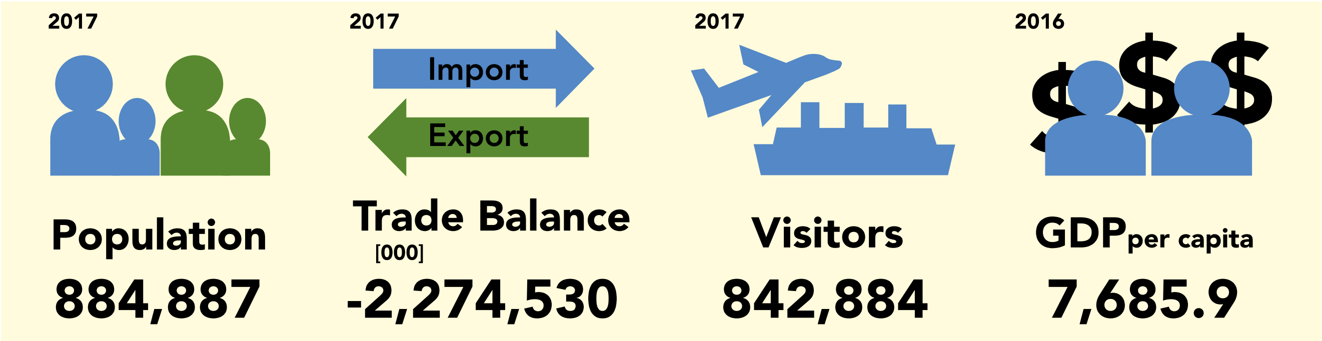


Figure 4: National Census 2017

Source: Fiji Bureau of Statistics

The country population grew by 0.6 per cent from the population count in 2007. The urban population has grown by 16.3 per cent with a subsequent decrease in rural population by 5.3 per cent. 55.9 per cent of Fiji's population is concentrated in major urban areas, with whereas the remaining 44.1 per cent spread across rural communities around the country. This has implications for the carrying capacity of the urban infrastructure to accommodate the high inflow of rural migrants and is one of the major contributing factors to the increased number of urban squatters. There are close to 78,000 people currently living in 128 squatter settlements in the major urban areas who also face significant threats from natural disasters due to poor housing stocks.

The median age of the population in the country is 27.5 years, indicating that 50 per cent of the population is fairly young (Figure 5).

According to the 2017 National Census, Fiji has an estimated GDP of FJ$4.63 billion, with FJ$7,685.9 per capita GDP (Figure 4). The Fijian economy grew by 4.2 per cent in 2017 from the previous year compared to 0.4 per cent growth in 2016. Tourism is the most important sector of the economy and accounts for more than 25 per cent of the GDP with the total average earnings of FJ$1.53 billion per year. Fiji Tourism is targeted to become a FJ$2.2 billion dollar industry by the year 2021, thereby increasing the number of employment opportunities in the country. Sugar and textiles exports remain important sources of revenue but have fallen in prominence as Fiji is unable to compete globally.

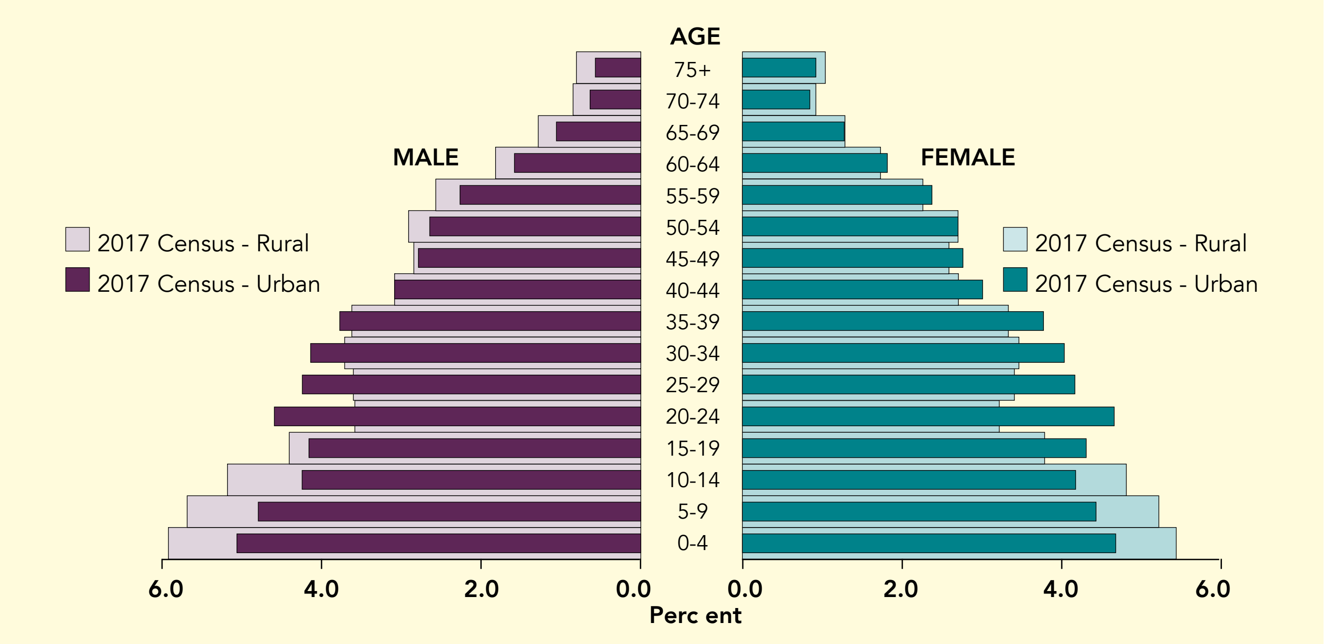


Figure 5: Age-Sex structure of urban and rural population, Fiji, 2017

Positive contributors to the economy during the 2007-2017 phase were: Wholesale and Retail (0.8 percentage points); Public Administration and Defence (0.4 percentage points); Construction (0.3 percentage points); Information and Communication (0.3 percentage points) and Education (0.2 percentage points). On the contrary, there was a contraction in the Agriculture, Forestry and Fishing, Accommodation and Food Service Activities, Real Estate Activities, Manufacturing and Financial & Insurance Activities from 2016 due to Tropical Cyclone Winston.

Government Structure

Fiji's system of Government consists of the Legislature, the Executive and Judiciary. The central Government comprises the Parliament, Cabinet and the Government Ministries. The Fijian Government is a parliamentary democracy, and the Constitution of the Republic of Fiji establishes Fiji's system of Government. It provides for three separate arms of the State – the Legislature (or Parliament), the Executive, and Judiciary. Under the executive, the Cabinet is the decision-making body of the Government and is chaired by the Prime Minister. Its member are Ministers appointed by the Prime Minister from among the members of Parliament.

There are also four administrative divisions (Central, Eastern, Northern and Western), each under the charge of a commissioner appointed by the central Government. The divisions are further subdivided into fourteen provinces, each of which has a provincial council. In addition, the island of Rotuma has the status of a dependency and enjoys a degree of internal autonomy, with its own island council.

The diverse impacts of climate change affect all major economic sectors in Fiji – from agriculture and forestry, tourism, water and energy. In response, the Government has established a network of bodies, committees, divisions and other entities to focus on climate change and disaster risk management initiatives. At the centre of the network are the Climate Change and International Cooperation Division under the Ministry of Economy, which is responsible for the implementation of the National Climate Change Policy (NCCP), and the National Disaster Management Office (NDMO) under the Ministry of Rural and Maritime Development and National Disaster Management, which manages Fiji's response to natural disasters. Both entities are meant to play a key role in coordination and policy advice on climate change and disaster risk management. Moreover, the Fijian Government is committed to the better integration of climate change and disaster risk management

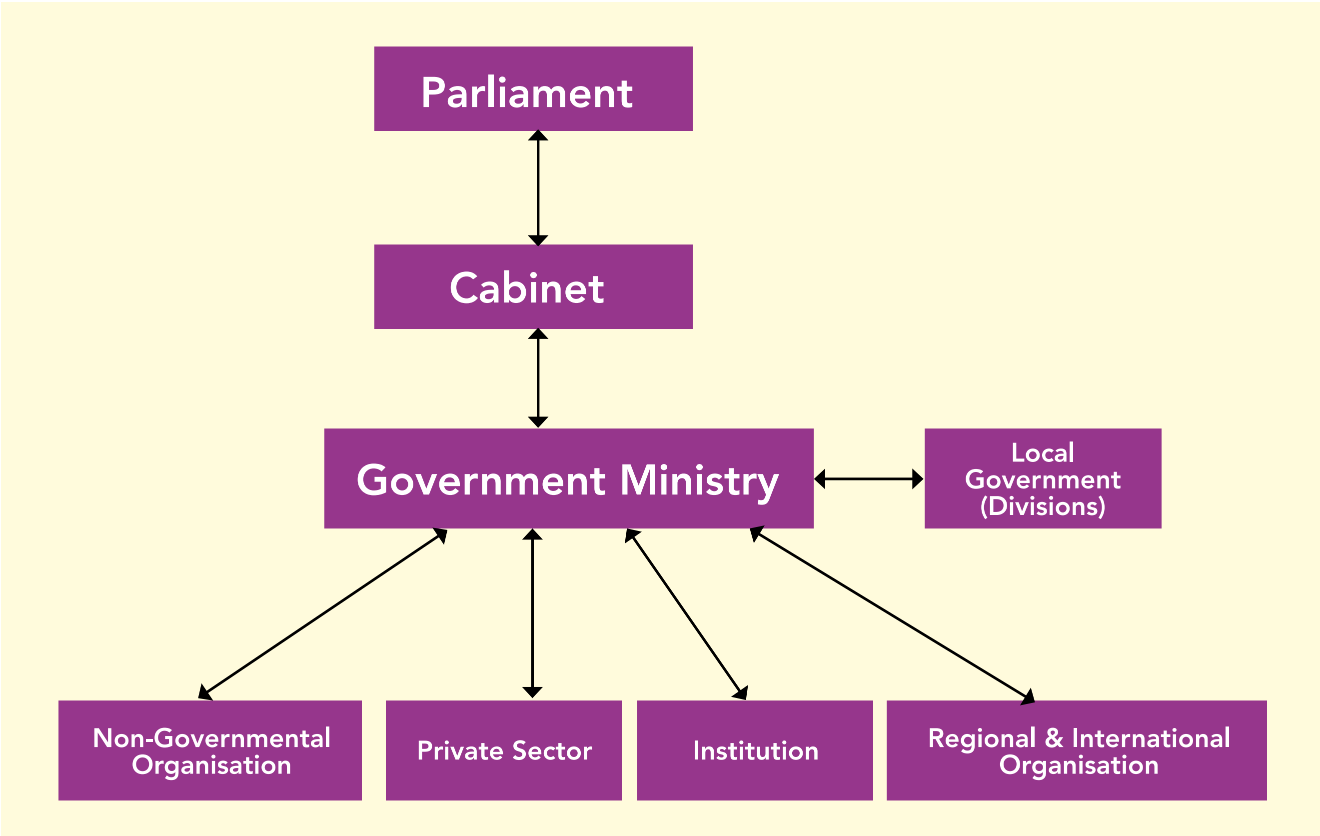


Figure 6: Central Government Structure

(CCDRM) into broader socio-economic development. This is through the National Development Plan (NDP), the Green Growth Framework (GGF), and also integrating CCDRM approaches into sub-national programming, including Community Development Plans (CDPs) for incorporation into the Integrated Rural Development Framework (IRDF).

At the local government level, the following institutions are addressing climate change and disaster risk management issues:

- Divisional Commissioners' Office
- i-Taukei Provincial Offices
- Department of Local Government

National Climate Change and Disaster Risk Management Policies and Plans

The National Climate Change Policy (NCCP) framework developed in 2007 defines the position of Government in addressing climate change variability and sea-level rise. It was reviewed in 2011, which resulted in the development of the NCCP 2012.[3] The policy is being reviewed to further reflect current and emerging climate change issues at the local, national and international level and will be updated to be the NCCP 2018.

Biodiversity

The environment and its resources are crucial for sustaining the economy, employment and food and nutrition security. Climate change has emerged as one of the major threats to biodiversity in the country. The people of Fiji are in a close-knit relationship with their surrounding ecosystems.

Accompanying the broadening use of natural resource has been the increasing demand on freshwater resources for both hydro-power generation and drinking water. Whether for subsistence consumption or income earning, there have been increasing risks to the environment and loss of biodiversity. Changes in both consumption and production patterns have led to increasing volumes of both solid and liquid waste being produced with associated pollution to the environment. Managing the impact of climate change will require a focus on adaptation and mitigation through building community resilience, strengthening food security, enforcement of standards on buildings and structures, and protecting coastal communities by way of reinforcement or in some cases, relocation.

In light of these threats, the Fiji National Biodiversity Strategy and Action Plan (NBSAP) 2007 has been revised and updated to NBSAP 2017-2024, which reflects the progress, successes and gaps in efforts towards effective and enduring conservation measures. The reviewed NBSAP

Table 4: Alignment of Respective National Frameworks to Regional and International Frameworks

Level	Climate Change	Disaster Risk Management
International	• UNFCCC • United Nations Convention on Biological Diversity (UNCBD) • United Nations Convention to Combat Desertification (UNCCD)	• Hyogo Framework for Action
Regional	• Pacific Island Framework for Action on Climate Change 2006-2015 (PIFACC)	• Pacific Disaster Risk Reduction and Disaster Management Framework of Action (PDDFA) • Framework for Resilient Development in the Pacific (FRDP)
National	• National Development Plan • Green Growth Framework (GGF) • National Climate Change Policy (NCCP) • CDM Guidelines • REDD+ Policy • Ministries Strategic and Annual Corporate Plans	• National Disaster Management Act • National Disaster Management Plan

3 Climate Public Expenditure and Institutional Review, 2015

focuses on six priority areas that include:

- Improving Knowledge
- Developing Protected Areas
- Species Management
- Management of Invasive Species
- Enabling Environment and Mainstreaming
- Sustainable Use and Development

Fiji's 2017-2024 NBSAP will be implemented through the NBSAP Implementation Framework after it has been revised. The NBSAP would highlight the need to address gaps in our knowledge, particularly with regards to better understanding our specific conservation needs.

This would build climate change resilience in Fiji and ensure that our forests, mangroves, coral reefs, freshwater systems, wetlands and marine areas are conserved, protected and managed sustainably.

Water and Sanitation

There has been a 3 per cent increase from 75 per cent to 78 per cent in total public accessibility to the treated and reticulated water supply since the Second National Communication (SNC).[4] Approximately 71 per cent of Fiji's overall population has access to improved sanitation.[5] Government recognises the importance of water and sewerage facilities in the socio-economic development of the country. Hence, under the operation of the Water Authority of Fiji (WAF), it has extended clean water supply to 98 per cent of the urban population in Fiji. Moreover, the Fijian Government has introduced the free water initiative for households with a total combined income of less than FJ$30,000 that are consuming less than 91,250 litres of water per year. This has further eased the financial burdens on Fijians.[6]

Table 5: Water and sanitation indicators

Water and sanitation	per cent of population
Access to clean and safe water in adequate quantities	78
Access to clean and safe water in adequate quantities, rural	58
Access to clean and safe water in adequate quantities, urban	98
Access to central sewerage system	25
Access to central sewerage system, urban	25
Access to central sewerage system, rural	0

4 SNC, 2014
5 NDP, 2017
6 ibid

Additionally, the Government has continued to invest in improving and maintaining existing water infrastructure by increasing the operating grant for WAF from FJ$58 Million in 2014 to FJ$89.6 Million in 2017.[7] This shows the commitment to improve water supply and sewerage services to the people of Fiji. Due to the threat of groundwater salination in outer remote islands of the country, awareness programmes and strategies for freshwater conservation are currently being employed. The development of feasible and clean methods of extracting groundwater and harvesting rainwater is also currently underway.

Energy

The Energy sector in Fiji has a major role in Fiji's NDC Implementation Roadmap. Considered as the largest contributor to the GHG budget in Fiji, this sector also has the potential to mitigate carbon emissions by resorting to renewable sources of energy. Approximately 90 per cent of Fiji's population has proper access to electricity, with plans to extend the supply to the remaining 10 per cent of the population in the next 5 years. Presently, just over 60 per cent of Fiji's energy is generated through renewable energy projects. In the last decade, the country's capacity in renewable energy generation has increased by 50 MW.[8]

Table 6: Energy indicators

Energy	
Access to electricity	90 per cent of population
Percentage of population with primary reliance on wood fuels for cooking	18 per cent
Energy intensity (consumption of imported fuel per unit of GDP)	2.89 MJ/FJ$
Energy intensity (power consumption per unit of GDP)	0.219 kWh/FJ$
Renewable energy share in electricity generation	67 per cent
Renewable energy share in total energy consumption	13 per cent

Existing and new renewable energy projects in Fiji are from wind, biomass, thermal, hydro and waste/biogas sources. There are four hydro-power projects that currently exist in Fiji and a wind power generation project. Due to the average low wind speeds at the location, the wind farm does not function at full capacity, so the Department of Energy is

7 MOE, 2017
8 NDP, 2017

carrying out wind monitoring at other locations around the country to set up future feasible wind plants. Biomass waste accumulated from Tropik Woods and Fiji Sugar Corporation is processed at the Nabou Green Energy Limited in Sigatoka to produce 10 MW of energy. Waste/biogas projects from piggeries and dairy-farms are also being undertaken in the country. Thermal energy, however, is still in its developing stages.[9]

To initiate further investments in the renewable energy sector, the Fijian Government has implemented tax incentives in the country to provide opportunities for households and the private sector to invest in small renewable energy projects. The inclusion of the private sector as Independent Power Producers (IPP) through non-renewable and mostly renewable sources is highly encouraged.

Transport

The transport sector (land, marine, and domestic aviation) is the primary consumer of fossil fuels in Fiji. It is the major GHG emissions contributing sector – 64 per cent of energy sector emissions and 39 per cent of overall emissions, mostly from road vehicles (71 per cent passenger cars and 18 per cent trucks). The transport sector contributes about 12 per cent towards Fiji's GDP and has 30 per cent capital budget allocation annually. This sector is also highly vulnerable to natural disasters. It accounts for 46 per cent of annual asset losses from disasters and will require an estimated investment of FJ$4.3 billion to increase sector resilience.

i. Land Transport

In the journey of transforming Fiji into a modern, safe and well-connected country, the Fijian Government has embarked on projects to improve transport infrastructure in the country. Substantial amounts of funds were allocated to the Fiji Roads Authority from 2014 to 2017 to undertake major structural upgrades of the following completed projects in the country:

- Four-lane road for Suva- Nausori corridor
- Expansions and rehabilitation works on rural and maritime roads in the country
- Installation and replacement of traffic and street lights around the country
- Construction of Stinson and Vatuwaqa Bridge
- Construction of roundabouts and re-designing of roads to ease traffic congestions
- Construction of footpaths in peri-urban and urban areas

9 NDC Roadmap, 2017

Incentives on fuel-efficient vehicles are currently enforced to promote the replacement of old inefficient vehicles. More policies and plans on safer and cleaner means of transportation are also currently being developed.

Continuous efforts to induce positive behavioural change in the public to address eco-friendly driving and the benefits of public transportation are also being emphasised.

Table 7: Transport Indicators

Transport	
Existing roads to be maintained (km)	7,524
Existing roads to be resealed (km)	340
Existing bridges to be upgraded (no.)	1251
Existing jetties to be upgraded (no.)	47
New streetlights to be constructed (no.)	500
Existing streetlights to be upgraded (no.)	2000
Number of fully automated motor vehicle inspection system (no.)	1
Number of permanent weighbridges	2
Dependence on imported fossil fuel per km travelled for transportation (per cent)	42 per cent
Vehicle emission levels (per cent)	50 per cent

ii. Sea Transport

Inter-island networking in Fiji is maintained through affordable shipping services providers to the islands across Fiji's Exclusive Economic Zone (EEZ). Fiji is prone to tropical cyclones, so the Government is determined to improve infrastructure and make jetties and ports resilient to natural disasters.

Inter-island shipping services in Fiji are being shared between Government Shipping Services and private shipping agencies. The aim to bring more fuel-efficient vessels in the country is being considered through incentives for private sector investments in new ships and equipment, together with subsidies for services to uneconomical routes under the franchise scheme.

iii. Air Transport

Air transport does not only connect islands within Fiji, but it also connects Fiji to the international community. Fiji has its own Pacific Flying School and Aviation Academy where International Civil Aviation Organization (ICAO) standard is training are provided for pilots, air traffic controllers, air navigation engineers, security and rescue fire officers for the Airports Fiji Limited. Refurbishment of the Nadi Airport and terminal to international standards has given Fiji's International gateway a new image. Similar facelifts and maintenance works are being planned for Nausori International Airport (Suva) and Waiqele Airport in Labasa.

Government has and will continue to subsidise domestic flights to make them more affordable. The introduction of more fuel-efficient and luxurious aircraft such as the A330-200 and A330-300 has ensured a more comfortable journey for locals and tourists.

Health and Medical Services

Good health and well-being are among the key goals for sustainable development in Fiji. To achieve international standards, there has been significant investment in human resources and infrastructure in the country by the Government and International donors. Attractive remuneration packages are being offered to newly recruited doctors and nurses to retain staff and improve the doctor-to-patient ratio. Government has taken two major steps to ensure that the people of Fiji have access to good health. Firstly, medical services have been decentralised to ensure the ease of access to the public. Secondly, the free medicine scheme ensures that household with a total income of less than FJ$30,000 have free access to basic and important medicines.

Non-communicable diseases (NCDs) continue to be the major cause of premature death in Fiji. A National Wellness Policy was put in force for Fiji in 2015 to ensure that a multi-sectoral and inter-disciplinary approach is being taken to educate the public on healthy living practices and adaptation to climate change related health concerns.

Climate-sensitive diseases such as vector-borne (food, water and air-borne) are becoming more common in the country. Emphasis and awareness are being placed on educating the general public about mitigating disease occurrences and adapting to changing environmental conditions.

Agriculture

The agriculture sector is one of the most fundamental sectors of the country's economy contributing FJ$200 million annually in export earnings.[10] This sector is diverse and is broken down into five subsectors: crops, sugarcane, livestock, fisheries and forests. It is a source of livelihood for many households and is necessary to ensure that people at all times have physical and economic access to sufficient, safe and nutritious food. The main crops for subsistence include taro, cassava and sweet potato. The main crops for export include ginger, taro, kava, cassava and "wild" harvest turmeric. The sugar industry, which used to be the country's backbone, has suffered a huge decline in the past decade due to a decline in productivity, shortage in labour and the increase in production costs. The decline in sugar production is owed to natural disasters and adverse climatic

10 Fiji Bureau of Statistics and the Macroeconomic Committee May 2017.

Table 8: Health Indicators

Health	
Premature mortality due to NCDs (< age 70 years)	68.2 per cent
Population prevalence of diabetes	30 per cent
Maternal mortality ratio	39.2 (8 deaths)
Infant mortality rate per 1000 live births	13.8
Number of health facilities meeting minimal standards for emergency and disaster preparedness	3 divisional hospitals 16 sub-divisional hospitals
Ratio of skilled healthcare worker (doctors, nurses, midwives) per 10, 000 population	Doctors -6.6 Nurses – 27 Midwives – 3.4
Average availability of selected essential medicines in public and private health facilities	80 per cent
Current health expenditure per capita, current FJ$	358.40
General Government expenditure on health as a proportion of general Government expenditure.	11.9 per cent
Ratio of household out-of-pocket payments for health to current health expenditure	25.3 per cent

Table 9: Agriculture Indicators

Agriculture	
Agriculture sector GDP contribution	FJ$ 541.8 million (8.1%) to GDP (2015)
Livestock	FJ$ 52.8 million (0.8 %) to GDP
Basic types of agriculture in Fiji	Subsistence, semi commercial and commercial
Main crops cultivated	Sugarcane, cassava, dalo, coconuts, yaqona, rice, and other plants (ginger, eggplant and tropical fruits)
Main livestock	Beef and dairy cattle, poultry, goats and pigs.

conditions, vastly affecting the replanting over the last 5 years.[11] About 37 per cent of the households in Fiji derives some form of income from agriculture.[12]

Climate change continues to threaten the agriculture sector. This sector provides an important source of livelihood for rural communities, food and nutrition security, income and employment and poverty alleviation. The Fijian Government aims to make the agricultural sector self-sufficient and a key player in the export market. The state of vulnerability of the sector will be further discussed in the Impacts, Vulnerability and Adaptation chapter.

The vision for restoring the balance in development that is sustainable for the country's future is being carried out under the National Green Growth Framework and the 5-Year and 20-Year National Development Plan for the country. Agriculture converges with both the fisheries and forestry sectors, together with the sugar sector. The agricultural sector has shifted from the previous Demand-Driven Approach to a diversified and economically and environmentally sustainable sector in Fiji.

11 MoE, 2017.
12 Fiji Department of Agriculture, 2009.

According to the 2020 Agriculture Sector Policy Agenda, the national goal for agriculture in Fiji is to "Build Sustainable Community". The strategies in place in the 2014 policy agenda focuses on using conservation and environmentally sound agriculture technologies and practices for the best use of land and water resources and prepare for possible changes in the climate. Current agricultural projects encourage sustainable land management, agroforestry landscape approach, organic farming and backyard gardening. The Fijian Government aims to address the regulation of fertiliser usage, land degradation neutrality and livestock management in the future. Development on climate-resilient local crops is also underway to cater for food security for the growing population.

The sugar industry continues to play a crucial role in the socio-economic development of the country. The industry contributes 5 per cent to the total GDP of the country and employs just over 200,000 people. The Fijian Government continues to empower and encourage farmers in the country by providing valuable incentives in the sugar sector. Moreover, in 2017, the third cane payout saw an increase of 18 per cent from 2016. Incentives have also been put in place for other sectors to encourage positive behavioural changes in farmers.

Forestry

Fiji forests include natural (indigenous) forests, coconut plantations, commercial pine and mahogany plantations and mangroves. The main drivers of deforestation in the country are agricultural development, infrastructure development and establishment of settlements. Similarly, the main causes of forest degradation have been identified as poor logging practices, fuelwood collection and burning of the forest.

Table 10: Forest Indicators

Forestry	
Land area covered by forest	60 per cent
Total forest area	1.16 million ha
Native forest (per cent of total)	87 per cent
Plantation forest (per cent of total)	13 per cent
Mangrove stock	50,000 ha
Main drivers of deforestation	Commercial and smallholder agriculture
Main driver of forest degradation	Timber harvesting
Forest sector export earnings	4.1 per cent (mainly wood chips and mahogany)

The SNC noted that logging from natural (indigenous) forests and forest plantations contribute on average 1.2 per cent of GDP and 4.1 per cent of export earnings but the performance of the sector in recent years has been declining for various reasons. The Fijian Government has been trying to reverse this trend but the use of forests for economic gain competes with the use of forests for environmental protection and GHG mitigation.

Fiji has adapted the national REDD+ programme, which supports reforestation of native and exotic forests. This programme has a two-strategy approach that ensures the protection of the forest while concurrently generating financial benefits under carbon-trading mechanisms.

The forestry sector cross-cuts through the energy sector in the country. Recent ventures into wood bio-energy have seen the potential growth in energy generated from wood bi-products from Tropik Woods Fiji and could be extended to other private stakeholders.

Land Resources/Mining

The Government continues to improve land-use and administration by undertaking the development of the Fiji Geospatial Information System, National Land Bank and National Land Register. This supports the development of iTaukei and state land for productive purposes such as leasing for residential plots, agriculture, and civil and commercial activities that promote the country's economic growth. This venture ensures efficient leasing of land that is currently idle under terms and conditions that are attractive to both landowners and tenants. The Land Use Decree 2010 governs the availability of land for investment opportunities. The Ministry of Agriculture and the Ministry of Forests are working in collaboration on the Action against Desertification Project.

For several years, Fiji's mining industry was predominantly the Vatukola gold mines. More recent explorations reveal that Fiji has a rich store of minerals, including bauxite, copper, iron and manganese. Currently, there are a total of 8 mining leases and 78 exploratory licenses issued in the country. This number is expected to increase in the future.

Increases in mining activities and exploration sites are monitored in the country under the Mining Act, which enforces policies and institutional frameworks for mining and quarrying and the monitoring and evaluation of operations. These policies and frameworks will be revised and updated for better monitoring in areas such as Occupational Health and Safety (OHS) and environmental safeguards.

There are also investigations for potential groundwater sites in order to increase production of and accessibility to sustainable clean water supply for all Fijians. More boreholes are to be drilled and local water testing laboratories to be upgraded to undertake water-quality testing and geochemical analysis in order to save the cost of sending samples overseas for analysis.

Coastal and Marine Resources

Fiji's Exclusive Economic Zone (EEZ) spreads across a total area of 1.3 million square kilometres. The Fijian Government continues to emphasise the importance of coastal mangroves and the ocean. Fiji's presidency at COP23 and co-presidency for the 2017 Oceans Conference have allowed Fiji to create awareness of the ocean and its importance for sustaining livelihoods in Small Island Developing States (SIDS). The Ocean Pathway launched under the Fijian presidency at COP23 calls for oceans to be an integral part of the

UNFCCC processes to ensure sustainable development and conservation of marine resources.

In recent years, Fiji has seen a decline in fish stocks, which is linked to overfishing and, pollution and exacerbated by global warming and climate change. The National Fisheries Policy, the Offshore Fisheries Decree 2014, the Offshore Fisheries Management Regulations 2014, and the establishment of Marine Protected Areas guide the management and development of sustainable fisheries within the offshore, inshore, coastal and aquaculture sub-sectors. Licenses have also been provided for offshore oil exploration in Fiji.

In the Paris Agreement, mangroves were recognised of its role as carbon reservoirs (Blue Carbon) and in Climate Change Mitigation. Recognising this and the numerous ecosystem services mangroves provide, Fiji is formulating a new Mangrove Management Plan to further safeguard this valuable resource. Additionally, under Section 21 of the State Lands Act, no crown foreshore land or any soils under the waters of Fiji are permitted to be leased without the approval and the declaration of the Minister in charge. Other important projects such as the Fiji Ridge to Reef Project, aims to preserve biodiversity, provide ecosystem services, sequester carbon, improve climate resilience and sustain livelihoods through a ridge-to- reef management approach. The need for restoration and rehabilitation of mangroves is more or less emphasised in the majority of the policy documents of the country, including the National Development Plan.

Tourism

The tourism sector is the leading contributor to the Fijian economy. In 2016 the tourism industry had a total income of FJ$1.6 billion, with a total number of visitors standing at 792,320 - a number more than 85 per cent of the Fijian population. The industry has targeted to become a FJ$2.2 billion industry by 2021. New Zealand, Australia and the USA continue to be the major visitor markets for the country. However, recent decisions to create new and direct links to China, Japan and Singapore have led to a significant number of visitor arrivals from China and India. Moreover, tourist numbers have increased by 15 per cent from 2008 to 2016.

The tourism industry is based on cross-sectoral interaction in the country. Apart from supporting major infrastructure development of hotels in the country, the Fijian Government also focuses on micro, small and medium enterprises (MSMEs) and other niche activities such as dolphin and whale watching, village tours, river rafting and zip-lining, snorkelling and boating, eco-tourism and promoting Fiji's cultural and heritage sites. These activities support MSMEs and local communities to improve their livelihoods and help alleviate poverty. Investments are also being made into the film industry to showcase Fiji through movies and TV series to attract and promote Fiji to a larger global audience.

Factors that drive the industry are also subject to the impacts of climate change, which can be a deterrent to tourists choosing Fiji as a holiday destination. The impacts of climate change on the industry are discussed further in the Impact, Vulnerability and Adaptation chapter.

Waste

The Fijian Government has taken strong actions relating to waste management in the country through numerous waste management laws. There are also several new Clean Development Mechanism (CDM) projects for waste management that convert waste to energy. The newly established Naboro landfill has the capacity to cater for all the waste generated from Nausori to Sigatoka complying with health and environmental standards. However, Naboro landfill is a source of methane gas, a powerful GHG. The Fijian Government is prioritising the area of research and development to utilise this methane for power generation.

There are five strategic goals governing the waste sector. These are the prevention of waste, recovery of resources from wastes, improvement of residual management, improvement in protection and monitoring of the receiving environment; and implementation of National Integrated Waste Management Strategy 2016-2025. Major actions taken to address the pledge of the Government include the establishment of the Nabou Green Energy plant, which utilises the bi-products of the timber and sugar industry. Moreover, under the Environment and Climate Adaptation Levy (ECAL) Act of 2017, a fee of 20 cents is charged for every plastic issued by the businesses that utilise a register on point of sale, in order to minimise the use of plastic bags. Small-scale biogas projects are ongoing at piggeries and dairy-farms to address waste management, health and energy needs for rural communities.

- Consideration will be given to the establishment of a Waste Management Authority to provide more efficient, effective and financially viable waste-management services to municipal councils.
- Waste recycling and transfer stations will also be developed in strategic areas around the country.

Culture and Heritage

The Fijian Government aims to protect and promote the uniqueness of the Fijian cultural heritage for sustainable development in the country. Fiji has a rich cultural heritage compromising language, food, festivals, rituals, arts and traditions that holds intrinsic value for both present and future generations. The Second National Communication mentioned the development of the National Cultural Policy. This policy, together with National Culture and Education Strategy sets the platform for protection and preservation of both tangible and intangible cultural heritage.

The upgrade of the National Archives and the Fiji Museum greatly contributes to the preservation of the country's heritage. The Fijian heritage is being promoted in the Tourism sector. Moreover, through the "Fijian Crafted" campaign income-generation activities are being promoted that improve the livelihoods of the Fijian people, as outlined in Fiji's National Development plan. Cultural heritage sites in the country are being promoted as attractive tourist spots around the country.

The Fijian Government has initiated the Cultural Revitalisation Programme, which promotes the iTaukei culture to urban youths in Fiji. This cultural mapping programme documents the Intangible Cultural Heritage of the iTaukei community that is its traditional home base (the village) and its custodians (elders and chiefs). It also contributes towards reviving and using traditional knowledge and solutions for addressing climate change and its impacts.

CHAPTER 2
GREENHOUSE GAS INVENTORY

Greenhouse Gas Summary

Fiji's main GHG emissions comprised carbon dioxide (CO_2) from the energy sector and smaller amounts of methane (CH_4) and nitrous oxide (N_2O) from agriculture and waste. Forestry emissions were understood to be slightly positive at around 400 Gg p.a. (0.4 Mt p.a.) but with a high level of uncertainty. Overall emissions were estimated to be around *2500 Gg p.a.* (2.5 million tons p.a.), which remained reasonably constant throughout the reporting period.

By way of comparison, the total world emissions for 2010 were around 49 Gt, of which 65 per cent were CO_2 emissions from fossil fuels, 11 per cent CO_2 FOLU emissions, 16 per cent CH_4 emissions, 6 per cent N_2O emissions and 2 per cent other gasses (IPCC 2014). For Fiji, 59 per cent (average 2006 – 2011) were CO_2 emissions, 15 per cent FOLU, 20 per cent CH_4 and 6 per cent N_2O emissions (Figure 7). With a world population of around 7 billion people in 2010, that amounts to an average of 7 tons of CO_2 eq. per annum per person. Fiji's per capita emission is estimated to be 2.8 tons, or around 40 per cent of the world average for the reporting period. In absolute terms, Fiji's total CO_2 eq. emissions were around 0.006 per cent of world emissions.

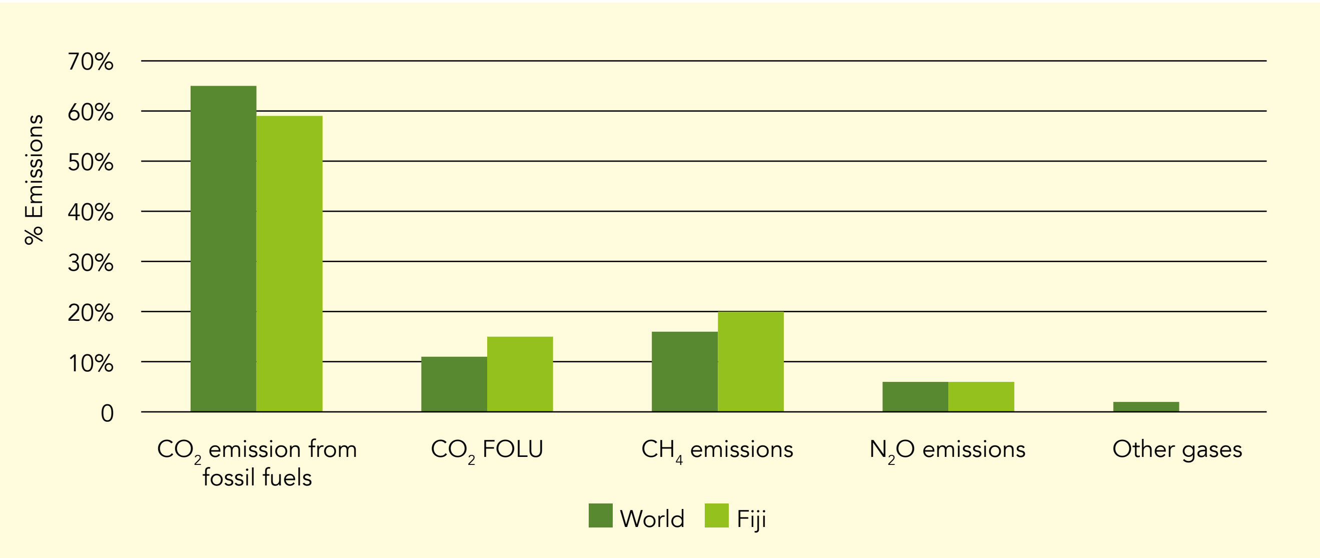


Figure 7: Percentage emissions by gases in the world and in Fiji

Source: http://blogs.worldbank.org/transport/when-island-buses-go-green

The table below shows the GHG emissions for the years 2006–2011. The values have been rounded to 2 significant figures to indicate the limits imposed by data uncertainties. Detailed Methodology and Data Documentation are provided in Appendix A.

Table 11: Fiji total GHG emissions 2006- 2011 (Gg)

Fiji total GHG emissions all gases CO_2 equivalent Gg							
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**Average**
Carbon dioxide							
Energy Gg CO_2	1767	1550	1333	1260	1526	1410	1474
Forestry Gg CO_2	310	330	570	-250	760	560	380
Total Gg CO_2	2077	1880	1903	1010	2286	1970	1854
Methane							
Energy Gg CH_4 CO_2 eq	2	2	1	1	2	1	1
Agriculture Gg CH_4 CO_2 eq	414	415	412	409	409	405	411
Waste Gg CH_4 CO_2 eq	63	84	80	86	111	130	92
Total Gg CH_4 CO_2 eq	479	500	494	496	521	537	504
Nitrous oxide							
Energy Gg N_2O CO_2 eq	4	4	3	3	3	3	3
Agriculture Gg N_2O CO_2 eq	146	146	154	143	140	146	146
Total Gg N_2O CO_2 eq	149	149	157	146	143	149	149
Total Emission Gg CO_2 eq	**2700**	**2500**	**2600**	**1700**	**3000**	**2655**	**2500**

As can be seen, the emissions have remained reasonably constant over the reporting period, with the annual variation dominated by logging volumes in the plantation forestry sector. 2009 was a year of a typical low logging output, meaning forestry removals (CO2 sequestration) were highest for that year (see table above). The graphs below show the yearly and aggregate behaviour in more detail.

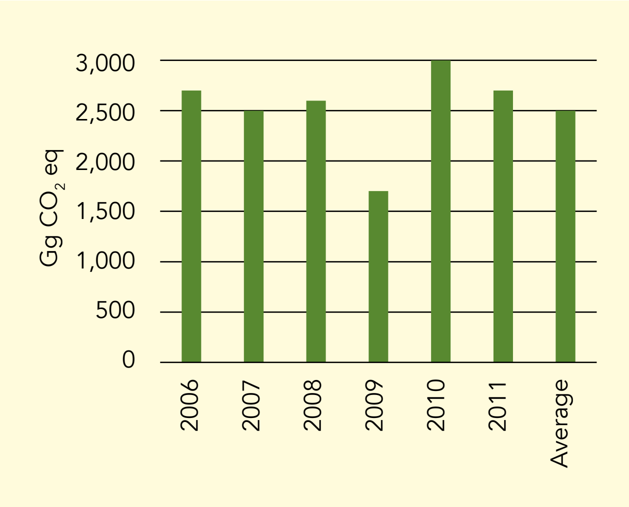


Figure 8: Fiji's total CO_2 eq. emissions time series 2006 - 2011 (Gg)

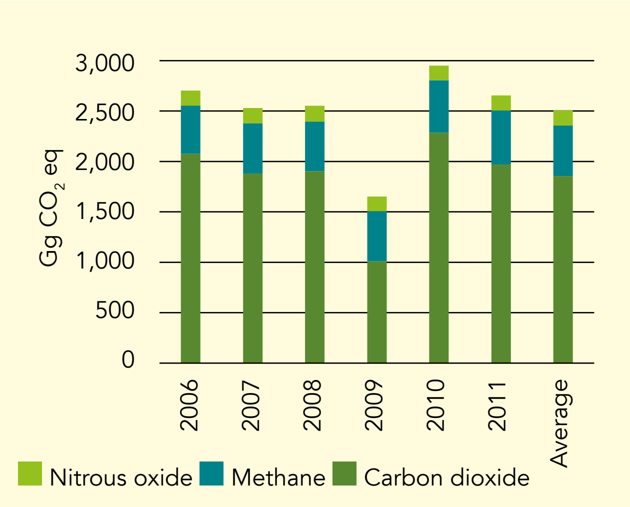


Figure 9: Total emissions by gas type

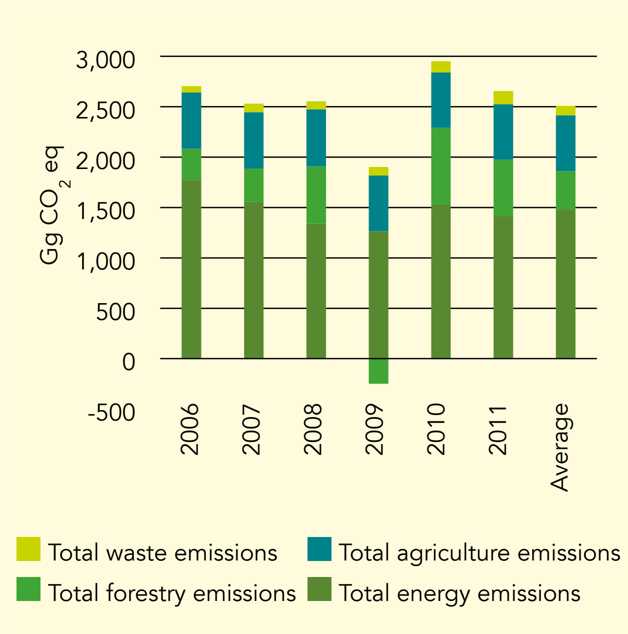


Figure 10: Fiji Total GHG emission by sector

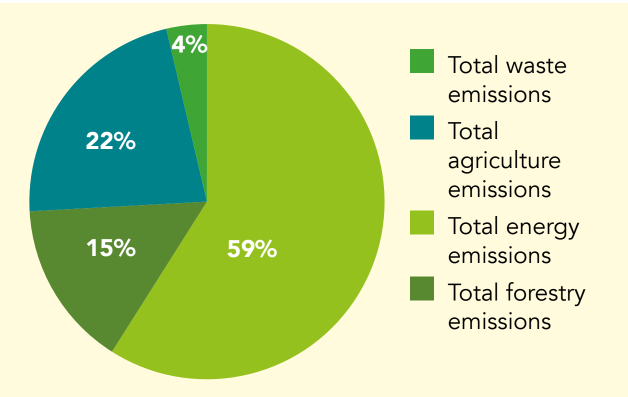


Figure 11: Fiji GHG emissions by sector (average 2006-2011)

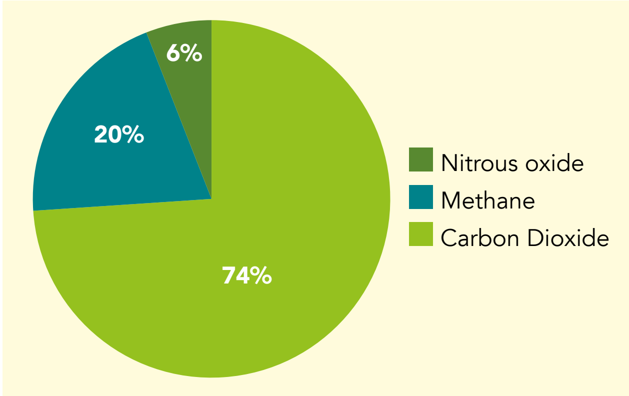


Figure 12: Fiji GHG emissions by type of gas (average 2006-2011)

Key Category Analysis

The key category level assessment shows the contribution of each source or sink category to the total national inventory level.

Table 12: Approach 1 level Assessment for the Fiji GHG Inventory for 2011 (with key categories in bold).

IPCC code	Category	Greenhouse Gas	Emissions Estimate (Gg CO_2 Eq.)	Level Assessment	Commulative %
1.A.3.b	**Land transport**	**CO_2**	**905**	**0.350**	**35%**
3.B.1	**Forestry**	**CO_2**	**380**	**0.147**	**50%**
3.A.1	**Enteric Fermentation**	**CH_4**	**314**	**0.121**	**62%**
1.A.1.a.1	**Grid diesel use (electricity)**	**CO_2**	**223**	**0.086**	**70%**
1.A.4.C	**Industrial consumption**	**CO_2**	**153**	**0.059**	**76%**
3.C.7	**Rice cultivation**	**CH_4**	**92**	**0.036**	**80%**
3.A.2	**Manure Management**	**CH_4**	**81**	**0.031**	**83%**
1.A.4.b	**Domestic consumption**	**CO_2**	**76**	**0.029**	**86%**
4.A	**Solid Waste Disposal**	**CH_4**	**65**	**0.025**	**88%**
1.A.4.a	**Commercial consumption**	**CO_2**	**61**	**0.024**	**91%**
3.C.6	**Indirect N_2O Emissions from Manure Management**	**N_2O**	**61**	**0.024**	**93%**
4.D.1	**Domestic Waste-Water treatment and discharge**	**CH_4**	**58**	**0.022**	**95%**
1.A.3.d.2	Marine transport	CO_2	55	0.021	97%
1.A.5.a	Off grid diesel use (electricity)	CO_2	22	0.008	98%
1.A.3.a.2	Air transport	CO_2	18	0.007	99%
3.C.5	Indirect N_2O Emissions from Managed Soils	N_2O	14	0.005	100%
3.C.4.f	Direct N_2O Emissions from Managed Soils	N_2O	11	0.004	100%

In terms of development objectives, agriculture, forestry and land transport are considered high-priority areas. Land transport is one of the highest rated key categories for 2011. Other key emission sources include Forest Land, Enteric Fermentation, Electricity Generation, Industrial Consumption of energy, Rice Cultivation, Manure Management, Domestic consumption of energy, Solid Waste disposal, Commercial Consumption of Energy, Indirect nitrous oxide Emissions from Manure Management and Domestic Waste-Water treatment and discharge.

Energy

The energy sector is the predominant emitter of GHGs in Fiji. The non-CO_2 emissions for this sector were negligible and outside the estimated accuracy of the main CO_2 emissions.

Table 13: Energy Sector emissions 2006-2011

	Energy Sector Emissions (Gg)							
	2006	2007	2008	2009	2010	2011	average	per cent
Land transport	927	912	926	885	886	893	905	59.8%
Marine transport	55	55	55	55	55	55	55	3.6%
Air transport	18	18	18	18	18	18	18	1.2%
Electricity production	286	200	216	233	299	238	245	16.2%
Domestic consumption	76	76	76	76	76	76	76	5.0%
Commercial consumption	67	63	58	56	62	59	61	4.0%
Industrial consumption	125	119	134	164	188	187	153	10.1%
Total	1554	1443	1483	1487	1584	1526	1513	100.0%

** Note that the value allocated to Marine Transport is only for scheduled and unscheduled inter-island transport (people and freight) and Tourism. Fishing use of marine fuels has been allocated to Industrial consumption, and it is assumed that the fishing takes place within national waters. Two-stroke fuel use, which includes outboard motors, brushcutters and miscellaneous motor spirit devices (up to 10 per cent of motor spirit imports) has been allocated to the Domestic Sector. Other diesel use has been allocated 50 per cent to Industrial and 50 per cent to commercial. Air transport is only for national flights.*

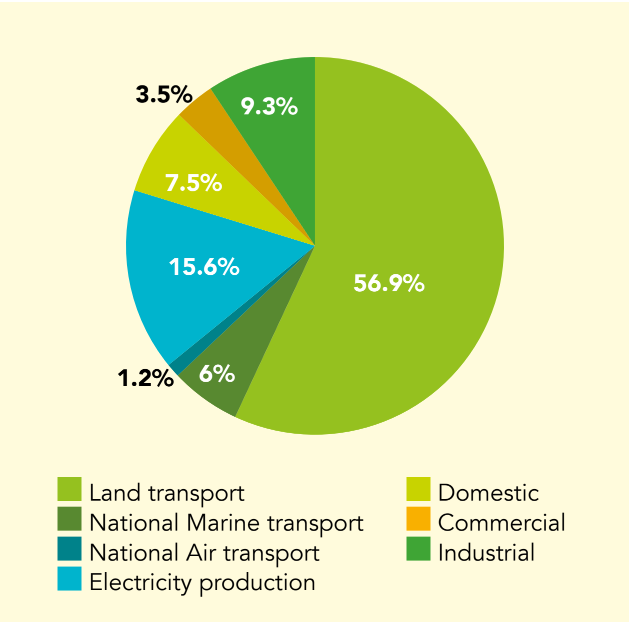


Figure 13: Average Energy sector CO_2 emissions including electricity from 2006-2011

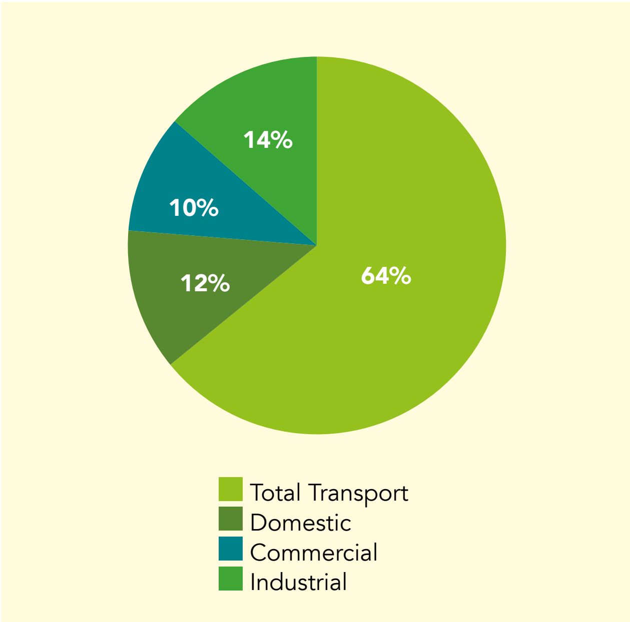


Figure 14: Average Energy sector CO_2 emissions 2006-2011 (excluding electricity)

The key imports of fossil fuels into Fiji include:

- Motor gasoline (sometimes called motor spirit, benzene, unleaded petrol or just petrol).
- Aviation gasoline (also called avgas). Chemically avgas is similar to motor gasoline and can be interchangeable.
- Shellite (a proprietary name for motor gasoline but with a separate import tariff, that is used for domestic lighting and cooking purposes).
- Kerosene (also called jet turbine fuel, Jet A1 or DPK).
- Diesel fuels, which include Automotive Diesel Oil (ADO), Industrial Diesel Oil (IDO), Marine Fuel Oil (MFO) 13 and various heavy fuel oils (HFO).
- Liquid Petroleum Gas or LPG (a mixture of Propane and Butane).

Figure 16 shows the FRCS fuel import data for the years 2006 until 2011. Here it can be seen that there is a marked change in the fraction of heavier fuel oils imported before 2009 that is not easily explained by the usage of the products (see later).[14]

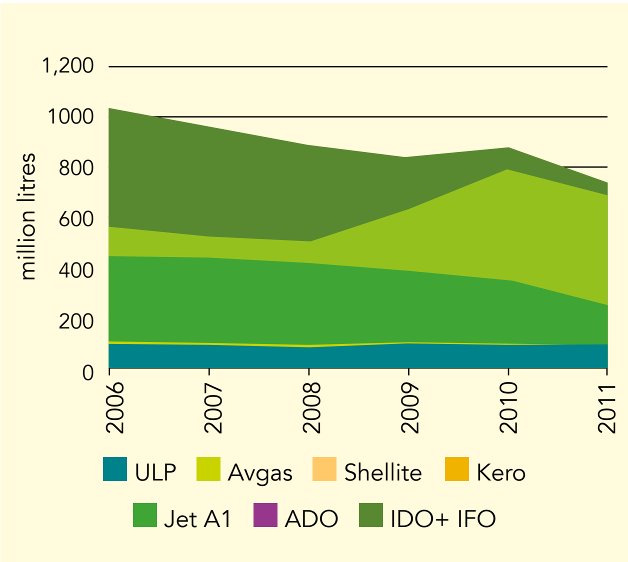


Figure 15: Fiji's total liquid fuel imports, (FRCS 2015 imports)

The retained imports are given in Figure 17 including locally used (Fiji Air) jet fuel.

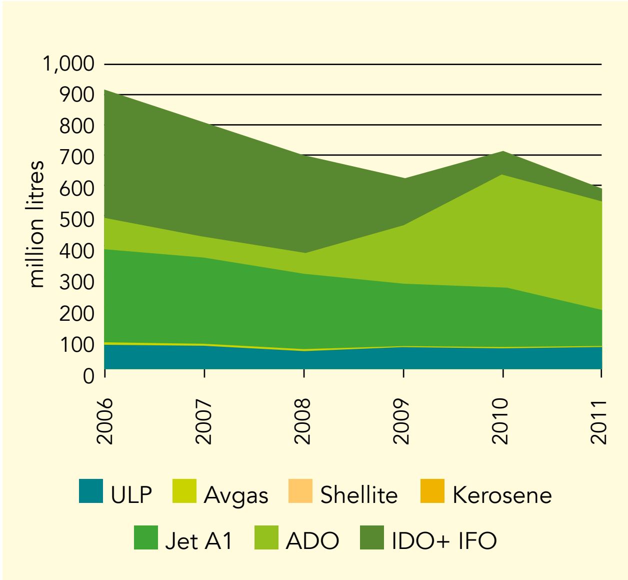


Figure 16: Fiji retained liquid fuel imports, (FRCS 2015 retained imports)

Figure 17 below shows the same data less the kerosene, which is mostly "exported" on Fiji Air international flights.

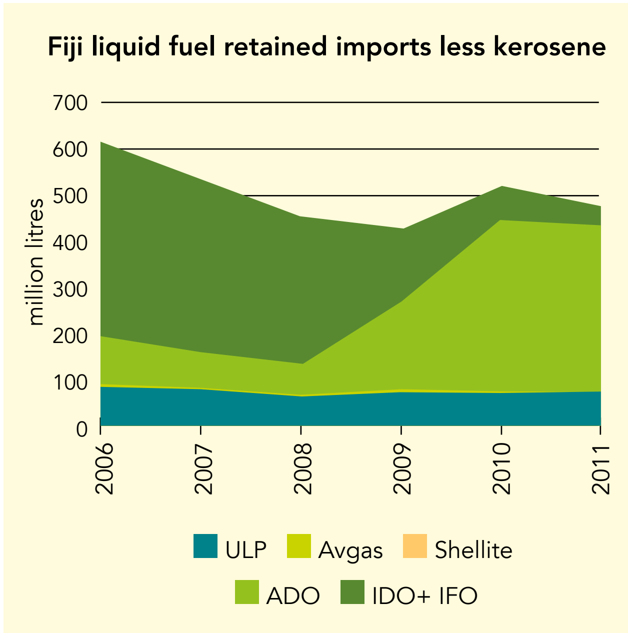


Figure 17: Fiji Retained imports less aviation kerosene, (FRCS 2015 retained imports)

13 Note most marine outboard motors use primarily two-stroke fuel, which is blended in country using a mixture of motor gasoline and two-stroke oil.

14 This needs clarification in terms of the customs data forms. The import data is from the column marked SADITM_SUPP_UNITS. The retained imports were from the SADITM_NET_MASS column. The difference between the two columns was taken as the bunkered fuel that was re-exported.

The difference between the supply and retained imports was accounted as the bunkered fuel.

Table 14: Liquid Fuel Emissions

Liquid fuels	Consumption (volume litres*10^6)	Consumption (TJ)	CO_2 emissions (Gg CO_2)	CH_4 emissions (Gg CH_4)	N_2O emissions (Gg N_2O)
Motor Gasoline	84.19	2760	191	0.00828	0.001656
Aviation Gasoline	2.5	81	6	0.000243	0.000049
Jet Kerosene	5	179	13	0.000536	0.000107
Dom Kerosene	25	887	64	0.002661	0.000532
Gas Diesel Oil	527.92	19750	1463	0.059249	0.01185
LPG		473	30	0.000473	0.000047

The time series for the CO_2 emissions are given in Figure 19 below showing a comparison with previous Fiji GHGI reports. Note that the non-CO_2 emissions for the energy sector are very small and, in terms of the data uncertainty, not worth reporting.[15]

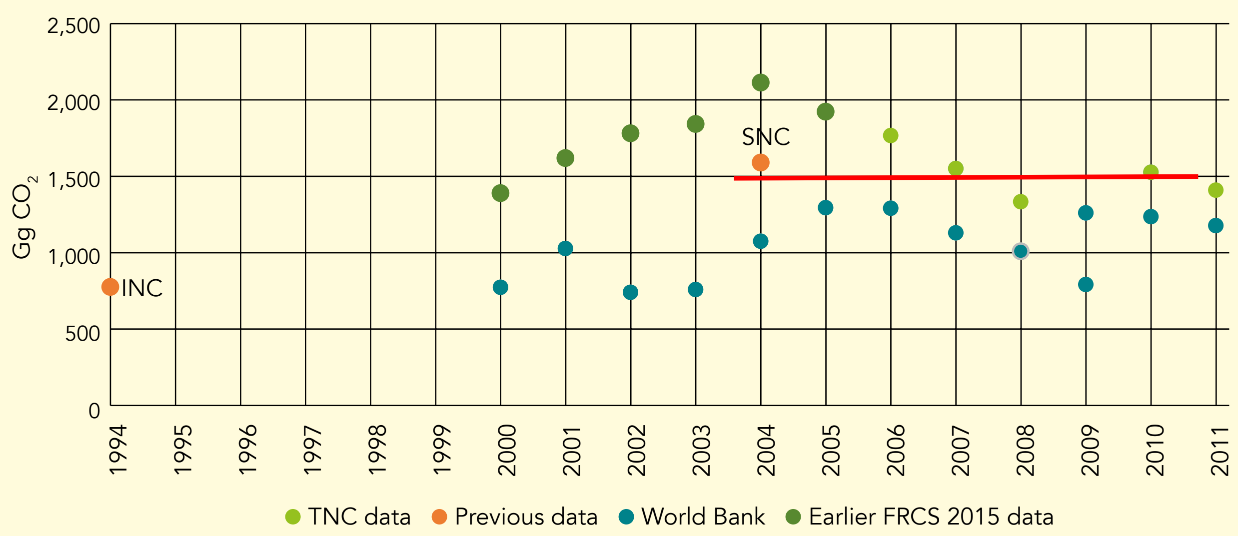
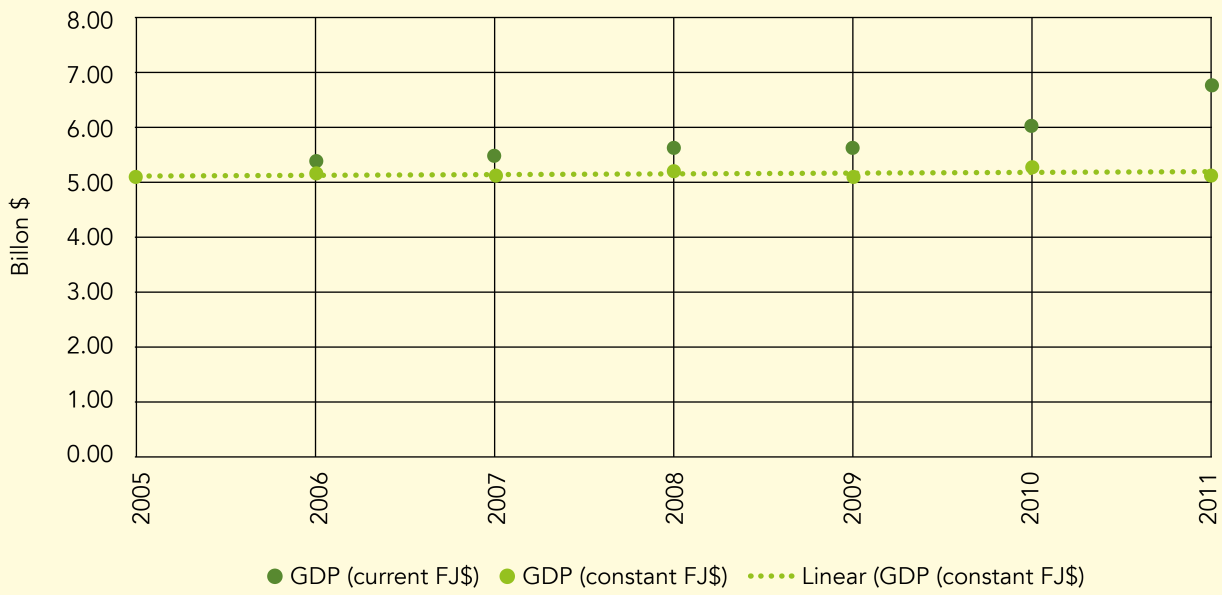


Figure 18: Time series TNC CO_2 emissions, INC, SNC and World Bank data

There is some difference between the current data for 2004 calculated using FRCS 2015 data and the SNC report, but the emissions value in the SNC is commensurate with the present data to within the estimated uncertainty. The relative constancy of the emissions data from 2006 until 2011 is noticed and thus is compared against the variation in Fiji's annual GDP in constant dollars (World Bank data) for the same period (Figure 20 below), which is also fairly constant. In addition, Fiji's population increased only slightly from 2005 to 2011.

Figure 19: Fiji GDP 2005 – 2011, (Fiji GDP)



Electricity Sector

The main electricity grid in Fiji is controlled by Electricity Fiji Limited (EFL). The EFL power system consists of hydro, diesel and a small wind capacity at Butoni. The current generation mix is shown below (Figure 21). The total installed power generation capacity is 269 MW, 94 per cent of which was run by EFL, delivering 872 GWh in 2013 (EFL, 2014).

The total EFL supplied generation (2000 until 2014) is shown below in Figure 22. This shows an increase in electricity

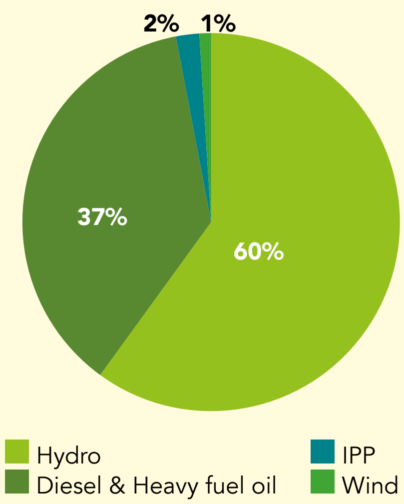
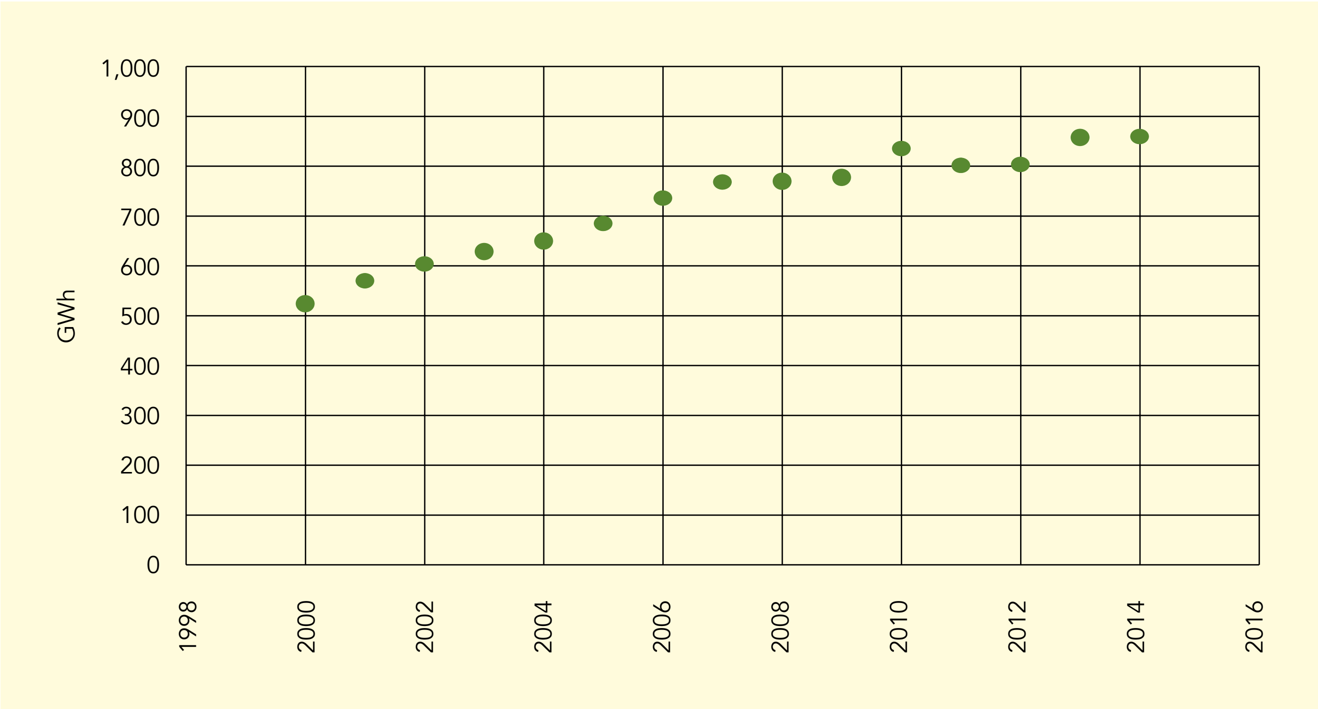


Figure 20: Electricity Generation Mix

production of just under 5 per cent from 2000 until 2008 and a reduction in growth to 1.75 per cent p.a. from 2008 onwards.

Figure 21: EFL Grid generation GWh/annum 2000–2014



In addition to the EFL supplied generation (including FSC and other IPPs) there is a separate supply at Vatukoula for the gold mine and various off-grid generation. The gold mine fuel consumption was obtained separately and attributed to the mining sector. In addition, the off-grid annual GWh was estimated to be around 6 per cent of EFL GWh (IRENA 2015), or around 20 GWh/annum. As off-grid units, generally do not run all the time, it has been assumed that at best 50 per cent of the units per installed capacity and that the units generate at a lower efficiency of around 0.3 litre of diesel per kWh.

The proportion of electricity generated by liquid fuels has been increasing since the 1990s due to increasing load growth and variable rainfall to feed the hydro dams in recent years (see Figure 22).

Figure 23, shows the change in generation from

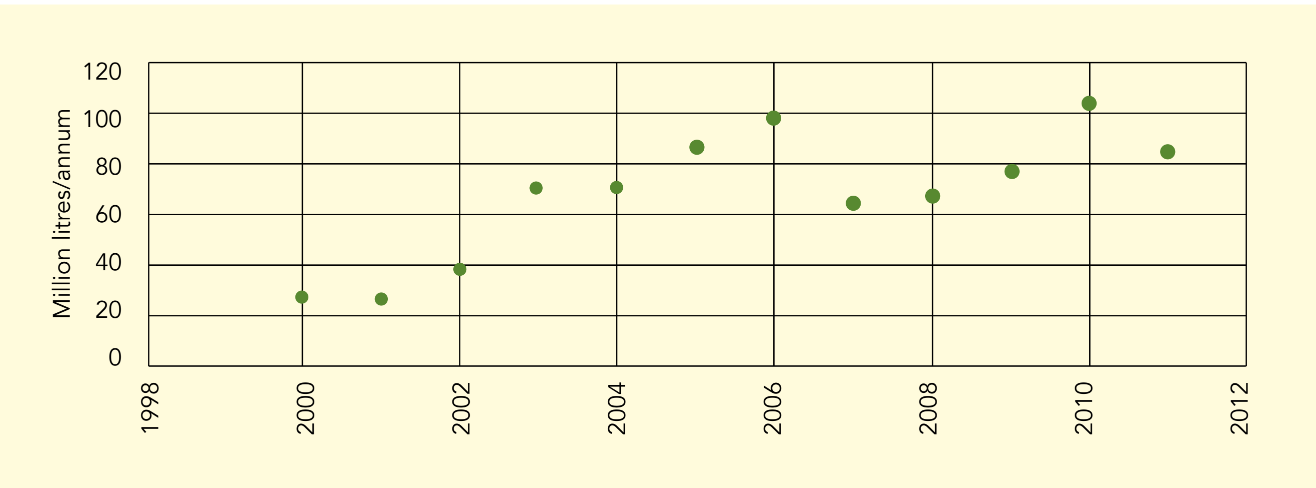


Figure 22: Diesel fuel used for electricity generation (total grid)

predominantly hydro in the 1990s to around a 50 per cent mix between 2003 and 2006 and the increase due to the Nadrivatu hydro capacity in 2007.

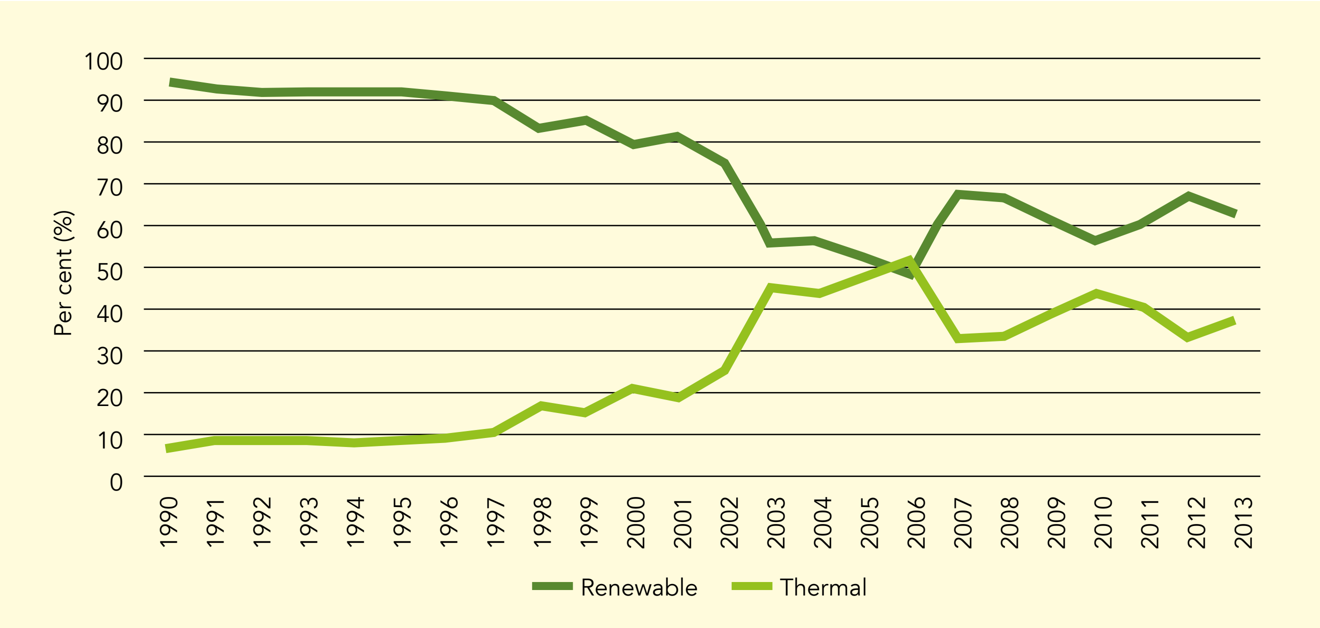


Figure 23: EFL generation mix 1990-2013

Source: FEA Annual Report, 2013

Line losses were estimated at 8.11 per cent in 2012 by consultancy group KEMA. Assuming these losses have been approximately constant, the emissions per kWh vary by year following diesel consumption as seen in Figure 25 below.

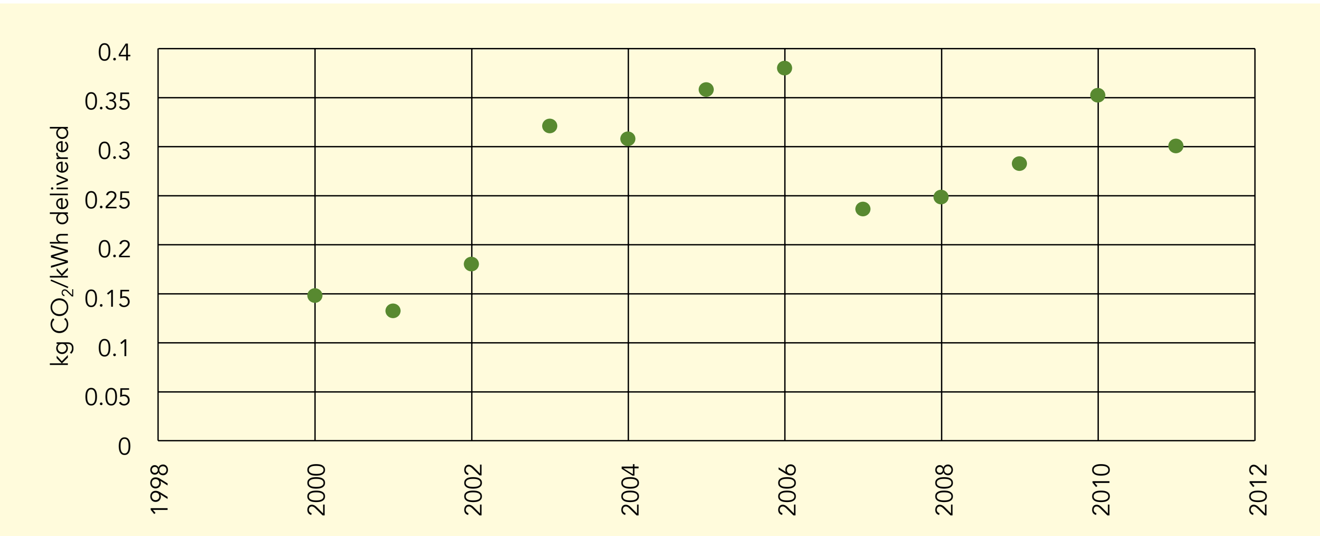


Figure 24: EFL CO_2 emissions per kWh delivered

The fuel used by EFL has changed in recent years towards a larger use of heavy fuel oil over industrial diesel to save costs. Because of possible overlap between the various fuel grades in the FRCS import data, it has not been possible to attribute emissions to anything other than diesel fuels in general and so in this analysis, they are lumped together (i.e. ADO, IDO, MFO and HFO). This attribution will generate a small error in converting litres into kg due to the higher-density of the heavy fuel oils.

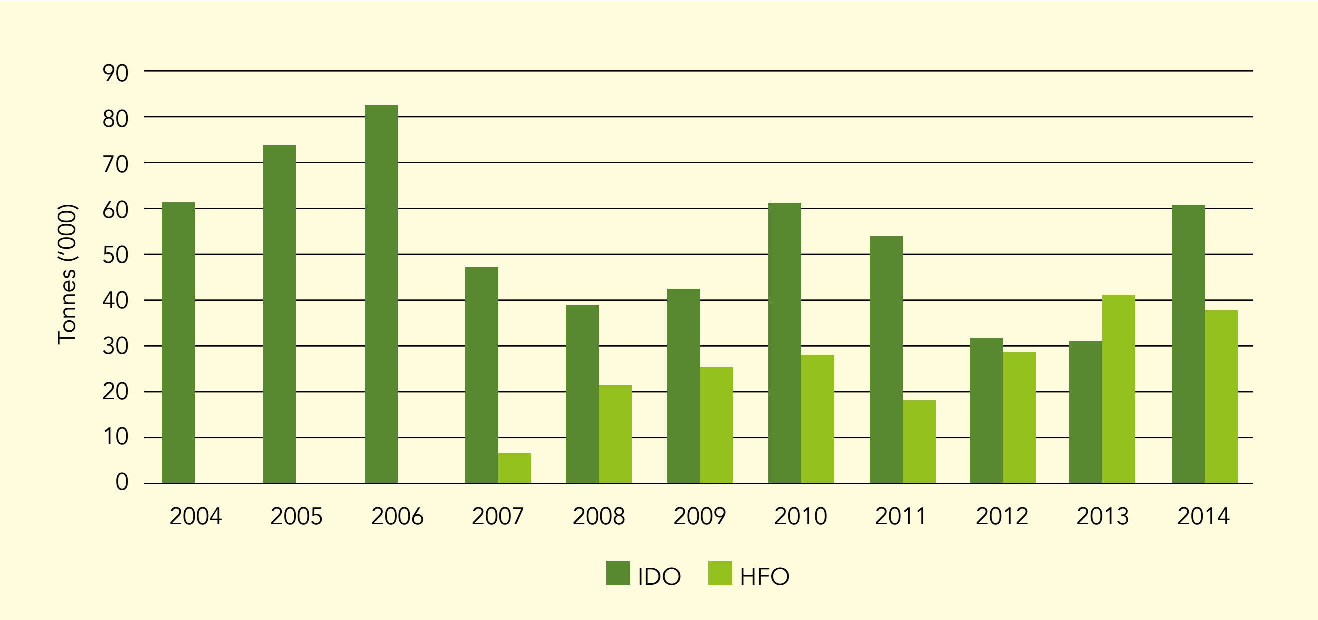


Figure 25: EFL IDO and HFO usage 2004–2014

The sectoral breakdown of EFL capacity is given in the 2013 annual report and is reproduced as Figure 27 below.

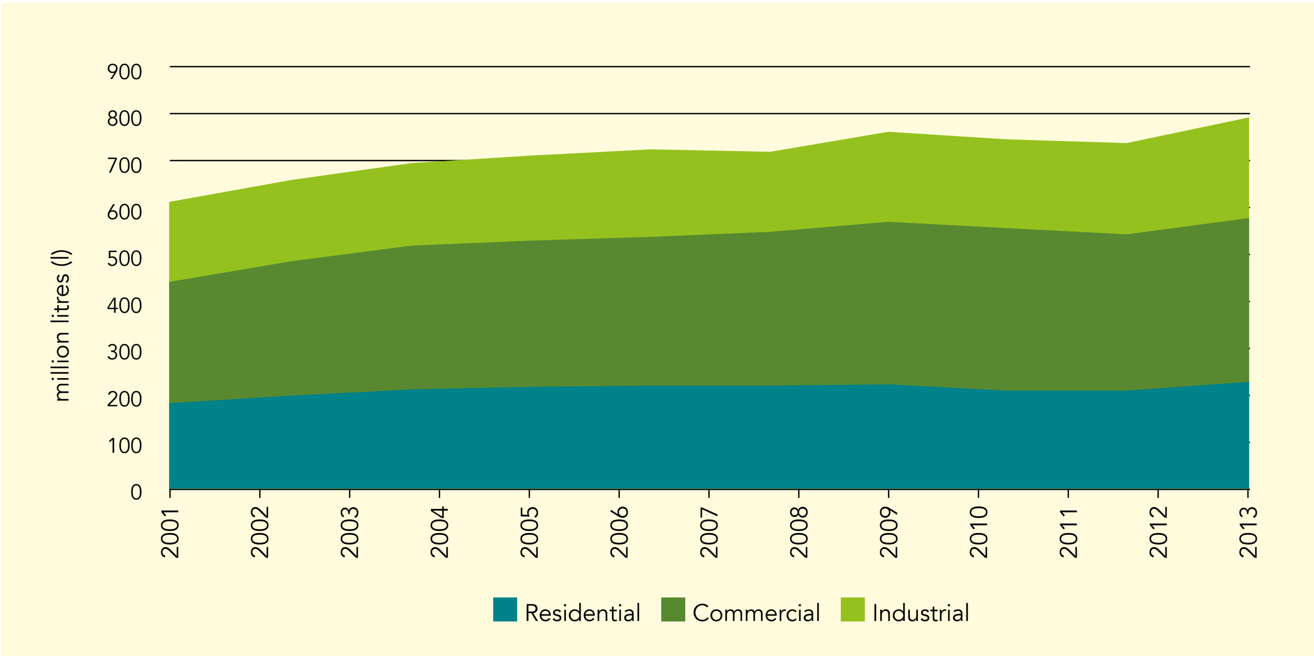


Figure 26: EFL sectoral breakdown 2004–2013

The data shows a relatively consistent share between the Residential (30 per cent), Commercial (43 per cent) and Industrial sectors (27 per cent) between 2004 and 2013 and these proportions will be used to attribute electricity-based emissions to the various sectors.

Figure 28 below shows the total electricity emissions from 2000 until 2011 (note this includes off-grid electricity but not the gold mine electricity emissions which are accounted for under mining).

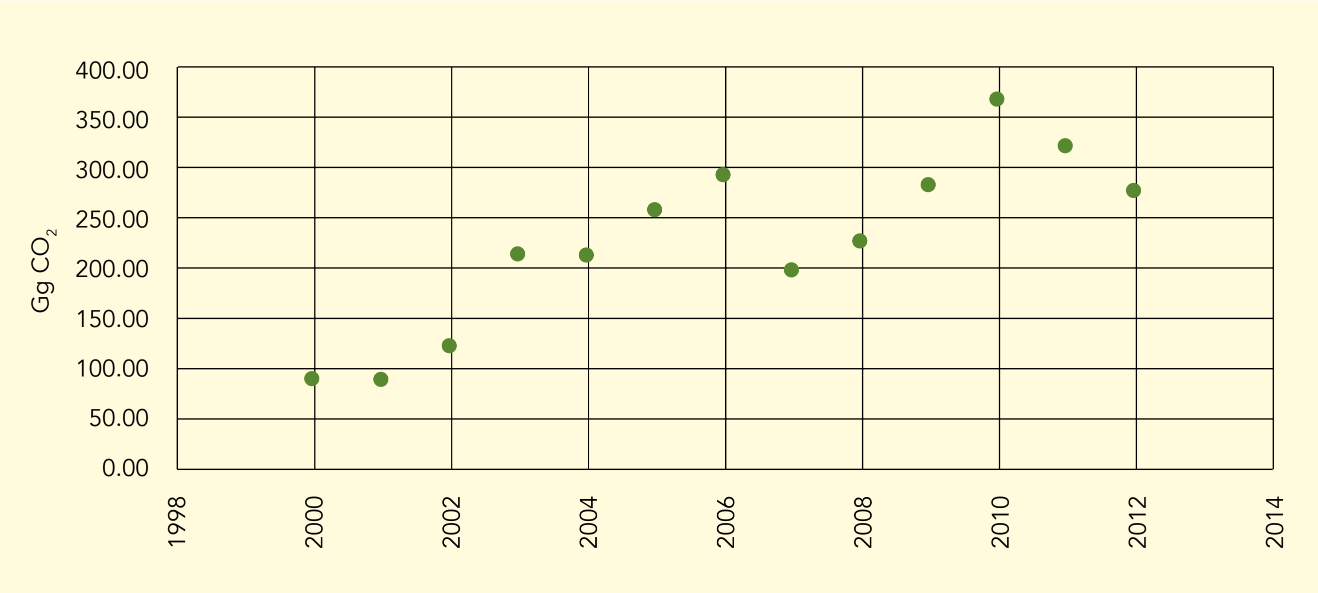


Figure 27: EFL total CO_2 emissions 2000-2012

Figure 28 below shows the total electricity emissions as a percentage of total emissions, illustrating the increase from the 1990s, when nearly all electricity was hydro, until 2010 when electricity emissions were around 20 per cent of Fiji's total emissions.

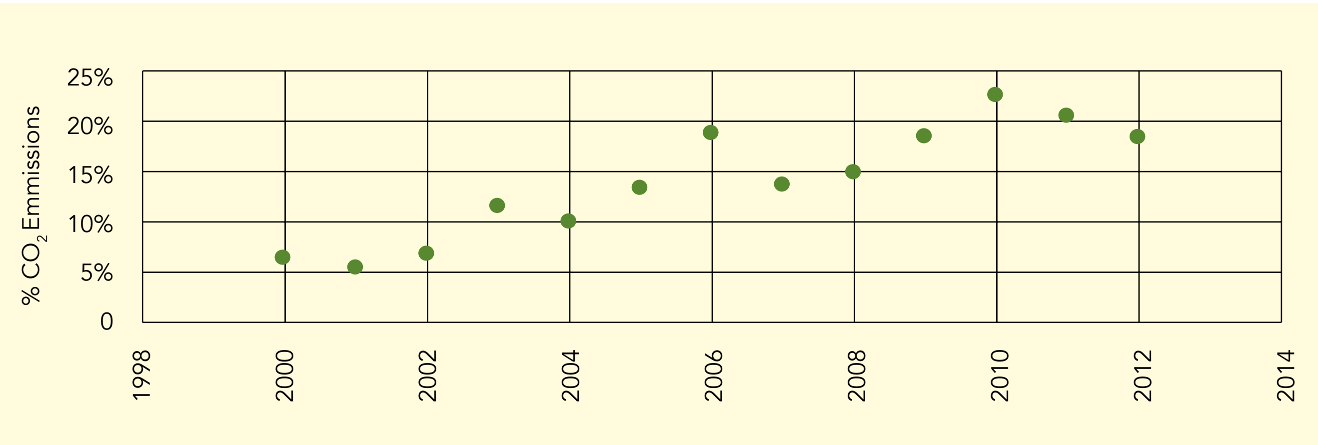


Figure 28: Electricity CO_2 emissions as percentage of total energy emissions

Mining

Data was obtained from Fiji's gold mining operation at Vatukoula. The data is presented in the table below (Table 15). Note that the total includes both diesels for mining and electricity production for the gold mine.

Table 15: Fiji gold mining fuel usage

Vatukoula Gold Mine million litres of diesel					
2006	2007	2008	2009	2010	2011
0	0.00	7.27	18.35	23.38	25.68

Food Processing

Data was obtained from the Fiji Sugar Corporation (FSC), in million litres diesel per annum. It might be noted that diesel used by the FSC has decreased considerably since the 1980s due to more efficient use of bagasse.

Table 16: Fiji Sugar Corporation: diesel emissions

FSC million litres of diesel					
2006	2007	2008	2009	2010	2011
1.4	1.7	2.1	2.1	2.2	1.6

Transport

Land Transport

A land transport model was constructed using vehicle numbers and types from the Fiji Land Transport Authority (LTA) using estimated fuel efficiency and estimated kilometres travelled.

Table 17: Vehicle numbers from LTA and model inputs for transport model 2006 – 2015

		Carrier	Commer-cial	Private	Hire	Rent-al	Mini-bus	Bus	Diplo-matic	Govern-ment	Taxi	Total
	2006	108	18626	53279	574	1529	358	1534	269	1135	5749	83161
	2007	97	18251	53872	560	1519	448	1491	296	1211	5904	83649
	2008	78	18626	55076	505	1537	481	1486	284	1282	5745	85100
	2009	175	17168	53927	472	1508	580	1505	295	1384	6071	83085
	2010	301	17112	54609	508	1587	579	1491	268	1456	6153	84064
	2011	382	17045	54130	513	1694	664	1524	260	1477	6325	84014
MODEL input	km/year	50000	60000	10000	40000	60000	60000	80000	20000	20000	7000	
	l/100km for kg		18	10	12	12	15	20	12	12	10	

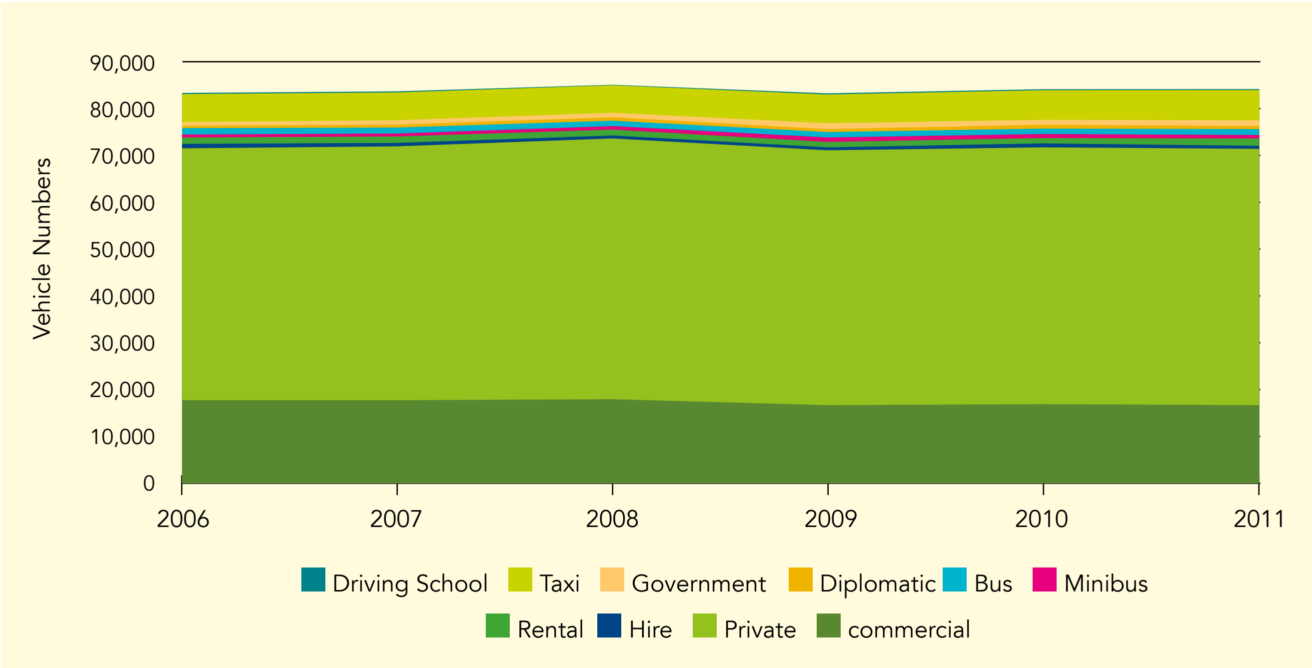


Figure 29: Vehicle numbers in Fiji with type breakdown

The average (2006–2011) fuel type distribution for the various vehicle categories is given in Figures 31–34.

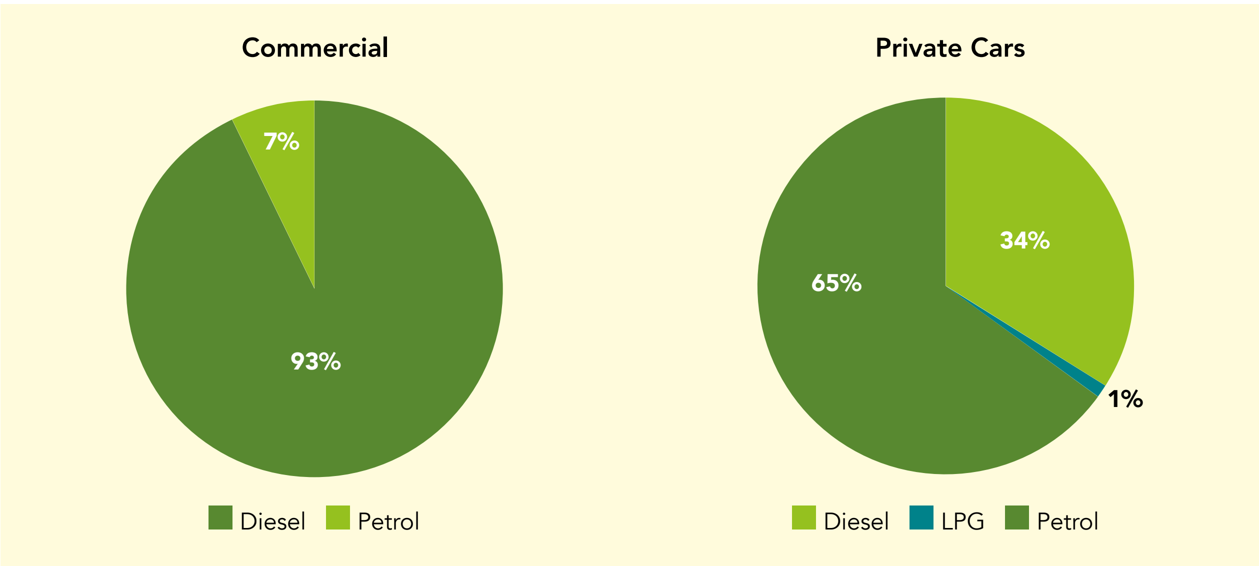


Figure 30: Fuel-type consumption for commercial vehicles and private cars

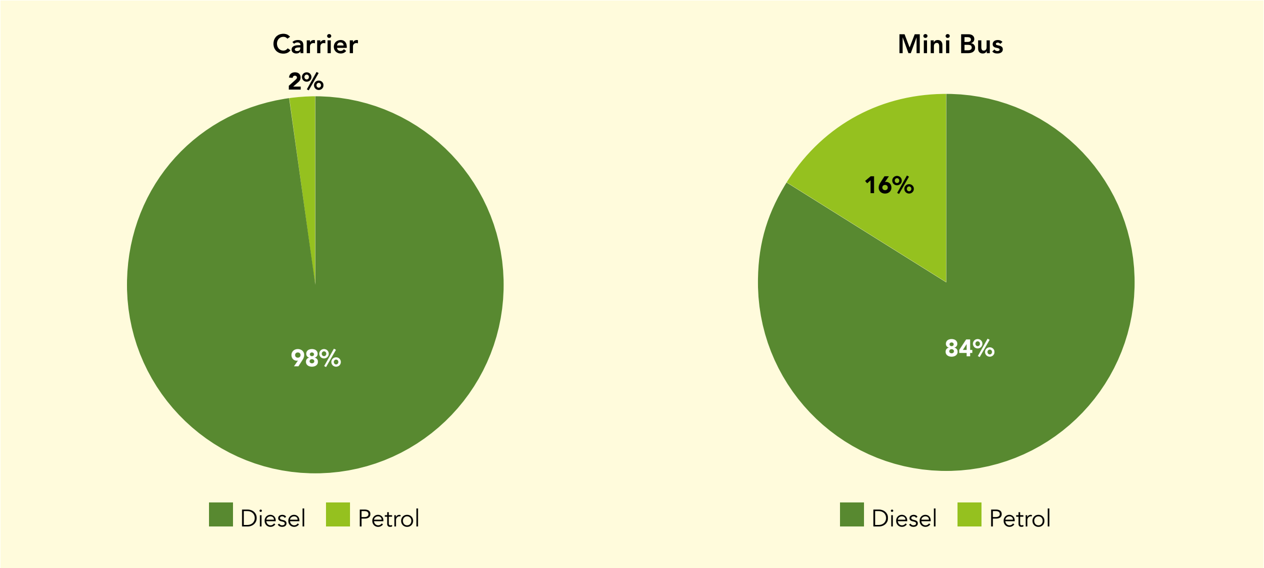


Figure 31: Fuel-type consumption for carrier vehicles and minibuses

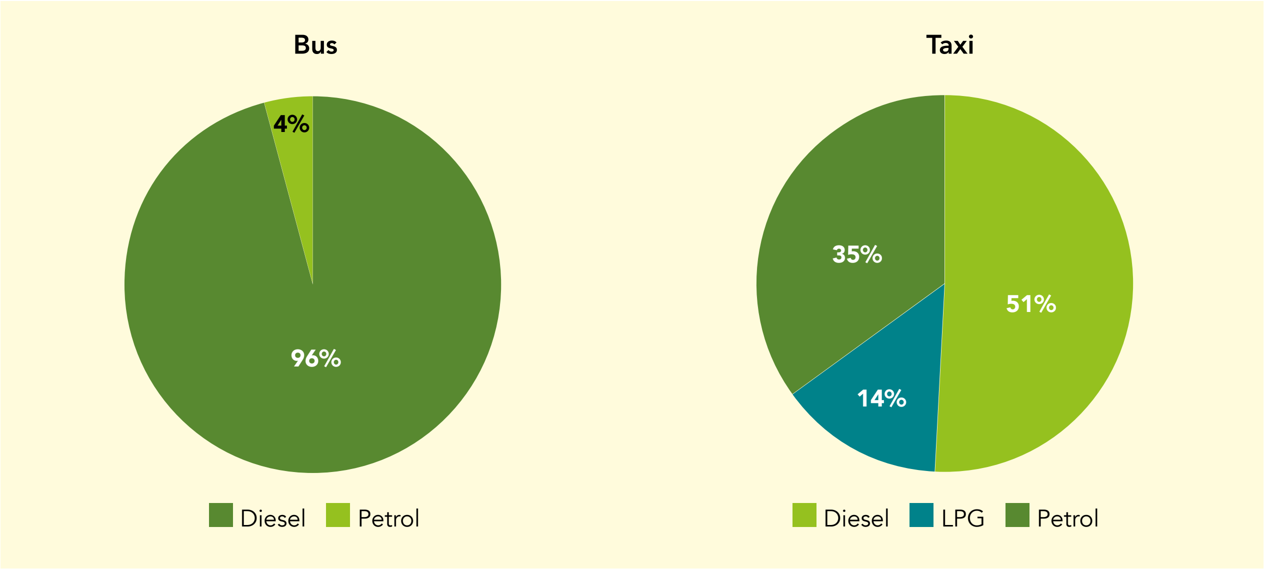


Figure 32: Fuel-type consumption for buses and taxis

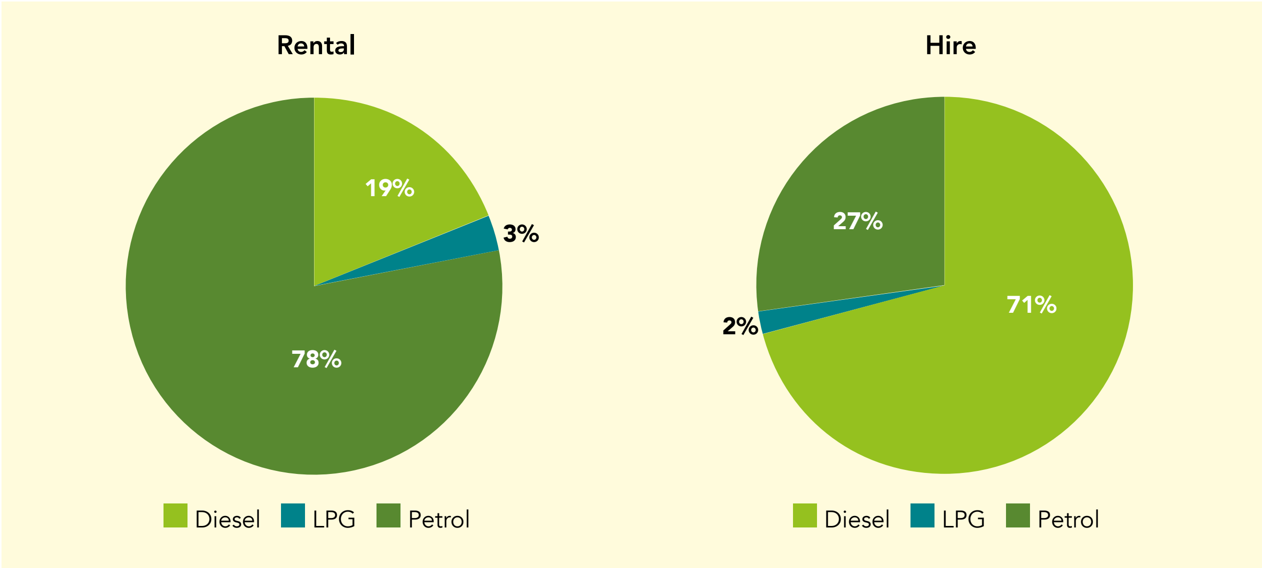


Figure 33: Fuel-type consumption for rental cars and commercial hire vehicles

As can be seen from the log graph below (Figure 34), the total number of registered vehicles in Fiji over the period 2006 until 2011 was relatively flat (increasing at only 0.1 per cent p.a.). This constancy in vehicle numbers supports the finding that Fiji's annual emissions were relatively constant from 2006 until 2011. It might be noted however, that more recent LTA data suggests that vehicle numbers have started to increase at around 6 per cent p.a. from 2012.

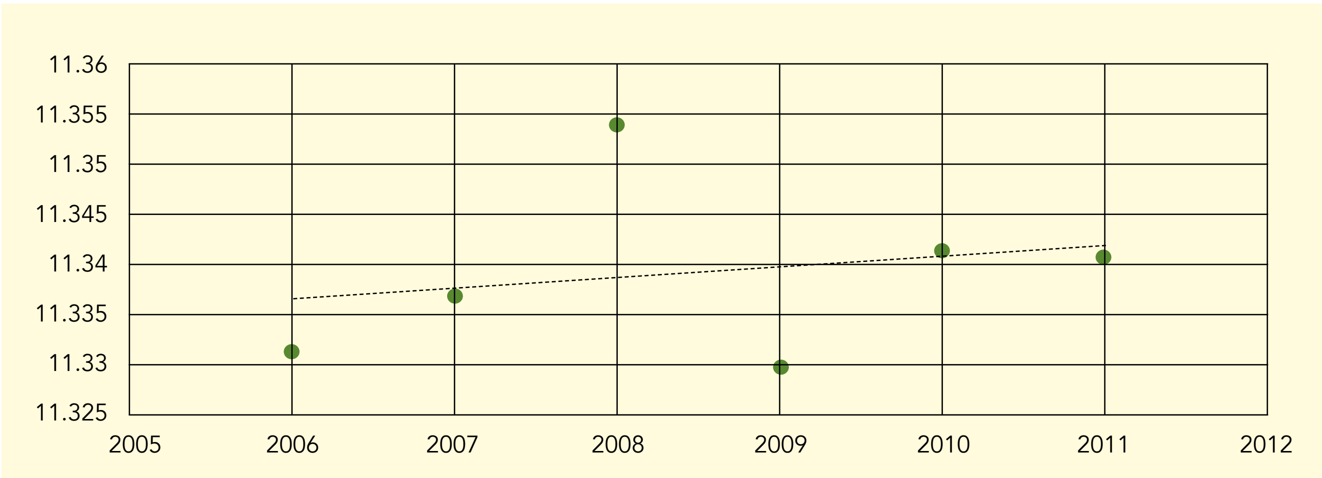


Figure 34: Logarithmic plot of vehicle numbers in Fiji 2006-2011

Land Transport Model (Motor Spirit)

The land transport model output for motor spirit (petrol) usage is given below (Figure 35). In this model, an additional 10 per cent has been added for "other uses" of motor spirit, including brush cutters (and similar), outboard fuel for boats and miscellaneous uses. A New Zealand consultancy report to the Government 2008 found that motor spirit was predominantly used for road transport (94 per cent) in that country with the remainder 6 per cent used for other purposes including agriculture, commercial and recreational marine (fishing, tourism and boating) and garden maintenance (lawnmowers and brush cutters).[16] As can be seen, except for the year 2008, the model shows a good fit with the observed imported fuel data.

16 Liquid Fuel Use in New Zealand, Prepared for: Ministry of Economic Development, November 2008, Outcome Management Services Ltd

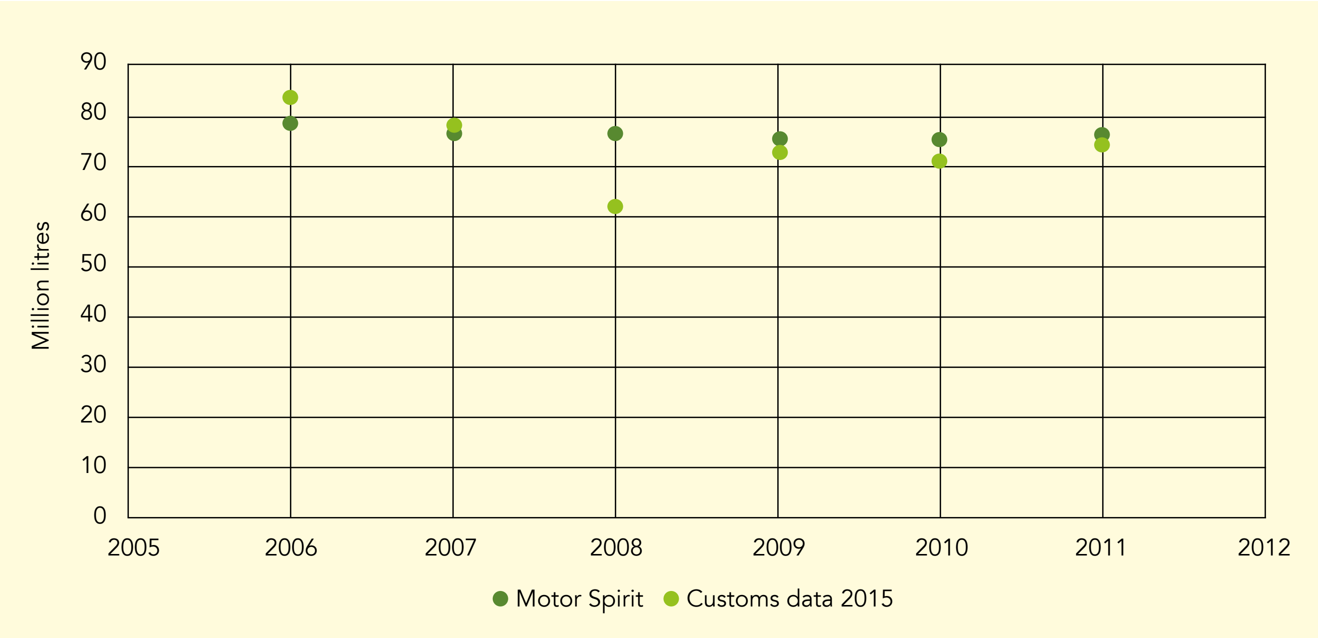


Figure 35: Comparison of FRCS 2016 motor spirit data with transport model

Land Transport Model (Diesel)

The same land transport model approach that was used for motor spirit was also used for diesel consumption, but here there were more consumption sectors to consider, including food processing (such as FSC), marine transport, off-road vehicles, mining and "other". The off-road contribution for the construction sector (buildings, roads and infrastructure) was estimated at 6 per cent of total road diesel used.[17] The "other" component was estimated at 7.5 per cent of the total consumption and would include fishing, tourism, agriculture, unknown industrial consumption and unknown commercial consumption (boilers) not accounted for in the total. The unknown consumption was allocated equally between the commercial and industrial sectors.

As can be seen (Figure 36), there is a reasonable agreement between the transport model and the FRCS (Customs) data 2015. The FRCS (Customs) data prior to 2008 appears to be higher than the model (for reasons unknown). In addition, as can be seen from Figure 36 (next page), the proportion of heavier imported fuel oils to automotive diesel changes substantially between 2008 and 2010 (also for reasons unknown). Note also that the model and the FRCS (Customs) data are not entirely independent, as the best fit was applied between the two data sets by adjusting the transport variables (km. travelled per annum and fuel efficiency of vehicles) as described earlier.

17 Assumption based on a consultancy report commissioned by the NZ Government to determine the off-road contribution in that country

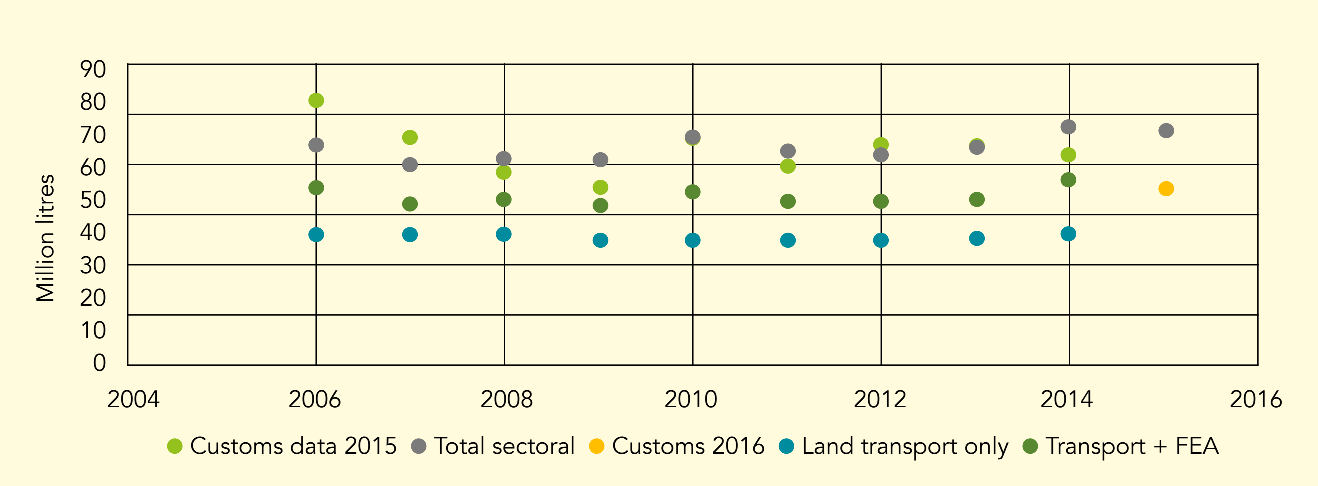


Figure 36: Comparison of FRCS 2015 diesel data with transport model

Marine Transport Consumption

Marine fuel usage was obtained from one company and estimated from the others using the published schedules of the main domestic carriers including Gounder Shipping, Bligh Shipping, Patterson Brothers, Venue Shipping and Consort Shipping. All shipping companies also use their craft for occasional unscheduled charters. The consumption for the companies that did not return fuel information was estimated using known (or estimated using vessel deadweight) engine power in kW, hours per week on scheduled routes and a specific fuel consumption of 0.3 litres diesel per rated kWh and assuming that the engine runs at around 75 per cent of rated load for economical fuel usage. This process gave an annual estimated consumption of around 8 million litres diesel per annum for the scheduled (2016) inter-island routes. In addition to the above, there are a various marine craft, five Fiji Navy ships, tugs, and a quite large tourist fleet, operating mainly out of Port Denarau,[18] servicing various tourist island destinations on the western side of Viti Levu. The total marine usage was estimated at around three times the scheduled inter-island usage, or around 24 million litres diesel per annum. In addition, a further 10 million litres were estimated for tourist vessels, making a total of 34 million litres for the marine sector.

In mid-2018 a new report[19] came to hand looking at mitigation options for the marine sector in Fiji. This report estimated the fuel use and emissions for the marine sector in Fiji. This is shown in Table 18.

18 An illustrative list of Fiji shipping can be found at SPC http://prdrse4all.spc.int/production/system/files/domestic_sea_transport_data_1.pdf

19 ADB Report "Mitigation Plan for the Maritime Transport Sector in Fiji" (2018)

Table 18: Marine fuel use in Fiji: estimates from 2018 ADB report

Subsector	Fuel consumption [kt]	CO_2 emissions [kt]
Government shipping services	1.11	3.44
Uneconomical routes	1.29	3.61
Economical routes	22	67
Small boats[1]	24	75
Fishing	8	25
Tourism	11	34
Other	6	19

The first consumption category given in the table above (Government Shipping Services) uses real fuel-use data obtained from Fijian Government Shipping services for scheduled routes and is considered to be of high accuracy (+-1 per cent). The "Uneconomic Routes" are of lesser accuracy, are for unscheduled services and use three months of data to estimate yearly usage. The "Economical Routes" are for private shipping and give the estimated usage, based on ship size and estimated annual hours at sea, with an uncertainty of between -50 per cent and +100 per cent. The total for these three categories comes to around 28 million litres of diesel fuel per annum (2015). This value can be compared with the estimate given above for marine transport of 24 million litres (2006-2011) and is seen to be well within the uncertainty level given (-14 million litres +28 million litres) and in terms of possible growth over the time elapsed quite close.

The "Tourism" sector in the ADB report, also included registered vessels that would be diesel-fuelled, giving a total of around 12 million litres per annum, very close to the 10 million litres estimated for this report. The "Fishing" sector in the ADB report similarly estimated usage at around 9 million litres. In the TNC report, using IPCC classification, this consumption has been ascribed to the "other" industrial (i.e. part of the 30 million litres of diesel as given in the next section below). Again, note that both the TNC report and the ADB report figures are estimates based on assumed usage and not on actual fuel use.

In the TNC report, small-boat fuel usage has been attributed to the domestic sector as part of the 10 per cent (8 million litres) of motor spirit allocated to "other" uses. Finally, the ADB report does not use standard IPCC conversion factors to estimate CO_2 emissions from fuel usage, making its estimates reasonably 11 per cent higher than expected.

Air Transport

An air transport model was constructed using website schedules for Fiji national flights and web-obtained values for the hourly fuel consumption of aircraft used by the airline. Of these, the ATR 72 uses jet turbine fuel (kerosene) on flights between Nadi, Suva and Labasa, and the De Havilland Twin Otters use aviation gasoline on all other regional flights. In addition, there are a number of smaller airlines that service the tourism sector, mainly on the Western side, and also privately-owned aircraft that service the privately-owned islands in the Fiji group. The scheduled flights' total consumption came to 1.8 million litres of avgas per annum and 3.7 million litres of aviation turbine fuel (kerosene). These numbers were rounded up to 2.5 million litres and 5 million litres, respectively, to account for use by other aircraft, delays and charter flights.

These estimates can be compared to the actual import data from FRCS (see Figures 38 and 39). As can be seen, there is good agreement (albeit with considerable yearly variation) for the period 2000 until 2008 (average around 2.5 million litres), after which the avgas component goes quite low. This, may indicate that there is a possible problem with the FRCS data in terms of fuel import specification, as there is no record of domestic short-haul flights decreasing by a factor of four over the period between 2008 and 2011.

Figure 37: Avgas retained imports

The aviation kerosene data from FRCS was not useable as it was far too high for purely local consumption and must have been mostly used for international flights, as indicated earlier. For reference, this data is given below. This data also shows a decline in consumption from 2006 but international fuel supply variation over time is often due to the cost of the fuel changing at competing airport refuelling terminals.

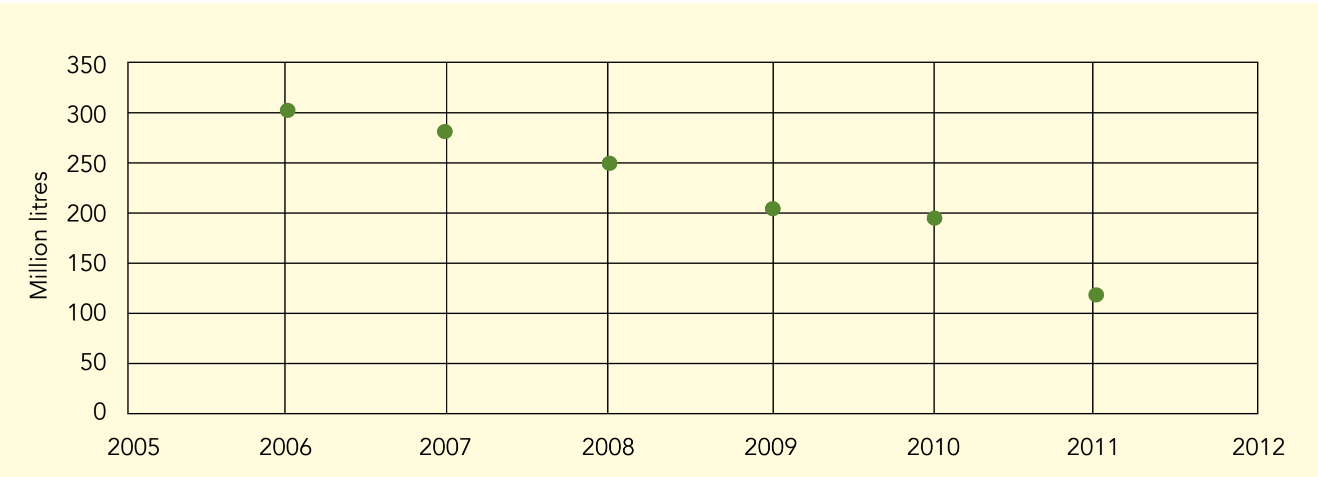


Figure 38: Jet A1 retained imports

LPG Consumption

Figure 40 shows the LPG consumption for the years 2006 until 2011 in terms of usage in the domestic, commercial, industrial sectors and for vehicles. The data is from the retailers and FRCS.

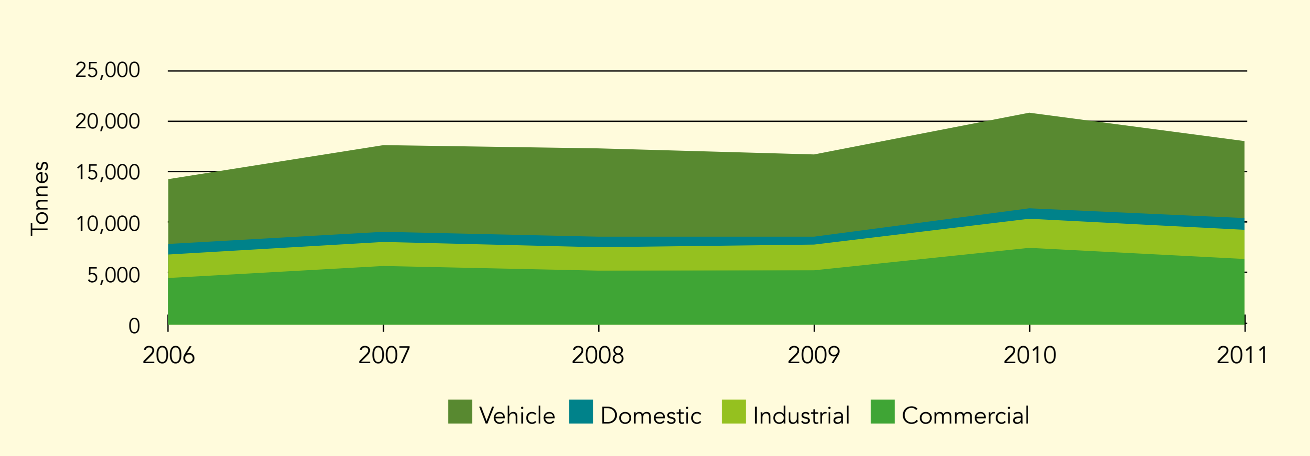


Figure 39: LPG consumption, gas retailers and FRCS 2016

Uncertainty and Quality Control: Energy

Quality control was instituted by comparing the sectoral approach with the reference approach. Here, there was a reasonable fit between the combined sectoral model and the reference data (FRCS, 2015), with the model some 12 per cent lower in 2006 and 16 per cent higher in 2009 (Figure 40). The overall difference was around 3 per cent averaged over the 6 years. Some of the annual differences could be due to national bunkering of fuel supplies, as imports from one year are used the next year. The average CO_2 emissions from the energy sector over the 6-year period for this TNC comes to 1500 Gg for both sets of data to within an estimated uncertainty margin of ±10 per cent.

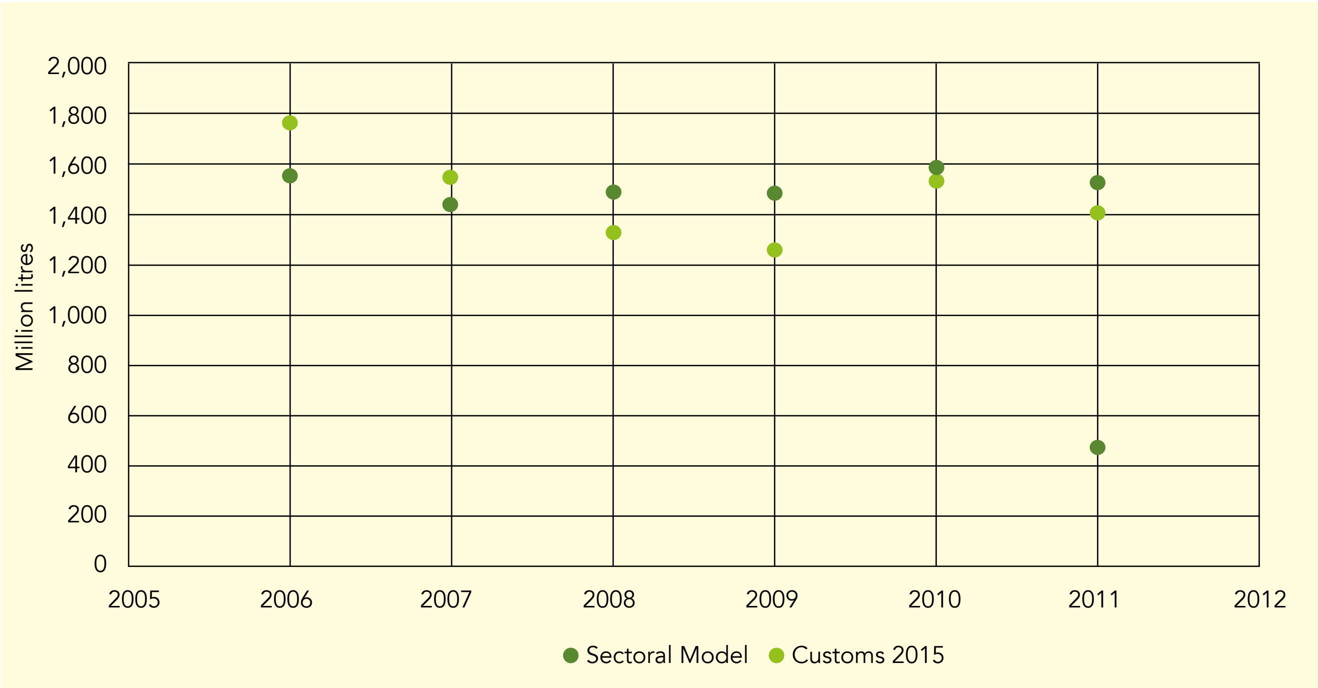


Figure 40: Comparison of Reference data (FRCS 2015) with combined sectoral model

Note again that the model and the FRCS data are not entirely independent, as the best fit is applied between the two data sets by adjusting the transport variables (km travelled per annum and fuel efficiency of vehicles) as described earlier.

Agriculture

Overview and Key Sources

The main emissions in this sector were CH_4 emissions from ruminant animals and agriculture and nitrous oxide emissions from managed soil and agriculture.

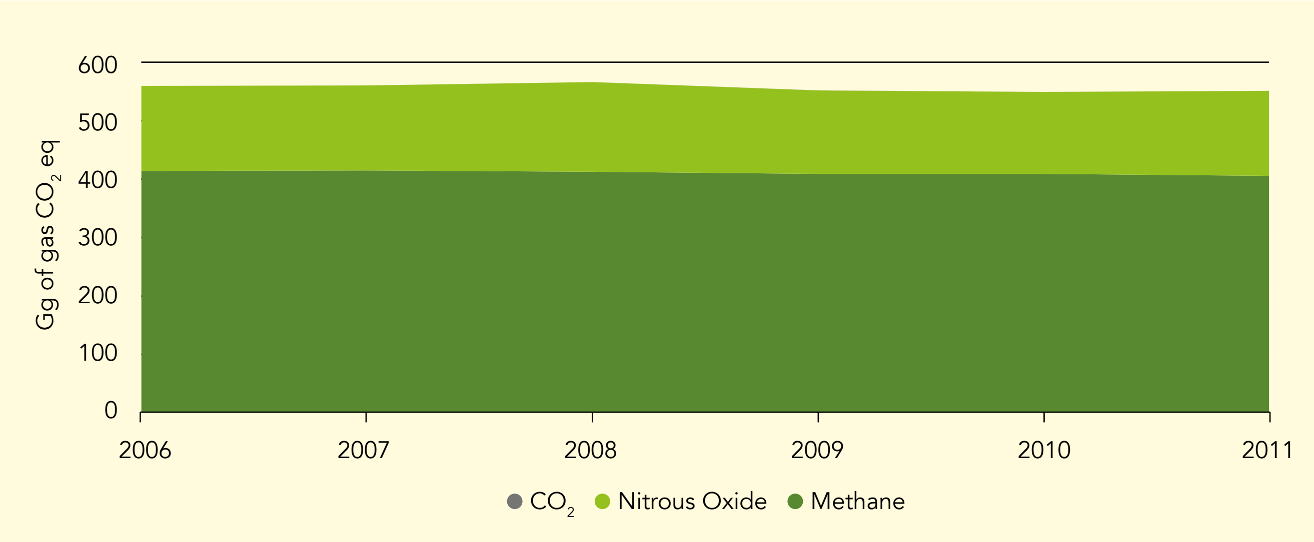


Figure 41: Agricultural emissions Fiji 2006-2011 (CO_2 not showing)

Agricultural GHG Summary

CH_4 emissions from the agriculture sector was around 15 Gg/year during the reporting period. The total nitrous oxide emission from different source categories in the agriculture sector were around 0.5 Gg/year, without much growth in emissions during the last few years in the reporting period. The CO_2 emissions due to urea fertiliser application are negligible and range from 0.03 – 0.13 Gg/year for the years 2006-2011. Table 19 below shows the total emissions of CH_4 and nitrous oxide by different category sources for the agriculture sector.

Table 19: Total emissions from agriculture sector

Gas and Source	Total per Source Category (Gg/year)					
	2006	**2007**	**2008**	**2009**	**2010**	**2011**
Methane (CH_4)						
Domestic Livestock						
Enteric Fermentation	11.23	11.23	11.23	11.23	11.23	11.23
Manure Management	2.9	2.9	2.9	2.9	2.9	2.9
Rice Farms	0.65	0.68	0.6	0.51	0.48	0.35
Total CH_4 Emissions by Agriculture Sector	***14.8***	***14.8***	***14.7***	***14.6***	***14.6***	***14.5***
Nitrous Oxide (N_2O)						
Direct						
- from synthetic fertilisers	0.042	0.04	0.068	0.027	0.024	0.041
- from animal excretion	0.23	0.23	0.23	0.23	0.23	0.23
Indirect (from volatilising and leaching)						
- from synthetic fertilisers	0.052	0.053	0.055	0.051	0.05	0.052
- from animal excretion	0.23	0.23	0.23	0.23	0.23	0.23
Total N_2O Emissions by Agriculture Sector	***0.55***	***0.55***	***0.58***	***0.54***	***0.53***	***0.55***
Carbon Dioxide (CO_2)						
Urea fertilisation	**0.09**	**0.09**	**0.13**	**0.19**	**0.09**	**0.03**

The AR5 global warming potentials were used to convert these non-CO_2 GHGs (CH_4 and N_2O) to CO_2 equivalent so that their contribution to the total agricultural emissions could be compared. Nitrous oxide emissions contribute only 26 per cent of the total GHG emissions from the agriculture sector, whereas CH_4 comprises the remainder of the agricultural sector emissions. CH_4 emissions from ruminant animals remain the largest contributor, whereas CH_4 emissions from rice farms only contribute 1.4-2.6 per cent of the total agricultural emissions.

Uncertainty and Quality Control

There was no significant change in CH_4 emissions from 2006 to 2011. The average value was 15± 8 Gg/year for the reporting period with an uncertainty of around 30 per cent. The trend observed for the years 2006 to 2011 was consistent with the activity data of animal population obtained from the 2009 census. Conversely, nitrous oxide emission shows a 10 per cent increase in 2008 due to the larger amount of N fertiliser application. The average nitrous oxide emission for the reporting period was 0.5 ± 0.3 Gg/year showing a similar level of uncertainty.

Table 20 below shows the data of agricultural CH_4 and nitrous oxide in CO_2 eq. for individual years and with a comparison to World Bank data for Fiji. The comparison shows that CH_4 estimation is more than the World Bank data, but it is certainly within the uncertainty range of ± 30 per cent. There is a good agreement between the nitrous oxide estimation and the World Bank data for nitrous oxide emissions when taking into account that the World Bank data considers AR4 GWP of 310 whereas the revised GWP for nitrous oxide in AR5 is 265 (the latter is used in this assessment).

Table 20: Agriculture emissions converted to CO_2 equivalent

Year	CH_4 (Gg)	CH_4 CO_2 eq (Gg)	CH_4 CO_2 eq (Gg) World Bank data	N_20	N_20 CO_2 eq (Gg)	N_20 CO_2 eq (Gg) World bank Data	CO_2	Total CO_2 eq (Gg)
2006	14.78	413.84	553	0.55	145.75	353	0.091	560
2007	14.81	414.68	554	0.55	145.75	353	0.092	561
2008	14.73	412.44	554	0.58	153.7	355	0.126	566
2009	14.6	408.8	NA	0.54	143.1	NA	0.19	552
2010	14.6	408.8	NA	0.53	140.45	NA	0.091	549
2011	14.48	405.44	NA	0.55	145.75	NA	0.03	551

GHG emissions in Fiji in the agriculture sector are thus seen to be relatively constant over the period 2006- 2011 within the uncertainty of 30 per cent and equal to around 550 Gg per annum CO_2eq.

Forestry

Overview and Key Sources

In terms of the policy, the National Forest Inventory, formalisation of the Fiji Forest Policy Statement and the National Forest Program provide the framework for the sustainable management of Fiji's forest resources (NAR January 2010). In Fiji, the management of productive plantations and their extension has a significant potential for high-value timber supply and rural development.

Moreover, forest plantations are sensitive to forest fires caused by droughts and heat spells or windbreaks caused by cyclones. The sensitivity of the natural forest ecosystems is relatively high, mainly due to population growth and the demand for greater agricultural production for food security, thus leading to deforestation. The current lack of financial competitiveness with agricultural land is potentially a major factor for forests being degraded or converted, thus leading to soil erosion and compaction or even landslides on steep slopes during heavy rainfall. Mangrove forests are highly sensitive when mangroves are cut for fuelwood, or the land is reclaimed for residential land.

Table 21 below gives the total estimated CO_2 emissions from the forestry sector in Fiji. The inter-year variation is attributed to the changes in logging volumes for the plantation forests. The overall emissions could vary from positive to negative, depending on the real annual variation in emissions from natural forests including, logging, reforestation, deforestation and degradation.

Table 21: Forestry emissions 2006 – 2011

Summary Forestry CO_2 Emissions (Gg CO_2)						
2006	2007	2008	2009	2010	2011	Average (2006-2011)
310	330	570	-250	760	560	380

The SNC notes, the calculation of emissions in the LUCF sector has closely followed the IPCC Revised 1996 Guidelines using Tier 1 default values provided where applicable and available. Some factors for annual growth rates were taken from the IPCC 2006 Guidelines. Emissions (+) and removals (-) of carbon dioxide in the LUCF sector is given in Table 22.

The removals in "growing forests" in the SNC include 3,800 Gg from closed forests and 3,070 Gg from open forests. But old-growth indigenous forests are in pseudo equilibrium with respect to carbon emissions over the long term and so cannot be classed as "growing forests" in the same manner as mature plantations that are no longer growing cannot be classed as growing forests. Additional removals can, of course, occur for reforestation and afforestation. Thus, in this report, the average long-term carbon removals for undisturbed indigenous forests are taken as zero[20]. Afforestation and reforestation were not significant for the reporting period; however, it is an important component under the REDD+ programme and will be reflected in future inventory works. The emissions, on the other hand, come from log removals, deforestation, including land-use change and disturbances due to weather events. These emissions have been calculated under the REDD+ programme to be around 0.3 per cent p.a. (in terms of area) for indigenous forests leading to around 730 Gg of CO_2 emissions per annum (including log removals) but with a high level of uncertainty.

For plantation forests, the SNC uses tier 1 values to calculate both removals and emissions due to logging. The present report uses tier 3 values to calculate the same, resulting in some differences. The CO_2 removals for pine plantations in this report (1800 Gg/annum) are around twice the values in the SNC (885 Gg/annum), and the mahogany CO_2 removals are somewhat lower (570 Gg/annum compared to 738.5 Gg/annum in the SNC). Similarly, the emissions from logging in pine plantation average 1700 Gg/annum (2006-2011) compared with 416.6/annum Gg in the SNC and for mahogany 770 Gg/annum compared to 15.2 Gg/annum. The result is that in the TNC, plantation forests have a relatively small negative net emission level of around 350 Gg/annum (averaged over 2006- 2011) and the net value for the indigenous and plantation forests together averages 380 Gg/annum CO_2 (2006 – 2011). Table 22 below details these differences for the TNC years 2006 until 2011.

Note that the pine and mahogany plantations appear to have been approximately constant in the area over the past 25 years and thus the average deforestation/reforestation emissions have also been taken as zero. Note also that the emissions due to disturbances (cyclones, droughts, pests and illegal logging and firewood removals) have not been taken into account and would in all likelihood increase the net emissions. The REDD+ program is working at defining emissions due to the disturbances. In addition, it must be noted that the uncertainty in the estimates for emissions due to deforestation of indigenous forests in particular, is very high and will also need further study to narrow down the estimate. These have been addressed in the Forest Reference Level, which is the more recent analysis of Fiji's Forestry emissions.

Table 22: Net emissions all forests 2006 – 2011, Forestry comparison SNC (2004) with TNC (Gg CO_2)

	2004	2006	2007	2008	2009	2010	2011	Average (2006-2011)
• Removals in growing forests								
Closed forests (indigenous)	-3,800.70	0	0	0	0	0	0	
Open forests (indigenous)	-3069.5	0	0	0	0	0	0	
Pine plantations	-885.5	-1800	-1800	-1800	-1800	-1800	-1800	-1800
Hardwood plantations (mahogany)	-738.5	-770	-770	-770	-770	-770	-770	-770
Total removals	-8494.20	-2570	-2570	-2570	-2570	-2570	-2570	-2570
• Emissions due to deforestation, land use change and disturbances								
Closed forests (indigenous)	Not recorded							
Open forests (indigenous)	Not recorded							
Total indigenous (net emissions including logging)		730	730	730	730	730	730	730
Pine plantations	Not recorded	0	0	0	0	0	0	0
Hardwood plantations (mahogany)	Not recorded	0	0	0	0	0	0	0
• Emissions from forest harvest								
Indigenous	74.7							
Pine plantations	416.6	1800	1800	1800	1300	1900	1700	1717
Mahogany	15.2	350	370	610	290	700	700	503
Total harvest emissions	506.5	2150	2170	2410	1590	2600	2400	2220
Net emissions plantations		-420	-400	-160	-980	30	-170	-350
Net emissions all forests	-7987.70	310	330	570	-250	760	560	380

Uncertainty and Quality Control

For plantation forests, good data were available for planting and removals and country-specific data (tier 3) was available for the carbon content of growing stock. IPCC methodology was used for the plantation forest sector and the variables were cross-checked against an equilibrium forest in which the total stock over time remained constant. This check gave good data for emissions from the plantation sub-sector.

For natural forests, there was reasonable data for removals (legal logging) but not for illegal logging and/or firewood collection. There was no satellite data for overall land conversions and nonspecific forest degradation.

Herold[21] calculated the carbon content of Fiji's natural forests at 125 Mt C for 1990 and 118 MtC (432 Mt CO_2) for 2000 suggesting a 0.6% p.a. decline using IPCC default methodology (tier 1). Payton and Weaver,[22] on the other hand, used sample plots (Tier 3) to calculate 157Mt CO_2 for Fiji natural forests, nearly 3 times lower than the tier 1 methodology. A 2010 FAO report suggested a net increase in natural forest stock of around 0.14% p.a. The REDD+ program (GIZ) estimated annual degradation of natural forests of around 0.3% p.a. Payton had good data for the carbon content of natural forests (Tier3) which was multiplied by the REDD+ annual degradation estimate to calculate emissions from natural forests.

The figures for natural forests and plantation forests were summed to get total emissions. Due to the limited data at the time of this assessment, the result can not be deemed as complete. Moreover, this study is not the most recent assessment of AFOLU sector emissions for Fiji's forests due to the time lag between the assessment and the publication of this report.

21 Herold, 2009
22 Payton and Weaver, 2011

Waste

Overview and Key Sources

CH_4 emissions from the waste sector for 2006-2011 are given in Table 23 below. The total emissions increased from 3.0 Gg to 6.2 Gg, showing a net increase of 107 per cent during the reporting period. It was also apparent that methane emissions from domestic wastewater treatment and discharge were almost constant, ranging from 1.8 to 2.3 Gg. The variation observed in domestic wastewater estimation is well within the uncertainty estimate of ± 35 per cent. CH_4 emissions from sludge treatment/removal were taken as negligible. For solid waste disposal sites, the emissions doubled from 2006-2007 and then remained constant for years 2007-2009 and then almost doubled in 2011 with respect to 2007-2009 emission levels. The IPCC waste model has in-built formulas that only approximate emissions to zero decimal places (in Gg), hence emissions from landfill for the year 2006 was recorded to be zero.

Table 23: Methane and total emissions from waste sector Fiji

Inventory Year	Methane emissions in Gg from different categories in Waste Sector			Total CH_4 emission (Gg)	Total CH_4 emission in CO_2-eq (Gg)
	Domestic Waste-Water treatment and discharge	Sludge Treatment	Solid Waste Disposal		
2006	2.0	0.0014	1	3.0	63
2007	2.0	0.0013	2	4.0	84
2008	1.8	0.0018	2	3.8	80
2009	2.1	0.0018	2	4.1	86
2010	2.3	0.0028	3	5.3	111
2011	2.2	0.0015	4	6.2	130

Figure 43 below, is the graphical representation of CH_4 emissions from different key categories within the waste sector. It is apparent that CH_4 emissions from domestic wastewater and solid waste disposal were very similar from 2007 to 2009 and then emissions from solid waste disposal increased rapidly from 2010 and almost doubled in 2011 in comparison to emission from domestic wastewater. The increase in CH_4 emissions from the solid waste is due to the use of a First Order Decay (FOD) model, which assumes that not all CH_4 is generated the year the waste is deposited, but it degrades slowly using first order and releases CH_4 in first few years. The Naboro landfill was commissioned in October 2005 and therefore did not generate much CH_4 in 2006 but it slowly increased by a factor of 8 in 2011 due to the nature of cumulative emissions over the years of the landfill and solid waste disposal.

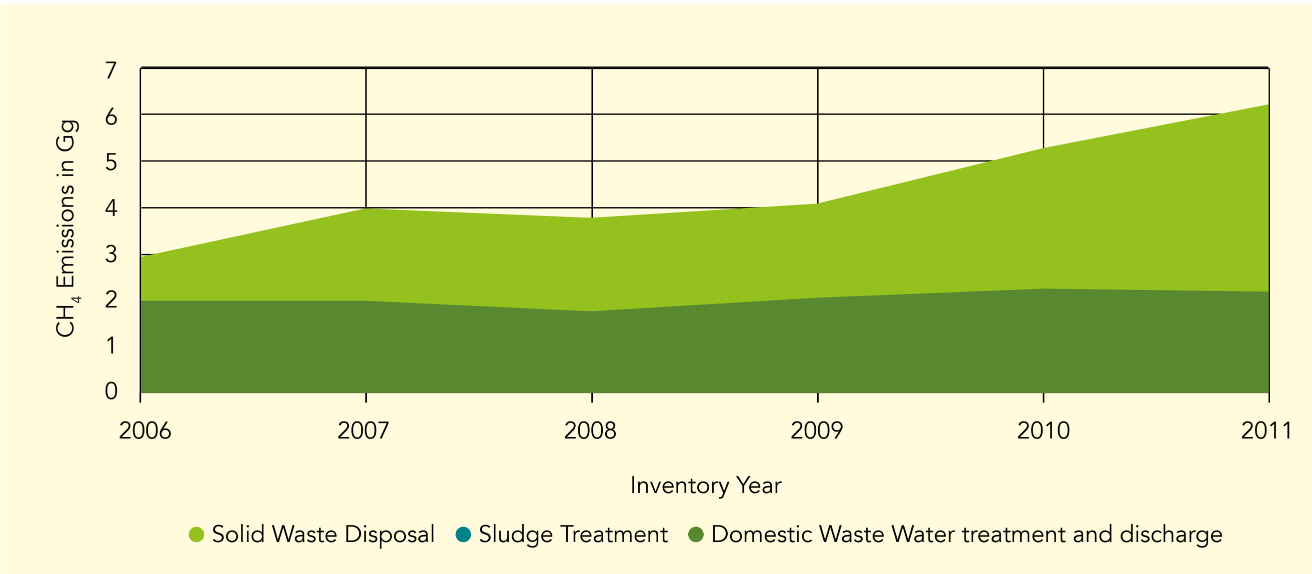


Figure 42: Waste emissions categories (sludge emissions too small to appear)

The total CH_4 emissions from the waste sector increased from 3.0 Gg in 2006 to 6.5 Gg in 2011. The increase was not linear across the reporting period. The percentage change with respect to 2006 emissions was approximately 30 per cent for the years 2007–2009 and then increased dramatically from 2010 onwards.

Table 24: Changes in waste emission 2006 - 2011

	2006	2007	2008	2009	2010	2011
per cent change w.r.t to 2006 emission	0	33	27	37	77	107
per cent change w.r.t to SNC	-29	-5	-10	-3	26	47

The increase in the cumulative amount of waste deposited in the landfill and solid waste disposal sites and increase in Biological Oxygen Demand (BOD) values in recent years could contribute to this trend. It is apparent that CH_4 emissions from the SWD is increasing quite rapidly in recent years and will continue to increase rapidly (see discussion below) if the landfill gas is not recovered.

Waste Data Sources

Table 25: Waste data sources description

Landfill Sources	There is only one anaerobic landfill in Fiji called Naboro landfill, which is a major source of methane. This is especially true when the waste composition comprises mostly of organic matter and given the wet tropical climate that causes faster anaerobic decomposition in the landfill to generate landfill gas. All the other municipalities in Fiji collect waste and dump at disposal sites of varying nature, some are well ventilated and some are deep and not managed well. In practice, 50 per cent of the landfill gas generated constitutes of direct CO_2, but the emission of CO_2 from landfill is not counted as per IPCC guidelines as this gas is of biogenic origin.
Biological Treatment of Solid Waste	Sludge was only removed at Kinoya Treatment Plant and was treated on-site using an anaerobic digester. The activity data for this particular assessment is the same as the BOD data obtained for wastewater treatment. Emissions from anaerobic digestion of sewage sludge at Kinoya Sewage Treatment Plant were estimated using equation 4.1 from chapter 4, Vol 6 of 2006 IPCC guidelines. The sludge removed in the wastewater and discharge treatment at Kinoya Sewage Treatment Plant, expressed in kg BOD is converted into Gg and then the above equation is applied.
Solid Waste Disposal (SWDS):	The Naboro landfill had a weighbridge installed in 2005, and therefore an accurate amount of waste deposited into the landfill was obtained from the Department of Environment and the landfill operator. Some city and town council provided estimated data based on truckloads in the absence of the site weighbridge. These latter data obtained were not reliable and hence the population data were used to calculate the amount of waste generated for all the other sites except Naboro landfill. Default waste characterisation data for the Oceania region was used. A simple FOD spreadsheet model (IPCC Waste Model) was developed to estimate CH_4 emissions from solid waste disposal in Fiji. The spreadsheet keeps a running total of the amount of decomposable DOC in the disposal site, taking account of the amount deposited each year and the amount remaining from previous years. This is used to calculate the amount of DOC decomposing to CH_4 and CO_2 each year. The spreadsheet also allows users to define a time delay between deposition of the waste and the start of CH_4 generation.
Wastewater Treatment and Discharge	There are in total 10 sewage treatment plants in Fiji that were considered in this assessment and the yearly BOD measurements were obtained from Water Authority of Fiji (WAF). However, data resolution for some treatment plants were very limited and in some instances, there was only one BOD measurement for the entire year. High-frequency data measurements were obtained only for Kinoya treatment plant and as such country-specific data was used, whereas for all the other stations, the default BOD value of 21.9 kg/cap/y was used. The BOD data obtained for Kinoya treatment plant ranged from 15.2 – 26.5 kg/cap/y with an average of 19.4 kg/cap/y, which is very close to the default value taking into account an uncertainty range of ± 30 per cent in BOD data cited in the IPCC 2006 good practice guidance. CH_4 emissions from wastewater treatment and discharge were estimated according to the procedure outlined in chapter 6 of Vol. 5 IPCC 2006 guidelines. In Fiji, most of the industrial wastewater flux is connected to the main sewer lines or discharged into natural waterways and there is no data available to quantify industrial emissions of CH_4 from wastewater handling.

To get an accurate assessment, it was also imperative to know the population that is actually connected to sewer lines and septic tanks. This data was lacking and therefore, the best practice was to assume that the urban population was connected to sewer lines or had septic tanks that have solid removed frequently. For Kinoya treatment plant it was well known that it catered for 150,000 people in the central division, hence the value remained same for all the years, but in recent years the total population for Suva and Nasinu has increased to 170,000. This also constitutes squatter settlement that may have pit toilets or septic tanks without any collection for treatment, which is omitted in this assessment. Hence a value of 150,000 for Kinoya station is perhaps the best judgment value. The uncertainty of the population data is 5 per cent as stipulated in the IPCC 2006 good practice guidance.

Table 26 shows the categories in the waste sector are not considered in this assessment.

Table 26: Waste sector categories not included in this assessment

Other waste sectors	
Incineration or burning of waste	Burning of clinical waste in three hospitals, Colonial War Memorial Hospital, Lautoka Hospital and Labasa Hospital, is a common practice. The average quantity and type of waste burned in hospitals were only available for years 2011 onwards. For 2011, the calculated CO_2 emissions amounted to 0.008 Gg/year, which is insignificant and is not reported here. The medical hospitals now have a better record and perhaps in future, this activity could be included.
Composting	Composting of market waste is currently practised by Suva City Council and Lautoka City Council but was not done on a large scale before 2011 and therefore emissions would be negligible for the accounting period and thus not considered here.

The emissions given in the SNC are compared with this report in Figure 43 below.

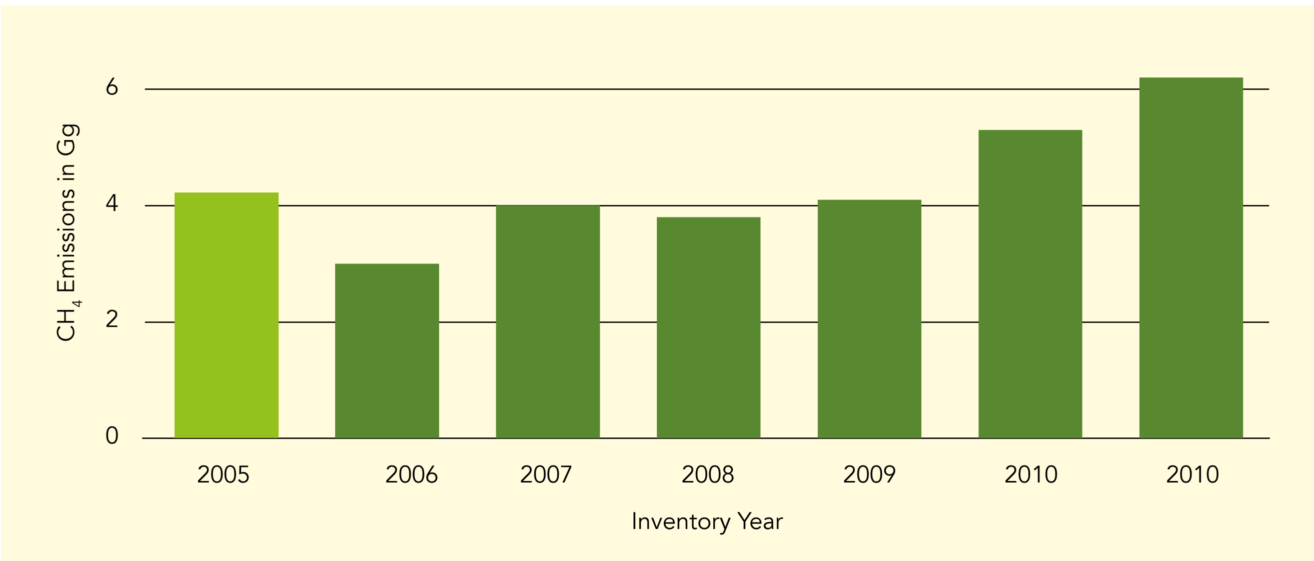


Figure 43: Methane emissions from waste sector comparison with SNC 2004

Total CH_4 emissions given in the SNC for the waste sector were estimated to be 4.2 Gg which is commensurate with the values in this report.

Uncertainty and Quality Control

The major source of uncertainty in estimating emissions:

- Tonnage of waste generated at each municipal SWD sites. Almost all the sites, except Naboro, did not have a weighbridge and therefore, the tonnage of waste was estimated using the default methodology.
- The lack of characterisation of waste. The default values for the Oceania region were used in the calculation, but these default values were typically for Australia and New Zealand, which could be different from local waste characterisation. Only Suva City Council, with the help of JICA volunteers, did a waste characterisation study and estimated the per cent organic component of our waste. However, the individual breakdowns of the organic matter were not known.
- Estimating the amount of waste that is actually deposited to SWD sites. Again, a default value for the Oceania region of 85 per cent was used, but it could be much lower for smaller towns, where people still practice burning or burying rubbish.
- The default value of zero for CH_4 oxidation was used in this assessment due to non-availability of country-specific data. Soil cover used at Naboro landfill could provide oxidation loss typically in the range of 10 per cent. This is not accounted for in the calculation but is very well within the uncertainty limit.
- The major limitation for estimating CH_4 emissions from wastewater treatment was the lack of BOD measurements.
- There was no account on what population size was serviced by sewer trucks collecting waste and dumping at the treatment plant. Hence, it is only logical that for major cities and towns, the urban population should be taken into account when calculating the emissions.

CHAPTER 3

IMPACT, VULNERABILITY & ADAPTATION

Fiji's Vulnerability to Climate Change

Fiji's first-ever Climate Vulnerability Assessment (CVA) was launched at COP23 in November 2017. The CVA encompasses the climate risks Fiji faces, which includes Fiji's high exposure to natural hazards such as cyclones, storm surges, severe storms, floodings, landslides, droughts and extreme temperatures. The CVA report was prepared for the Government of Fiji by the World Bank and Global Facility for Disaster Reduction and Recovery (GFDRR). The report projects and outlines the impending impacts of climate change in the coming decades, unveiling the threats on Fiji's economy, livelihoods and poverty levels, health, food security and infrastructure. Recognising these potential risks, the analysis also identifies interventions in key priority areas to reduce vulnerability and build resilience. These key areas include; *building inclusive and resilient towns and cities; improving infrastructure services; climate-smart agriculture and fisheries; conserving ecosystems and building socio-economic resilience*. The report provides a quantitative basis for understanding the physical threats to the country created by natural hazards and climate change and the development needs and opportunities of the country as identified in the 20-year and 5-year Development Plan.

The National Adaptation Plan Framework for Fiji has also been formulated, and provides guidance on the development and implementation of the National Adaptation Plan (NAP). The Fiji NAP will serve to implement the adaptation component of the National Development Plan, the CVA and the National Climate Change Policy. Moreover, the NAP will provide the basis to comprehensively address climate change through integrating adaptation options into national development planning.

Climate Change Projections

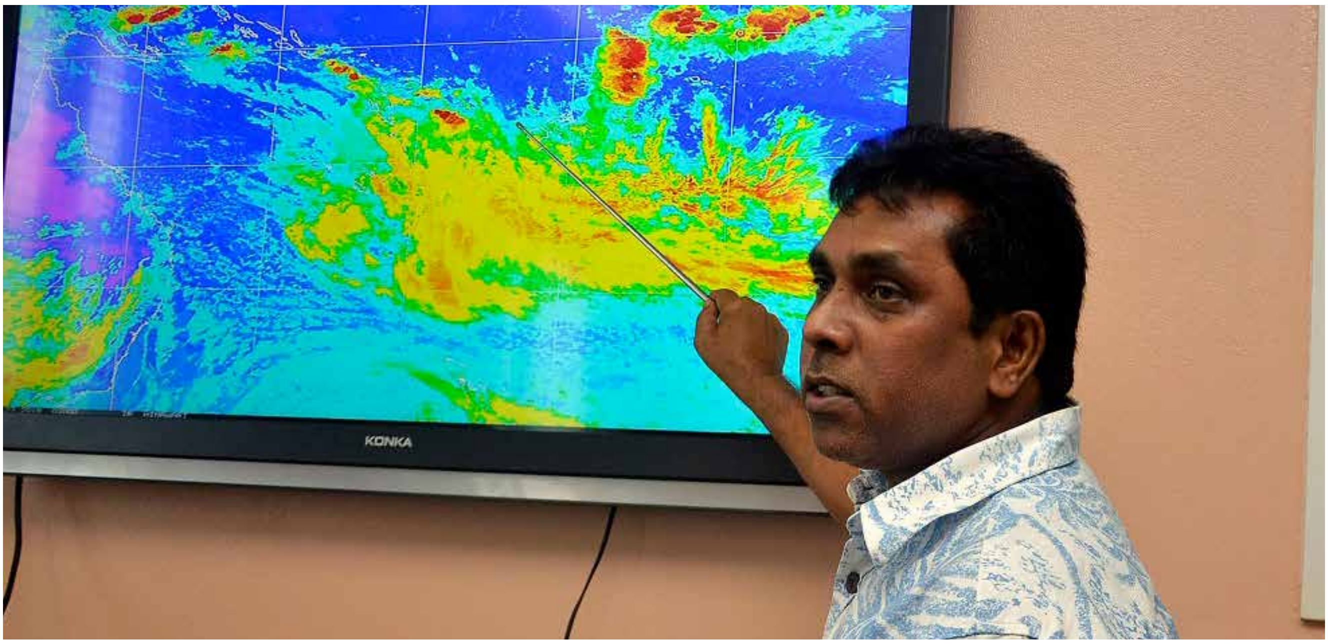
Climate projections for Fiji have been derived from up to 24 New Global Climate Models (GCMs) in the Coupled Model Intercomparison Project (phase 5) (CIMP5) database. The exact number may be different for each of the different scenarios. The model used also gives different projections under the same scenario. This means that there is no single projected future for Fiji, rather a range of possible futures for each emission scenario. The range is described in Table 27.

Temperature

Further warming is expected over Fiji under all Representative Concentration Pathways (RCP), with warming up to 1.0°C by 2030. There is a growing difference in warming between each RCP.

While relative warm years and cool years and decades will still occur due to natural variability, there are projected to be more warm years and decades on average in a warmer climate. There is very high confidence that temperatures will rise because:

- It is known from theory and observation that an increase in GHGs will lead to a warming of the atmosphere; and
- Climate models agree that long term average temperatures will rise.



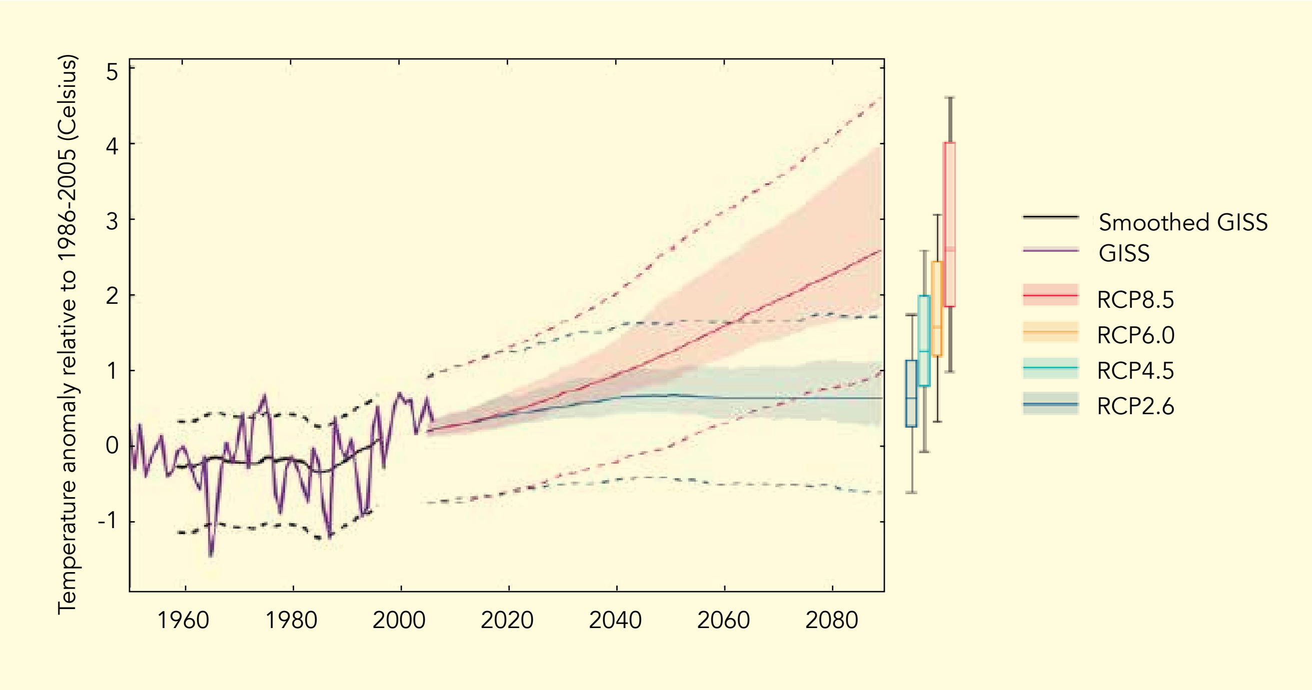


Figure 44: Historical and simulated surface air temperature time series for the region surrounding Fiji.

Rainfall

The CMIP5 models show a range of projected annual rainfall change from an increase to a decrease and the model average indicates little change. The range is greater in the highest emissions scenarios (Figure 45, Table 27). There is a greater model agreement for a slight increase in November to April rainfall in the Fiji region. There is a range of projections for May to October rainfall with the model average indicating little change.

The year-to-year rainfall variability over Fiji is generally larger than the projected change, except for the models with the largest projected change in the highest emission scenario by 2090. The effect of climate change on average rainfall may not be obvious in the short or medium-term due to natural variability. In the November to April season Conformal Cubic Atmospheric Model (CCAM) indicates for a group of three models that project a mean rainfall increase over the entire region, rainfall may increase more than the regional average on the west, but increase less or even decrease in the eastern half of the two main Fiji islands. CCAM indicates any east-west pattern to be weak in the May to October season.

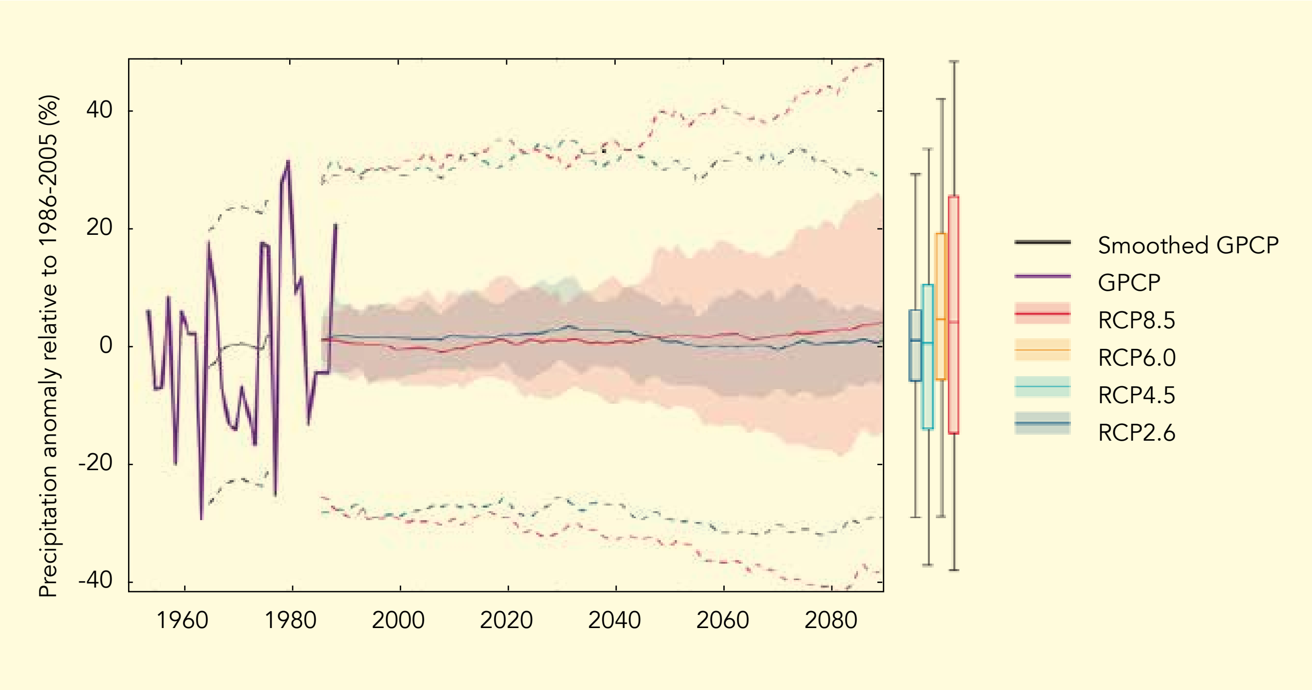


Figure 45: Historical and simulated annual average rainfall time series for the region surrounding Fiji.

Projected changes in the annual and seasonal mean climate for Fiji under the following four emissions scenarios: RCP2.6 (very low emissions, in dark blue), RCP4.5 (low emissions, in light blue), RCP6.0 (medium emissions, in orange) and RCP8.5 (very high emissions, in red) are given in the Table 27 below. Projected changes are given for four 20-year periods centred on 2030, 2050, 2070 and 2090, relative to a 20-year period centred on 1995. Values represent the multi-model mean change, with the 5–95 per cent range of uncertainty in brackets. Confidence in the magnitude of change is expressed as *high*, *medium* or *low*. Surface air temperatures in the Pacific are closely related to sea-surface temperatures (SST), so the projected changes to air temperature given in this table can be used as a guide to the expected changes in SST.

Source: https://forafewsummersmore.wordpress.com/tag/rain/

Table 27: Different Climate Projections for Each Emission Scenario

Variable	Season	2030	2050	2070	2090	Confidence (magnitude of change)
Surface Air temperature (°C)	Annual	0.5 (0.4–0.8)	0.7 (0.5–1)	0.7(0.4–1.1)	0.6 (0.3–1.1)	Medium
		0.6 (0.3–1)	0.9 (0.6–1.4)	1.1 (0.7–1.8)	1.3 (0.8–2)	
		0.6 (0.4–0.9)	0.9 (0.6–1.3)	1.2 (0.9–1.8)	1.6 (1.2–2.5)	
		0.7 (0.5–1)	1.3 (0.8–2)	1.9 (1.4–2.9)	2.7 (1.9–4)	
Maximum Air temperature (°C)	1-in- 20 year event	0.6 (0.1–0.8)	0.7 (0.2–1.1)	0.7 (0–1)	0.7 (-0.1–1.2)	Medium
		0.6 (0.1–0.9)	0.8 (0.3–1.2)	1.2 (0.5–1.7)	1.3 (0.7–1.9)	
		NA (NA–NA)	NA (NA–NA)	NA (NA–NA)	NA (NA–NA)	
		0.8 (0.1–1.3)	1.4 (0.6–2)	2.2 (1.4–3.1)	2.9 (1.7–4.1)	
Minimum Air temperature (°C)	1-in-20 years event	0.5 (0.2–0.9)	0.7 (0.2–1.1)	0.7 (0.4–1)	0.6 (0.1–0.8)	Medium
		0.6 (0.3–0.8)	0.9 (0.4–1.3)	1.1 (0.8–1.5)	1.3 (0.9–1.9)	
		NA (NA–NA)	NA (NA–NA)	NA (NA–NA)	NA (NA–NA)	
		0.7 (0.3–1)	1.3 (0.9–1.9)	2.1 (1.6–2.7)	2.9 (2–4.1)	
Total Rainfall (per cent)	Annual	2 (-4–8)	2 (-3–8)	0 (-9–9)	1 (-6–6)	Low
		0 (-7–8)	-1 (-11–7)	2 (-9–14)	1 (-14–10)	
		3 (-3–11)	2 (-8–10)	3 (-7–14)	5 (-6–19)	
		1 (-5–9)	1 (-10–11)	1 (-15–15)	4 (-15–25)	
Total Rainfall (per cent)	Nov-Apr	2 (-3–11)	3 (-4–10)	1 (-7–12)	1 (-5–11)	Low
		1 (-7–10)	0 (-7–10)	4 (-7–20)	2 (-11–13)	
		4 (-4–13)	2 (-9–11)	4 (-8–16)	6 (-7–22)	
		1 (-4–13)	2 (-6–13)	4 (-14–21)	8 (-10–32)	
Total Rainfall (per cent)	May-Oct	2 (-6–9)	2 (-8–11)	0 (-12–9)	1 (-9–11)	Low
		1 (-9–11)	-2 (-12–8)	-1 (-13–11)	0 (-20–10)	
		3 (-9–11)	3 (-6–10)	3 (-11–14)	3 (-7–15)	
		0 (-10–10)	-1 (-14–10)	-2 (-18–12)	-1 (-21–18)	
Mean sea-level (cm)	Annual	13 (8–18)	22 (14–31)	31 (19–44)	41 (24–58)	Medium
		13 (8–18)	23 (14–31)	35 (22–48)	47 (29–67)	
		13 (8–17)	22 (14–31)	34 (22–47)	49 (30–68)	
		13 (8–18)	25 (17–35)	42 (28–58)	64 (41–88)	

There is a range in model projections in mean rainfall, with the model average indicating little change in annual rainfall but an increase in the wet season, with more extreme rain events.

Climate Risk Profiles

Return periods (years) are used as a measure of the likelihood of an extreme event. It is a statistical estimate of how often an extreme event of a given magnitude is likely to be equalled or exceeded. This method is used to provide a climate risk assessment associated with extreme events in Fiji.

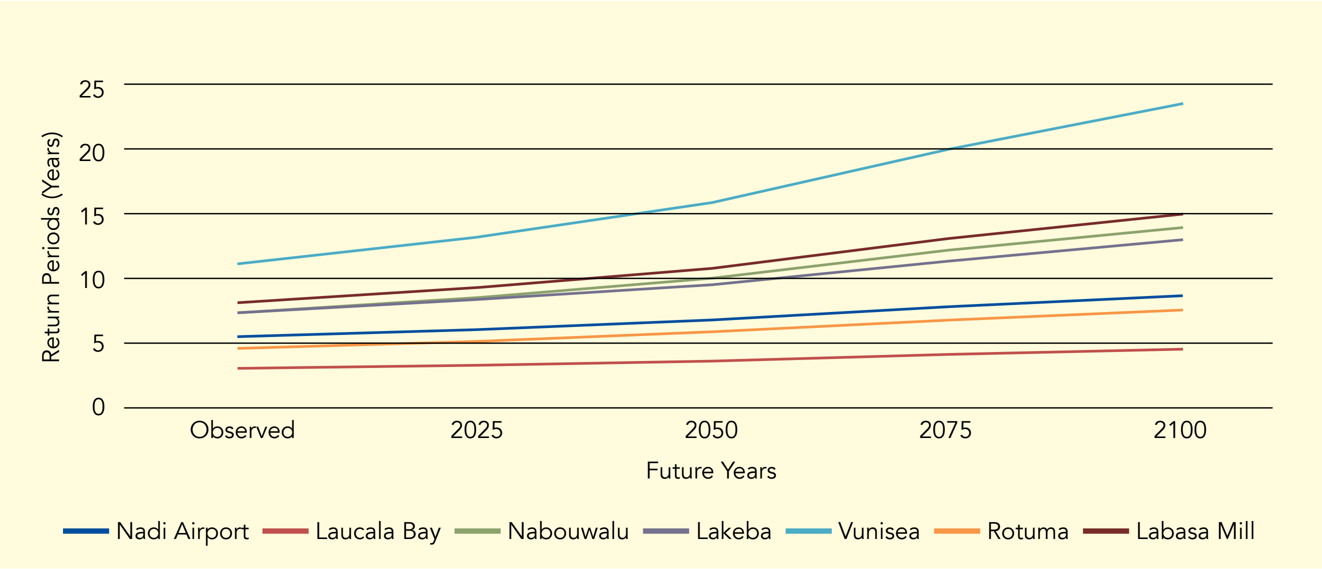


Figure 46: Return periods for daily maximum rainfall (200 mm) at selected sites in Fiji projected to 2100.

The Maximum rainfall is projected to become less frequent by 2100 at various locations in Fiji.

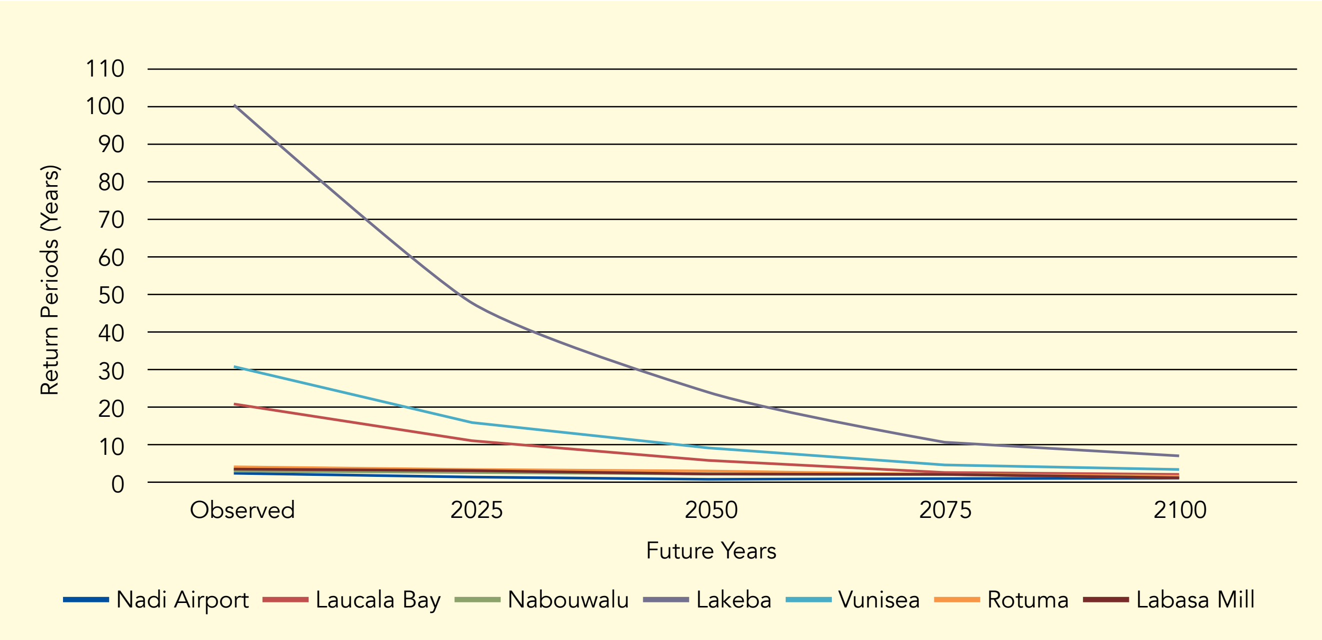


Figure 47: Return periods for daily maximum temperature (35°C) at selected sites in Fiji projected to 2100.

The recurrence of the maximum temperature exceeding 35˚C is expected to shorten in future and become a normal occurrence by 2100.

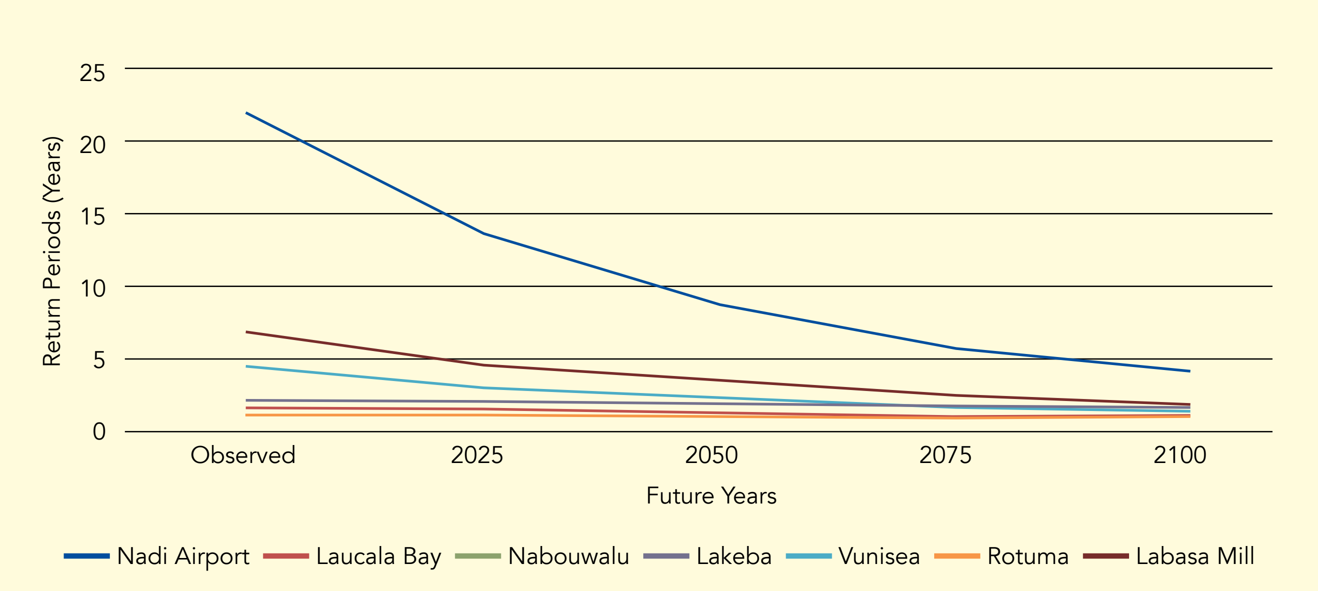


Figure 48: Return periods for daily minimum temperature (16ºC) at selected sites in Fiji projected to 2100.

The return period of the daily minimum temperature of 16˚C at selected locations in Fiji is becoming more frequent than currently observed.

Sea-Level

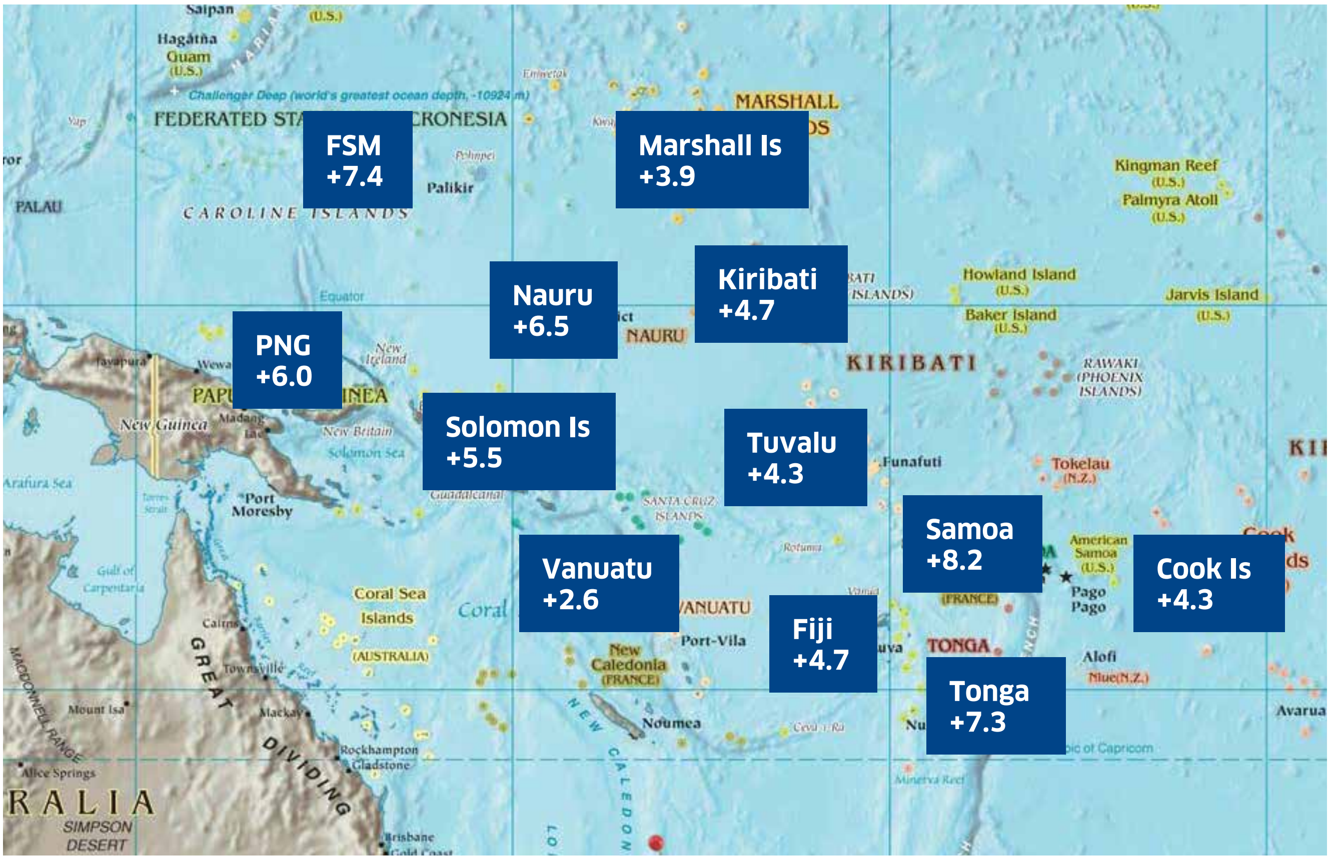


Figure 49: Short-term data from Tide Gauges suggest the sea-levels are rising in the Pacific region.

The sea-level trend at the Lautoka SEAFRAME station for the period 1993 to 2015 is increasing at +4.7mm/year. However, the observational record is relatively short in climate terms and therefore it is still prone to the effects of shorter-term ocean variability (such as El Niño and Pacific decadal oscillations). As the data sets increase in length, the linear trend estimates will become increasingly indicative of the longer-term changes and less sensitive to large annual and decadal fluctuations. Nevertheless, similar trend values are being observed across the region.

Summary of Fiji's Future Climate

Climate has implications in all walks of life, which makes it so crucial to understand the possible future climate of Fiji. This is essential for people and the Government in order to plan for changes and potential risks.

- At a glance, El Niño and La Niña events will continue to occur in the future, but there is little consensus on whether these events will change in intensity or frequency.
- Annual mean temperatures and extremely high daily temperatures will continue to rise.
- There is a range in model projections in mean rainfall, with the model average indicating little change in annual rainfall but an increase in the wet season, with more extreme rain events.
- The proportion of time in drought is projected to decrease slightly. Sea-level will continue to rise.
- Ocean acidification is expected to continue. The risk of coral bleaching is expected to increase.
- Wave height is projected to decrease across the area in the wet season, with a possible small increase in dry season wave heights.
- Tropical cyclones (TCs) are projected to be less frequent but more intense.

Fiji's Vulnerability to Disaster Risk Events

Disaster events are a common phenomenon that wreaks nationwide havoc in the country. Fiji regularly experiences natural disasters of geological and hydro-meteorological origin. In the past 37 years, a total of 124 natural disasters, affecting almost all parts of the country, have been reported. 50% per cent of these events were TCs, followed by floods (33 per cent) and earthquakes (8 per cent). Some of the events prompted a declaration of a state of disaster by the Government (Table 28). Moreover, disaster events directly affected close to 3.3 million people between 1970 and 2016. Majority of the people affected (74 per cent), have been impacted by TCs, floods and severe storms. According to the 2013-2014 Fiji Household Income and Expenditure Survey (HIES),[23] (Figure 50), TCs and floods are the most common shocks experienced by Fijians. Droughts have also significantly affected people (26 per cent) over the same period, despite the fact that only six recorded drought events occurred (Figure 50). Landslides are also frequent and recurrent throughout Fiji however, the occurrence and impacts are difficult to quantify and therefore, there is limited data on this. Nonetheless landslides triggered by rainfall events pose a significant threat to lives, sources of revenue and transportation networks.

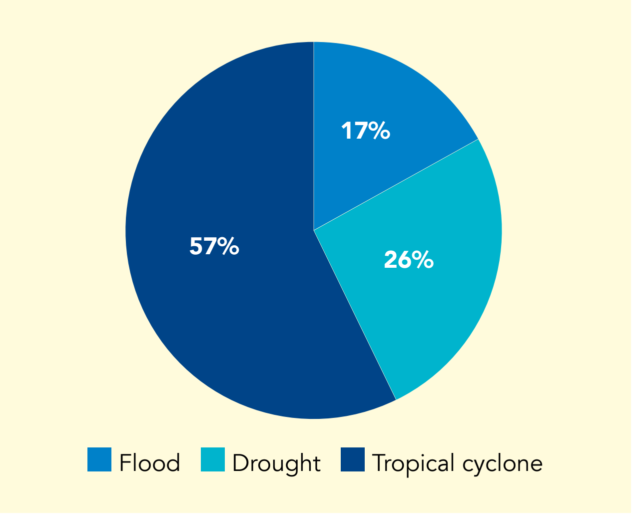


Figure 50: Percentage of people affected by major disaster events between the years 1970 to 2016.

Tsunamis and earthquakes are infrequent events and have not had a significant impact over this time period. However, these events have the potential to pose a significant threat when they occur as Fiji is a small island nation surrounded by the ocean.

Table 28: Direct impact of major disasters, 1970–2016

Disaster	Number of Events [a]	Number of people [b] affected	Number of people killed
Drought	6	840,860	0
Tropical cyclone (TC)	66	1,888,490	355
Flood	44	563,310	103
Sever local storm	2	8,370	17
Earthquake	10	0	5
Tsunami	2	0	0
Total	130	3,301,030	480

Sources: Lal, Singh, and Holland (2009), with figures updated to include January 2009, January 2012 and March 2012 flood events; tropical cyclone data are as reported by the Government of Fiji and include TC Tomas, TC Evan, and TC Winston.

a. Number includes major events only.

b. Numbers are rounded to nearest 10

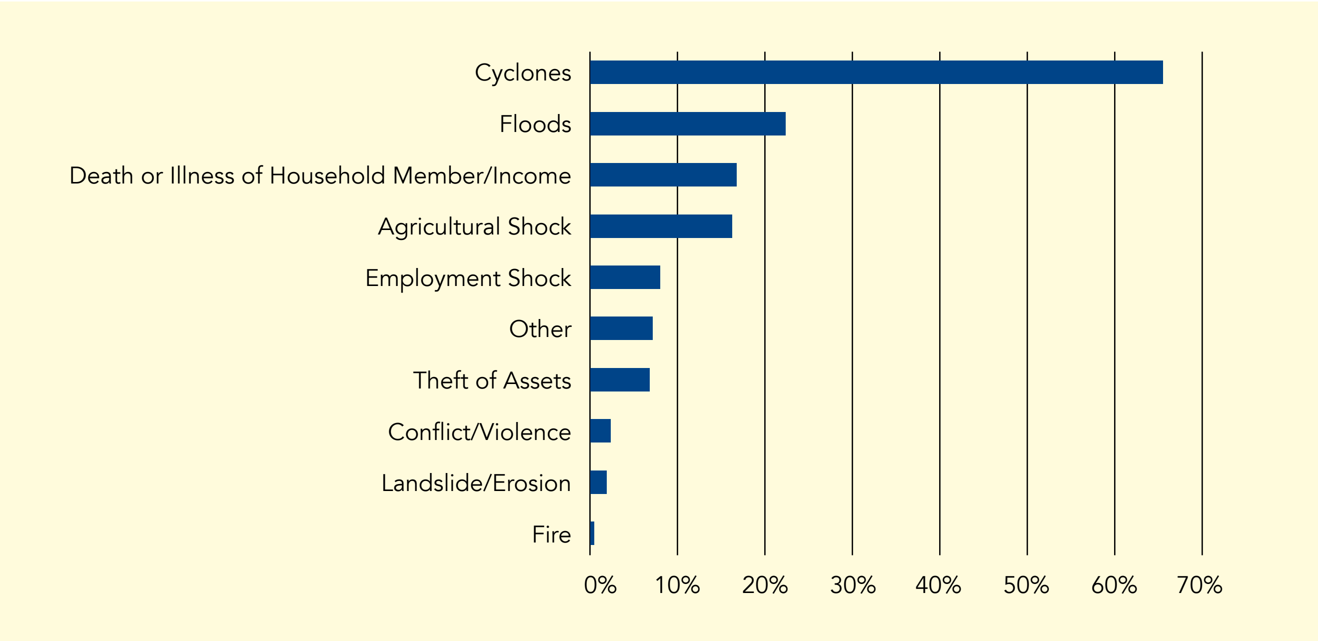


Figure 51: Percentage of Fiji population who experienced shocks during the 12 months before the HIES survey 2013-2014. Source World Bank team estimates from Fiji Bureau of Statistics, HIES 2013-2014.

Tropical Cyclones

The most serious climate hazard for Fiji is TCs, in the context of total damage and loss. Impact of TCs is most significant at the coast, but since Fiji is a small island nation, the whole country can be severely affected from widespread flooding, landslides and storm-force winds causing damage to infrastructure, livestock, agriculture and loss of lives. The occurrence of TCs in Fiji on average is one per year. Notably, Fiji has experienced numerous severe cyclones in the past 25 years which has had a significant impact on the economy and has caused fatalities (Table 28), TC Winston (category 5) being the most severe (Table 29). The frequency and intensity of cyclone occurrence in Fiji are problematic and is one of the major barriers towards economic growth and development. Moreover, the unbudgeted expenses and losses the country incurs when a TC hits the nation are significant. For example, the estimated average annual asset losses from TCs amount to FJ$152 million, which accounts for about 1.6 per cent of the country's GDP. Asset losses from the 100-year event amount to FJ$1,070 million, which is about 11.1 per cent of the national GDP. [24]

24 GoF, 2017.

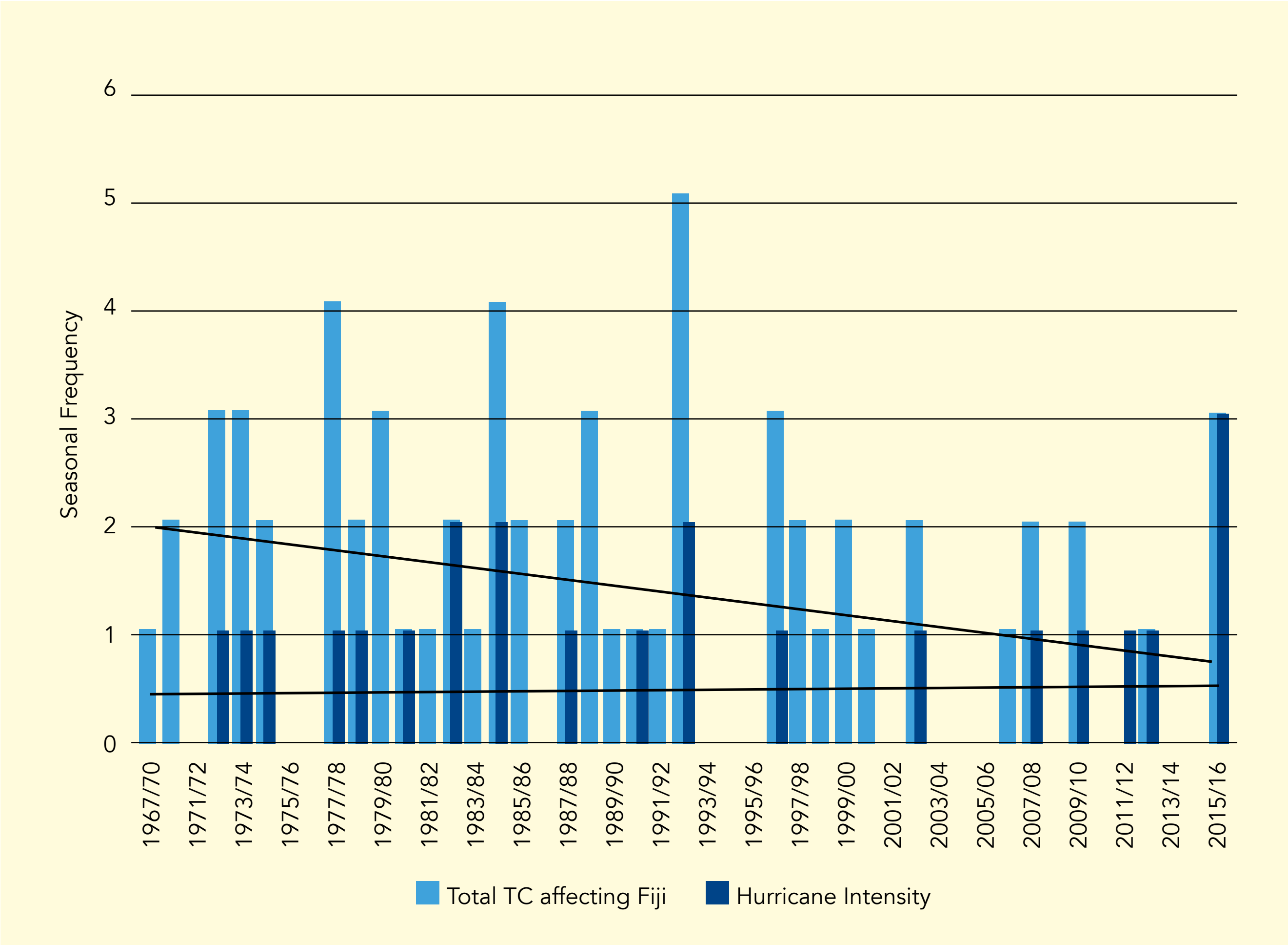


Figure 52: Trends in tropical cyclones affecting Fiji since 1969/70 season.

TCs usually affect Fiji from November to April, noting tropical cyclones have also affected the country in May and October, as in the TCs of 1974/75, 1996/97, 1972/73 and 1997/98. On average, 1 to 2 cyclones affect some part of Fiji every season. There have been 14 seasons when Fiji was not directly affected by cyclones. In contrast, Fiji experienced five tropical cyclones during the 1992/93 TC season, and four in 1977/78 and 1984/85 TC seasons (Figure 52). A decreasing trend in both the number of TCs and severe TCs with hurricane intensity affecting Fiji has been observed in the last 4 decades. Despite this observed trend, the past two seasons have produced the most severe cyclones in the region, which were TC Pam and TC Winston. This is consistent with the climate change projections for tropical cyclones, which suggest that while the total number of tropical cyclones affecting our region is likely to decrease through this century, the proportion of more severe tropical cyclones may increase.

Table 29: Summary of cyclone and damage cost

	Category	Lives lost	Damage cost (FJ$)
TC Winston (2016)	5	44	FJ$2.0 billion
TC Evan (2012)	4	0	FJ$194.9 million
TC Ami (2003)	3	17	FJ$100 million
TC Kina (1993)	4	23	FJ$170 million

Source: FMS, Government of Fiji 2013

TC Winston

The catastrophe caused by TC Winston affected about 62 per cent of the country's total population, mainly affecting the Western and the Northern Divisions (Figure 54). This is equivalent to about 540,000 people impacted by the cyclone's maximum average wind speeds of 233 km/hour, and peak wind gusts of around 306 km/hour as it made landfall on the country's main island, Viti Levu. Moreover, many small islands were impacted by storm surges, mainly Koro Island and the Southern coast of Fiji's second-largest island, Vanua Levu. The storm surges caused sea flooding resulting in inundation about 200 meters inland in some areas. The perilous storm caused the loss of 44 lives, destroyed entire communities and left about 40,000 people requiring immediate assistance. The storm caused approximately 80 per cent of the nation's population to lose power, including the whole of Vanua Levu, as power and communication systems were destroyed.[25] Furthermore, about 30,300 houses, 495 schools and 88 health clinics and medical facilities were damaged or destroyed. Crops and livestock were also severely affected, compromising the livelihoods of about 60 per cent of the nation's population.

25 GoF, 2016b

Summary of Damage and Losses

The Post Disaster Needs Assessment (PDNA) led by the Government following TC Winston, estimated the cost of the damage and losses at FJ$1.99 million, FJ$1.29 billion (US$0.6 billion) in damage (i.e. destroyed physical assets) and FJ$0.71 billion (US$0.3 billion) in losses (Figure 53). Recovery and reconstruction needs by sector are estimated at FJ$1.96 billion (Table 32).

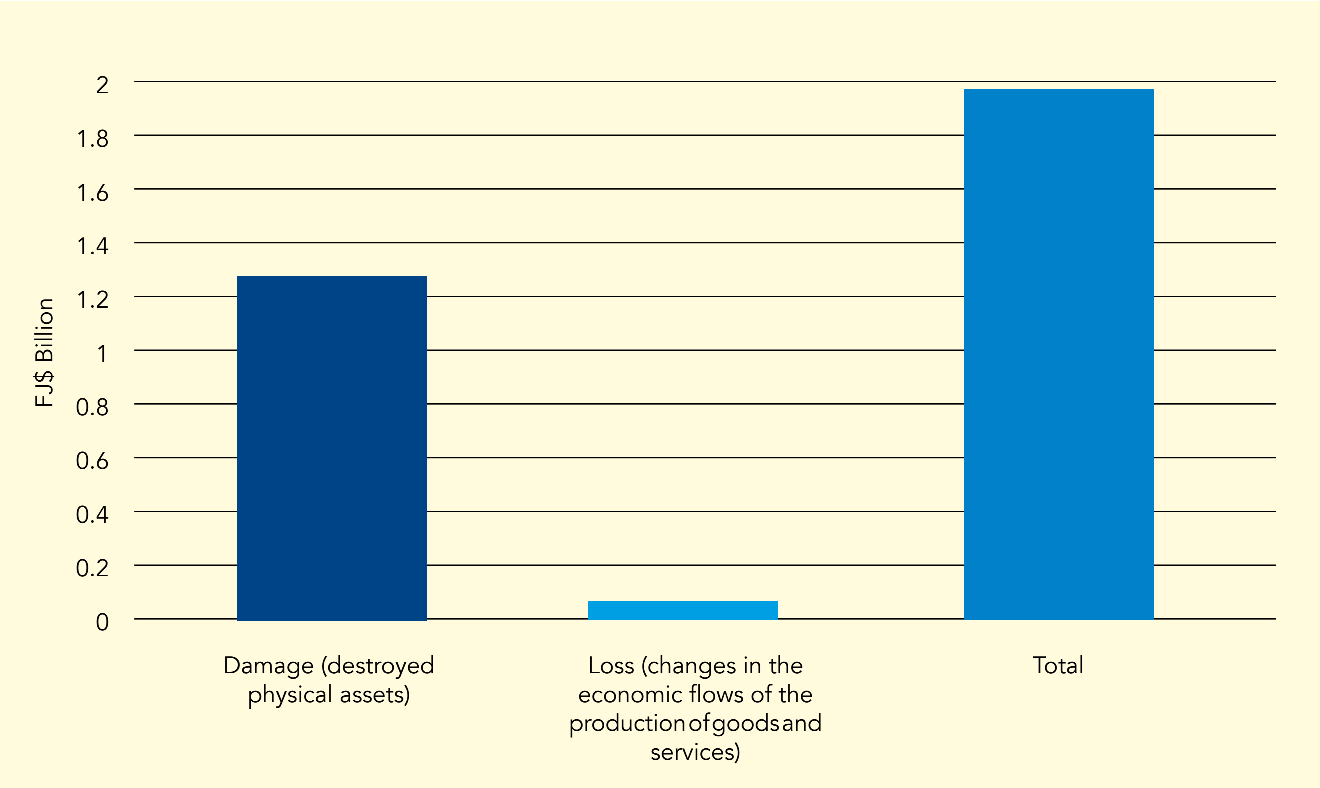


Figure 53: Estimated Damage and Loss in Billion FJ$ (These figures exclude the environment sector, as environmental assets and flows of environmental services are not included in the national accounts).

Table 30: Summary of Disaster Effects by Sector

	Disaster Effects (FJ$ million)			Share of Disaster Effects[a] (per cent)	
	Damage	**Losses**	**Total**	**Public**	**Private**
Productive Sectors	**241.8**	**594.5**	**836.3**	**12**	**88**
Agriculture	81.3	460.7	542.0	7	93
Commerce and Manufacturing	72.9	69.9	142.8	49	51
Tourism	76.1	43.9	120.0		100
Mining	11.5	20.0	31.5		100
Social Sectors	**827.9**	**40.0**	**867.9**	**12**	**88**
Education	69.2	7.4	76.6	100	
Health	7.7	6.2	13.9	100	
Housing	751.0	26.4	777.4	2	98
Infrastructure Sectors	**208.2**	**40.4**	**248.6**	**84**	**16**
Transport	127.1	2.4	129.5	98	2
Water and Sanitation	16.9	7.9	24.8	100	
Electricity	33.0	8.1	41.1	100	
Communications	31.2	22.0	53.2	30	70
Cross-Cutting Issues	**239.6**	**660.1**	**899.7**	**4**	**96**
Environment [b]	232.5	629.8	862.3		100
Culture and Heritage	5.1	0.8	5.9	23	77
Disaster Risk Management	2.0	29.5	31.5	100	
Total (Excluding Environment [c])	1,285.0	705.2	1,990.2	78	22
Grand Total	**1,517.5**	**1,335.0**	**2,852.5**	**84**	**16**

Source: Estimations by PDNA Assessment Team.

a. A breakdown of the public/private ownership for damage and loss (rather than the cumulative breakdown for disaster effects) is provided in Annex 1.

b. Estimation of environmental losses includes ecosystem service losses for 2016-18 for native forests, mangroves and coral reefs. Total recovery time may stretch beyond this timeframe.

c. These figures exclude the environment sector, as environmental assets and flows of environmental services are not included in the national accounts.

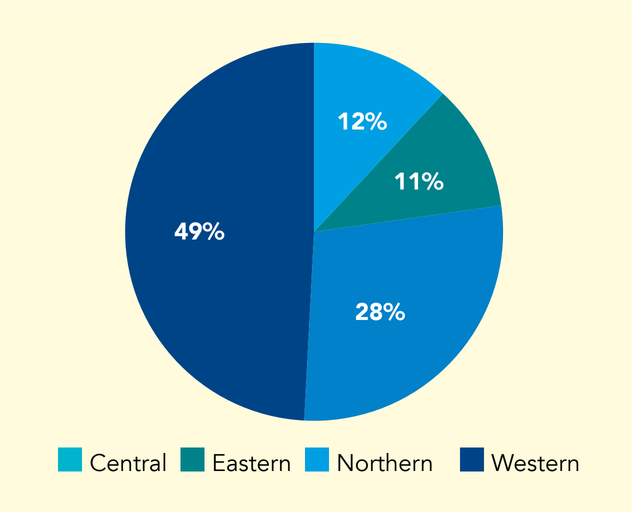


Figure 54: Share of Total Effects of TC Winston by Division

Source: Estimations by PDNA Assessment Team

Table 31: Total Damage and Production Losses Caused by TC Winston by Province (FJ$ million)

Province	Damage	Production Losses	Total Effects
Ba	526.0	142.0	68.1
Ra	230.8	86.1	316.9
Cakaudrove	183.2	131.5	314.7
Bua	57.4	94.0	151.3
Lomaiviti	102.3	45.5	147.8
Tailevu	53.9	66.8	120.7
Naitasiri	43.3	29.2	72.5
Macuata	15.5	28.1	43.5
Lau	23.5	13.3	36.8
Nadroga/Navasa	16.4	18.5	34.9
Rewa	5.6	2.5	8.1
Serua	1.3	1.1	2.3
Namosi	1.2	0.9	2.1

Table 32: Recovery and Reconstruction Needs by Sector (FJ$ million)

	Recovery	Reconstruction	Resilience	Total
Productive Sectors	**94.1**	**173.6**		**267.7**
Agriculture	65.3	96.1		161.4
Commerce and Manufacturing	17.8	43.5		61.3
Tourism	5.0	29.0		34.0
Mining	6.0	5.0		11.0
Social Sectors	**12.4**	**1,261.7**		**1,274.1**
Education		385.9		385.9
Health	12.1	18.8		30.9
Housing	0.3	857.0		857.3
Infrastructure Sectors	**15.3**	**250.7**	**18.8**	**284.8**
Transport	3.2	174.7		177.9
Water and Sanitation	3.6	20.7		24.3
Electricity	2.1	25.9	5.8	33.8
Communications	6.4	29.4	12.0	48.8
Cross-Cutting Issues	**63.0**	**27.4**	**12.0**	**99.7**
Environment	60.8	13.1		73.9
Gender	1.6	13.1		73.9
Culture and Heritage	0.6	8.5		9.1
Disaster Risk Management		2.7	12.0	14.7
ELSP	**31.5**			**31.5**
Total	**216.3**	**1,713.4**	**30.8**	**1,957.8**

The social and psychological impacts are beyond measure as one in every five households lost a significant share of their personal belongings and had their homes damaged or destroyed. Considering that most people cannot afford to carry personal or house insurance, rebuilding homes is one of the key challenges. Additionally, the safety of women and children throughout the reconstruction process is also one of the major concerns in some villages.

Table 33: Hazards

Hazard	Events	Vulnerability and risk	Threat	Impacts	Average annual cyclone losses
Tropical cyclone	➢ 2016 ➢ 2012 ➢ 2003 ➢ 1993	➢ Damaging winds, rain and storm surge. ➢ Effects of cyclone are most significant at the coast, but the whole country can be severely affected. ➢ Most severe cyclone events caused widespread flooding, landslides and damage to agriculture and livestock and loss of lives.	Climate change projections suggest that the number of category 4 and category 5 tropical cyclones in the region is likely to increase however the total number of storm is likely to decrease.	➢ Direct impacts Loss of life and damage to housing and infrastructure. ➢ Indirect impacts Interruption of supplies and services across various sectors of the economy.	➢ Estimated at more than FJ$1.5 million or 1.6 per cent of Fiji's GDP with much larger losses for rare events. ➢ Losses from 100 year cyclones are estimated at around FJ$1070 million which is around 11.1 per cent of Fiji's GDP. (Estimates are based on hazards and vulnerability from the PCRAFI model).

Floods

Floods in Fiji are common occurrences and are expected to increase, leading to large and growing economic losses. Fiji on average, has experienced more than one flood each year for the past 40 years.[26] Flooding events are typically coastal floods, fluvial floods and pluvial floods. Coastal flooding in Fiji mainly occur during cyclones or tropical depressions. Fluvial floods (rivers bursting banks) and pluvial floods (swarming of drainage systems), occurs as a result of continuous and intense rainfall. Damages sustained as a result of flooding is widespread since much of the population and infrastructure are either located along the coast or on large river floodplains subject to long-duration flooding and in smaller catchments prone to flash flooding. Flood losses are expected to grow significantly in the absence of adaptation to heavier rainfall.

Coastal flooding is characterised by a combination of four contributors: mean sea-level (plus sea-level rise), astronomical tide, storm surge and wave-induced elevation of the sea. The impact of storm surges and coastal flooding can be mitigated by coral reefs and mangroves. Reefs have the potential to reduce storm-wave power by 97 per cent and wave height by 84 per cent. However, anthropogenic influence has led to the degradation of reefs and mangroves. Likewise, increased water temperature and ocean acidification are primary causes of coral bleaching and destruction, which is likely to increase under all emissions scenarios (high level of confidence).[27] In addition to this, coastal development is a major cause of mangrove degradation. These influences greatly reduce any mitigating benefit of coral reefs and mangrove ecosystems, leading to increased coastal erosion and ultimately increased vulnerability to extreme water levels and other indelible threats of climate change.

26 GoF, 2012.

Table 34: Annual Asset Losses from flood events

	Average Annual Asset Losses (percentage of GDP)			Asset losses from the 100-year event (percentage of GDP)		
	2017	2050	2100	2017	2050	2100
Fluvial floods	2.6 per cent	3.6 per cent (37 per cent)	4.1 per cent (58 per cent)	23.3 per cent	26.7 per cent (15 per cent)	28.4 per cent (22 per cent)
Pluvial floods	1.6 per cent	2.3 per cent (45 per cent)	2.8 per cent (72 per cent)	15.1 per cent	20.5 per cent (36 per cent)	23.6 per cent (56 per cent)
TOTAL	4.2 per cent	5.9 per cent (40 per cent)	6.9 per cent (64 per cent)			

Source: World Bank team based on SSBN simulations. Note: Above figures assume unchanged economy.

Table 35: Floods

Hazard	Flood Events	Vulnerability and risk	Threat	Impacts	Average annual flood losses
➢ Coastal floods ➢ Fluvial floods ➢ Pluvial floods	➢ 2004 ➢ 2009 ➢ 2012 (2 events) ➢ 2014	➢ Much of the population and infrastructure are located on large river floodplains subject to long-duration flooding and in smaller catchments prone to flash flooding. ➢ Flooding caused by rainfall can occur during cyclones as well as during extreme rainfall events. ➢ All major rivers discharge to the ocean and can be affected by elevated sea-levels (during periods of either high tides or storm surges).	➢ Extreme daily rainfall events in Fiji are expected to increase in both frequency and intensity. ➢ High uncertainty on the magnitude of expected change to annual average rainfall (disagreement among the outputs of the different climate models).	➢ Direct impacts Loss of life and damage to housing and infrastructure ➢ Indirect impacts Interruption of supplies and services across various sectors of the economy	➢ Estimated at more than FJ$400 million or 4.2 per cent of Fiji's GDP. ➢ Majority of these floods is from high-frequency, low-intensity events. ➢ These cause large cumulative losses, especially on roads and other transport infrastructure and on residential buildings. Another fraction is from rarer events, including tropical cyclones.

Table 36: Landslides and Droughts

Hazard	Events	Vulnerability and risk	Threat	Impacts	Average annual losses
Rainfall-triggered landslides	➢ 2011 ➢ 2012	➢ Fiji is at high risk from landslide events because of the country's steep terrain, weathered rock properties and the frequent cyclone, storm and heavy rainfall events. ➢ A recent global landslide susceptibility map shows Fiji as having moderate to very high susceptibility in the interior of each island, based on analysis of slope, forest loss, presence of roads, and seismicity.	➢ Extreme daily rainfall events in Fiji are expected to increase in both frequency and intensity. ➢ High uncertainty on the magnitude of expected change to annual average rainfall (disagreement among the outputs of the different climate models).	➢ Direct impacts Loss of life and damage to housing and infrastructure. ➢ Indirect impacts Interruption of supplies and services across various sectors of the economy.	
Droughts	1998	➢ At present Fiji has faced relatively short, seasonal droughts, lasting a few months or less on average. ➢ However, on the onset of a drought, an average of 20-30 per cent of the land area in Fiji experiences drought conditions. ➢ The state of drought in Fiji is officially declared by the National Disaster Management Office (NDMO).	➢ Droughts pose a high level of risk and will continue to be so into the future. ➢ However, there is uncertainty on whether droughts will change in intensity or frequency, which adds to the complexity of planning for climate change adaptation.	➢ Direct impacts Decrease in agriculture production, the mortality of livestock, and lack of drinking water. ➢ Indirect impacts - Fire breakouts adversely affecting the forestry sector. - Health implications due to the reduced quality of the drinking water. - Low movement of water in rivers during drought periods linked with saline water intrusions.	The economic impact of the damage caused by Fiji's 1998 drought was estimated at between FJ$275 million and FJ$300 million.

Geophysical Events and Sea-Level Rise

Geophysical events such as earthquakes and tsunamis are not caused by climate change; however, the impacts of climate change such as sea-level rise increase the portion of the population and assets that will be exposed, adding to the country's vulnerability.

Moreover, the chance of Fiji experiencing moderate to strong earthquakes in the next 50 years is about 40 per cent.[28] Despite being located within an area of low seismic activity, it is bounded by the Pacific Ring of Fire, which is a region that is associated with extreme seismicity, volcanic activity and tsunamis.[29]

Fiji has been issued tsunami warnings on a number of occasions following high-magnitude events in the region. These events have a high possibility of causing tsunami run-ups; however, Fiji has experienced only five tsunami run-ups. The highest run-up, exceeding 1m in height, followed the Suva Earthquake in 1953. The other four events were recorded in 1881, 1884, 1979 and 2017, and were insignificant.[30] The Global Tsunami Model (GTM) predicates 0.2 per cent probability of such an event occurring in a given year, which also accounts for regional tsunamis affecting Fiji. The cost incurred in losses due to earthquakes and tsunamis is expected to be around FJ$5 million per year on average.[31]

State of Vulnerability of the Different Sectors

Food Security and Nutrition

About 37 per cent of the households in Fiji derives some form of income from agriculture.[32] Income generated from agriculture is particularly important for a large number of people living below or close to the poverty line. Thus, even a minor setback to the agriculture sector would mean immense pressure on these households to make ends meet. For example, a 1 per cent decrease in agriculture income would drive an additional 1,000 people into poverty and worsen the lives of those already living below the poverty line.[33] A large number of people also rely on subsistence farming, which is not only economical but helps meet dietary requirements. Hence, threats such as cyclones and floods not only cause economic setbacks but can also affect the health of the population as a whole.

Agriculture

Resilience to climatic conditions is relatively high for traditional crops and production systems.[34] However, with the decline in traditional farming practices in recent decades and the introduction of conventional farming practices to meet commercial production needs, the food production systems have become more susceptible to climatic variability posing a serious threat for food security.

In the last 16 years, the agriculture sector has suffered damages and losses from cyclones and floods amounting to about FJ$791 million. During this period, the country has suffered from 14 major events (six tropical cyclones and eight major floods). Cyclones cause destruction to crops, trees, farming and fishing equipment and related infrastructure, the death of livestock and destruction of the reef ecosystems that support fisheries. In particular, cassava, which is one of the main subsistence cash crops, is highly sensitive to tropical cyclones.[35] Floods also have detrimental effects, causing crop damage due to inundation. These damages lead to negative impacts on productivity and thus, implications for food security and economic loss.

In light of long-term impacts of climate change, increased shoreline erosion, inundation and reduced surface water, represent a major threat to food production in low lying areas (Table 38). Supposing a shift of the South Pacific Convergence Zone (SPCZ) away from Fiji within the next 50 years, El Nino-like conditions will become more common in the Pacific, leading to saltwater intrusion of streams and groundwater sources,[32] reduction of freshwater flow from upstream tidal flow and groundwater discharge resulting in reduced capacity to flush out brackish water. High salinity levels in crop substrates create a hostile environment for normal crop production, which is particularly important for staple crops such as taro. Salinity risks constrain both agricultural and economic development and are expected to increase in the future.

Table 37: Potential impacts of climate change on Fiji crops, livestock and forestry

32 Fiji Department of Agriculture, 2009.
33 GoF, 2017

34 McGregor et al. 2008.
35 IGCI, 2000.

HAZARD/ CHANGE	EXPECTED IMPACT
Changes in rainfall pattern	Changes may disrupt planting, flowering patterns, vegetative growth and harvesting patterns, which may affect productivity.
	Heavy, concentrated rainfall can lead to waterlogging and a higher risk of certain plant diseases, leading to higher rates of mortality; can also lead to erosion.
Changes in temperature	Existing cultivars of crops such as mango, papaya, and tomato can be adversely affected by high temperatures at specific stages of their development.[a]
	The incidence of pests and diseases may increase across a range of crops and livestock; increasing minimum night-time temperatures have already been demonstrated to increase the spread of taro leaf blight, which poses a major risk for the important local taro industry.[b]
	Higher temperatures may increase stress for livestock.
	The availability of maize and soy-based animal feed could be affected by climate change, resulting in increased costs for Fiji's poultry and pig industries, which are heavily dependent on imported feed. [c]
Sea-level rise and sea flooding	The land area available for agriculture may be reduced; the sugar industry has an estimated 5,000 ha of land that is under threat from saltwater intrusion.[d]

Table 38: Possible impact of Climate Change on selected crops

Crop	Climate change/climate variability impact in recent decades	Climate change impact (2030-2050)	Climate change impact beyond 2050
Sweet potato	Major impact of ENSO induced droughts	Moderate	Moderate to high
Cassava	No discernible impact	Insignificant to low	Low to moderate
Taro	Affected by ENSO induced droughts and cyclones.	Low to moderate	Moderate to high
Giant taro	No clearly discernible direct impact	Insignificant	Low
Yam (domesticated)	Impact from ENSO-induced droughts and cyclones	Moderate to high	High
Rice	No information available	Moderate to high	High
Breadfruit	Changing rainfall affecting fruiting patterns.	Insignificant to low	Low to moderate
Aibika/bele	No apparent impact	Low	Low to moderate
Banana	Cultivation at higher altitudes with warmer temperatures	Low	Low to moderate
Coconuts	Loss of palms close to sea and cyclones	Low	Low to Moderate
Coffee	leaf rust	Moderate	High
Cocoa	No discernible impact	Insignificant	Moderate to High
Oil Palm	No direct climate change impact	Insignificant	Low
Sugar	Severe impact of cyclones, floods and droughts associated with ENSO cycles	Low	Moderate

Table 39: Expected impacts of climate change on specific agricultural products

Source: Estimations by Assessment Team.

a. Taylor, McGregor, and Dawson 2016.
b. Ministry of Agriculture, Taro Industry Plan, 2016.
c. Taylor, McGregor, and Dawson 2016.
d. Personal communication from staff at Sugar Research Institute of Fiji, 2017."

CATEGORY	PRODUCT	SHORT-TERM IMPACT (TO 2030)[a]	MEDIUM-TERM IMPACT (TO 2050)[b]
Staple foods	Sweet potato	Moderate	Moderate to high
	Cassava	Insignificant to low	Low to moderate
	Taro	Low to moderate	Moderate to high
	Yams (domesticated)	Moderate to high	High
	Breadfruit	Insignificant to low	Low to moderate
	Rice	Moderate to high	High
	Banana	Low	Low to moderate
Exports	Coconuts	Low	Low to moderate
	Cocoa	Low	Moderate
	Sugar	Low	Moderate
	Papaya	Low to moderate	Moderate to high
Livestock	Cattle	Low	Moderate
	Pigs	Low	Moderate
	Poultry	Moderate	High

Source: Taylor, McGregor, and Dawson 2016. a. Temperature rise of +0.5°C to 1.0°C regardless of emissions scenario. b Varying temperature rise, from +0.5°C to 1.0°C (RCP 2.6) to +1.0°C to 2.0°C(RCP 8.5).

To safeguard the agricultural sector and ensure food security, the implementation should be based on regular climate change assessments and crop modelling. This will help inform national planning and promote good agricultural practices which will not only help implement food security measures but also strengthen efforts to improve bio-security to further protect agricultural systems against invasive species, pests and diseases. There is also a need to strengthen Fiji's disaster preparedness efforts in the agriculture sector, as highlighted in the Disaster Risk Reduction Plan. This can be done by establishing means to safeguard, protect and enhance the resilience of supply systems and promoting breeding and cultivation of indigenous and improved seed varieties. Furthermore, it will be crucial to strengthen research collaborations with farmers, communities and national research institutions with regional and international support.

Additionally, promoting the inclusion of climate-smart agriculture and nature-based solutions in farming practices and training, and in aspects of policy and planning will be key drivers of change for building resilience in the agriculture sector. Other priority actions and ongoing efforts to build adaptive capacity and resilience include increasing adoption of sustainable soil and land management techniques; improving water management systems, encouraging diversification of agricultural produce and raising education and awareness on best-practice agriculture and climate change.

Climate Change Impacts on International Trading, Agriculture, Food Prices and Food Security

It is envisaged that the global impacts of climate change on agriculture and food prices will have serious ramifications for food security in Fiji. The impact of climate change on global food commodity may be more severe than its impact on domestic production. Moreover, the global grain crops such as rice and wheat are more prone to the impacts of climate change than Pacific island root crops such as taro.[36] This would mean increases in the price of imported grains, affecting the part of the population that is heavily reliant on grain crops. Concurrent to this, market substitution opportunity for traditional crops such as taro, cassava and breadfruit may become more apparent. There is a high degree of uncertainty on the impact of climate change on the global food prices since it is dependent on a number of factors such as the farmers' ability to adapt to the changing climate, the rate at which the population is growing, economic growth and changes in diet. Models show that regional food prices (because of climate change) will increase in the East Asia and Pacific region between 1 and 5 per cent by 2030.[37]

Poor people face the greatest challenge when changes affect food prices and threaten food security, since food expenses take a relatively large part of their income. The HIES 2013–14 survey showed that poor people on average spend 29 per cent of their income on food, while some spent even more.

36 Taylor, et al., 2016.
37 Hallegatte et al. 2016

People above the poverty line spend about 18 per cent. Thus, an increase in the food prices even by 1 per cent would undesirably limit access of underprivileged households to a sufficient and nutritious diet. This consequently affects health and physical and cognitive development, especially in the case of children.

Climate change impacts on port and air infrastructure will interrupt commercial activities that depend on transportation of goods into the country. These impacts include increased frequency and duration of port closures, disruption to airline operations/shipping delays, damage to cargo and goods, increased costs of sea trade and shipped goods, increased maintenance and replacement costs, increased risk of liability resulting from port and air infrastructure damage and higher insurance costs. These will affect the demand and supply and ultimately the prices of goods. The segment of the population that is highly dependent on imported goods will have to face the brunt of price hikes, also affecting limitations on the capacity to cope with climate change.

Fisheries

With the increase in population and economic growth, the demand for fish domestically is expected to increase over the medium and long term.[38] However, the supply is expected to decline as a result of increased sea surface temperature, sea-level rise, ocean acidification, increased rainfall, sea current variability and reduced nutrient availability (Table 40). These environmental factors, together with adverse management practices, pose a significant threat to coastal fisheries. There is lack of sufficient evidence to suggest irrefutably the impacts of climate change on fisheries in Fiji; however, findings from a recent study of the Pacific project a 50-80 per cent reduction in maximum catch potential due to climate change.[39] A study on the vulnerability of Tropical Pacific Fisheries and Aquaculture to climate change also suggests the decline in demersal fish, targeted invertebrates, and intertidal and sub-tidal invertebrates. On the contrary, near-shore pelagic fish will thrive until 2035 but will decrease significantly by 2100.[40] The findings also suggest that the supply of the eastward migrating tuna will only remain stable until 2100 due to climate change, with future supply depending on how well they are managed. Furthermore, significant decreases in zooplankton are expected, which imposes a great threat to the food chain.[34]

The study also highlighted the benefits of climate change for freshwater and estuarine fisheries expected, with increases in rainfall and river flow providing quality habitats, cue for fish migration and enhancement in reproduction and recruitment. In terms of aquaculture, the study suggests that shrimp, tilapia and milkfish are likely to benefit from medium-term changes so long as they are not impacted by cyclones, floods, or storm surges. These benefits, however, are negligible compared to the loss of coastal and oceanic fisheries due to climate change.

Table 40: Expected impact of climate change on Fiji fisheries

38 Dey, M.M., et al., 2016

39 Asch, et al., 2018.

40 SPC, 2011.

HAZARD/CHANGE	EXPECTED IMPACT
Increase in sea surface temperatures	Coral bleaching may lead to loss of fish habitat.
	Migration and spawning times may change for tuna and similar pelagic fish.
	Demersal fish expected to be less productive due to changes in recruitment.
	Fewer areas suitable for seaweed aquaculture.
	Survival/growth of ornamental products, oyster spat, and sea cucumbers may be reduced.
	Growth rates for shrimp aquaculture may increase.
Sea-level rise	Area and productivity of estuarine fisheries may increase.
	Fisheries infrastructure and communities may be forced to relocate.
Ocean acidification	Reduction in aragonite concentration expected to reduce the productivity of invertebrates.
	Areas suitable for seaweed aquaculture will be reduced.
	Survival/growth of ornamental products, oyster spat, and sea cucumbers may be reduced.
Increased/more concentrated rainfall	Greater runoff may smother reefs if high levels of sediment persist.
	Area of freshwater fish habitats may increase, along with water availability for aquaculture.
Change to sea currents	Catch of skipjack, and yellowfin tuna may increase; albacore tuna may decrease.
Decreased nutrient availability	Nutrient availability (e.g., zooplankton biomass) may decrease due to increased stratification and shallower mixed layer.

Sources: Bell et al. 2011; Rosegrant et al. 2015

In light of these impacts, adaptation measures are articulated in the National Development Plan and the Green Growth Framework pertaining to the fisheries sector which include upgrading existing aquaculture facilities, establishing more marine protected areas and other sustainable fisheries management practices working in close collaboration with communities. Sustainable management and informed decision-making can be further strengthened with improved data on capture and status of inshore/coastal and offshore marine resources.

Furthermore, effective on-the-ground implementation capacity and conservation of coastal ecosystems such as mangroves, seagrasses and coral reefs could be a proactive approach towards safeguarding the fisheries sector.

Health

The impact of climate change on health is apparent in terms of the prevalent climate-sensitive vector-borne diseases, which is likely to increase over time.[41] Water-borne diseases and diseases transmitted through insects such as mosquitoes are highly sensitive to climatic conditions, because changes in the conditions have the potential to lengthen the transmission season of these vector-borne diseases and also change their geographic range.[42] Additionally, climate change has the potential of exacerbating present-day health problems, including cardiovascular and respiratory diseases, infectious diseases and malnutrition. Fiji faces a significant threat from climate change in terms of its effects on social and environmental determinants of health. This includes clean air, safe drinking water, sufficient food, secure shelter, hygiene and sanitation. Moreover, Fiji is highly susceptible to climate-sensitive diseases such as dengue fever, leptospirosis and typhoid fever along with diarrhoea, which becomes widespread post floods and cyclones.

In the Pacific, La Niña conditions have been strongly associated with **Dengue** outbreaks.[43] There have been eight dengue outbreaks in Fiji over the last 50 years, and seven have occurred during La Niña (wet) conditions. The El Niño (dry conditions) event in 1998 also caused a dengue outbreak, but this was because there were sufficient breeding grounds, largely in the open water containers kept close to people's homes.[44] The flood events of January and March 2012 led to a large number of cases reported for the Western Division. Dengue outbreaks are projected to increase under both high-and low-emission scenarios (Figure 55).

41 Hallegatte et al. 2016.
42 WHO, 2015
43 Hales et al., 1999.
44 FMS, 2003.

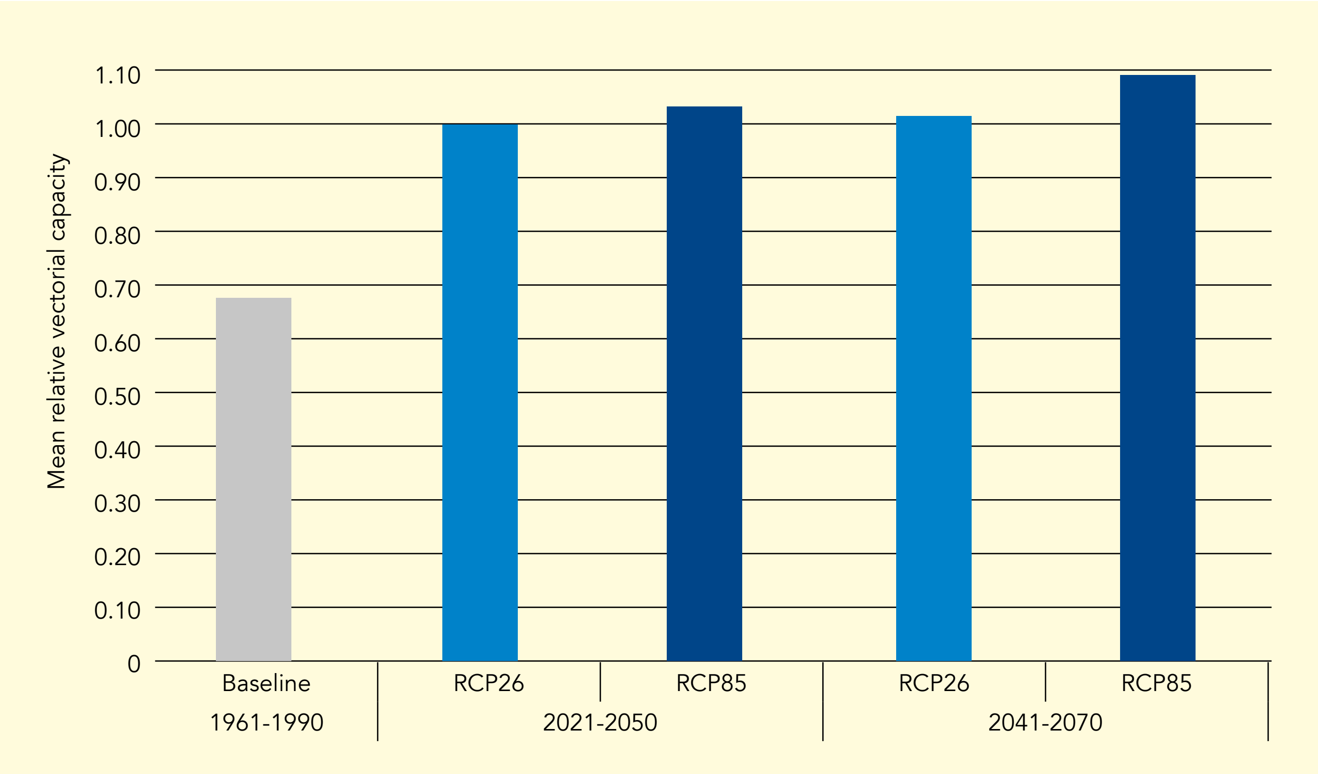


Figure 55: The mean relative vectorial capacity for dengue fever transmission is projected to increase towards 2070 under both a high and low emissions scenario.

Source: WHO, 2015

Leptospirosis is another climate-sensitive disease, that is endemic in Fiji and can lead to large outbreaks. Between 20 and 100 cases of Leptospirosis have been reported annually in the past 15 years. This disease is associated with higher temperatures and higher rainfall patterns in tropical areas. Infection is spread through exposure to infected animals or exposure to soil and water contaminated by faeces of infected animals, which is why young male farmers are highly vulnerable to the disease. Outbreaks of Leptospirosis have been noted following flooding and cyclone events. Transmission is more likely following these events because people and leptospirosis vectors come into close contact.[45] In particular, outbreaks have occurred in evacuation centres where people were in close vicinity to each other and had greater contact.

Typhoid outbreak is also common following floods, cyclones and mass food distribution events. Significant factors of transmission include poverty, poor sanitation and hygiene and the movement of healthy carriers. People living in evacuation centres are also at greater risk since sanitation and hygiene of the facilities are poor.

A study carried out in 2001 of diarrhoea in infants in Fiji showed a 3 per cent increase in diarrhoea cases for every 1°C increase in temperature.[46] Higher temperatures create optimum conditions for pathogens to thrive and pose a greater risk of contamination during drought and floods. Accordingly, as warmer climatic conditions occur, epidemics could become more frequent, occur at any time of the year, and even become endemic.

There are also predictions of serious health impacts if, climate change were to disrupt Fiji's social, economic and ecological systems.[47] Extreme heat would pose direct climate change-related threat to health, while malnutrition would be an indirect threat. Increased heat causes restlessness, increasing the risk of hypertension-related fatality. It is worth noting here that the majority of houses are not equipped with air-conditioning or ventilation units, which will make withstanding hotter conditions difficult. Moreover, acquiring this kind of equipment would be a burden for

45 PCCAPHH, 2012.
d Country-level analysis, completed in 2015, was based on health models outlined in the Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s. Geneva: World Health Organization, 2014. The mean of impact estimates for three global climate models are presented. Models assume continued socio-economic trends (SSP2 or comparable).

46 Singh et al., 2001.
47 Ibid.

most Fijians. Hotter days would also mean people refraining from physical activities, which would lead to increase in the case of obesity and associated NCDs.

Malnutrition-related illness linked to climate change is also inherent when extreme weather events disrupt supply and prices of fresh fruits and vegetables, pushing the population towards a greater intake of processed foods that are high in salt and sugar. Furthermore, with climate change causing increases in sea surface temperatures, rising sea-levels and changes to the mixing of ocean layers, nutrients and fish supply may become limited. Reductions in fish supply would mean reduced intake of protein, considering fish is an important source of protein in Fiji. Moreover, consumers will then be compelled to purchase canned fish, which is high in salt content. The damaging impacts of climate change on agriculture and fisheries create serious concerns for food security and higher incidences of NCDs as reliance on imported foods will become inevitable.

Health and Climate Change initiative

Piloting Climate Change Adaptations to Protect Human Health (PCCAPHH)

This project commenced in 2010 with Fiji being among seven countries to participate in a four-year global initiative that aims to develop and build the capacity of the health sector to respond effectively to climate-sensitive diseases. The project was a partnership between the Fiji Ministry of Health, the World Health Organization, the Fiji Red Cross Society, and United Nations Development Programme, with funding from the Global Environment Fund (GEF). A model for climate-based early warning system was created to provide timely and reliable information on potential outbreaks of climate-sensitive diseases at pilot sites, and to pilot health adaptation activities in selected vulnerable sites in Ba and Suva. The PCCAPHH project was completed in 2015.

Table 41: Project Outcomes

Outcome 1: An early warning system provides reliable information on likely incidence of climate-sensitive health risks	Outcome 2: Health sector institutions have the capacity to respond to climate-sensitive health risks based on early warning information	Outcome 3: Disease prevention measures piloted in areas of heightened health risk due to climate change
Achievements:		
i. Some Health care facilities monitor climate-sensitive health outcomes (including outbreaks) and report them regularly; ii. Fiji is validating the Early Warning System (EWS) model for diarrhoea. More data is required to complete the other three Climate Sensitive Diseases (CSDs) (dengue, typhoid, leptospirosis); iii. MOU with FMS for data sharing.	i. Climate Change and Health program will be taught in FNU (College of Medicine, Nursing and Allied Sciences) from 2019. This is after workshops and consultations especially during the project period to review environmental health courses taught at the University; ii. Revised pathology (serology and microbiology) forms to facilitate better reporting and investigation of climate-sensitive diseases such as dengue, typhoid, leptospirosis etc.; iii. Vulnerability Reduction Assessment for the study sites of Ba and Suva showed that health workers have increased their preparedness to impacts of climate change and have the capacity to manage the burden of climate-sensitive health risks (especially the CSDs); iv. MoHMS has launched its first *Climate Change and Health Strategic Action Plan (2016 – 2020),* and it is in the early implementation phase; v. Climate Change and Health is now officially part of the Health Emergency Unit – since 2016; and vi. Training for health workers - CCH is integrated with Emergency/Disaster management and training is offered to sub-divisional and divisional staff.	i. The Fiji Red Cross Society developed seasonal calendars which are used by communities as simple EWS. ii. The pilot sites have climate and health champions who need to be refreshed with follow up training and resources.

Source: Ministry of Health

With increased coordination and partnership with Fiji Meteorology Services, there will be an opportunities for useful climate change interventions relating to the health system and closer monitoring and management of climate-sensitive diseases and emerging health concerns. This includes strengthening early detection capability of climate change impact on health. Enhancing the public health response to reported climate-sensitive diseases will be important in reducing risk and spread of diseases.

There are also concerns over improving and developing new health facilities that are climate-resilient and energy-efficient.

Human Settlements

About 10 per cent of the country's population, lives in more than 200 squatter and informal settlements. Fiji's population has grown rapidly over the last eight years by an estimated 29,720 people. About 63 per cent of this rapid growth has occurred in unplanned, extralegal (in some cases, illegal), and informal settlements.[48] This makes up 20 per cent of the urban population living in the ever-growing urban and peri-urban informal settlements, which are mostly vulnerable to natural hazards. Also, about 12 per cent of the urban population and 6 per cent of the rural population dwell in low-lying coastal zones, that are lower than 10 meters or are adjacent to the coastline.

In 42 informal settlements assessed in the census carried out by the Department of Housing in 2015-2016, an average of 38 per cent of households have incomes below the urban basic needs poverty line, with the median income being FJ$7,800 (the country average is FJ$9,589). Majority of these households are headed by single females (17 per cent) and have shared or no access to potable water (13 per cent), while 28 per cent had any access to electricity. The residency duration in these settlements was found to be 11 years, but since there is no legal security of tenure, the inhabitants can be evicted as and when the landowner wishes.

The high growing rate of rural poverty is concerning and is partly linked to the impacts of natural hazards. Additionally, 8,500 residents in 37 rural settlements around the Northern, Western and Southern Division experience stress from El Niño-related drought. The socio-economic strength to cope and recover each time an event occurs diminishes, further reducing resilience to the next hazard event and adding to the high cases of rural poverty.

Considering these housing situations, there is a need to develop and support the construction of cost-effective and context-relevant disaster-resilient model homesteads for both rural and urban communities as identified in the Disaster Risk Reduction Plan. Additionally, to reduce disaster risks, efforts should be endowed to implementing robust barriers to protect coastal boundaries of urban centres and rural communities with hybrid or nature-based solutions.

Housing: Many poor people live in buildings vulnerable to natural hazards.

Fiji is described as a well-housed nation in terms of number, size and quality of its houses in comparison to the other countries with similar income per capita.[49] Notably, however, the conditions of houses are not uniform across all areas. With the increasing national housing need (around 600 units per year) and the scarcity in serviced subdivisions for any income group, issues such as overcrowding, self-building illegally on vacant state land, and entering into extralegal, and informal occupancy arrangements without proper lease agreements are becoming more common. Figure 56 shows the common housing types in Fiji, which are concrete/masonry, timber frame houses with either tin/iron cladding or the traditional house type–bure. The traditional house type is more common in the Northern and in the Eastern Division.

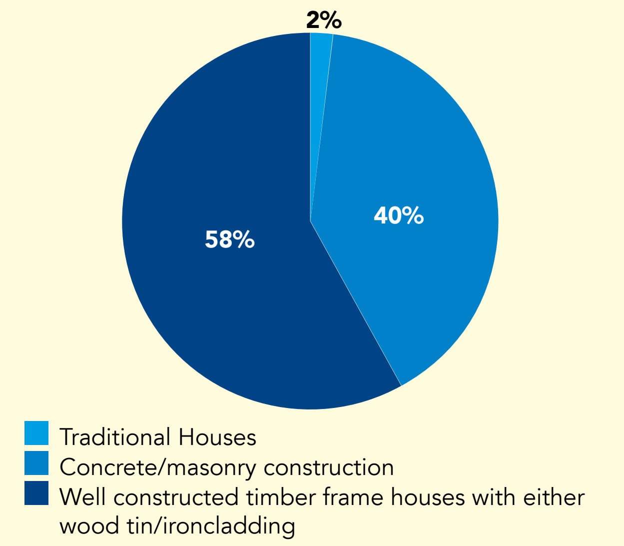


Figure 56: Construction typologies that are typical in Fiji.[50]

Informal settlements consist of the housing stock of poorer quality than the wider housing stock. This represents a higher incidence of poverty and associates with the underlying insecure land tenure of the residents. Housing stocks are also not uniform within the informal settlements. Moreover, most house types in some settlements, especially rural and informal are timber frame and tin/iron roofing. The Department of Housing has reported that in 42 settlements, there are only 10 per cent concrete houses and 90 per cent timber frame and tin/iron, with most of the houses built using recycled materials and of varying construction quality. Such settlements have reduced resilience and are highly susceptible to damage and loss of assets as a result of natural hazards.

48 Fiji Bureau of Statistics

50 Fiji Bureau of Statistics, 2007 census.

In addition to this, the majority of the households are also financially constrained to secure house insurance, giving them no choice but to rebuild using up personal savings and often under debt. TC Winston destroyed 7.5 per cent of the total housing stock and caused significant damage to an additional 6.3 per cent of the houses, with costs from damage and loss amounting to about FJ$777.4 million.

The Government's initiatives and plans to address housing backlog and future urban growth through the new development of residential lots can also ensure that environmental and climate risks are integrated. Furthermore, appropriate national building codes and infrastructure design should also be enforced, especially on key facilities and public assets. Recognising the vulnerability of people living in informal settlements, efforts should be scaled up to upgrade these settlements or help to provide affordable serviced lands and housing.

Moreover, a comprehensive study and hazard mapping of climate-change implications for human settlements are yet to be conducted for Fiji. There is a great need for such an assessment since about 90 per cent of the population live on the coast, where most industries and business centres are also located. Most of the urban centres are highly susceptible to flooding as they are located in floodplains. The vulnerabilities of rural communities along the coast is also concerning as sea-level rise, storm surges and cyclones have significantly affected these communities and will continue to do so in the future to the extent that some of these communities will need to be relocated. A village in Vanua Levu (Vunidogoloa village) was relocated in 2013, becoming Fiji's first village to be relocated[51] as a result of rising seas. Other villages are also being assessed to identify the communities in need of relocation. Since then, two more villages have been relocated, and further forty-three have been identified to be moved. In this regard, the Planned Relocation Guideline has been recently developed (2018), which, will be instrumental in informing the developmental processes of the relocation of these vulnerable villages.

51 McNamara, et.al., 2015

Infrastructure

Transport

The transport sector contributes about 12 per cent towards Fiji's GDP and has about 30 per cent capital budget allocation annually.[52]

Table 42: Key physical assets in the transport sector

Assets	Quantity
Sealed road network	1700 km
Unsealed road network	5800 km
Bridges/crossings	1342
Jetties	47

Transport Sector Vulnerability

Fiji has made it a priority over the past several years to upgrade poor road networks that had suffered from a lack of systematic maintenance and strategic planning. While much has been done to improve the principal and secondary roads, bridges and jetties, the poor condition of a large portion of the land and marine networks in the urban, rural and coastal areas, make them vulnerable to damage or failure during a major climate event. Moreover, there is no redundancy in the road network configuration and the poor state of many assets makes land transport highly susceptible to climate hazards at present and in the future. Three major natural hazard events (Nadi and Lautoka floods in 2012, TC Evan in 2012 and TC Winston in 2016) caused widespread damage to the transport sector.

TC Winston caused estimated damage of FJ$127 million to the transport sector, with more than 80 per cent attributed to land transport alone. Despite this, recurrent extreme weather is likely to cause more damage over the long-term than by a major event such as this. This sector is more predisposed to hazards such as increased rainfall intensities, sea-level rise, storm surges and riverine flooding. These events have the potential to cause, washouts of low-lying and coastal roads and bridges, landslides on roads located on unstable soils, temporary network disruptions and the further degradation of already ageing marine assets.

Increased intensity and frequency of storms and increased severity and speed of winds will also have consequences for aviation infrastructure and contribute to disruptions to airline operations, negatively impacting tourism, which is one of the key income-generating sectors for the country.

52 GoF, 2014

Increased maintenance and replacement costs can lead to increasing travel costs. The inconvenience and increased cost of travel can deter tourists from choosing Fiji as a travel destination.

In light of these impacts, there is a concern for building capacity and institutional strengthening for a transport strategy that is coherent and comprehensive to ensure that infrastructure can withstand current and future environmental and climate risks. Upgrading work is essential in order to incorporate current and future environmental and climate risks into infrastructure designing. This can be further supported by developing certification standards for climate-proofing transport infrastructure and establishing enforcement measures to ensure compliance.

Water

The Water Authority of Fiji is the national water and wastewater treatment providers.

Table 43: Key physical assets in the water sector

Assets	Quantity
Water pipelines	4000 km
Water treatment plants	44
Wastewater treatment plants	11
Pumping stations	220

Less than half of the rural population does not have access to piped water services, whereas the urban areas have widespread supply. There is limited coverage of sewerage service in both urban and rural areas, with the majority of the population depending on-site sanitation facilities. Health and environment risks arise due to lack of infrastructure and maintenance of onsite wastewater systems. This is due to limited funding for the sector to address challenges of insufficient cost recovery or, to finance operation, maintenance, or capital investments. This situation has improved markedly since 2010, when the Water Authority of Fiji (WAF) took over. The ramification of this was that budgetary resources were increased and there were better cost recovery and increased investment in maintenance.

There is high exposure of water and wastewater infrastructure to natural hazards and climate change. This is because climate-related considerations were not incorporated in the system architecture and in the location and design of individual facilities previously. Moreover, the most significant water sector vulnerabilities are:

- **Inadequate protection against runoff intrusion into pumping stations and water treatment plants.**

Majority of the facilities are located in low-lying areas that are subject to significant submersion during flooding events of a five-year return period or higher. The flooding depths are beyond what these facilities can cope with. Major concerns are the runoff of the wastewater, polluting the environment and failure of electrical equipment leading to disruptions of services.

- **Insufficient protection of key assets against soil erosion and landslides.**

  The main water and wastewater lines running through the main urban centres are highly exposed to soil erosion and landslides. The poor watershed management and intense runoff causing soil erosion has increasingly impacted the quality of water sources and compromised its treatability.

- **The lack of diverse water supply sources for the urban population.**

  The water supply source in Fiji is predominantly surface water sources (70 per cent) which supply all major urban centres. The rural water supply is primarily groundwater, which is also a common source for small towns.

The Water Authority of Fiji currently services 440,000 people who depend only on the surface water source. This makes them highly susceptible to changes in the hydrological system, and disruptions and failures in water production and transmission. Moreover, half of the water supply originates from freshwater sources in coastal and low-lying areas, which makes the population more vulnerable to saltwater intrusion as sea-level rises.

To address these issues, there is a need to upgrade, repair, relocate and build new water and sanitation infrastructure that is protected against flooding and other climatic events. Moreover, building codes, zoning and minimum standards for the construction and management are crucial factors that should be considered in designing and developing these infrastructures.

There is thus, also a considerable need to support and promote various other water sources such as rainwater harvesting and desalination. Water resource management plans could also be important strategies to address the issues of saltwater intrusion and protect freshwater aquifers. Existing plans can be enhanced based on national experiences and international best practices and additionally ensuring that climate and disaster risks are incorporated. In this regard, hazard maps and downscaled climate projections will be useful tools in constructive planning and decision-making.

Also, to increase adaptive capacity, greater community involvement in water resource management is encouraged alongside strengthening the capacity of NGOs and Government departments to inform and educate communities on sustainable and climate-resilient water management and sanitation.

Energy

Access to electricity is available to 98 per cent of the urban population and 80 per cent of the rural population. The rest of the outer islands utilise off-grid electricity mainly from the Rural Electrification Program of the Department of Energy (DoE), which uses diesel/hybrid generators for mini-grids and solar home systems (SHS) and diesel plants for private generation.

EFL's power generation mix for 2016 is presented in Figure 57.

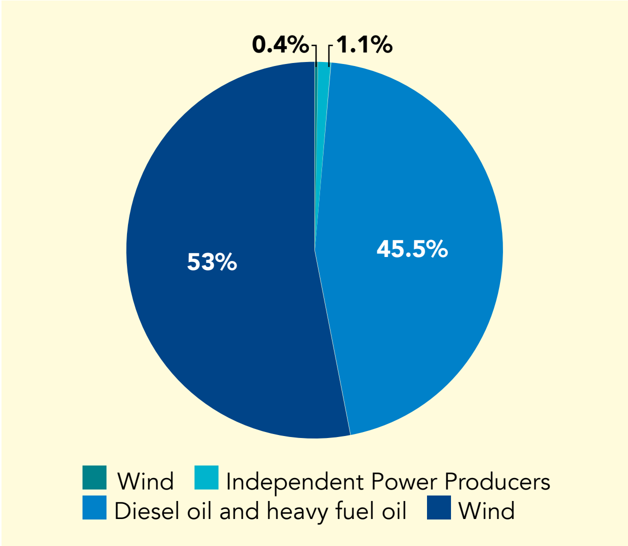


Figure 57: Electricity power generation mix for 2016

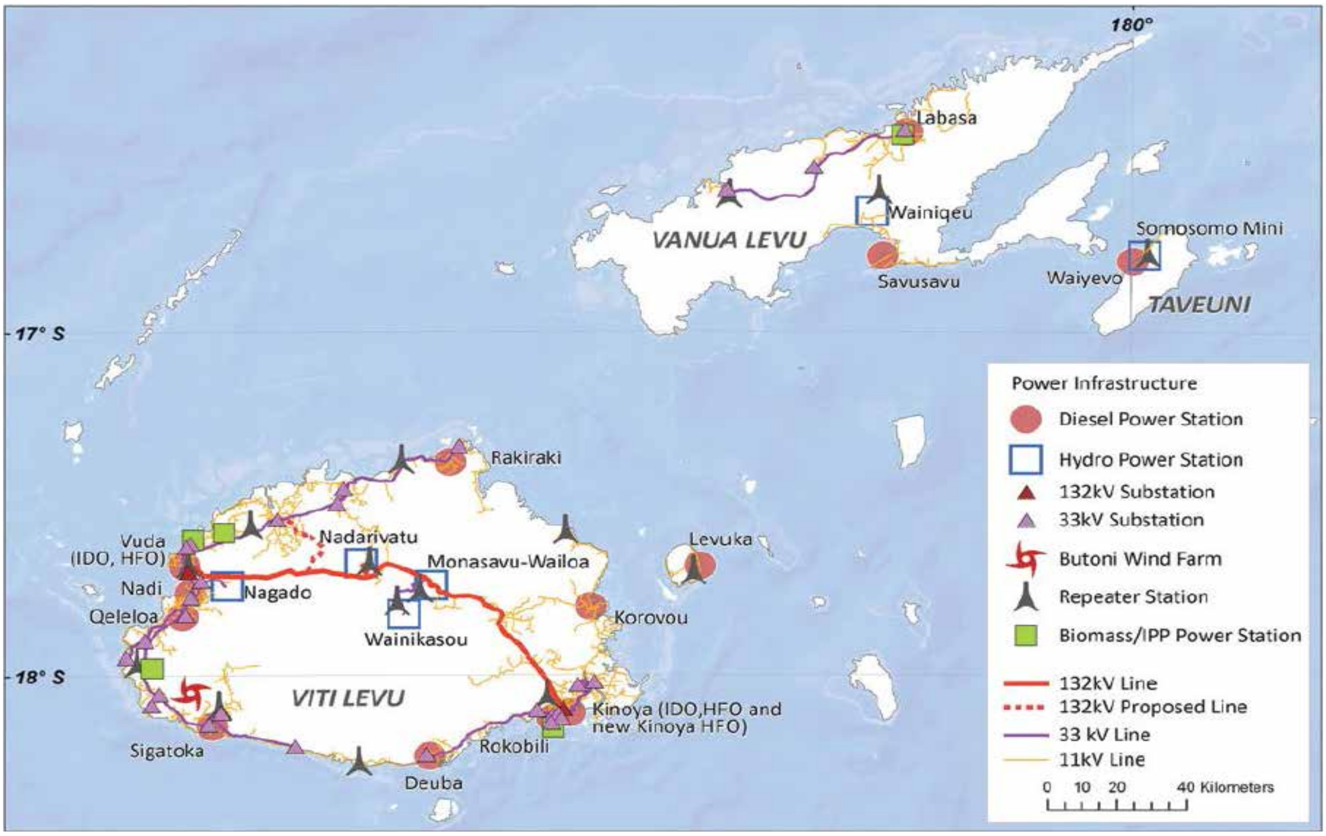


Figure 58: EFL's power infrastructure, as of December 31, 2016

Source: EFL

Table 44: Key physical assets in the energy sector

Assets	Quantity/ coverage distance
Power generation stations	20
Substations	40
High-voltage transmission lines	174 km
Sub-transmission lines	534 km
Distribution lines	9246 km
Diesel/hybrid mini-grids	400
Solar home systems	7500

According to the Climate Vulnerability Assessment, all assets are exposed to natural hazards, but there is a low vulnerability. This is because the assets are generally well maintained. The main vulnerabilities for the energy sector include:

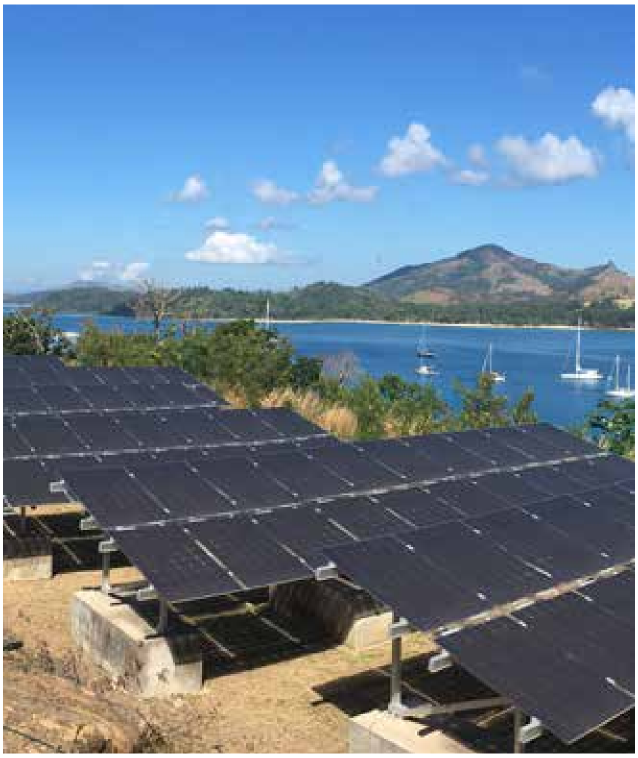
- Hydro-power stations are negatively affected by drought. This is concerning, since 55-65 per cent of energy supply generation in Fiji is through hydroelectric schemes.
- Strong winds and cyclones have a negative impact on the wind power stations.
- Flooding and storm surge negatively impact diesel power stations and substations. Frequent flood events impose a risk to a high portion of the grid and transformer assets. The analysis done by World Bank projects, that in the event of a 100-year return period flood (both pluvial and fluvial flood), 30 per cent of the country's transformers and 11 per cent of the power plants will be exposed to more than 20cm of flooding. The losses rendered from this exposure were not reported, since data was not available for the flood protection and exact location and elevation of the energy assets.
- Transmission and distribution lines located above ground are negatively affected by strong winds and cyclones, in particular falling trees, and by high temperatures (which reduce transfer capability). Transmission and distribution lines located below ground are negatively affected by flooding and coastal erosion.
- Solar home systems and mini-grids are negatively affected by strong winds unless they can be dismounted prior to the event. Diesel generators for mini-grids are impacted by flooding and storm surges. The design and construction and installation standards can be reviewed so that they are flood-proof and resilient to storm surges.

Recent extreme weather events give evidence of this vulnerability and the substantial costs that result from damage to electricity infrastructure. For instance, the estimated cost from TC Winston amounted to FJ$41.1 million, due to the damages to electricity infrastructure and lost revenues to EFL. In addition to this, the unserved energy to the economy is estimated at FJ$88.5 million.

The risks for the energy sector will undoubtedly increase with unprecedented weather events and changes in rainfall patterns and temperatures due to climate change. Concerning issues include reductions in generation efficiency; generation and transfer capability due to increased temperatures; damage to network infrastructure from more intense storms and tropical cyclones; damage to coastal assets such as transformers and substations due to increases in sea-level and storm surge. These risks have economic and service delivery implications.

To reduce these risks and build the capacity for resilience and adaptation, diversified and distributed generation options can be explored and investigated. This can be achieved through increasing investment in solar generation and feasibility studies for new biomass power plants.

Opportunities to enhance the protection of key energy assets through insurance is one of the key components of the broader Disaster Risk Financing Strategy the Government is keen on exploring. Also, a long-term resilience strategy for the energy sector based on climate-risk model will be valuable for the implementation of cost-effective measures and to direct resources effectively to priority areas.



Health and Education

The services provided by the health and education sector are crucial to society and a hindrance to their operation can have significant implications for community well-being. These services are delivered across the country to 110 inhabited islands spread over 18,300 km², with many facilities located in rural and remote maritime areas.

Table 45: Key physical assets in the health sector

Service Facilities	Number of Facilities
Specialist hospitals	3
Divisional hospitals	17
Sub divisional hospitals	88
Health centres & Nursing stations	104

Table 46: Key physical assets in the Education sector

Service Facilities	Number of Facilities
Early childhood education centres	942
Primary schools	731
Secondary schools	170

Exposure of health and education assets to natural hazards is high. This is due to lack of input design from professionals, poor quality of construction materials and insufficient maintenance of facilities in past years. These risks are further exacerbated in rural and outer islands, where it is difficult to access technical support, skilled labour and suitable cheap materials. The damage incurred from TC Winston (mainly to schools) was evident of this systematic failure of building and the lack of due diligence to strict compliance with the building code and technical support.

Tourism

The tourism industry contributes about 38 per cent of Fiji's GDP and 48 per cent of exports by attracting over 750,000 tourists every year. Because of Fiji's prime location, the country receives about 40 per cent of all regional visitors. Tourism is a source of income to 90,000 people, providing 21,000 jobs. It also offers an opportunity for development in Fiji. It is expected that by 2040, international visitors will increase to 1,200,000 per year, creating 57,000 jobs and a further US$190 million in Government revenue.

Tourists' choice of destination is greatly influenced by climatic conditions. Climate change could therefore, affect the attractiveness of the country, especially if temperatures increase. This however, does not only affect Fiji but also affects competitor tourist destinations. An assessment of the expected impact of temperature change on tourism revenues by 2030 for several countries (compared with a no-climate-change scenario), shows that an increase in the frequency of high temperatures is a significant disadvantage. The modelling done by the World Bank projects 18 per cent reduction in revenue for Fiji's tourism industry by 2030. Despite the fact that the model is fairly simple and factors influencing destination choice are quite complex, it is sufficient to say that increased temperatures will be a hindrance to the development of the tourism industry in Fiji and make Fiji less attractive as a holiday destination.

The tourism industry is also vulnerable to:

- **Increased natural hazard events, including sea-level rise**. This includes tropical cyclone and coastal flooding, which cause damage to assets of the tourism industry and affects tourist transportation. Previous disasters in Fiji have resulted in a temporary decreases in tourist numbers after major events. For example, a 2.5 per cent decrease in tourist arrivals was noted after TC Evan hit in 2012. There is still reasonable doubt about the longer-term impact due to climate change on touristic attractiveness to Fiji. Concerns of safety, convenience and suitable weather conditions are key factors influencing choices for holiday/conference destination. Climate change would favourably affect these factors, and thus, there are concerns about the implications of the longer-term impacts and how these will affect the industry.
- **Environmental quality and ecosystems**. Temperature change, sea-level rise, and ocean acidification could affect the pristine environment that attracts many tourists to Fiji. Poor management of these resources and changes in climate conditions could adversely affect environmental quality.
- **Public health risks**. Epidemics have had the strongest impact on tourism revenue in the past. It is most important that these risks are reduced and managed so that health concerns do not negatively impact Fiji as a choice of holiday destination.
- **Weakened infrastructure.** Climate-induced impacts affect air and road transport. Increases in energy prices in response to climate action may also impact travel costs and tourists' destination choices.

Biodiversity and the Natural Environment

Nature is inclined to have high resilience and be vastly adaptable to climate variability. However, the rate at which these changes are occurring is beyond their adaptive threshold, which makes them highly vulnerable. This also implies that many of the diverse natural environments and biodiversity may have already reached or passed their tipping points as a result of climate change. For example, the degradation of coral reefs is beyond repair as many of the coral species are not able to adapt to or cope with ocean warming and acidification. Furthermore, increases in the intensity of storms and cyclones concurrently cause further damage to coral reefs.

Fiji's natural environment and biodiversity from terrestrial, freshwater to coastal and marine ecosystems is mainly impacted by anthropogenic activities which include over-exploitation, habitat loss, coastal development and urban, agricultural and industrial pollution. The impacts of these activities are aggravated with climate change and such impacts could potentially change entire coastal and marine ecosystems.[49]

Vulnerability to events such as cyclones is relatively high for biodiversity and the natural environment due to the extent of loss and damage incurred and the time it takes for the environment to return to its original state to provide the same quality of ecosystem services. For example, the natural environment suffered loss and damage worth FJ$899.7 million as a result of TC Winston. The impacts of the cyclone included fallen trees and loss of foliage, uprooting and destruction of hard corals and death of fish and other marine life. Native forests, mangroves and coral reefs require at least 10-15 years to fully recover from the shock and provide the same level of ecosystem services they did prior to the cyclone, provided that structural restoration is implemented and no additional pressures from development activities occur. The socio-economic worth of these ecosystems and the biodiversity is unfathomable and degradation can have serious implications, since these natural ecosystems provide essential services that sustain livelihoods and well-being.

The management and monitoring of ecosystems can be further strengthened to protect natural resources from coastal development pressures and overexploitation coupled by climate change. To support and restore degraded habitats, there is also a drive for stronger community engagement and close and effective coordination between Government officials, NGOs and all relevant stakeholders.

It will be essentially useful for areas to be mapped out and prioritised based on ecosystem services that ensure food security, water security and its value for adaptation and disaster-risk reduction. In addition to this, the identification of climate-vulnerable species of flora and fauna can also ensure proper management and protection. This can also be achieved through making useful linkages to relevant policies and initiatives and strengthening the capacity of implementing agencies.

Combined Asset Risk Assessment from Floods and Cyclones

Modelling results by the World Bank suggest that the estimated annual losses across various sectors in Fiji as a result of floods and cyclones would amount to between FJ$500 million and FJ$560 million, which is more than 5 per cent of Fiji's GDP. Exceptionally rare and extremely destructive events can result in losses greater than FJ$1 billion. Nonetheless, recurring events such as floods, which occur almost every year, contribute to significant losses and burdens.

The analysis suggests that the majority of the asset losses (not including the agriculture sector) is for buildings and transport infrastructure (Figure 59). This is explained in terms of the total asset value and the high risk of exposure of these assets to natural disasters. Moreover, most economic activities are dependent on these sectorial assets and disruptions and asset losses cause substantial negative macroeconomic impacts.

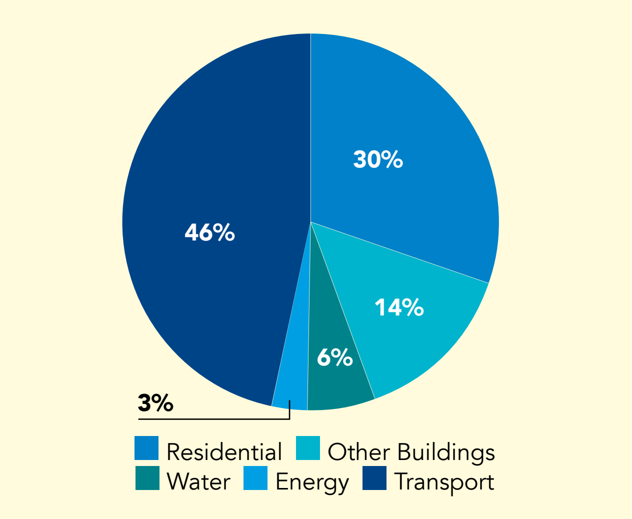


Figure 59: The distribution of asset losses due to tropical cyclones and floods for Fiji.

Source: World Bank 2015.

Note: Does not include agricultural asset losses.

This assessment is limited to cyclones and floods and does not include losses generated from the full range of hazards to which Fiji is vulnerable and thus does not fully capture the entirety of the situation. However, the study provides reasonable estimates to evaluate risk-management policies and support the inclusion of risk in the development planning process.

Vulnerability and Socio-economic Factors

Socio-economic factors amplify vulnerability to natural hazards. Rehabilitating lives after a natural disaster is determined by how people are able to cope financially. For instance, how easily and efficiently people can rebuild houses depends on whether or not they have access to savings and on the availability of aid from the community or the Government.

Furthermore, according to the survey (Country household survey (HIES) 2013-14), most of the population can cope with shocks without relying on extreme coping strategies. The survey was based on how people coped in the aftermath of TC Evan in 2012. The extreme coping strategies defined in the survey included reduction in food intake, forced sale of assets, reduced expenditures on health or education or even taking children out of school (Figure 61). Fewer than 10 per cent of the people surveyed resorted to these extreme coping strategies. The case for these coping strategies is relatively low as compared to other developing countries and this could be due to people using their savings and the financial assistance they received from the Government, friends or family members.

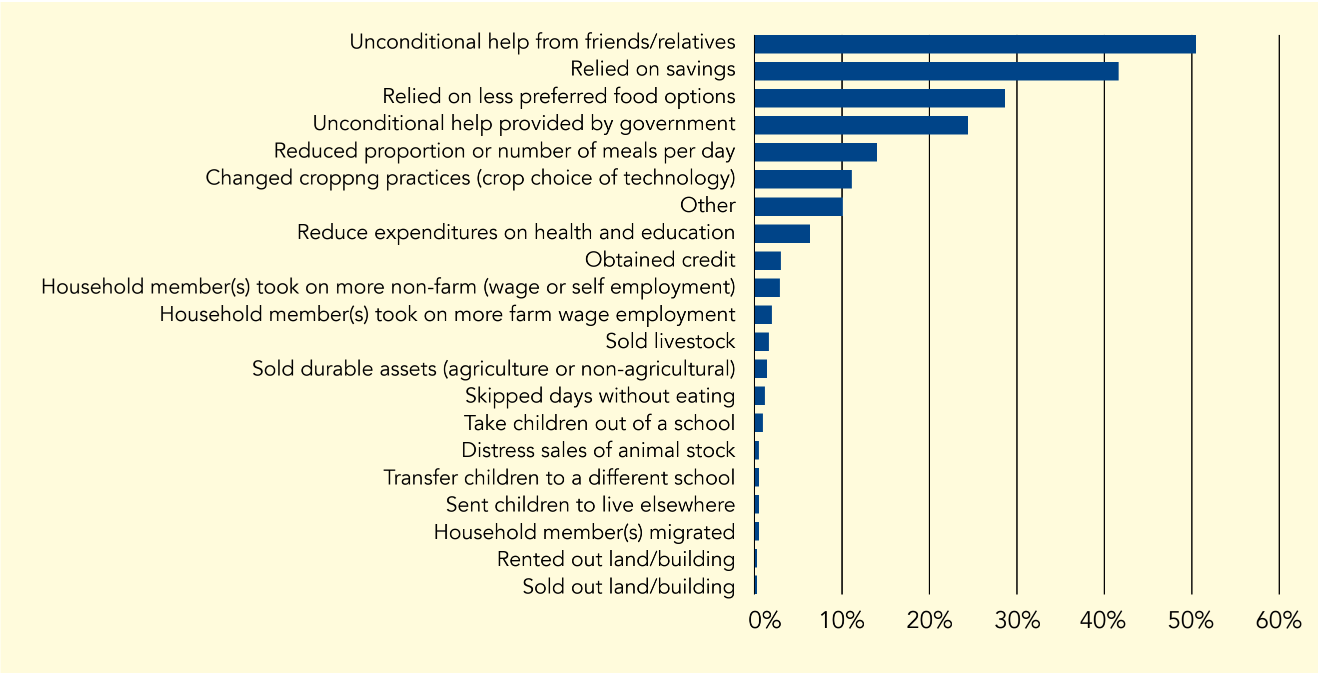


Figure 60: Multiple coping mechanisms used by households in Fiji. Few households have to engage in mechanisms with long-term detrimental impacts, such as taking children out of school.

Source: Fiji Bureau of Statistics, HIES 2013-2014

The social protection system in Fiji plays an important role in providing assistance to the vulnerable populations to meet their basic needs. The main social protection programs in Fiji are the Poverty Benefit Scheme (PBS), Care and Protection Allowance (CPA) and Social Pension Scheme (SPS), all inbuilt with a Food Voucher Program, in addition to a Free Bus Fare Program and a Food Voucher Program for pregnant women in rural areas (Figure 61).

The agency administering these programs is the Department of Social Welfare, under the Ministry of Women, Children and Poverty Alleviation (MWCPA). Recognising the importance of social assistance programs, Government increased funding from FJ$20.4 million in 2009 to FJ$33 million in 2015.

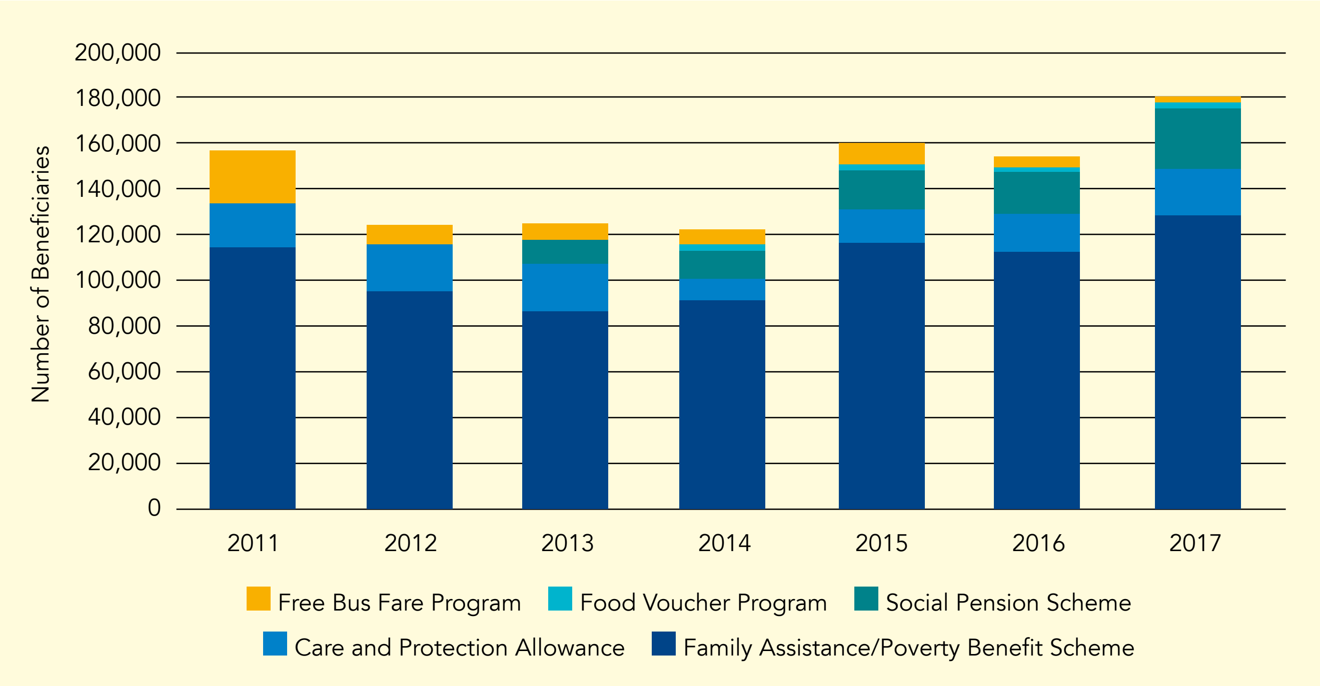


Figure 61: Increase in beneficiary numbers under the core social protection programs

Source: Government of Fiji 2016b

Note: The coverage of the Poverty Benefit Scheme has been estimated assuming an average household size of five individuals, based on the 2007 census

The social protection system played a crucial role in equipping the Government to effectively and efficiently provide support to the affected population after TC Winston. A total of FJ$19.9 million was disbursed as the Government scaled up its three main social assistance programs (Table 47). Existing beneficiaries received top–up payments to their regular benefit amounts irrespective of whether they resided in the affected areas. Following this was the development of a food voucher payment of FJ$4.6 million for two months to the social assistance recipients.

Table 47: Changes to the Social protection system after TC Winston

PROGRAM	CHANGES	BUDGET IMPLICATIONS
Poverty Benefit Scheme	Increase in household monthly benefit amount from FJ$160 to FJ$177.	Budget increased by FJ$8.2 million to cater for an additional 2,294 beneficiaries.
Social Pension Scheme	Eligibility age decreased from 66 to 65 years.	Budget increased by FJ$23.2 million to cater for an additional 8,000 beneficiaries.
Child Protection Allowance	Increase in benefit amount from a maximum of FJ$110 to FJ$119 per child per month.	Budget increased by FJ$1.6 million.
Disability Allowance	New initiative for people living with permanent disabilities; monthly allowance of FJ$90 per person.	Budget allocated FJ$7.97 million.

Source: Assessment by World Bank team based on Government of Fiji budget 2017–18

Other supporting systems through which assistances was provided were the Fiji National Provident Fund (FNPF) and the Help for Home Initiative. The FNPF allowed affected members to withdraw cash, nine days after TC Winston and within two months, had disbursed approximately FJ$250 million to its members. This however, can result in eventual reductions in the pension payouts for members if their accounts are not replenished.

Another strategy adopted by the Government was the Help for Homes Initiative, which is available to homeowners to support the construction of a cyclone-resilient starter home or to undertake preliminary roofing repairs. Further to this, advice is also being provided to households to ensure that houses are repaired and reconstructed to an appropriate, durable standard.

The additional assistance provided by the Government in response to TC Winston was effective in helping households cope and recover from the aftermath of the catastrophe. The impact evaluation of Government's efforts showed that 37 per cent of all households that received additional cash assistance had lost their entire dwelling, 74 per cent sustained damage to their roofing and 49 per cent lost their crops or harvest. Figure 62 below shows that 99 per cent of the cash assistance was spent on food and materials to repair damaged homes, clothing and school supplies.

According to the evaluation, beneficiaries under the PBS (comprising of the poorest 10 per cent of the population) were more likely to be more resilient to the aftermaths of the cyclone and recovered within three months after the cyclone hit as compared to households who did not receive the additional benefits. Moreover, social protection systems have been further strengthened since TC Winston, to meet the demands of the programs and to cater for the ageing population. These are summarised in Table 48 below.

Table 48: Support provided under Phase 1 of the Fiji Government's Help for Homes initiative for affected households, based on the losses they experienced

LEVEL OF DAMAGE	MATERIALS GRANT AMOUNT	PURPOSE
Minor damage to the roof	FJ$1,500	Sufficient to jump-start partial repairs
Major damage to the roof	FJ$3,000	Sufficient to jump-start partial repairs
House destroyed	FJ$7,000	Sufficient to construct 1 room (15m^2 floor area) able to withstand Category 3 wind speeds

Source: Government of Fiji

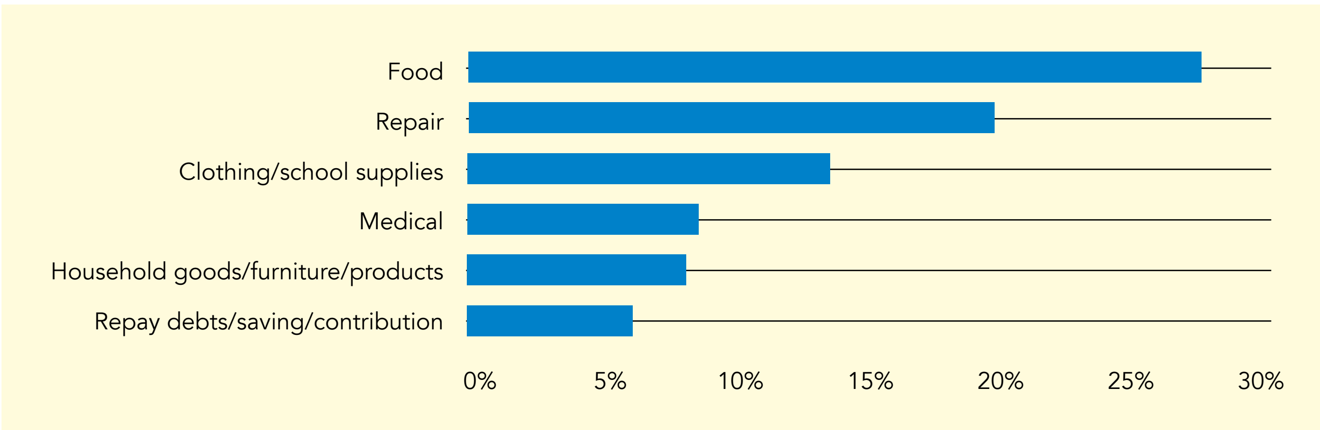


Figure 62: Percentage of top-up assistance spent on various items.

Sources: Fiji Bureau of Statistics; World Bank, TC Winston Impact Evaluation, June 2016; Ivaschenko et al. 2017.

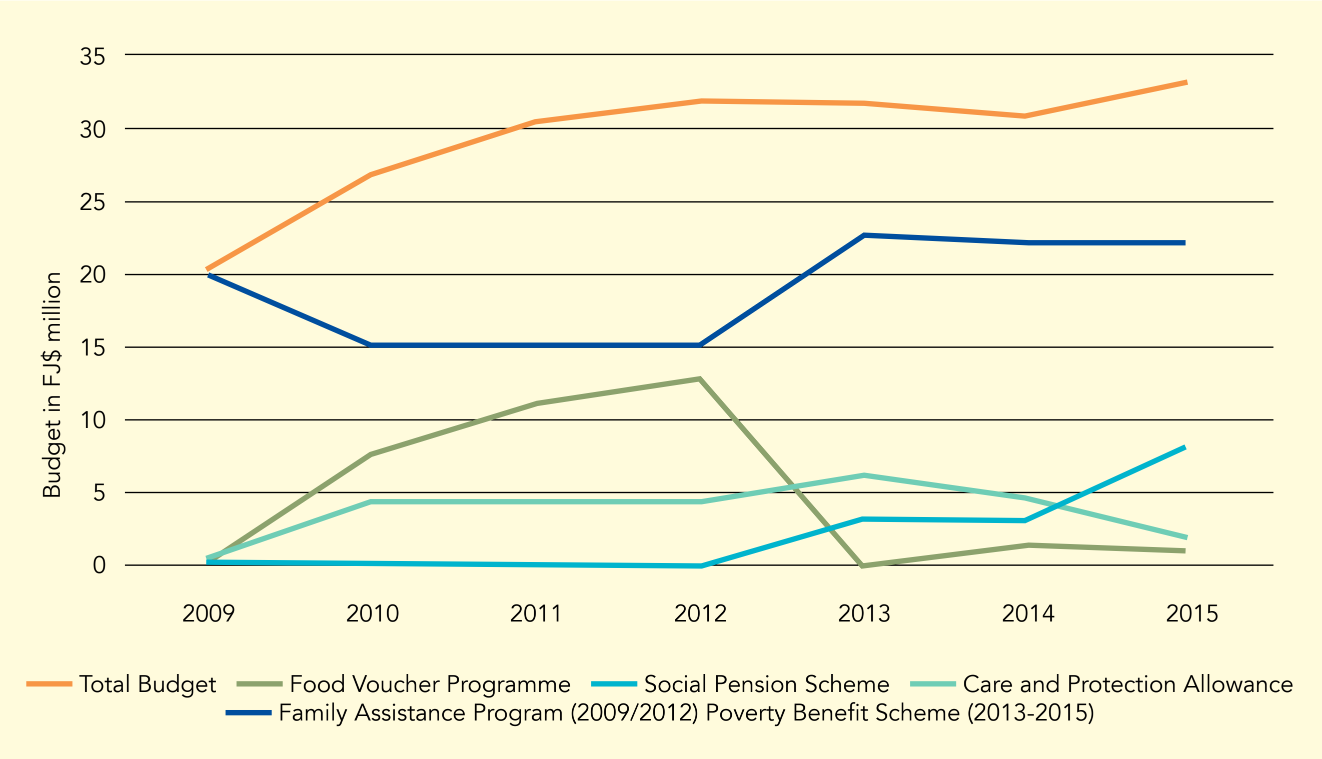


Figure 63: Government Budget for Social Protection Programs

Source: Fiji Budget Estimates (2012-15) as reported in Government of Fiji 2016b

Table 49: Changes to the Social protection system after TC Winston

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Poverty Benefit Scheme	Increase in household monthly benefit amount from FJ$160 to FJ$177	Budget increased by FJ$8.2 million to cater for an additional 2,294 beneficiaries
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Disability Allowance	New initiative for people living with permanent disabilities; monthly allowance of FJ$90 per person.	Budget allocated FJ$7.97 million

Source: World Bank team based on Government of Fiji budget 2017-18

These people have low welfare scores but are still above the program's threshold and therefore do not qualify for benefits. The system thus only retains the active beneficiaries, which means that assistance is only scaled up for these people, while the near-poor population does not receive benefits.

The system can thus be upgraded to categorise people in different bands and maintain a record of this in the system so that they are able to also provide assistance to the near-poor in the event of a natural disaster.

Table 50: Challenges and means of improving Social Security System

CHALLENGE	RESOLUTION
Geographical targeting of beneficiaries according to hazard-affected areas	Upgrading and centralising of social protection program databases
Extension of benefits to near-poor families just above the poverty threshold of the program	Upgrading of database and electronic entry of non-eligible beneficiary records
Budget for scaling up social protection programs in the event of a natural hazard	Exploration of social protection financing options and contingency loan options

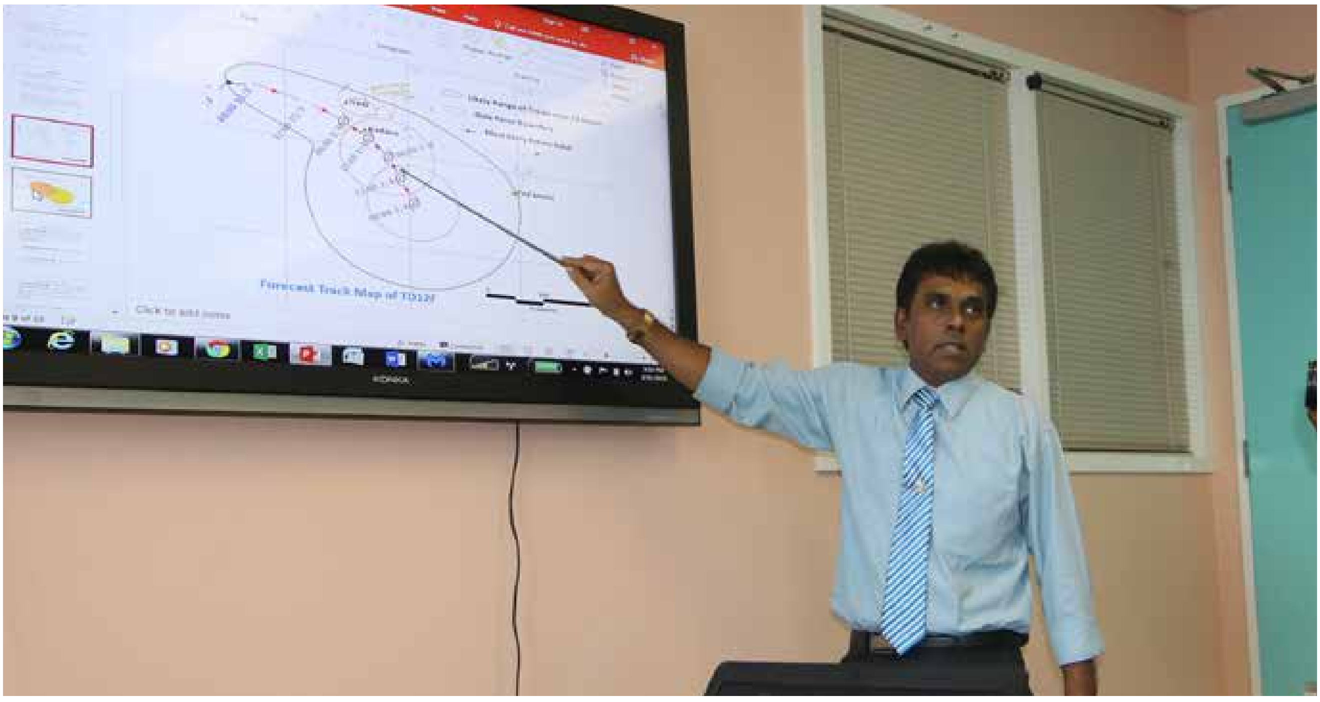
Source: World Bank team, CVA.

Fiji's Early Warning System

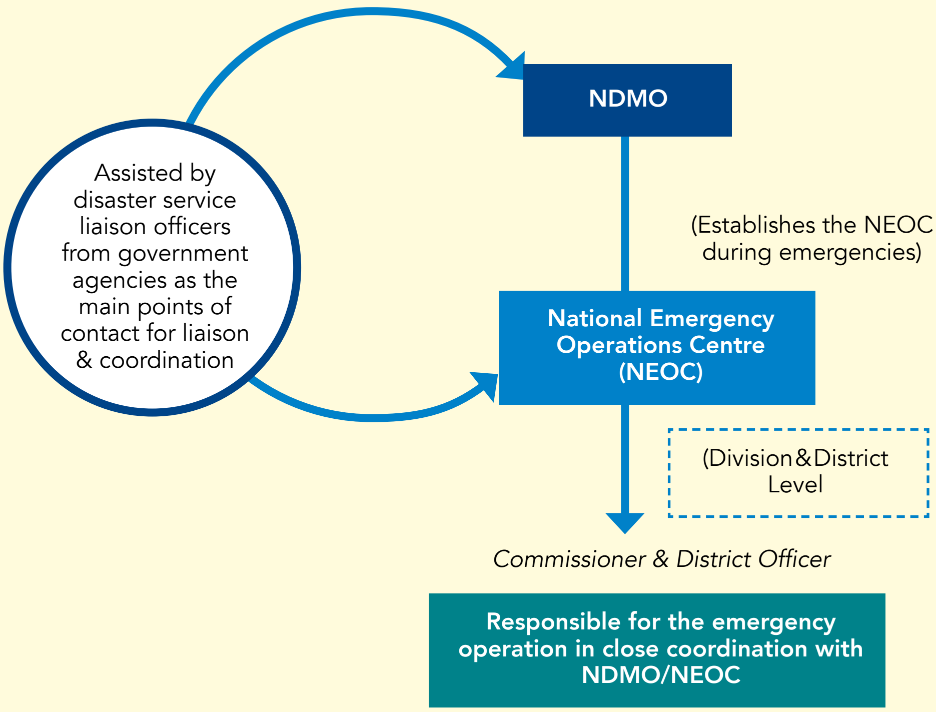
The institutional framework and operational procedures for disaster risk management are governed by the Natural Disaster Management Act (1998) and the National Disaster Management Plan (1995). Fiji also has a Cyclone Support Plan (1997) detailing the practical aspects of cyclone management, which includes the procedures for preparedness, warnings, response measures and establishes clear roles and lines of responsibility. Such an operational plan only exists for cyclones. These policies are formulated by the National Disaster Management Council (MDMC) and are managed by the National Disaster Controller. The Fiji Meteorological Service (FMS), the Hydrology Division (part of FMS), the Seismology Section (under the Mineral Resources Department) and NDMO are key agencies that are responsible for early warning and preparedness.

Table 51: Function of the Hydrology, Seismology and FMS

Hydrology Division	Responsible for flood forecasting through monitoring stream flows within Fiji's rivers.
Seismology Section	Monitoring seismic activity. Fiji has six seismic monitoring stations which are linked to the regional Oceania Regional Seismic Network (ORSNET).
FMS	Responsible for monitoring rainfall, cyclone and other weather-related activity.



These agencies monitor the activities on a 24-hour basis all year round and are required to notify NDMO if they detect an activity that is likely to pose a threat to the country and requires the issuance of an early warning. In such cases, NDMO sends out early warning messages to the public through print media, radio, websites, text messages and social media. However, there is still no integrated system of early-warning standard operating procedures in place to facilitate information flows prior to and after events.



Note:

- *Divisional Commissioners have overall authority to manage and direct disaster emergency operations within their respective divisions.*
- *Subordinate to the National Disaster Controller and the NDMC- Emergency Committee.*
- *Has the autonomy to activate divisional emergency operations if warning of approaching disaster is issued and has power to control all agency resources within the division.*

Figure 64: Institutional Framework of Fiji's Early warning system

The Government has designated about 800 emergency evacuations sites for communities across the country. These are generally school buildings, churches and community halls. These buildings however, have not all been assessed for their ability to withstand cyclones, nor have all the centres been provided with WASH (water, sanitation and hygiene) facilities, backup generators or other similar facilities to ensure adequate well-being of the occupants during and after disaster events. Furthermore, the centres have not been evaluated to ascertain their general suitability and ease of access and comfort for vulnerable members of the community, such as the disabled and the elderly.

To improve the emergency response coordination during TC Evan, the Government introduced the National Disaster clusters. These clusters are grouped in the areas of Communications; Education; Food Security and Livelihoods; Health and Nutrition; Logistics; Public Works and Utilities; Shelter; Safety and Protection; and WASH. These nine clusters also play the role of helping coordinate with National and International partners. These clusters are activated at the onset of a natural disaster.

Despite Fiji's having well-established early warning systems to alert the public about the dangers of TC Winston, Fiji's lack of experience of a category 5 tropical cyclone meant that the people did not fully comprehend the extent of its impact and were not fully prepared to withstand its full impact. This was evident as coastal communities only prepared for strong winds but were not prepared for the strong storm surges that destroyed many villagers and caused fatalities. Another issue was the language and terminology, which was noted as a major barrier in the communication of weather information and warnings to the community, including people with disabilities . This limited people's awareness of how they might be affected and the intensity of the storm.

Vulnerability by Disability and Gender

People's gender and disability are also factors that need consideration when assessing the level of vulnerability of communities. This is because of the impacts of natural disasters and climate change do not have an equal effect throughout the population.[53] The extent of the impact some people face is further aggravated by the existing vulnerabilities and inequalities they already face in society.

Gender inequality is a significant concern in Fiji, whereby behaviour and role of women are largely influenced by the island societal systems and cultural values. Women are further stereotyped based on socio-economic status, ethnicity and geographical location.[54] Also, people with disabilities are more vulnerable, since minimum care and services are provided to them in the traditional family and community context and the environment has been designed without consideration for the special needs of persons with disabilities. Physical obstacles, as well as social and attitudinal barriers, prevent citizens with disabilities from participating in community life. People with disabilities are often isolated or even shunned. Opportunities for them for appropriate health care and basic human rights for pre- and post-disaster risk preparedness are often denied and overlooked.

Moreover, during times of natural disasters, it is the elderly and the people with disabilities who are more likely to be injured or face death than people without disabilities. This is because of their limited mobility and lack of access to aid, shelter, evacuation and relief centres.[55] Additionally, people with disabilities are underrepresented in planning and decision-making for disaster preparedness.

Children are also amongst the more vulnerable groups. This is mainly because of health issues arising from events such as flooding, to which they are more prone. This would mean missed days at school and missed days at work for caregivers who are mainly women. Since some schooling facilities are used as evacuation centres, they must remain closed until people are able to return to their homes. It is thus critical that such needs and concerns are addressed adequately in disaster risk management planning.

The LGBTI (lesbian, gay, bisexual, transgender, and intersex) community is well represented in Fiji with organisations advocating their rights and non-discrimination. Despite this, there are still concerns of prejudice and intolerance against sexual minorities in the public domain. Regardless of not having evidence that sexual and gender minorities experience unequal impacts of climate change and disasters, it is in the best interest of society to consider their vulnerabilities and capacities and to reduce their risks in the event of a disaster.

As highlighted in the CVA report of Fiji, gender-differentiated vulnerabilities should be assessed based on the areas of:

- Endowments with an emphasis on health, education and social protection;
- Economic opportunities focusing on participation in economic activities and access to and control over key assets; and
- Agency, which includes freedom from violence and the ability to have a voice and influence in governance and political processes.

These three key areas are linked to providing a substantial basis to determine women's and men's socio-economic resilience to climate change and disasters.

53 Bradshaw and Fordham, 2013.
54 ADB, 2015.
55 UNISDR 2014; Hemingway and Priestley 2014.

Limited Resilience of the Overall Population

The CVA adequately estimates the impact of natural hazards on assets and the population's well-being through modelling. This was firstly done by assessing people's ability to cope with and recover from asset losses, which include their income, the diversification of income, savings and ability to borrow. This was modelled based on data from the HIES 2013-14 survey. Secondly, the Government's response measures to TC Winston were evaluated to determine its ability to provide post-disaster support to the population. This study suggested that asset losses from tropical cyclones and floods affect people unequally, having a greater effect on the poor people than the average (Figure 66).

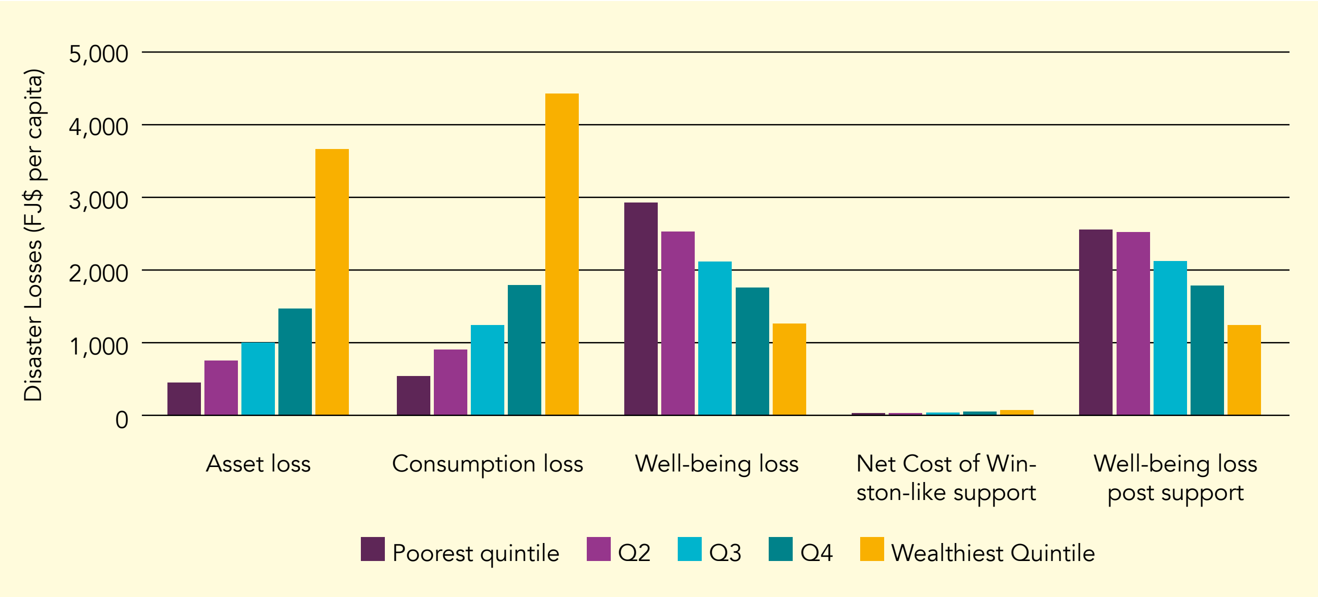


Figure 65: Impact of 100-year tropical cyclone event on Ba Province. While the wealthiest quintile loses more in assets and consumption in absolute terms, the poorest quintiles lose more well-being, even considering the support provided by the Government.

Source: World Bank team based on the socio-economic resilience models (CVA).

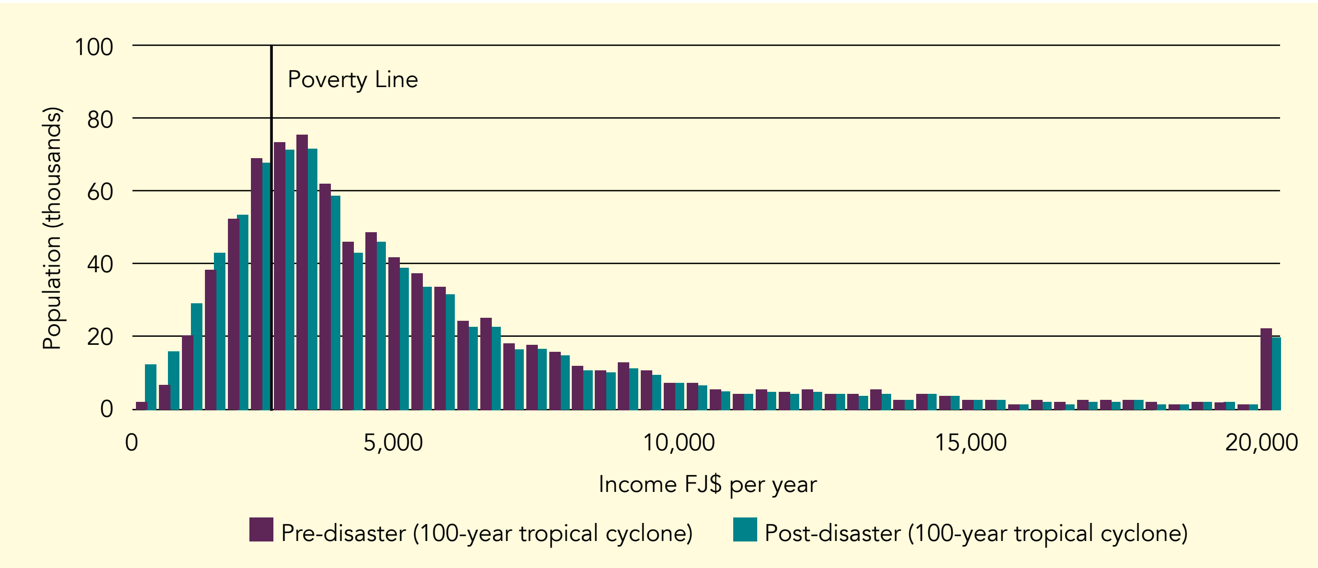


Figure 66: Effect of a 100-year tropical cyclone on the income distribution of the country. Such an event would push almost 50,000 people into poverty.

Source: World Bank team, based on the socio-economic resilience models (CVA).

Based on the assumption that people responded similarly to TC Winston, the Government support programs were effective to partly compensate for the losses incurred. For instance, for the bottom 20 per cent, the target support reduces the well-being losses due to the disaster by 17 per cent. Since finance is needed to scale-up support programs, Government resorts to taxes, with the implications that the unaffected richer households will have to incur this cost. This, however, is insignificant and does not have a profound impact on the well-being of the wealthier population.

The fact that the poor people are more likely to be affected, it follows that natural hazards can cause significant increases in poverty. The impacts of disasters on income distribution and poverty in Fiji were also modelled based on the impacts of natural disasters on the asset losses of individuals (Figure 66). This shows a large shift in the number of people below the basic need poverty line, comparing before and after a modelled TC with a 100-year return period against the basic need poverty line. This shift is likely, even with Government support programs in place.

The socio-economic resilience in Fiji is estimated at 56 per cent.[56] This means that the ability of the population to cope with and recover from disaster losses is limited. To put this into context, if the Fiji economy experiences FJ$1 loss in asset as a result of a disaster, the impact on the population's well-being is equivalent to a drop in national consumption by FJ$1.8. In this regard, disaster losses are not evenly distributed in the population and generally have a greater impact on the destitute.

Moreover, because of the economic losses they incur as a result of tropical cyclones and floods, about 25,000 people can be pushed into poverty annually. [57] This impact on poverty varies by year to year depending on the extent of the natural disaster, with bigger events having the potential to push about 100,000 people into poverty at once. This further highlights the vulnerability of the country to natural hazards and the importance of managing natural hazards to eradicate poverty.

These scenarios suggest that 32,400 Fijians could be driven into poverty by 2050 as a result of tropical cyclones and floods. This accounts for 3.8 per cent of the population and an increase of more than 25 per cent over current levels (Figure 66). In view of the current population, a 100-year flood in 2050 could force about 15 per cent of the population into poverty. These estimates however, do not represent the severity of poverty in the country and therefore, do not fully capture the impact of changes in poverty on well-being.

It is worth noting that managing disasters and climate change is essential to eradicate poverty over the short-term as well as over the long-term. Though economic development will do away with chronic poverty in Fiji, severe natural hazards will likely push people back into temporary poverty, which will require an efficient and effective social safety net system. Impact of natural disasters depends on the resilience of the population, which is the time it takes to recover from the shock and return to pre-disaster levels. This is dependent on the efficiency of social safety nets and on the economic opportunities and financial instruments available to households. It is thus critical that the Government have a robust social protection system that supports the destitute and helps people come out of poverty traps.

Table 52: Impact of tropical cyclones and fluvial and pluvial losses on poverty

Hazard	Average Number Of People Falling Into Poverty Every Year (percentage of total population)	People Falling Into Poverty For The 100-Year Event (percentage of total population)
Tropical cyclones	7,300 (0.9 percent)	48,000 (5.7 percent)
Fluvial floods	11,400 (1.4 percent)	105,000 (12.5 percent)
Pluvial floods	7,000 (0.8 percent)	66,000 (7.8 percent)
TOTAL	**25,700 (3.1 percent)**	

Source: World Bank team, based on the socioeconomic resilience models (CVA)

57 This estimate assumes that pluvial and fluvial flood losses from tropical cyclones remain limited. An extreme-case sensitivity analysis assuming that 40 per cent of tropical cyclones losses are due to pluvial and fluvial losses (and removing these losses from the flood estimates from SSBN) reduces the number of people falling in poverty every year by less than 10 per cent.

Climate Change: Longer-Term Threats

Most of the natural hazards affecting Fiji will be influenced by climate change. The short-term and long-term changes in climate and environmental conditions will impact tropical cyclones, river and pluvial floods, coastal floods and droughts. However, uncertainty about future climate conditions and how it will affect natural hazards, makes it difficult to estimate future losses arising from these events. The CVA contains an analysis of tropical cyclone damages and floods, in modelling for longer-term threats but because of the lack of data on landslides and drought, this assessment is only deemed a partial assessment. Regardless, results from this analysis presented here sufficiently foreshadow the anticipated risks associated with climate change and its impact on the key sectors of the economy.

The future losses are also dependent on factors, such as socio-economic trends, development and economic growth. Since it is difficult to account for this, the CVA estimates are based on an unchanged Fiji economy. Thus, this analysis is not a projection of future losses but a stress test to assess the threat that climate change poses for the country.

The impacts of climate change are likely to have implications for everyday life and economic activity. Economic sectors such as the agriculture sector are sensitive to variations in climatic conditions. For instance, changes in average temperature and rainfall will affect the yields of various agricultural products as well as increase exposure to various pests and diseases. Moreover, events that are considered and managed presently as extremes may become common phenomena in the future.

The uncertainty driving the impacts of existing natural hazards and those of future climate-related events is the predicament behind identifying and assessing interventions to manage risk. In the context of tropical cyclones, building resilience will be advantageous because tropical cyclones will continue to affect Fiji regardless of how climate change materialises. On the other hand, adapting to a change in rainfall is problematic since the change is uncertain. The intensity of future climate change is also one of the driving factors of long-term threats. This is the basis for the need for global efforts to reduce GHG emissions.

Adaptation interventions to address long-term trends also have the possibility of being misguided if climate change is miscalculated. Thus it is also upon policymakers to ensure that future interventions are to be articulated that will benefit the community regardless of how climate change materialises. This is referred to as "low regret" intervention, suggesting that there are little or no regrets in implementing an intervention in the future, which will still be beneficial despite climate change and its future implications.

Sea-Level Rise will Multiply Coastal Risks and Threaten some Settlements in the Absence of Major Investments

Lack of investments into coastal protection and the change in mean sea-level will lead to permanent inundation of some areas and regular flooding of other zones, making these coastal areas uninhabitable or economically unviable. Increases in regional sea-level of 87–135 cm by 2100 are expected to result in more frequent extreme water levels and coastal flooding during tropical cyclones, combined with high tides and wind waves.[58] Projections under a high-emissions scenario suggest water levels of 3.2 m above sea-level at Lautoka every other year by 2100, compared to current estimates of once every 100 years. The high flooding frequency will mean that land in one of the major coastal urban areas of the country will not be suitable for regular and intensive use. Structures will need to be erected in these areas to provide protection against coastal flood water.

Large investments will be required for coastal protection, which will be of great value for protecting high-density and high-value areas but a challenge when it comes to the protection of low-density small settlements and outer islands. This is in the context of unit protection cost, which is much higher for small settlements and can go beyond financing capacity. Building coastal protection and valuable infrastructure will be worthwhile for high-density areas such as cities.[59] According to an analysis in the CVA with the DIVA model (a global coastal protection model) and based on very simple assumptions about coastline characteristics, population densities and protection costs, at least 8 per cent of the Fiji coastline would require investment in protection by 2030 to maintain the current level of risk. The people of coastal areas for which protection will not be vested, will have to live with increased risk levels or be relocated. This issue may be most prevalent in outer islands with small populations and limited resources to manage coastal risks.

A comprehensive coastal study is required to make effective decisions taking into consideration structural and non-structural solutions, as well as nature-based and hybrid solutions. The facets of the study would have to include physical dynamics of the coastline (e.g., geology, protective mechanisms, sand drift and coral health); the potential impact of sea-level rise, increased storm surge, tsunami,

58 Haigh, 2017.
59 Hallegatte et al., 2013.

and coastal flooding; and the existing and potential exposure and coastal use. The implications of this study will entail informed decisions on where and which solution to adopt which includes whether to adopt nature-based, hard infrastructure or hybrid solutions.

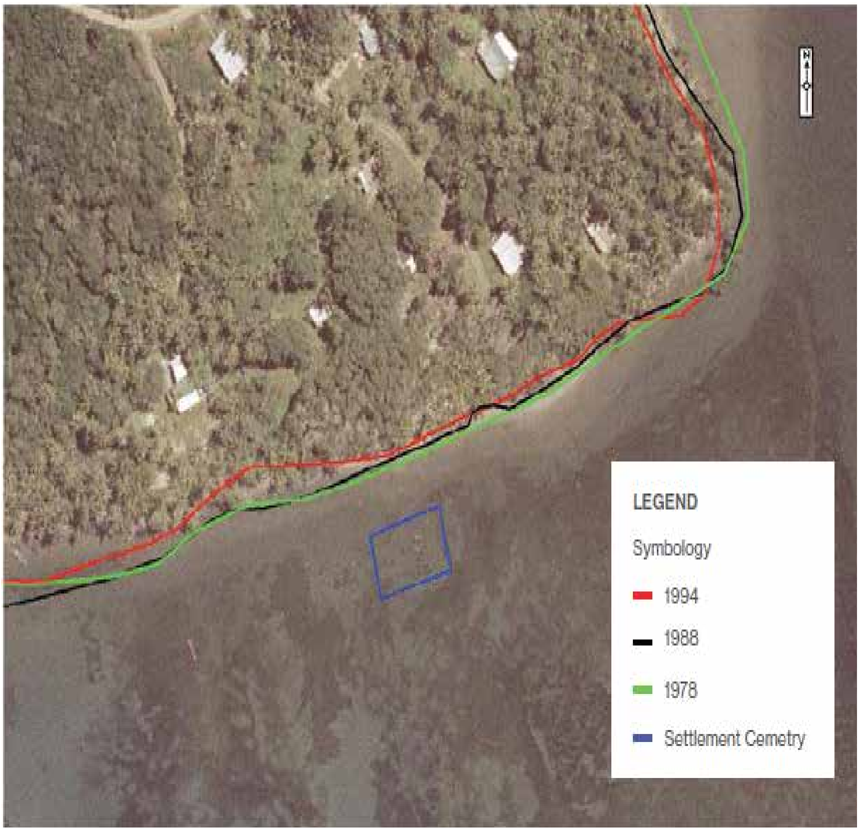


Figure 67: Aerial image showing changes in coastline over time, Toguru, Central Province.

Source: Government of Fiji.

Major Intervention Areas to Adapt to Climate Change

A variety of actions is needed to increase the adaptative capacity to counteract the threats posed by climate change, increase resource use efficiency and escalate resilience of the ecological system and the society to quickly recover from damages incurred from extreme climate variability. In the context of policy, the main thematic areas identified are Food Security and Nutrition, Human Settlement, Infrastructure and Biodiversity and Natural Environment. These are addressed in national documents such as the National Climate Change Policy (NCCP) 2018-2030, National Development Plan (NDP) 2017a and the Green Growth Framework. The National Adaptation Plan (NAP) for Fiji formulated recently will draw from these documents and prioritise key actions on the respective themes. The interventions within the NAP will oversee national development pathway towards climate-resilient development and reduce climate change vulnerability. The NAP will moreover ensure a strategic approach for adaptation inclusive Government process and structure by bringing adaptation efforts across multiple Government entities together under one document.

The Government has also embarked on a number of projects since TC Winston to enhance the resilience of the country as a whole. For example, the Government established the Construction Implementation Unit to ensure that reconstruction in the education and health sector is done according to quality standards conforming to the national building code. A country-wide bridge vulnerability assessment was also commissioned for the prioritisation of maintenance and reallocation of funds in the road sector to address the existing maintenance backlog issue. Furthermore, stronger support has been reinforced for risk-management initiatives such as the Project for Planning of the Nadi River Flood Control Structures, alongside exploring housing insurance options and strengthening the coverage of social safety nets.

The CVA for Fiji focuses on analysing the current and future hazards and long-term stresses affecting Fiji. Under the CVA, priority areas were identified where interventions could further minimise the impacts on well-being, assets and development prospects. These priority areas include building inclusive and resilient towns and cities, improving infrastructure services, developing climate-smart agriculture and fisheries, conserving ecosystems and building socio-economic resilience. There are 125 interventions across these priority areas detailed in this document (appendix 1 of the CVA) with the intention to "build on Government's efforts to reduce climate and disaster risks, better prepare for natural disasters, and respond swiftly to major shocks". The proposed interventions, however, would require a significant cost of FJ$9.3 billion over the next 10 years. The projects that are already part of the existing plans will cost the Government FJ$4.2 billion, whereas the new projects proposed under the intervention have an estimated cost of FJ$5.1 billion. The priority areas of intervention include housing/land use, hazard management, transport, water, energy, health/education, environment, agriculture, fisheries and social protection. The estimated costs in the priority areas are summarised in Table 53.

Table 53: Estimated costs of planned and proposed projects in priority areas to increase adaptive capacity and increase resilience.

Sector	Investment Needs (FJ$ million)			Recurrent Costs (FJ$ million)		
	Planned	New	Total	Planned	New	Total
Housing/ land use	63	152	215	175-440		
Hazard management	n.a	2,106	2,106			
Transport	3,098	1,591	4,689			
Energy	271	175	446			
Water	685	447	1,132			
Health/education	5	568	573			
Environment	55	22	77			
Agriculture	11	3	14			
Fisheries	6	14	20			
Social Protection				47	4	51
Grand Total	4,194	5,078	9,272			226-491

Source: World Bank Team

The implementation of these interventions is a key challenge for a developing country like Fiji. Executing these interventions will require informed decision-making, especially in terms of maintenance of public assets, the wise use of Government revenue as well as support from the international community.

Country assessments such as the CVA are useful and crucial tools for developing a resilience strategy for the country. One of the major challenges for the country, however, are mobilising resources for the implementation of projects. Additionally establishing implementable projects that are dependent on reliable data is a key challenge for the country. The CVA for Fiji is based on existing data sets and models as well as global models applicable to Fiji. The country has limitations in the availability and existence of relevant data that would be valuable for more effective modelling and useful for evidence-based decision-making. Nevertheless, such country assessments set definitive pathways for development in the context of climate risks, which inform planning and investments to mitigate and adapt to climate change. This is crucial for the country, since climate change poses an on-going risk that hinders achievement of development objectives, affects the economy and the people and is the primary cause of unbudgeted expenses when natural disasters occur.

National Adaptation Plan (NAP)

In response to International commitments and National needs, under the leadership of the Ministry of Economy, the Government of Fiji has prepared a National Adaptation Plan. The NAP will serve to implement the adaptation component of the National Climate Change Policy and the National Development Plan. However, there are already worthwhile projects pioneering adaptation by civil society, regional organisations, and multilateral entities. For this reason, the National Adaptation Plan will reinvigorate collaboration between the Climate Change and International Cooperation Division and the many stakeholders relevant to adaptation. Knowledge sharing and institutional learning are seen as fundamental ingredients of success. Greater collaboration will also enhance coordination and reduce the duplication of efforts.

Community Based Vulnerability Assessments and Adaptation Measures.

Case study 1: Korobebe, Nagado, Naboutini, Koroiyaca and Narokorokoyawa Villages (Sabeto catchment)

The Pacific Community and the US AID carried out climate change vulnerability assessments for communities in six Pacific Island countries, which included Fiji. The project 'Vegetation and land cover mapping and improving food security for building resilience to a changing climate in Pacific island communities', ran from January 2012 to February 2016. The main goal of the US$4 million regional projects was to evaluate and implement innovative techniques, and management approaches to increase climate change resilience of terrestrial food production systems for communities in selected Pacific Island countries.[60]

The methodological approaches to assess climate vulnerability and develop proposed adaptation interventions for the selected communities included:

- The participatory rural appraisal (PRA) process- quantitative and descriptive information was collected from communities on three tenets of vulnerability – exposure, sensitivity and adaptive capacity. Using this, the overall vulnerability was determined. The index scores indicated the extent of vulnerability of the community to the projected climate change effects;
- land-use surveys; and
- Household and Income expenditure surveys (HIES).

As specified in the report[61], the assessment was based on indicators for the elements of exposure, elements of sensitivity and elements of adaptive capacity. The index score sheets for the communities are provided in Appendix B.1, B.2, B.3.

The indicators for the elements of exposure included:

- Temperature: Numbers of hot days increased, Number of cold days decreased;
- Precipitation: Rainfall has become increasingly unpredictable;
- Plant and animal behaviour: Changes in flowering and fruiting of fruit trees like breadfruit and mango, Changes in animal behaviour such as egg-laying by chickens; and
- Climate-induced disasters: Landslide, Drought, Fire, Cyclone, Flood.

The elements of sensitivity include the indicators which result from hazards such as landslides, drought, floods, the outbreak of diseases and cyclones. These include:

- Agriculture and food security - loss of productive lands, loss of crop production, loss of productive lands and farm animals, production decline, damage to crops, loss of crops;
- Forest and biodiversity - loss of forest cover, loss of biodiversity, damage to trees;
- Infrastructure - trails and roads damaged, trails, roads and settlements are damaged, damage to buildings and public utility;
- Water resources and energy - loss of freshwater (buried), reduction of fresh water, loss of freshwater (contaminated), damage to infrastructure, damage to water infrastructure; and
- Human health - the emergence of water-borne diseases.

The findings suggested that the extent of vulnerability to climate change for all the communities is high or very high in the case of Naboutini village. Other findings included:

- Changes in the local climate;
- High exposure for all villages;
- Medium to high sensitivity for all villages; and
- Medium adaptive capacity for all villages.

From these findings, it can be inferred that adaptation measures are necessary to reduce the impacts of climate change. Communities can achieve improvements in their adaptive capacities as recommended in the report, by:

- Improving awareness of climate change impacts;

60 SPC,USAID, 2016
61 Ibid

- Improving income sources;
- Improving their relationships with government and non-government organisations; and
- Improving some of their infrastructure and services.

The report also highlighted the vulnerability of the four villages in terms of food security. According to the study around 50 per cent of calories in the average villager's diet came from imported sources (rice, flour and noodles) and more than 60 per cent of the protein came from imported sources (tinned fish, frozen chicken, and dhal). In this regard, it was recommended that communities produce and consume local foods, which would contribute towards improving household incomes from savings on buying imported foods. Other findings included; nutrient deficiencies within the crop systems, especially of phosphorus and potassium. It was also found that the communities depend to some extent on wild foods for food security. Also, key problem for livestock production in the villages is not having a reliable water supply.

Adaptation Interventions at the Community Level

The following adaptation interventions were proposed based on the findings of the assessments and food production systems survey:

- Establish village coordination committees;
- Facilitate tree planting on hilltops;
- Establish contour barriers on farmed hill slopes;
- Promote the planting of local staples – taro, cassava, sweet potato, yams;
- Promote the planting of vegetables, rice, and promote the use of locally produced foods;
- Develop local chickens/ducks/broilers in villages for eggs and meat;
- Develop pig production and honeybee production in the villages;
- Develop appropriate technologies to support adaptation strategies;
- Identify and record incremental benefits arising from the new technologies (using cost-benefit analysis);
- Conduct training on preparation of locally produced foods;
- Support development of new livelihood options;
- Conduct agri-business skills training;
- Make available information on appropriate technologies in a form suitable for the communities;
- Establish and implement a training programme on climate change threats and adaptation measures related to food insecurity at the community level; ensure a gender focus in all training;
- Identify sources of climate risk information at the local level; disseminate information and ensure that vulnerable households and schools have access to relevant information;
- Design a participatory method for developing community adaptation plans;
- Ensure participatory development of adaptation plans;
- Design and implement early warning systems to enable the dissemination of information on the main threats for the communities;
- Provide training for all the necessary personnel to operate and maintain the early warning system;
- Engage primary and secondary school authorities to agree on climate change input into the appropriate curriculum; and
- Develop and distribute awareness and education material to schools and communities.

Case study 2: Rapid Vulnerability and Adaptation Assessment of Communities in Seaqaqa, Vanua Levu (Seaqaqa District; Nadogo, Navudi, Navai, Savulutu, Korolevu, Sevacagi and Naseva)

The rapid vulnerability and adaptation (V&A) of these sites were part of the EU Global Climate Change Alliance (GCCA) for addressing climate change adaptation in the Pacific executed by the Pacific Centre for Environment and Sustainable Development (PaCE-SD), the University of the South Pacific. These were the six most vulnerable sites identified by the Provincial Development and District Office (DO) of Seaqaqa. The objectives of the assessment were to assess the level of vulnerability of the sites identified; assess the level of community perception on climate change, assess the coast, water supply, health and sanitation and gain traditional knowledge on techniques for preservation and security. The assessment was carried out based on the PaCE-SD rapid assessment technique.[62]

The findings from the assessment (see appendix B.4 and B.5) of the site suggest that the communities have varying levels of vulnerability to water resources and health and sanitation sectors. Moreover, it was noted that the lack of proper water supply was the main contributing factor to inadequate sanitation and personal hygiene.

Other field observations suggest that there are no proper drainage systems which could be a contributing factor to poor road conditions during heavy rainfall. This is also a major impediment of timely supply of sugarcane to Labasa Sugar Mill.

62 Limalevu, 2011

Adaptation Interventions

For these sites, the following adaptation interventions were recommended:

- Education and awareness on proper waste disposal including sanitation and hygiene;
- Prevent deforestation, animal husbandry and farming at water sources;
- Crop diversification with cash cropping should be encouraged;
- Design proper water storage and using settlement technique to reticulate clean water;
- Work in collaboration with the DO's Office, Ministry of Health and the Water Authority of Fiji and Rotary Pacific Water Foundation to enhance sustainable community-based adaptation; and
- Explore options on using renewable energy for electricity and borehole operation.

Case study 3: Vunidogoloa Village Relocation Project

Due to the constant flooding of this village during heavy rain and high tide, the site was considered for a pilot relocation project under the disaster risk reduction and climate change adaptation initiative by the Government. The relocation of the thirty families of Vunidogoloa village to Cevuvu settlement cost a total of US$978,229. The successful completion and relocation of the project ensured that families have access to a safer place that does not face threats from natural disasters. Additionally, the Ministry of Agriculture via the Rural and Outer Island (ROI) programme provided assistance for the construction of fish ponds and purchased breeding cattle for the community. Also, the Ministry of Labour and the International Labour Organisation contributed to additional livelihood initiatives such as copra drier and resources for pineapple planting.

The focus of the project was to look at what modality could be applied for Fiji as it was noted that different circumstances required different approaches. Hence some of the lessons learned which were useful for developing the relocation guidelines include:

- Procurement of political support is important;
- Identification of land – land issue to be resolved;
- Early identification of financial support to be included in the budget;
- A multidisciplinary and multi-stakeholder approach to be engaged and Government to provide support and project implementation;
- Need for proper planning; and
- Project is community-driven.

Table 54: Climate Change Adaptation Projects

Project	Objective	Outcome and activities
The USAID project	Evaluate and implement innovative techniques and management approaches to increasing the climate change resilience of terrestrial food production systems for communities in Fiji.	Introducing integrated agricultural production systems after conducting vulnerability and adaptation assessments at selected sites. Activities were supported by improved land-system data and analysis tools such as vegetation and land use mapping and the application of GIS.[2] Pilot sites reflecting different agricultural ecosystems were established in six Fijian communities with a range of farming systems, namely, Korobebe, Nagado, Naboutini, Koroiyaca and Narokorokoyawa in the Sabeto catchment area, and Narikoso Village on Kadavu.
RESCCUE Project Fiji RESCCUE stands for the Restoration of Ecosystem Services against Climate Change	Aims at supporting Adaptation to Climate Change (ACC) through the development and implementing of Integrated Coastal Management (ICM), resorting especially to economic analysis and economic and financial mechanisms.	• Developing a provincial ICM plan in the Kadavu and Ra Province and also. • Promoting and implementing alternative household waste management methods. • District and private-sector sewage management. • Improving freshwater fishing practices and defining protected areas in watercourses. • Restoring riverbanks. • Assisting with community MPAs and locally-managed marine areas plus sustainable coastal fishing practices. • Restoring and protecting mangroves. • Controlling coastal erosion. • Promoting and trialling more sustainable growing and animal-husbandry practices. • Reforestation and promoting sustainable agroforestry models.
Pacific Ecosystems-based Adaptation to Climate Change Project (PEBACC)	Ecosystem-based Adaptation (EbA) is a holistic approach to adaptation planning that seeks to harness the potential of healthy ecosystems and biodiversity to strengthen social and ecological resilience. EbA is a nature-based solution and is increasingly seen as a pragmatic and sustainable option for securing resilience in social and ecological systems impacted by climate change.	• Fiji: Ecosystem and Socio-economic Resilience Analysis and Mapping. • Taveuni: Ecosystem and Socio-economic Resilience Analysis and Mapping. • Macuata Province: Ecosystem and Socio-economic Resilience Analysis and Mapping. • Ecosystem-based Adaptation: Options Assessment and Master Plan - Taveuni. • Ecosystem-based Adaptation: Options Assessment and Master Plan - Macuata Province.
The Micro Project Program	The project addresses WASH, Rural Electrification, and Hydrological surveys.[3]	• Education access/facilities, rural transport systems (access roads, construction and/or upgrade of existing footbridges (including suspension bridges), upgrading of small bridges). • Area of water supply and sanitation. • Rural electrification and housing/kitchen upgrade facilities and infrastructure.

Project	Objective	Outcome and activities
Reforestation of the Degraded Foothills of the Sugar Belt (REFOREST) Project	The project is focused on watershed management and is designed to improve livelihoods and empower people and communities through reforestation.	• Strengthen rural sugar-income dependent communities in response to the EU's Sugar Price Reform and the adverse conditions in the Sugar Industry. • To improve the livelihoods of sugarcane dependent populations, increase income and reduce poverty.
Improvement of Key Services to Agriculture (IKSA) Project	The IKSA project is one such Accompanying Measures for Sugar Protocol 2013 (AMSP) programme and is a six-year project from 2012-2018. The project is funded by the European Union (EU) and implemented by the Pacific Community (SPC). It aims to help cushion the economic and social impact of the sugar sector restructuring by supporting a diversified market-driven agriculture sector.	• Improved production of the horticultural crop through the provision of enhanced horticulture research and extension, nursery development and market access.
Rural Access Roads and Associated Infrastructure (RARAI) Project	RARAI project is working on upgrading all sugarcane access roads in the Malolo, Drasa and Koronubu areas in Fiji's Western division. The project is also working to improve associated drainage, watershed management and other infrastructure in these areas.[6] The programme is also designed to improve the livelihoods of sugarcane dependent populations, increase income and reduce poverty.	• Around 30,000 people living in Fiji's cane farming communities in Malolo, Drasa and Koronubu are expected to benefit from the RARAI project, which will also provide employment opportunities to local residents during its construction phase. The project is also expected to improve the transportation of 89 per cent of cane produced in Drasa; 82 per cent in Koronubu and 65 per cent in Malolo.
WASH Project Fiji	In partnership with the Water Authority of Fiji (WAF), Oxfam's WaiNaBula water, hygiene and sanitation (WASH) project in Fiji aims to strengthen the capacity of the most vulnerable communities to reduce and manage WASH-related diseases.	• Oxfam is working with communities to improve their ability to access water, maintain sanitation facilities and effective hygienic practices. This one-year project (2017-2018) is supported by the Australian Government.

CHAPTER 4
MITIGATION

Mitigation Overview

Fiji has proved that it is serious about mitigating climate change. It was one of the main countries arguing at the Paris 2015 UNFCCC meeting for a lower temperature target (1.5°C) and was the first parliament in the world to formally sign off on ratifying the final Paris Agreement on 15 February 2016. With the advent of category 5 cyclone Winston, 5 days later on 20 February, it was also proven that the country would be one of the more vulnerable to the effects of unmitigated climate change and that the adaptation costs will be considerable.

Fiji has had a two-pronged formal mitigation strategy for the past decade or so. The first prong has been to reduce fossil fuel CO_2 emissions in the energy sector, and the second prong has been to increase sequestration by improving forestry practice and increasing net areas of natural forests.

Energy sector mitigation has been mostly concentrated in the electricity sector, with a move from diesel-fuelled generation to various renewable options. The national electricity generator, the Fiji Electricity Authority (FEA), now Energy Fiji Limited (EFL), has had plans to become between 90 per cent and 100 per cent renewable for over a decade. A recent target for this objective was for 90 per cent Renewable Energy (RE) by the year 2015. Unfortunately, this target was not reached due to consumption growth in the electricity sector and a lack of funding for various Independent Power Producers' (IPP) renewable energy projects, so the timeline has had to be exended into the 2020s. The Fiji iNDC 2015 suggested a target of 100 per cent renewable generation between 2020 and 2030, but again this target was conditional on requisite funding being made available from the international community for the transition. In this respect, there are two funding sources being investigated, free-market funding from commercial entities that could make a profit from their joint ventures with the EFL (the IPPs) and international funding for mitigation

of CO_2 emissions. Because between half and two-thirds of existing electricity generation in Fiji is via existing hydro schemes, the cost of generation in Fiji has been relatively low with the rates per kWh charged to consumers also being very low, particularly in comparison with the charges made in other Pacific nations. This has made securing funding for profitable free-market renewable energy schemes to the Viti Levu grid difficult. The situation is quite the opposite off-grid with high costs for small diesel sets and high fuel costs, usually making them uneconomical in comparison with renewable alternatives, in particular, solar PV.

The forestry sequestration effort, on the other hand, has proceeded via the externally funded REDD+ program, which has been working closely with the Fiji Forestry Department, mostly on rehabilitating natural forests. The big problem with the forestry sector has been the unavailability of reliable data and the fact that forests can be either be large sinks or large sources. Rising temperatures caused by climate change will likely favour the latter scenario due to increasing forest fires and strong cyclones.

In terms of Fiji's international obligation to mitigate climate change, from an ethical and fairness perspective, it is obvious that the onus is on the countries that have caused the bulk of past emissions to financially assist developing countries in reducing their emissions. From the Second National Communication (SNC) and this TNC report, while Fiji's overall emissions are minuscule in terms of the world's total emissions (around 0.006 per cent,) Fiji's per capita emissions for CO_2 in the energy sector have been hovering around 1.5 tons per annum for the past decade compared to the world average of around 6 tons per capita per annum and 10 to 20 tons per capita per annum for some of the richer countries. Developing countries all have difficult decisions to make in terms of climate change mitigation. They all want to do their fair share but realise that they also need to develop their economies in order to improve the well-being and health of their populations. Thus, if the mitigation projects can be configured to be economically advantageous, then there is a win-win situation, and both mitigation and development objectives are achieved. On the other hand, if the economics are not clear and the projects need to be entirely externally funded, or top-up funding provided, then the timelines are also not clear and the initiative for the transition is changed from the Government to the aid provider.

From a global perspective, time is rapidly running out to reduce emissions sufficiently quickly to keep below 1.5°C of global warming and the developing countries, including Fiji, require urgent signals from the developed countries both that they are capable of reducing their own emissions by the required amount and that they are serious about financially assisting the developing countries to do the same.

Mitigation-Related National/Regional Policies and Programs

Mitigation-related policies and programs have not changed much since the SNC. This situation has been due to the slow transfer of external funding for mitigation purposes. In terms of local policy, Fiji has been working on an updated National Energy Policy, but the final version is not yet finalised. Existing policies related to climate change mitigation have mostly been covered in the SNC, and thus this report will just present a brief review.

Regional Energy Policy Documents Referenced in the SNC:

The first regional energy policy, the Pacific Islands Energy Policy and Plan (PIEPP), was developed in 2002, to act as a guideline for the development of national energy policies in the Pacific region. A review by the developers' Council of Regional Organisations of the Pacific (CROP) Energy Working Group (EWG) and PICs in 2004 showed the PIEEP being split into the Pacific Islands Energy Policy (PIEP) and a Pacific Islands Energy and Strategic Action Plan (PIESAP). Endorsed in 2005 and revised in 2007, the Pacific Plan for Strengthening Regional Cooperation and Integration (PPSRCI) included strategies to promote and make available reliable, affordable and environmentally sound energy options. It also indicated that adaptation and mitigation efforts should be linked to the Pacific Climate Change Framework for Action on Climate Change - (2006-2015) as well as to efforts to facilitate international financing on climate change. As mentioned above, much of the anticipated financing has still not eventuated.

The SNC noted that PIEP was replaced in 2009 by the Framework for Action on Energy Security in the Pacific (FAESP) due to the urgent need to increase energy security and efficiency. FASEP was based on 11 guiding principles, taking into account sustainable livelihoods, climate change, and gender and cultural issues as well as the need for improved planning, capacity development and energy efficiency, allowing stakeholders and PICs to work as one. FASEP was associated with the Implementation Plan for Energy Security in the Pacific (IPESP), which linked directly to the implementation of FASEP. IPESP had indicators, set targets and milestones for specific regional strategies under each theme.

National Energy Policy Documents Referenced in the SNC

The SNC noted that the first National Energy Policy (NEP) for Fiji was developed with the help of PIESAP and approved by the Fijian Cabinet in 2006. The main aim of the policy was achieving overall growth and development of the economy by optimum use of energy resources. However, between 2005 and 2013, the country underwent slow economic growth mainly due to unsustainable fuel price increases. At that time, the pressure to reduce emissions by limiting fossil fuel imports was not so severe. An easily implemented means of reducing emissions by economic mechanisms is to increase fuel prices for the consumer. Nevertheless, there is still a potential conflict between economic growth objectives and reducing emissions, and thus, getting the balance right is still difficult.

The SNC also noted that a review of the 2006 NEP was underway, with a draft submitted in July 2013. The main goal of the draft NEP is to ensure that all Fijians have access to affordable and reliable modern energy services. The other two goals are to ensure sustainability of energy supplies, by establishing environmentally sound and sustainable systems for energy production, procurement, transportation, distribution and end-use, and the reduction of the import bill by lowering fossil fuel imports, which would be realised by encouraging efficient use of energy and the use of indigenous energy sources. These goals would also decrease emissions from energy sources and would thus be mostly consistent with climate change objectives.

However, the NEP draft also highlights the increasing demand for energy in Fiji, the lack of improvement in Fiji's energy efficiency, underutilisation of the untapped renewable energy potential and the high dependence of the transport sector on fossil fuels. All these problems are also hindering emissions reductions in the country, with the issue of the transport sector's dependence on liquid fuel being the largest in terms of Fiji's emissions profile. Around 60 per cent of the country's energy emissions are attributed just to the land transport sector. To combat the energy-related issues, targets have been set that are aligned with the SE4all initiative (see later), and specific policies have been adopted in the respective areas of grid-based power supply, rural electrification, renewable energy, transport, petroleum and substitute fuels and energy efficiency.

The draft NEP is accompanied by the Draft Strategic Action Plan, which highlights the strategies needed to implement the respective policies. Overall there are four main strategy areas in the draft action plan:

- Strategy 1: Promotion of private investment in electricity generation
- Strategy 2: Strengthening transparency and effectiveness of regulation
- Strategy 3: Encouraging investment in small-scale renewable energy generation
- Strategy 4: Improving the efficiency and effectiveness of management of the electricity grid

Strategy 1 was mentioned in the background section and is currently hampered by the low cost of existing EFL generation (grid electricity only). Strategy 4 also applies to the EFL, but the management of the EFL is thought to be reasonably effective compared to other Pacific countries, as demonstrated by the low prices it can offer to consumers without substantial Government subsidies and the relatively low grid losses sustained in Fiji. Strategy 3 is mostly concerned with the off-grid generation, which, while contributing to the NEP goal of increased access to modern energy supplies, is not likely to decrease national energy emissions substantially. Strategy 2 is mostly concerned with promoting strategy 1 so that IPPs are treated fairly.

The Second National Energy Plan has not yet been finalised, but it is clear that the problem of reconciling increased economic output, necessitating increased energy use and low energy prices, with environmental sustainability, necessitating reduced CO_2 emissions, is a difficult one. In addition, it is clear that achieving the emissions reductions is highly likely to require non-private sector investment in renewable energy alternatives. While promotion of private sector investment can be a Government strategy, promoting aid transfers is more difficult becasue the prerogative lies mainly in the hands of the prospective donor organisations and countries.

National Cimate Change Policies

In terms of policies directly influencing environmental matters, Fiji has an Environmental Management Act and a National Climate Change Policy (NCCP). The most pertinent to the TNC is the latter.

The National Climate Change Policy was endorsed by the Fiji Cabinet in 2007, based on the earlier Climate Change Policy Framework. It was aligned to the Roadmap for Democracy and Sustainable Socio-economic Development, 2009–2014, which highlighted the need for priority protection for the environment, sustainable management and utilisation of natural resources. A review of the framework undertaken in 2011, reflected the current and evolving issues on climate change at the local, national and international levels. This review led to the development of the National Climate Change Policy, in accordance with the 2011 Corporate Plan of the Department of Environment under its Climate Change Programme. This policy was endorsed by cabinet on 19 January 2012.

The policy had a clear vision "*A responsible and exemplary Fiji, leading the Pacific in combating climate change and achieving resilience while attaining sustainable development.*"

To realise this vision, the policy had eight objectives with specific implementation strategies for each objective. One of the objectives was to: *"Reduce Fiji's greenhouse gas emissions and implement initiatives to increase the sequestration and storage of greenhouse gases."* Thereby affirming official recognition of mitigation options for Fiji.

Fiji's Low Emission Development Strategy (LEDS)

As articulated in Article 4, Paragraph 19 of the Paris Agreement, "All Parties should strive to formulate and communicate long-term low greenhouse gas (GHG) emission development strategies…." and building from the Copenhagen Accord (2009) – Paragraph 2 - "A low emission development strategy is indispensable for sustainable development". In light of the current and projected impacts of climate change and recognising that greenhouse gas emissions need to peak and rapidly decline to achieve a net target of zero emissions after 2050, Fiji embarked on the process of formulating a Low Emission Development Strategy. The objective of the Fiji LEDS is to outline long-term vision for low emission development to 2050. The LEDS is a national-level, economy-wide development strategy, being developed by the country with technical support provided by the Global Green Growth Institute (GGGI). The Fiji LEDS complements and is well aligned with the work that the Fijian Government is already carrying out for mitigation under the Paris Agreement, which includes the development of the NDC Roadmap and supporting the implementation of renewable energy projects. The LEDS document will be a powerful tool that will support and enhance NDCs, sustainable development goals and policies, plan for a greener and more resilient development and for complementing the objectives of the Green Growth Framework and the National Development Plan. The LEDS will be the overarching document which will be instrumental in policy and decision-making and guiding development priorities for de-carbonising the economy.

Potential Climate Change Mitigation Sectors in Fiji

The next step is the identification of potential mitigation sectors for Fiji, which can be ascertained from the sectoral breakdown of GHG emissions. As identified in the inventory section of this report, the main sources of emissions in Fiji are the energy sector, forestry, agriculture and waste. There are virtually no industrial emissions, since the cement factory producing clinker shut down at the turn of the millennium. The sectoral breakdown of Fiji's total emissions is as given below (Figure 68).

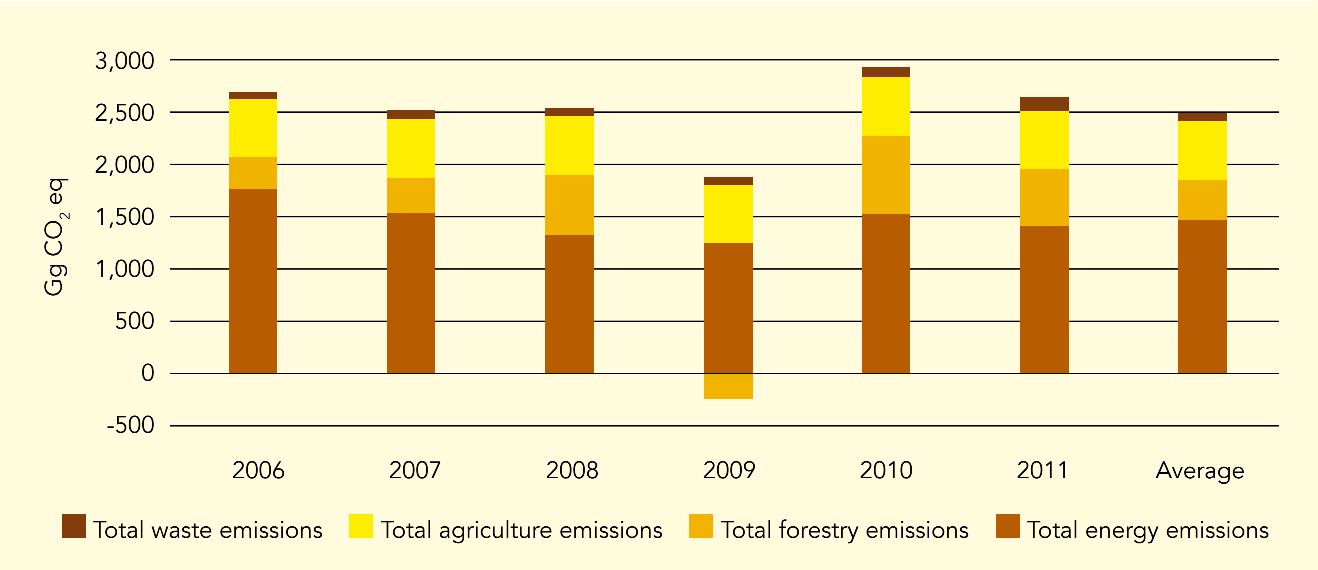


Figure 68: Fiji Sectoral Emissions Distribution

Energy Sector

The energy sector mitigation has been mostly concentrated in the electricity sector, with a move from diesel-fuelled generation being replaced by various renewable options. Unfortunately, consumption growth in the electricity sector and a lack of funding for various IPP renewable energy projects has meant that this target has not been reached, and the timeline has had to be postponed until the 2020s. Fiji's iNDC 2015 suggested a target for 100 per cent renewable generation between 2020 and 2030 however, this target was made conditional on requisite funding being made available from the international community for assistance with the transition.

The GHGI analysis in the TNC for the period 2006 until 2011 in Figure 70 shows the sectoral breakdown for the energy sector. The breakdown does not vary significantly from the iNDC, with the bulk of emissions (65 per cent) allocated to transport (air, sea and land) and, electricity (16 per cent) and the remainder (19 per cent) to commercial, domestic and industrial use of liquid fuels (including LPG).

In terms of mitigation options, the electricity sector is the most salient target, since the readily available opportunity exists in the form of substituting renewable energy options for fossil fuel-powered generation. Substitution of intermittent options such as wind and solar is aided by the relatively large proportion of existing hydro generation, which has inherent storage. There are options in the transport sector, but these are more difficult to implement, especially in an economy that is intent on growing. Economy-wide energy efficiency measures have also been identified in all earlier reports as low-hanging fruit that are usually cost-effective to implement. In terms of mitigation of fossil fuel emissions by offsetting emissions in the forestry sector, both the SNC and the TNC identified the REDD+ program as the most viable option.

Fiji's Initial National Communication (INC) indicated that the energy and transport sectors contributed 100 per cent of total CO_2 emissions. The Second National Communication (SNC) showed a somewhat different distribution in the GHGI section (Figure 69), but in the mitigation section (page 95 of SNC), it inclined more towards the INC analysis and gave quite different numbers than the GHGI section, with transport (land sea and air) being around 70 per cent of the total emissions and the electricity sector 30 per cent. The uncertainty in the sectoral emissions is thought to be high, since much of the data in the INC, the SNC and also the TNC had to be estimated from sectoral use models rather by relying on real consumption data (see GHGI chapter).

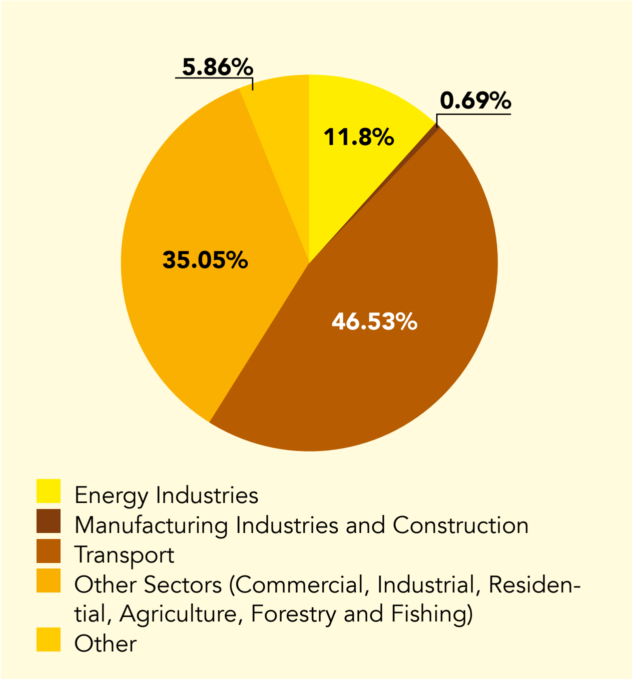


Figure 69: SNC GHGI sectoral distribution

Electrical Power: For mitigation, Fiji has many opportunities that have been identified elsewhere for transferring most, if not all, of its electricity generation to renewable options. In this regard, the relatively high installed capacity of hydro of around 120MW presents itself as a large-scale storage facility for intermittent renewable inputs to be fed to the main grid. The wind has been trialled at Butoni with mixed results. Large scale biomass is also an important option that is part of the mix from the FSC and timber producers. In addition, small scale biomass is a distinct possibility, but offer a lower scale of the opportunity.

Geothermal was identified as early as the 1960s, but due to the relatively small nominal capacity of individual sites, this technology has not progressed to large scale implementation which in any case may be incompatible with the urgent timescale presented by climate change. In addition, other sources such as wave and other ocean energy have also been investigated over the past decades but are not close to implementation at a commercial scale.

The SE4all report gave the current generation to 2012 and estimated to 2015, mix as below.

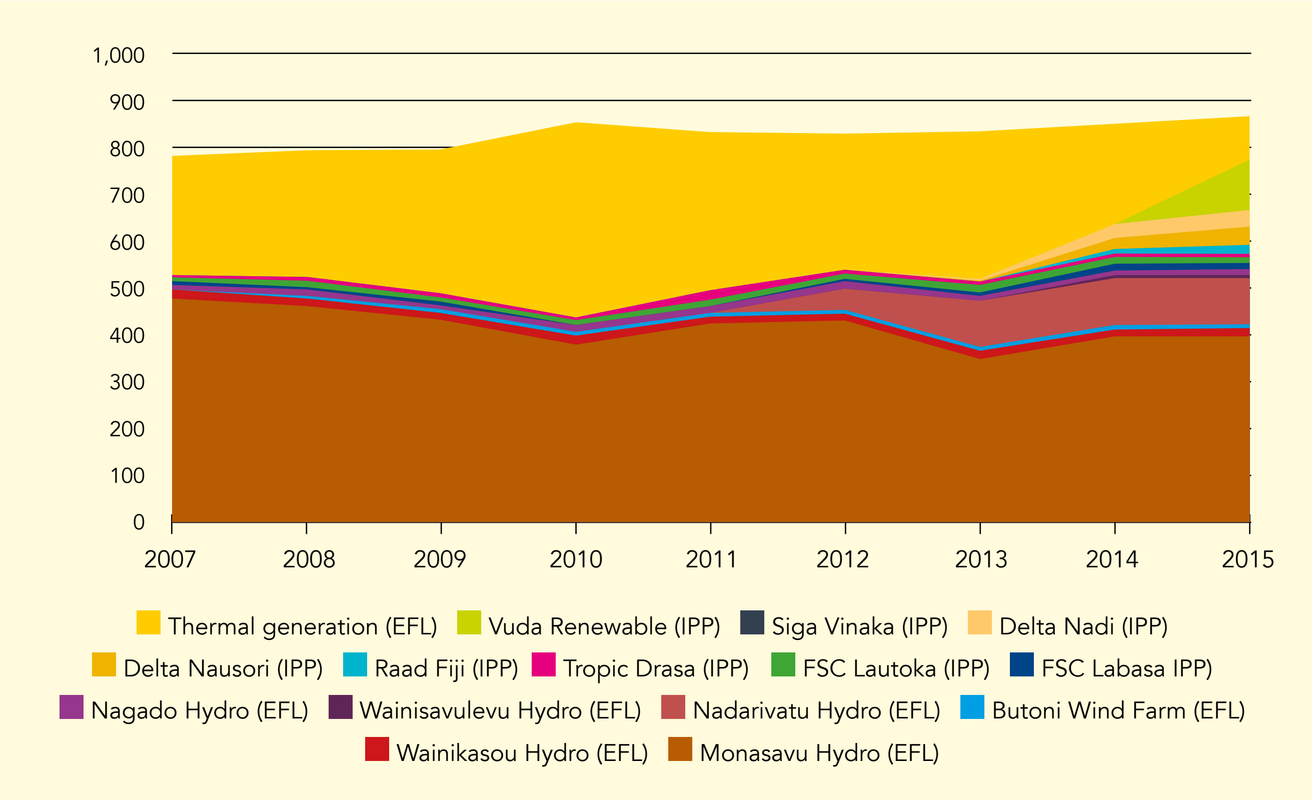


Figure 70: SE4all report generation to 2015

The actual mix obtained from EFL annual reports to 2014 (and separate data for 2015) shows a much smaller contribution from biomass (Tropik Woods Drasa, Siga Vinaka, FSC and Vuda Renewable) and an increasing contribution from diesel due to low rainfall in 2014 and 2015.

Thus, the electricity mix situation by the end of 2015 has turned out to be quite different from that imagined by the SE4All report, making the transition to renewables all the more difficult and urgent.

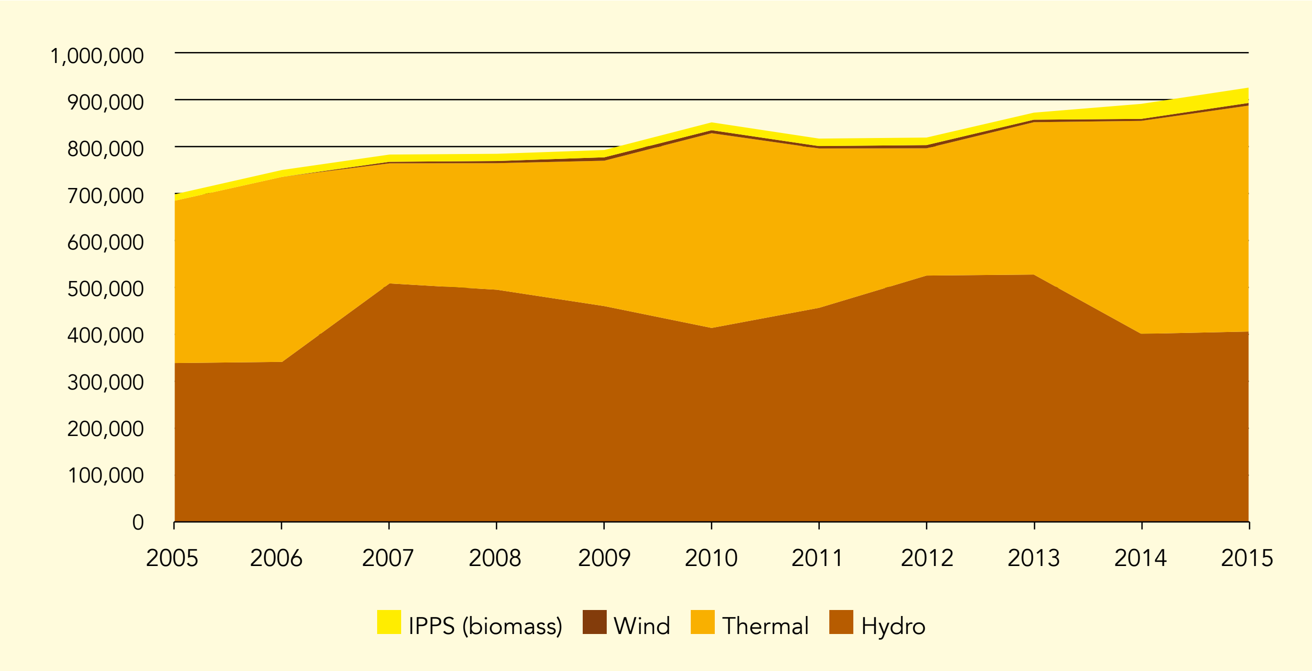


Figure 71: Actual energy mix for electricity generation (EFL reports)

Transport: The addiction of modern society to individual transport options is also common to Fiji, and the country has been increasing its number of motor vehicles at around 5 per cent per annum from at least the 1970s. The rate of increase slowed towards the turn of the century and was relatively flat between 2002 and 2011, but the growth has resumed at around 6 per cent p.a. from 2012. In addition, the average engine size distribution has been moving in the wrong direction for energy and emissions savings. One good point is that post-2015, lower import taxes on hybrid vehicles and smaller engine sizes has led to an increase in these vehicle numbers in the past few years, and there has been some move to using LPG (see the GHGI analysis for land transport). On the downside, the reduced duty has meant even more imported cars are being brought into the country. Importantly, it is also likely that the infrastructure requirements (roads, bridges etc.) that have been needed to accommodate such an increase in vehicle numbers will be a burden on national financial resources and is also taking away aid dollars from mitigation options (expenditure on road infrastructure was the single highest item in the 2016 Government budget and has continued to be high in 2018). Importantly, this large expenditure is now locking in development to this particular transport mode. This path makes mitigation in this sector difficult and more-or-less constrained to fuel switching (either biofuels or electric vehicles) rather than mode changing, for instance, to improve public transport systems or motor-less transport options (walking and cycling).

The SE4All report mentioned several initiatives in the 2009 budget. This includes:

- Motor Vehicles: To assist low- and middle-income earners in purchasing new fuel-efficient motor vehicles, the fiscal duty on new motor cars and other passenger vehicles with the capacity not exceeding 1500cc was reduced from 32 per cent to 15 per cent. The vehicle age limit for used or reconditioned motor vehicles imports was reduced from 8 to 5 years. These measures will also assist in reducing fossil fuel imports and minimise pollution.
- New Buses: Duty concessions are currently available for all buses with Euro4 and Euro3 engines and for LPG taxis. To improve quality and safety of public service transport, the fiscal duty on new buses for the transport of 23 persons or more was reduced from 32 per cent to 5 per cent, and import excise was reduced from 15 per cent to 5 per cent. All bus proprietors were encouraged to take advantage of this reduction as soon as possible in order to reduce fuel consumption in public transport.
- New Trucks: To facilitate availability of affordable transport for commerce, the fiscal duty on new trucks of gross vehicle weight not exceeding 3 tons was reduced from 32 per cent to 15 per cent.

Energy Efficiency: has also been identified as a relatively low-cost and easily implemented option, but one that has not been seriously implemented in the country for various reasons including financial constraints. Energy efficiency will become more important as higher-cost renewable resources are employed, but as efficiency improvements are always limited by the laws of physics, they are unlikely to yield the reductions needed for the complete decarbonisation that would be necessary to mitigate climate change by the mid-century.

Forestry

Mitigation in the forestry sector in Fiji has been assisted by GIZ aid programs since 1985. From 2009 over 20 million Euros have been spent by GIZ in the Pacific as part of the REDD+ program with the latest 2011 program "Coping with Climate Change in the Pacific Island Region" focused on reducing emissions in this sector. The main aim of the program has been to reverse degradation in the natural forest sector and to encourage afforestation and reforestation, but work has also been done on plantation forests. The 2015 GIZ report by Haas notes that: "Although there is a general consensus that the current rates of deforestation and degradation are modest compared to some neighbouring Pacific nations, Fiji has experienced significant forest loss and forest degradation in the past". The latter is expected to contribute the most important share to the GHG emissions from the forest sector, but the dimension is still poorly understood. Commercial selective logging represents the most important driver of natural forest degradation, particularly because logging practice is generally unregulated and unsustainable, resulting in declining timber resources and ecosystem services. Although Fiji´s harvesting regulatory framework, the 2013 Forest Harvesting Code of Practice, has been amended to include Reduced Impact Logging (RIL) standards, these are not being effectively implemented on the ground due to insufficient technical capacities of the logging companies and lacking enforcement by the responsible Government agencies.

Ministry of Forestry is the Fiji National REDD+ focal point, and the Emissions Reduction Program (ERDP) is part of the Government supported national REDD+ programme. The multi-sectoral National REDD+ Steering Committee (RSC) has endorsed the development of the ERDP and will continue to be the official body to guide its further development and implementation. The RSC is the official approving body for REDD+ activities in the country and includes key sector agencies.

Other Mitigation Options

Other interventions have been identified in various sectors, including agriculture and waste. Agriculture is particularly difficult to mitigate because the main source of emissions, which are ruminants and fertiliser use, are tied directly to economic output. It is worth noting that there are opportunities to move from using inorganic fertilisers to organic farming whilst still increasing output. In the waste sector, opportunities have been investigated for turning waste emissions into usable energy. Based on a recent UNDP assessment of waste resources, it appears that some (MSW, biomass and livestock) of the waste streams identified in Fiji have a reasonable potential for power generation. Some of these potential projects could play a valuable role in stand-alone electricity applications and be particularly effective for electrification in remote rural areas. On the other hand, waste residues and resources, resulting mainly from medium and large sources and enterprises, provide opportunities for large-scale centralised power generation. The major constraints identified for implementation of waste-to-energy projects during the study were low awareness and lack of appropriate information on waste to energy, inadequate technical capacities to develop real projects, low availability of financial services, insufficient institutional capacity and some unspecific and unfavourable policy frameworks. It was also observed that the capacities and requirements to deal with risks associated with waste-to-energy initiatives among key stakeholders remains generally low, both in public and in the private sector.

Existing and Planned Mitigation Interventions

Mitigation interventions for emissions reductions can be of two types: economic interventions that influence the economic viability of emitting devices and technologies, and physical interventions that replace emitting devices and technologies with others of low or no emissions and while (hopefully) equal or comparable utility.

Economic Interventions

These are broad-brush policies that are intended to influence physical emissions by controlling the costs involved. Such interventions might include increasing the costs of the things we don't like and want to remove (in this case CO_2 emissions) and decreasing the costs of things we like and want as replacements, such as energy-efficient appliances, renewable energy devices, electric vehicles etc.

Reduced charges for the things we want: As noted in the SNC, Fiji has already put in place changes in import policies, and concessional funding is available to businesses involved in renewable-energy activities. Renewable-energy-related products are also exempted from import duty. A 10-year tax holiday is available to anyone undertaking a new activity in processing agricultural commodities into biofuels, and the diesel used for blending with biodiesel attracts a duty of only FJ$0.05/L compared to the normal duty of FJ$0.18/L. In addition, there is a low tax on the importation of hybrid electric vehicles (this tax, however, has been modified in the 2016 budget). The problem of the latter approach in terms of hybrid vehicles is that it could lead to an increased total consumption of liquid fuels and hence emissions as the number of imported vehicles becomes too extensive (reflected in the 2016 budget change).

Increased charges for the things we don't want: Policies aimed at controlling emissions by increasing duty and charges for imported fuels and the duty on imported vehicles have not been implemented to the same extent in recent times for fear that they might work against economic growth objectives, which are running parallel to the emission-reduction objectives. In particular, the reduction in VAT on transport fuels is likely to encourage increased consumption.

Physical Interventions

There have been a number of reports produced in the last few years looking at physical mitigation interventions but only one, the SE4all report, has given substantive detail as to how the transition to renewable energy might unfold. The current national mitigation policy target is to get the most mitigation from transferring all (at least as much as possible) of the electricity sector to renewables by a nominal date of around 2030. This target has been proposed by several stakeholders, including the EFL, the Fiji Department of Energy and the Climate Change Division as part of the iNDC (2015) submission.

Power Sector Mitigation

The SE4all report notes that the EFL's power development plan aimed to generate 90 per cent of all its electricity from renewable resources by 2015, but this goal was not achieved. To achieve this target, EFL estimated that the 90 per cent RE goal would require an investment of FJ$800 million (US$400), of which EFL intended to finance FJ$450 million. The rest would be provided by private sector IPP investment. The discussions for IPP projects in Fiji have been underway for over 20 years, but, only a few of the numerous projects proposed have reached financial closure to date (2015). The only significant project except for the FSC and Tropik Woods biomass IPPs has been a 10 MW biomass project with GIMCO (now Nabou Green Energy), a joint venture between the Korean Government and Tropik Woods. EFL is particularly careful about maintaining the security of supply and has been critical of historical outages pertinent to the existing biomass IPPs. IPPs have found it difficult to penetrate the EFL grid bcause of the low kWh cost of electricity in Fiji, a financial constraint of around 21c/kWh (Fijian currency) for cost-effective agreements with the EFL. However, on the global front, the lowest cost for grid-connected PV (2016) has been as small as US 3cents per kWh for a system in Dubai (i.e. 6c/kWh Fijian). In Europe, the rates are somewhat higher with the lowest in Germany in 2016 being around 11 US cents/ kWh or close to the 21cents Fijian.

The 2015 iNDC submission suggested that around US$500 million (FJ$1,000 million) would be needed for near 100 per cent renewable energy in the electricity sector, consistent with the EFL estimate of FJ$800 million. Moreover, Fiji's iNDC contribution was conditional "on a combination of robust global market-based mechanisms and direct aid transfers."

The SE4all, documents the planned mitigation options in the pipeline for the EFL as presented in table 55 below.

In terms of the future, the report sees a mix of renewable energy using increased hydro, grid-connected solar, large-scale biomass projects and a substantial geothermal initiative. These, coupled with modest energy efficiency gains are projected to make the country fossil-fuel free in the electricity sector by 2030. The EFL annual report (2014) suggested that electricity consumption was increasing at 2.86 per cent p.a., an increase that would give 1400 GWh in 2030 as per SE4all report.

Table 55: Mitigation Option

Project Name	Installed MW	Annual GWh	Investment Million US$	Status
Qaliwana Hydro	17	39	90	Feasibility completed, looking for an IPP to develop & sell to EFL under a Power Purchase Agreement (PPA).
Wailoa Downstream Hydro	28.6	135.7	227	Feasibility completed, looking for an IPP to develop and sell to EFL under a PPA.
Upper Navua River hydro	Data not available	Data not available	Data not available	Fiji Meteorological Office to install rainfall gauges and monitor this for 5 years before undertaking any feasibility studies.
Naboro Waste to Energy	Data not available	Data not available	Data not available	EFL jointly with the DOE is currently preparing to undertake a feasibility study. Once completed IPP to develop this Energy Plant via Expressions of Interest.

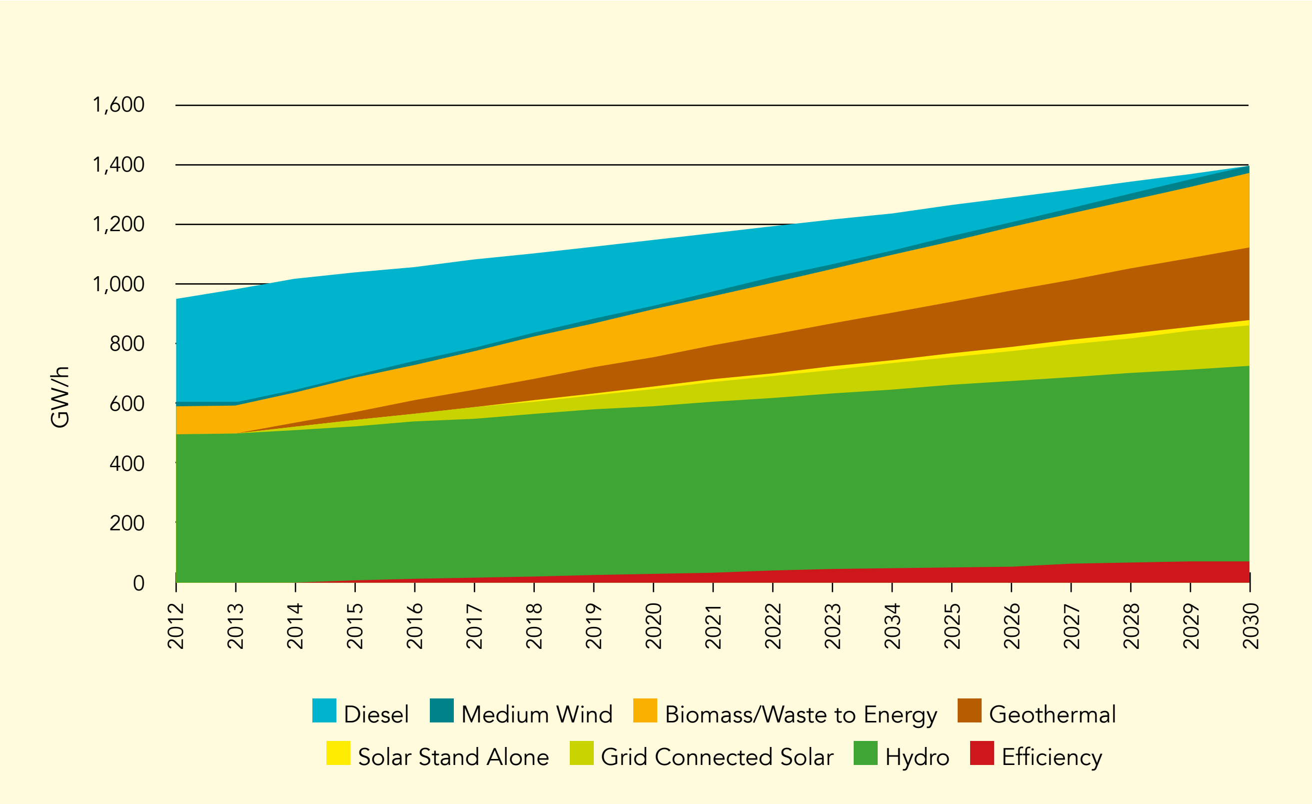


Figure 72: SE4all proposed mitigation action

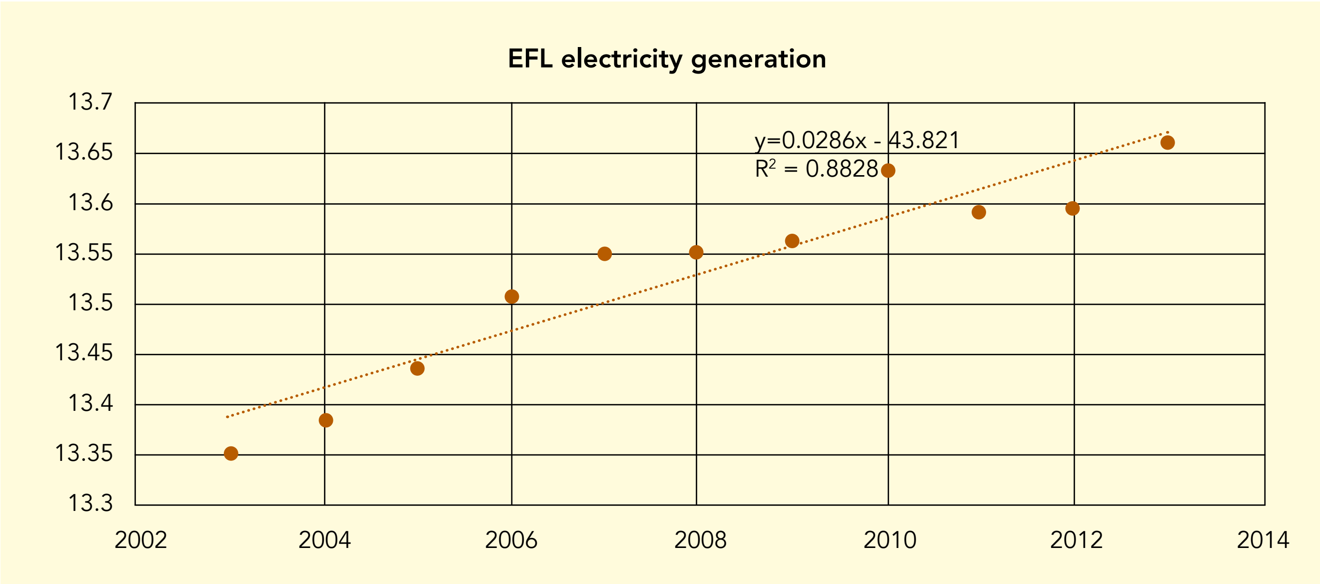


Figure 73: Logarithmic graph of actual EFL generation (EFL reports) showing an increase of 2.8 per cent p.a.

For off-grid options, the same report suggests solar standalone PV systems and energy efficiency. The report also suggests phasing out of wood stoves and improving access to modern fuels, reaching 100 per cent by 2030. However, fuel-efficient, smokeless wood stoves in rural areas are a good option in terms of emissions reductions for cooking as they are emissions neutral. It is important in this respect to ensure health risks from smoke emissions are reduced. While this aspect is important from both an equity (between urban and rural populations) and a development

point of view, implementing off-grid generation is not likely to substantially mitigate existing emissions and then only if it replaces existing diesel generation.

In summary, the SE4all report suggests around FJ$920 million would be needed between 2015 and 2030 or a little over FJ$60 million /year.

Overall the SE4all target for Fiji is for 99 per cent renewable energy electricity generation by 2030 and 25 per cent of total energy consumption from renewable energy sources by the same year. The cost of meeting the above targets was similar to that proposed by the EFL, i.e. FJ$800 million by 2030, but including energy efficiency measures and rural electrification. As noted, the 2015 iNDC costed the renewable transition at around US$500 million or FJ$1 billion, including energy-efficiency measures.

While the geothermal contribution would be attractive because it has a very high capacity factor (it can be available most of the time) compared with solar and wind options (only available when the wind blows or sun shines), the small individual size of the units makes the estimated cost look somewhat low. The cost for a solar PV alternative, however, is still reducing globally, especially as improved battery storage options become available. In this respect, it would be recommended to undertake advanced modelling of the Fiji grid with particular emphasis on grid stability. A similar study was recently produced for the Samoan grid [63] which, while much smaller than the Fiji grid, has a much higher penetration of solar PV than currently under investigation by the EFL and a much smaller hydro component.

The important aspect of any transition to renewable energy is to ensure that the introduced systems will be capable of withstanding high-intensity cyclones such as Cyclone Winston, that produced such devastation in Fiji in February 2016. In this respect, engineering studies need to be completed urgently to assess the damage done to the larger PV systems in Vanua Levu, Vanuabalavu, Koro and elsewhere in areas affected by the cyclone. These studies should also be compared to other Pacific areas damaged by cyclones (Samoa, Vanuatu, others) to produce a regional set of cyclone standards for PV systems.

Energy Efficiency

Fiji has had a strong energy-efficiency program for some decades located within the Fiji Department of Energy. In particular, the Energy Conservation and Efficiency (ECE) Programme in the department is focused on educating the public on the importance of using energy efficiently. This is undertaken through public awareness programmes, energy audits, use of energy-efficient equipment and the adoption of standards and labelling for refrigerators and freezers.

Standards and Labelling: Introduction of energy labelling and energy standards into appliances for better understanding of energy consumption information for the general public through the adoption of internationally recognied Australian and New Zealand Standards and Labelling.

As of 1 January 2012, the Minimum Energy Performance Standards and Labelling Program (MEPSL) came into effect for refrigerators and freezers. As per the regulations, all imported household refrigerators and freezers must comply with the following standards: FS/AS/NZS 4474.1 and FS/AS/NZS 4474.2

63 Grid Stability Assessment for the Upolu Island – Samoa, IRENA, Jose Gomez, June 2015

As mentioned above, energy-efficiency improvements have been on the drawing boards in Fiji for many decades, but actual improvements have been modest. The SE4all report details a program to remedy this situation, including:

- Continue to increase public education and awareness of energy efficiency by providing targeted information to end-users on the range of energy-saving technologies and options available. This should include encouraging businesses to undertake energy audits and to factor in the operating costs of energy use as well as the capital costs when investing. Public awareness campaigns should be informed by analysis of energy consumption patterns and market research of appliance purchases. Education and awareness campaigns should target specific groups;
- Extend the current system of energy labelling and minimum energy performance standards to all widely imported electrical appliances and industrial equipment that contribute substantially to energy demand. A system will be put in place to prevent and protect consumers from the use of false energy rating labels; and
- Develop and implement an energy information database, so that demand-side data is collected and analysed, and a verifiable data trail is created upon which energy savings can be verified. Where possible this data should be disaggregated by rural and urban users, sex and socio-economic groups. This database will be integrated with other supply-side energy information databases where possible.

Transport

2016/17 budget: In the new budget changed the tax structure for imported vehicles somewhat including an incentive package for those that invest in setting up of electric vehicle charging stations.

The following incentives and fiscal duty changes applicable to vehicles will be available:

- Seven (7) years tax holiday shall be granted a subsidy up to a maximum of 5 per cent of the total capital outlay incurred in the development of electric vehicle charging stations provided that the capital expenditure is not less than FJ$3,000,000. 7 per cent of the total capital outlay incurred in the development of electric vehicle charging stations provided that the capital expenditure is not less than FJ$10,000,000. Loss carried forward of 8 years.
- Reduce duty on new passenger vehicles with engine capacity not exceeding 2500cc from 15 per cent to 5 per cent from 1 January 2017.
- Reduce duty on New Rough Terrain Vehicles (RTV) from 15 per cent to 5 per cent under Concession Code 131.
- The specific duty rate on second-hand vehicles will be increased as follows:
  - >1000 < 1500cc vehicles will now attract FJ$7,500 specific duty;
  - >1500cc < 2500cc vehicles will now attract FJ$11,500 specific duty >2500 cc < 3000cc vehicles will now attract FJ$18,000 specific duty; and
  - >3000cc vehicles will now attract FJ$23,000 specific duty.
- From 1 January 2017, the following specific rates of duty will apply on second-hand hybrid vehicles:
  - < 1500cc vehicles will attract FJ$2,000 specific duty;
  - >1500cc < 2500cc vehicles will attract FJ$2,500 specific duty;
  - >2500 cc < 3000cc vehicles will attract FJ$3,000 specific duty; and
  - >3000 vehicles will attract FJ$6,500 specific duty.
- All-new hybrid vehicles will continue to attract zero duty.

In addition, the VAT on petrol and diesel has been reduced from 15 per cent to 9 per cent.

Agriculture

Emissions here are mostly CH_4 and nitrous oxide with smaller amounts of CO_2. This is a difficult sector to deal with because, as mentioned, reductions here conflict with economic growth initiatives. In this regard, Fiji should follow international examples, e.g. New Zealand ruminant research, reduce the use of inorganic fertiliser and switch to organic farming methods where possible, e.g. the Korean initiative and Ranadi plantation.

Waste

Emissions in this sector are relatively small and population-related. The usual mitigation option in this sector is to try to convert all methane emissions from decomposing organic waste to CO_2, preferably using the heat gained productively.

Forestry

The forestry sector has been a high priority for emissions mitigation due to the possibility of using this sector for both mitigation and revenue gathering, via obtaining funding through international credits for planting forests in Fiji. As mentioned, the main effort here has been the REDD+ program. In this regard, the most recent document detailing mitigation options has been the April 2015 SPC/GIZ report by Manuel Haas, mentioned earlier. The reductions here revolve around a REDD+ logging scenario to reduce degradation in logging natural forests. The prime move is to reduce the extraction rate to 21 cubic metres per hectare from existing extraction rates of around 50 cubic metres per hectare. This would result in the annual extracted volume reducing from around 62,500 m^3 per annum under conventional logging to 26,250 m^3 per annum (Table 12 of the Haas report page 23). The REDD+ scenario would then reduce emissions from around 0.25 million tons CO_2 per annum to 0.07 million tons per annum. Notwithstanding the mistake made in emissions from the degradation reductions identified earlier, this plan would see long-term emissions falling to zero and natural forests becoming a sink in the longer term to 2030. It would, however, rely on landowners showing considerable restraint in terms of obtaining revenue from natural forest logging and would preclude illegal logging. The report notes: "Among the most important elements towards the broad implementation of REDD-SFM activities on the ground is the establishment of functional forest governance structures such as forest surveillance procedures and a national forest information system. Such structures can ensure that selective logging is carried out in compliance with the regulations of the FFHCOP and reduce illegal, unregulated and inappropriate timber harvesting."[64]

64 Haas, 2015, p24

GHG Emissions in Fiji – Current and Pojected Trends (Scenarios)

In terms of predicting future emission trends, the population growth has been relatively low (less than 1 per cent p.a.) largely due to emigration. In addition, GDP was relatively flat from 2006 until 2012, in constant FJ$, but increasing at around 6 per cent p.a. from that date. The number of registered privately owned motor vehicles on the roads was also flat between 2006 and 2012 but has increased at a rate of over 6 per cent per annum since 2012. Electricity consumption, on the other hand, has slowed from 5 per cent per annum prior to 2008 to little under 2 per cent per annum from that same date. In early 2016, Fiji experienced a severe cyclone (Winston) which has caused considerable economic and infrastructure disruption. Additionally, with the rate of acceleration of climate change effects since 2015, further weather disruptions are expected. The inherent uncertainty in the future for this island nation would suggest two scenarios, one for relatively static GHG emissions for the mid-term future (until at least 2020) and one with a modest increase of between 2 per cent and 3 per cent per annum. These scenarios are similar to those suggested in the IRENA report (2014) for liquid fuels however the IRENA liquid fuel data from the Reserve Bank of Fiji differs from the FRCS data reported in the GHGI Chapter.

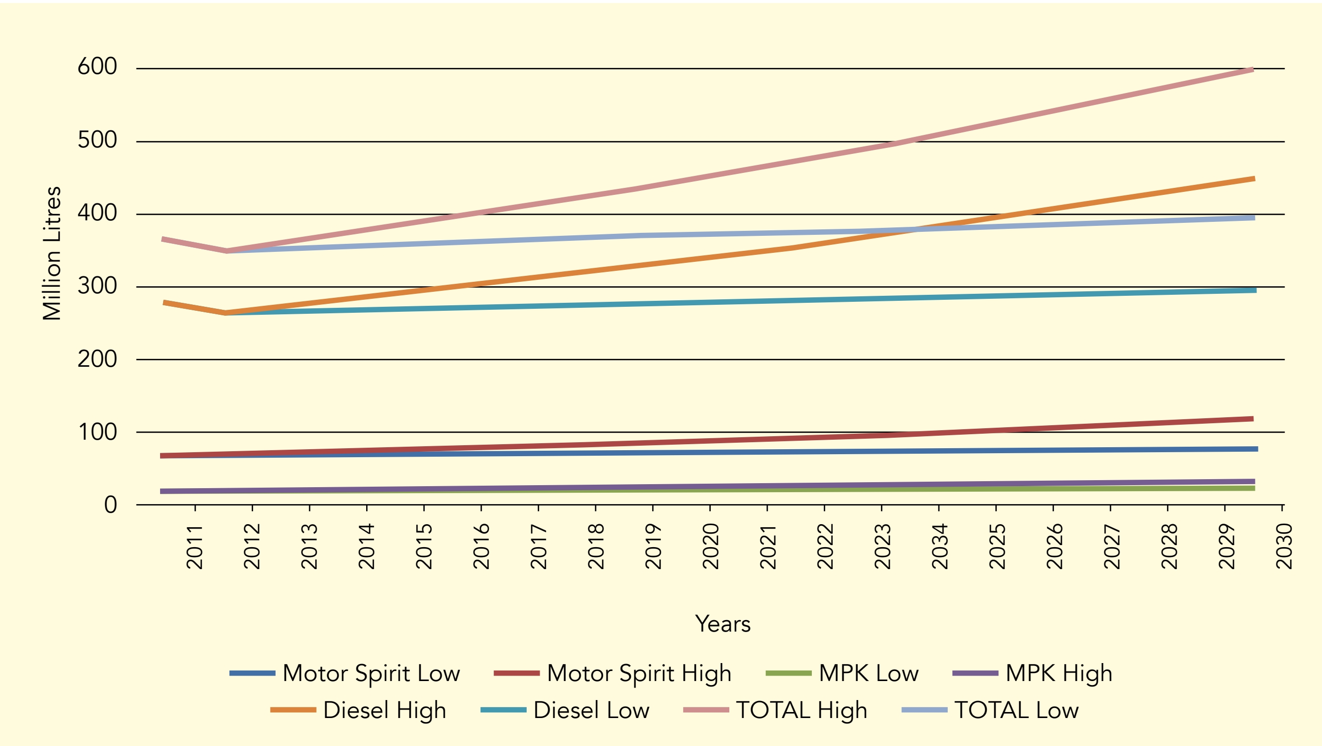


Figure 74: Fiji projected fuel demands to 2030 (Reserve Bank data)

Proposed GHG Abatement Measures/Technology Options

Electrical Power Options

While the geothermal contribution mooted in the SE4all report would be attractive as it has a very high capacity factor compared to solar and wind options that have a low capacity factor, the small individual size of the geothermal units makes the estimated cost look somewhat low. The cost for a solar PV alternative, however, is still reducing globally (see earlier Dubai PV at 3 cents US/kWh) and improved battery storage options are also becoming available.

Alternate scenario to the SE4all projections: In terms of the time needed to put in large-scale renewable energy supplies, it is thought that the current trends in terms of generation mix would in all probability extend for around 5 years, at least until 2020. The current trends are for around 1 per cent increase per annum for hydro, a 0.6 per cent increase for thermal, a 2 per cent increase for biomass and 1 per cent increase for wind and solar. These increases are incorporated in the figure below showing the likely generation mix to 2020 (note assuming rainfall is approximately constant 2016-2020).

For the following decade (2020-2030), an alternate scenario to the SE4all would be to replace the geothermal generation with grid-connected solar PV with around 20 MW installed per annum from 2020 until 2030, giving a total of 200 MW installed by that date. Then using the same assumptions as of the SE4all report, that solar PV has a capacity factor of around 18 per cent, this would give the scenario to 2030 in Figure 76. Here, it is assumed that biomass generation increases at 10 per cent p.a. from 2020 and hydro increases by 2 per cent p.a. In addition, from 2020 it is assumed that energy efficiency improvements compensate for any further growth in consumption on the main Viti Levu grid. The energy efficiency improvements would have to reduce consumption by around 3 per cent p.a. This would make the main grid close to 100 per cent renewable by 2030.

It might be noted that after the Nadarivatu hydro addition the size of any proposed hydro is anticipated to decrease rapidly with only one scheme greater than 10 MW identified, the Wailoa Downstream project. In the Pilot Study for Comprehensive Renewable Energy Power Development, Tokyo Electric Power Company for Japan Bank for International Cooperation (JBIC) identified some 24 smaller possible hydro projects, but they were mostly in the range of a few MW with the smaller ones likely to be uneconomical to pursue.

In terms of the PV, however, it is likely that the 18 per cent capacity factor in the SE4all report is somewhat optimistic.

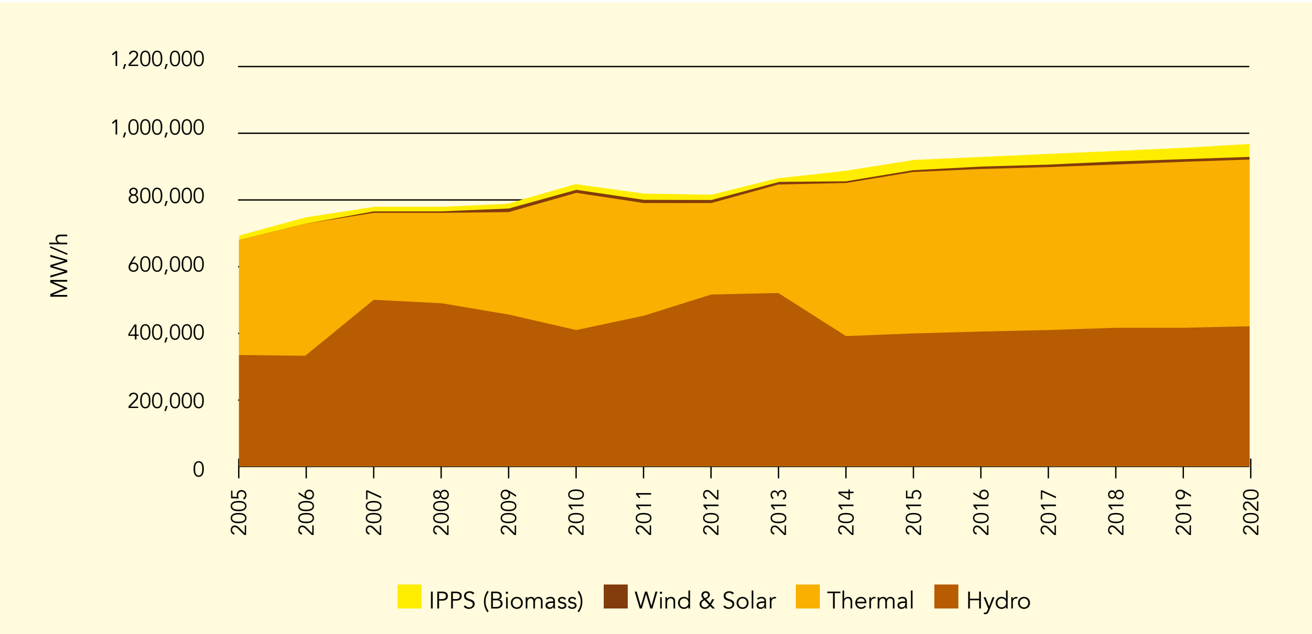


Figure 75: Projected EFL generation to 2020 using BAU

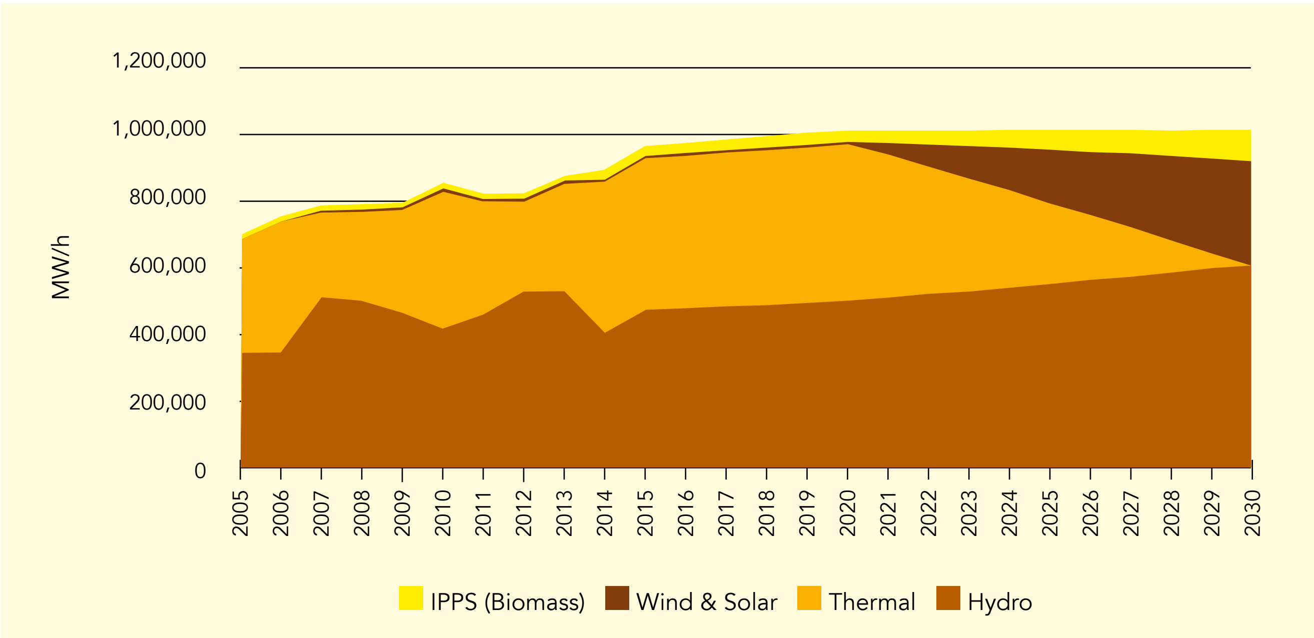


Figure 76: Projected EFL generation to 2020 using BAU

Detailed modelling will need to be undertaken to examine the interaction between the hydro storage component and the intermittent PV component to determine the effective capacity factor for PV into the Fiji grid more accurately (including a grid stability study). Preliminary modelling was undertaken with the renewable energy modelling program HOMER[65] which showed that as much as 300 MW may be required for the Viti Levu grid to account for the seasonal variation in hydro supply. This would imply a lower limit of around 12 per cent effective capacity factor for PV, which would mean the PV annual increment would need to be increased to 30 MW installed per annum (or the timescale extended a further 5 years to 2035) for a total PV capacity of 300MW. The difficulty in the detailed modelling will be to predict rainfall with the uncertainties presented by climate change.

65 https://www.homerenergy.com/

The cost implications for this alternative renewable energy transitions are given in the table below:

Table 56: Cost implication for renewable energy transitions

	2020-2030				
	GWh	CF	Cost/kW	MW	Cost
	Increase		FJ$kW	Installed	FJ$million
	SE4ALL				
Geothermal	240	0.8	7,000	34	240
Biomass	160	0.5	3,000	37	110
Solar PV	130	0.18	3,000	82	247
Hydro	160	0.45	6,000	41	
Wind	35	0.22	2,500	18	45
Total ex EE	725			212	886
	Revised				
Geothermal	0	0.8	7,000	0	0
Biomass	60	0.45	3,000	15	46
Solar PV	315	0.12	3,000	300	899
Hydro	130	0.45	6,000	33	198
Wind	0	0.22	2,500	0	0
Total ex EE	505			348	1,143

The revised cost, excluding energy efficiency costs, increases only slightly from around FJ$900 million (SE4all) to FJ$1.15 billion (revised transition). Subject to the detailed grid modelling there may be a need to introduce some form of additional short term electrical storage, especially in Vanua Levu. At present cost of around US$2000/kWh, 100 MWh storage (around 1 hour of the full grid load), could cost some 200 million US$ or FJ$400 million. In addition, the existing diesel plant could be used for longer-term energy mismatches. It might be noted that this level of storage would be identical to that installed by Elon Musk (Tesla) in South Australia in 2017.[66] As mentioned, after 2020, the alternate scenario given above relies on improvements in energy efficiency to offset further consumption growth.

Energy Efficiency Options

Energy efficiency will become more important as higher cost renewable resources are employed, but as efficiency improvements are always limited by the laws of physics, it is unlikely to give the reductions needed for complete decarbonisation. The SE4all report suggested that around FJ$3 million per annum would be needed to remove 7 GWh of load per annum (between 1.0 per cent and 0.7 per cent p.a). Specific suggestions in the SE4all report included:

- Public education and awareness of energy efficiency should be provided to end-users on the range of energy-saving technologies and options available. This should include encouraging businesses to undertake energy audits and to factor in the operating costs of energy use as well as the capital costs when investing. Public awareness campaigns should be informed by analysis of energy consumption patterns and market research of appliance purchases. Education and awareness campaigns should target specific groups.
- Energy labelling and minimum energy performance standards program should be continued to all widely imported electrical appliances and industrial equipment that contribute substantially to energy demand. A system will be put in place to prevent and protect consumers from the use of false energy rating labels.
- An energy information database should be developed, so that demand-side data is collected and analysed, and a verifiable data trail is created upon which energy savings can be verified. Where possible this data should be disaggregated by rural and urban users, sex and socio-economic groups. This database will be integrated with other supply-side energy information databases where possible.

66 Harmsen, 2017

In addition, training in energy auditing should be provided by the Fiji based Universities to ensure that there are capable staff available to carry out energy audits.

Transport Options

As mentioned earlier mitigating the transport sector is very difficult due to the social attachment people have for individual motorised transport and the economic benefits perceived by the Government for such transport. From a key sector analysis, land transport is the single largest source of GHG emissions. The SE4all report gave the following options for both transport and liquid fuels:

- **Promote the fuel efficiency** of imported motor vehicles in order to reduce petroleum consumption. This includes continuing to enforce age limits for second-hand vehicles and provide import tax incentives. It may also include introducing new measures such as labelling for vehicle fuel economy of imported land transport vehicles.
- **Marine transport**: Investigate the potential and cost-effectiveness of energy efficiency and renewable energy solutions for sea vessels, including biofuels, solar and sail-assisted sea transport and efficient motors, vessel design, and improved maintenance models to improve the overall efficiency and reduce fuel consumption in sea transport within Fiji.
- **Government action:** Support the development and implementation of the Department of Transport's land and marine transport policies that encourage a shift towards more energy-efficient forms of land and sea transport.
- **Cost reductions:** Reduce the cost of imported petroleum products by negotiating directly with fuel suppliers and reviewing the pricing templates for petroleum products. Also, continue to explore the costs, potential benefits and risks of bulk procurement of petroleum, building on existing studies and initiatives in this regard. This may include regional cooperation or the creation of a single (bulk) buyer to improve bargaining power.
- **Data collection**: Improve the transparency of petroleum supply, including collecting data on fuel quantity imports, re-exports, consumption, and pricing and making this data publicly available.
- **Research into biofuels**: Continue research to explore the potential for increased production and use of biofuels. This includes encouraging the production of coconut oil in remote islands and the use of locally produced molasses for ethanol production. Any actions for the widespread development of biofuels in Fiji should be based on rigorous analysis showing that it is both technically and economically feasible and should be mindful of the risks, in particular, the trade-offs between the production of crops suitable for conversion to biofuels and production of food and cash crops.

The present report would endorse the above suggestions, with the exception of reducing imported fuel costs. Reducing fuel costs only encourages consumption and hence, will promote emissions. It would be better to increase the cost of fuels and use the tax to research biofuel production and other low emission transport options. It is noted; however, that increasing fuel costs is not a popular option for the users of private vehicles. Note that the SE4all report concurs with earlier suggestions in the GHGI section on the problem with data collection of fuel imports, re-exports and consumption. The figure below shows the vehicle numbers in Fiji from 2006 until 2015 (data from the Fiji LTA).

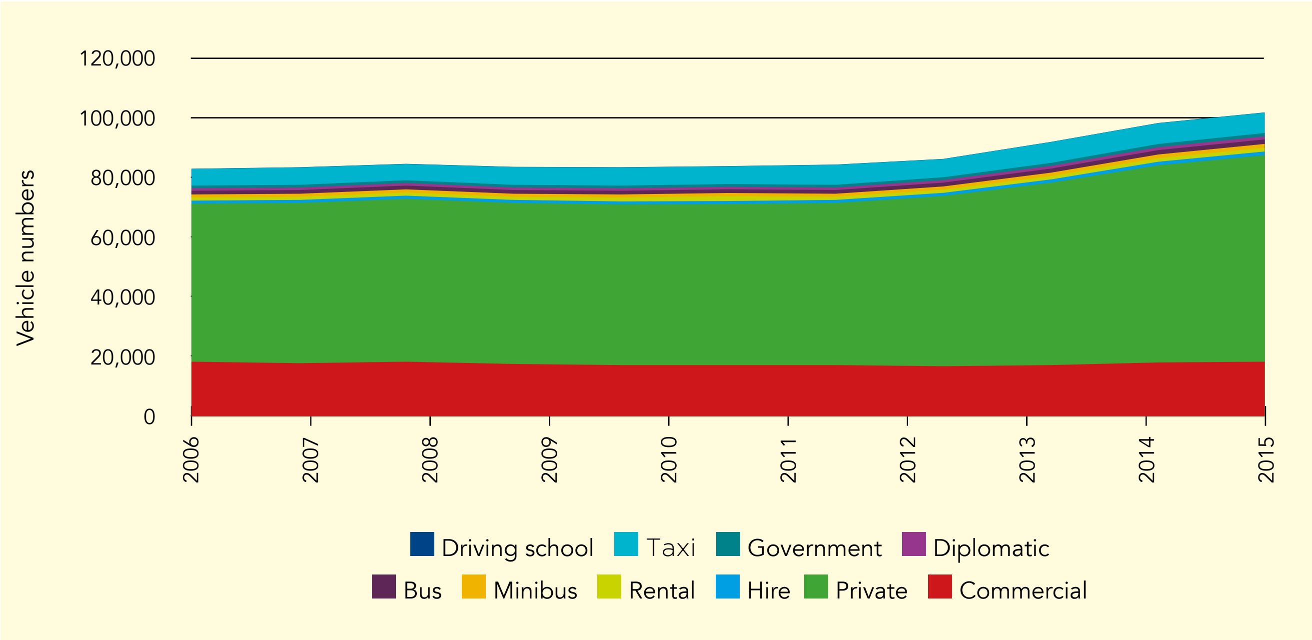


Figure 77: Vehicle numbers in Fiji from 2006 to 2015 (LTA data)

Other Transport Actions

As discussed, the transport sector is difficult to deal with as it is a socially sensitive area and one that is thought to be commensurate with development and growth. Nevertheless, as it is the largest emitter of CO_2, the sector needs a coherent plan involving all the transport stakeholders (LTA, motor vehicle vendors and oil companies) for urgent climate change mitigation. Some of the interventions include:

- Increase duty on high-fuel-use vehicles (except bus and goods vehicles);
- Discourage car use in urban areas by introducing the time-of-hour entry charges;
- Improve public transport options, possibly light rail Suva-Nausori and Nadi-Lautoka;
- Subsidise public transport;
- Introduce education/health programs to encourage bicycle use and walking; and
- Investigate fuel-switching options:
  - Electric-national trials, Government vehicles changing to pure electric where possible; and
  - Biofuels national trials.

In this regard, it would be recommended that Fiji adopt a mitigation policy making it a fast follower of international transport-mitigation trends. In the last few years (2015-2018), the transition to fully electric vehicles worldwide has accelerated, and the number of full-electric vehicles has been increasing. In addition, the performance of these vehicles is starting to compete with fossil-fuelled models in terms of speed and range.

Tourism Options

The wild card in the climate change mitigation mix will be tourism. Tourism is a good income earner for Fiji and arrival numbers have been increasing to well over 600,000 persons per annum in recent years. Unfortunately, tourism, especially from visitors using long-haul flights, is responsible for considerable CO_2 emissions, and while the emissions are currently the responsibility of either the country of origin or exist in the limbo of "international transport", if the world does decide to attack climate change seriously, this situation will have to change. Tourism may then become a stranded asset, as will fossil-fuel reserves. In this case, tourist numbers may decline considerably, causing financial stress to host countries with large tourist potential. Sustainable tourism can be encouraged, but the large emission load of getting people to an isolated island such as Fiji will be a difficult hurdle to surmount.

Forestry Options

The current mitigation plan for forestry is adequately overseen by the REDD+ program. The emphasis on rehabilitating natural forests remains a priority. The main additions here are to ensure reliable data acquisition and better sharing of data.

- The forest decree is currently being revised to legally comply with the new forest policy from 2007. New elements of the decree will incorporate legal provision for enforcement of the FFHCOP, REDD+, sustainable value-chains, privatisation of Fiji Pine Ltd. and

Fiji Hardwood Ltd. and other measures to create sustainability, as documented in the policy;

- Harvesting regulation was developed. By its endorsement, the Code of Harvesting Practice (FFHCOP) will be legally established and enhance the options for forest protection and sustainable utilisation;
- Fiji is conducting national land-use mapping. The land-use mapping report for the Emalu pilot site was published in October 2015 and serves as a blueprint for land use mapping processes in the future project communities; and
- Free, prior and informed consent guidelines is drafted and already implemented in Emalu. The draft will enter a national consultation process in order to not only address REDD+ but to be valid for all sectors in Fiji.

Future Forestry Options: The key to longer-term mitigation in the forestry sector is to encourage the planting of native species rather than short-term plantation species such as pine and mahogany. Unfortunately, it has been difficult to get landowners to plant such species as they prefer the quicker growing varieties in order to get quicker financial return. It is likely, however, that some form of financial incentive would be needed to facilitate such a change to planting long-life native species. REDD+ estimates that natural forests will be net negative in emissions to the tune of around 0.7 million tons CO_2 by 2030, with an average reduction of around 0.56 million tons over the decade 2020-2030 (see the table below).

Table 57: REDD+ projections of annual emission reductions

Year	Annual reductions Mt CO_2
2020	0.20
2021	0.30
2022	0.39
2023	0.50
2024	0.57
2025	0.62
2026	0.68
2027	0.69
2028	0.71
2029	0.72
2030	0.72
Average	0.56

Agriculture Options

As decreasing animal numbers would conflict with economic growth options, the main option available would be to decrease nitrous oxide emissions by reducing nitrogen-based fertiliser application and substituting organic fertilisers. This option is being trialled for some species by several agricultural ventures including Ranadi Plantation (near Pacific Harbour) and Korean Government-sponsored agricultural projects. The move of organic fertilisers into large-scale sugar plantations would need to be investigated.

Other Sectors

Other interventions have been identified in various sectors to provide opportunities for large-scale centralised power generation, including waste, waste residues and resources, resulting mainly from medium and large sources and enterprises. The major constraints identified for implementation of waste-to-energy projects during the study were low awareness and lack of appropriate information on waste to energy, inadequate technical capacities to develop real projects, low availability of financial services, insufficient institutional capacity and unspecific and unfavourable policy frameworks. It was also observed that the capacities and requirements to deal with risks associated with waste-to-energy initiatives among key stakeholders remains generally low, both in public and in the private sector.

Training and Technology Transfer Opportunities

Fiji is fortunate to have three universities located in the island group. The University of the South Pacific (USP), the Fiji National University (FNU) and the University of Fiji (UniFiji) run courses and do research work on both renewable energy and sustainability.

As a member of the Pacific Energy Oversight Group (PEOG) and Pacific Energy Advisory Groups (PEAG), USP is working together with other regional organisations and development partners to help Pacific Island nations advance towards an energy-secure future while supporting their climate change mitigation efforts. A brief description of some of the projects are given below:

- USP-KOICA Renewable Energy Project (East Asia Climate Change Partnership): 2010-2013: A 2 Million USD grant from the Republic of South Korea for a project entitled ‘Renewable Energy Generation, Resource Assessment, and Capacity Building Programme for Sustainable Economic Development of the Pacific Island Countries' has assisted USP in undertaking a comprehensive renewable energy capacity building initiative. This project had the following 3 main components:

- Renewable Energy assessment in all 12 USP member countries and establishment of a Data Bank at USP.
- Renewable energy Capacity Building in the USP region.
- Establishment of a 45-kW grid-connected solar PV system at the USP, Laucala lower Campus and development of a renewable energy training centre.

The first component involved setting up 24 Integrated Renewable Energy Resource Assessment System (IRERAS) in USP member countries. This equipment records major meteorological parameters required for renewable energy applications (solar radiation, wind speed, etc.). There are also 5 dedicated wind energy measurement systems deployed at selected locations in Fiji. The ocean energy potential in the region was also evaluated using Waverider Buoys (wave energy), ADCPs (tidal current energy) and CTD probes (OTEC potential). The data recorded is transmitted to a central server housed at USP's Japan-Pacific ICT Centre.

The second component comprised a number of activities. The project funded 8 regional students to undertake a Master's programme at USP. They worked on renewable energy resources assessment in their respective countries after spending the initial 6 months (taking two courses) at USP. Majority of them have completed their studies and graduated.

Under the third component, a 45-kW grid-connected PV (GCPV) system was installed at the USP's marine campus. This was among the first two grid-connected PV (GCPV) systems in Fiji. This system is also being used as a research/ training tool where studies on PV/grid interaction are carried out. A training workshop on grid-connected systems was held at USP in November 2012.

- Projects DIREKT and L3EAP
  - The 1.2 million Euro ACP-EU funded project (DIREKT- small Developing Island Renewable Energy Knowledge and Technology transfer network) envisages strengthening the science and technology of renewable energy systems in the PICs and other small island countries. The main objective was to enhance cooperation between the institutes involved in renewable energy science and technology development in the ACP region and EU institutions. The project ended in 2013.
  - L3EAP (2013-2016) was funded by the Edulink programme of ACP-EU with the main objective to increase the capacity of universities in African, Caribbean and Pacific Group of States (ACP) to deliver high-quality lifelong learning courses on the topics of energy access, security and efficiency.
- USP/ASU VOCTEC program
  - The main objective of this training program was to help improve the sustainability of renewable energy investments and infrastructure by increasing the regional capacity of qualified technical trainers and technicians to install, operate, and troubleshoot off-grid solar photovoltaic (PV) systems. USP was the Pacific counterpart for this Arizona State University led and USAID funded initiative (2013-2015).
- Development of Solar Photovoltaic and Hybrid systems

  With the help of funds from the US and French Governments, solar PV demonstration systems have been installed at the main USP campus. A 2.6 kW GCPV system serves as an electric vehicle charging station (first of its kind in the region). USP installed solar water pumping system at three schools in Vanua Levu and one school in Viti Levu with the Taiwan Government's support. These systems have helped the schools to stop using diesel generators for water pumping. French funding has also enabled the implementation of a solar light micro-financing initiative where remote communities are encouraged to replace their inefficient and polluting kerosene/ benzene lamps with clean/efficient solar lights. French funding has also supported the USP project on establishment of solar hybrid refrigeration systems for remote fishing communities.

In addition, USP offers a number of courses in renewable energy technologies at the undergraduate and postgraduate levels. An introductory course on renewable energy is part of the university's B.Sc. (Physics) and the new Bachelor of Engineering (Electrical Engineering and Mechanical Engineering) programmes. There are additional courses on various aspects of renewable energy applications. USP also offers Post Graduate Diploma (PGD) and M.Sc. in renewable energy.

The Renewable Energy research group within the Faculty of Science, Technology and Environment (FSTE) is actively engaged in research. Some of the areas of interest are:

- High penetration of solar PV in island grids:

opportunities and challenges;

- Wind energy assessment; design, development and testing of rotor blades/turbines;
- Solar Photovoltaic: Development of dye sensitised solar cells and other thin-film solar cells;
- Design and Performance analysis of standalone systems, grid-connected and hybrid systems;
- Biomass and Biofuel: coconut and dilo oil[67] based biodiesel, cassava-based ethanol;
- Ocean energy: Assessment of ocean energy potential (wave, tidal and OTEC) and design and development of energy extraction devices;
- Mini and microgrid control systems;
- Flywheel based storage systems; and
- Energy planning.

USP PaCE-SD: Pacific Centre for Environment and Sustainable Development is dedicated to empowering its people with adequate knowledge to be able to adapt to the impacts of climate change and also pursue sustainable development. The Centre collaborates with relevant faculties across the University as well as national, regional and international development partners in the CSO and NGO sector. As a way of mainstreaming climate change and sustainable development into the development process, the Centre also works with regional Governments in an advisory capacity. The Pacific region and individual Island nations have made a strong commitment to international efforts to prevent further irreversible environmental change and to promote sustainable development by becoming a party to numerous international "Multilateral Environmental Agreements". PaCE-SD is a partner in making those commitments a reality.

The Centre serves the University through several components:

- Postgraduate Teaching and Training (Formal and Informal) - Postgraduate Diploma, Masters and PhD studies in Climate Change are available with brief workshops and training;
- Research, Consultancy and Publications - New research and projects address the issue relating to climate change, the environment and sustainable development;
- Community Engagement - Community outreach (rural) is vital and has been achieved through Government agencies, USP's Institute of Applied Science and CROP agencies to address their specific needs;
- Corporate Capacity Building - This refers primarily to our human resources and infrastructure-related capacity building to promote and strengthen the Centre. PaCE-SD has had several interns pass through under this initiative; and
- Communication and Visibility - PaCE-SD recognises the need for raising awareness on climate change related issues at all levels of society, and has produced communication materials and carried out awareness-raising campaigns at high school, tertiary and community level.

FNU

The Fiji National University has similar training options to USP and in addition, has research projects on renewable energy and offers a trade diploma in Renewable Energy engineering.

UniFiji

The University of Fiji offers a Master's degree in Renewable Energy Management.

PacTVET Project

This EU funded project implemented by the Pacific Community and USP is developing benchmarks, competency standards and courses on Training of Trainers (ToT) to create a pool of national trainers in the areas of climate change and sustainable energy.

67 Oil obtained from a Fiji native plant, also used for beauty products

Barriers for Mitigation Options

There are many barriers for effective mitigation options in Fiji, many of which are common to developing countries in general and some are country-specific.

Capital/Finance: The main barrier to mitigation options being realised in Fiji (and most developing countries) has been the slow progress of finance transfer from the international UN mitigation effort. To date, there has been an emphasis on obtaining market finance and on market mechanisms to pay for mitigation options. Projections for the current global NDCs indicate that some trillions of US$ would be needed to be transferred to developing countries just to keep the temperature increase below 3.7 degrees. Unless this transfer eventuates, the action plans developed for mitigation are not likely to occur. To progress to keep the temperature increase below 2 degrees will require an even higher level of transfer and a real commitment on the part of the developed nations of the world and at the same time a real level of decrease in developed country emissions.

Trade Barriers: In addition to ensuring trade barriers on emission-reducing imports are made low, tariff barriers to emission enhancing products and technologies, for example, fossil fuels and motor cars may need to be increased. Finding the appropriate path between reducing and increasing tariffs may be difficult. Import tariffs in Fiji on most renewable energy products are already low or non-existent, and the tariffs on energy-efficient vehicles are favourable (see earlier).

Vested Interests: These constitute a considerable barrier in several areas. One is in terms of data sharing. In Fiji, it has been difficult to extract sectoral liquid fuel data from the major oil companies with only one of the three companies offering limited access to data. Another is in the transport sector where the vehicle importing companies have considerable interest in increasing the number of vehicles. It was also found during stakeholder feedback that the bus transport companies are actually lobbying against the possible introduction of rail transport options. Finally, the vested interest of the private sector in growing the economy is often at odds with serious emissions reduction.

Institutional and Administrative Difficulties: Such in-country difficulties can be serious obstacles to easy technology transfer. Also included here might be the difficulty in retaining qualified people in administrative positions in Government. In Fiji, the Climate Change

Division and International Cooperation within the Ministry of Economy need substantial strengthening and ways found to ensure that the whole of Government cooperation is secured for climate change mitigation and adaptation interventions.

Regional Cooperation: This has generally not been a large problem in the Pacific as there are a number of regional organisations (SPC, SPREP etc.) fostering cooperation all with good intentions in terms of assisting with climate change mitigation and adaptation.

Access to information: Again, this has not been a large problem for Fiji, which has three universities and a polytechnic institute. In addition, regional organisations provide access to information as required. However, there could be improvements in information sharing between Government departments in terms of timeliness and stronger collaborations.

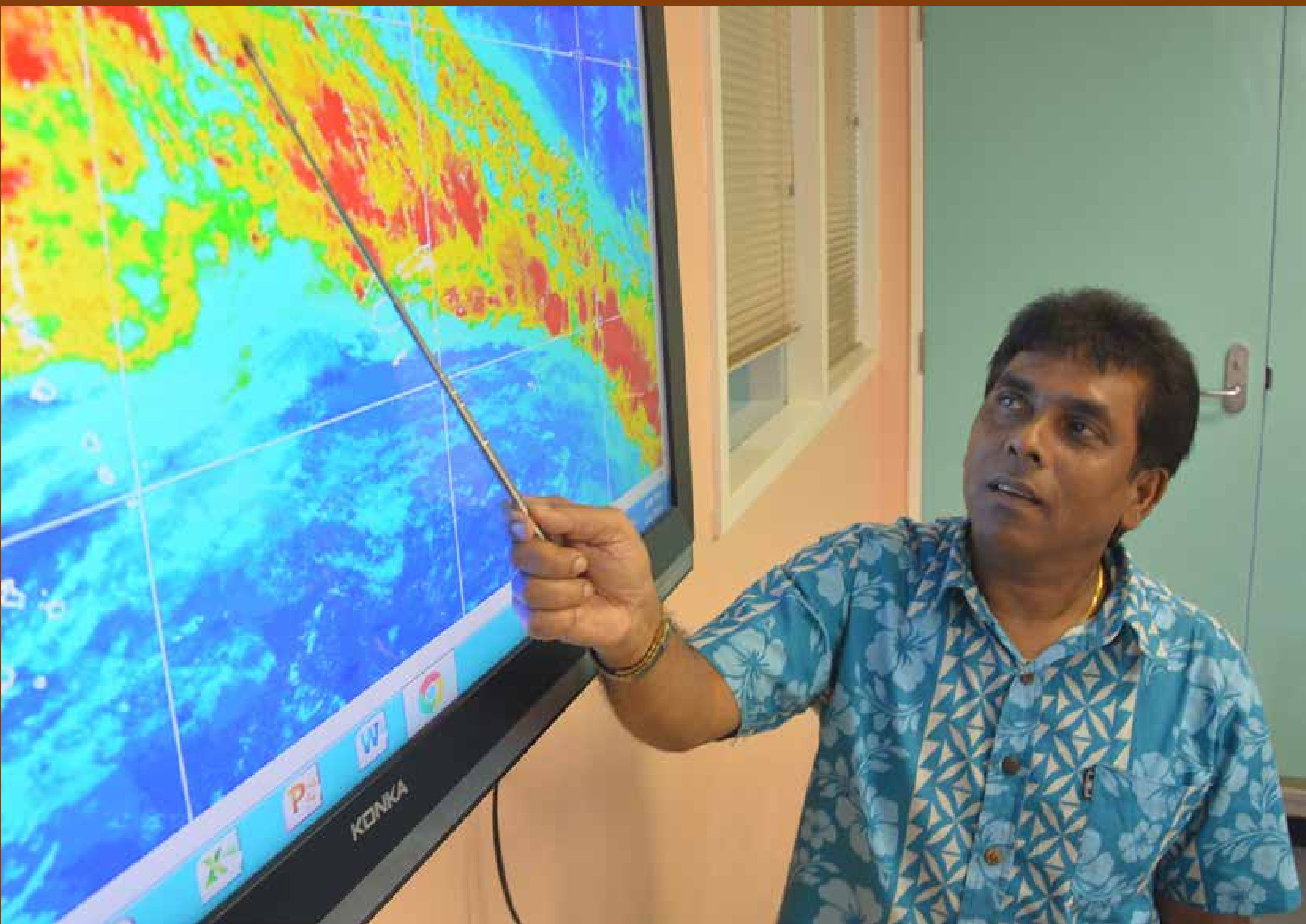
Differing Needs: The differing needs of all developing countries compared to the developed nations is a serious barrier globally to emissions reduction, a barrier that has played out at all of the major UN meetings designed to encourage countries to cooperate on emissions reductions. The issue is one equity and of who has been responsible for past emissions. In almost all cases, developing countries insist that climate change must be integrated with development not subservient to development.

Economic incentives: There has been a problem of private sector participation in Fiji, particularly in terms of the on-grid electricity sector. The difficulty of finding funding for incentives for landowners to plant native trees was also discussed in the text.

There are of course other barriers including the lack of expertise in-country to facilitate the realisation of mitigation options, but these are largely also related to lack of finance due to a brain drain of experienced people from the country to greener pastures in terms of salaries. Government departments, in particular, have great difficulty retaining qualified staff due to relatively low salary levels. Training is obviously needed, but unless such measures are accompanied by mechanisms to keep the trained staff, they are less likely to succeed.

Conclusions and Summary

With the hindsight of the 2015 Paris agreement and the present commitments from the countries of the world leading to a projected temperature increase in excess of 3°C, it is difficult to be optimistic in terms of conclusions for any specific country such as Fiji. Nevertheless, there are options for Fiji to do its share in terms of both mitigation and adaptation. The key barrier, however, detailed above, is securing the required finance for its technology needs. In addition, it is clear that developing countries need to see some real action from developed countries both to give incentive to their own efforts and to spearhead mitigation measures, such as electric vehicles and solar PV, that can be then cost-effectively transferred to developing countries.



CHAPTER 5:
OTHER INFORMATION

Technology Transfer

Article 4.5 of the United Nations Framework Convention on Climate Change (UNFCCC) promotes the development and transfer of environmentally sound technologies from developed countries to developing countries (non-Annex 1) as means of enabling the international community to fulfil the requirements under the convention.

Fiji is heavily reliant on imported high tech goods because national research and development capabilities are in their infancy. Given its strong natural resource base and a highly literate and technically knowledgeable young population, there is both a need and an opportunity to focus on attracting appropriate, affordable and accessible technology to complement efforts to address climate change and achieve growth that is sustainable. The increasing global emphasis on open source development creates a favourable climate for developing countries to build technological advances. It is important that these initiatives are tailored to suit the research and development requirements in Fiji. A logical starting point would be to strengthen institutional support in resource-based sectors and to then proceed upstream on the resource mobilisation and manpower rationalisation fronts.

Technology research and development in Fiji is driven by the private sector and backed by insistutions of higher learning. Fiji has thus far operated without a national policy/ framework on the development and use of technologies, and policies are needed that support rather than impede the private sector. Since Fiji is an increasingly important player in the global production value chain, there is a need for platforms that can provide for the absorption, digestion and refining of imported "green" technologies.

TNA Approach

In the Fiji Rapid TNA, it was noted that the scoring mechanism for identifying the prioritised technologies as per the manual relies on fairly subjective criteria and on the relatively ad-hoc selection process to define the relevant stakeholders. As such, more emphasis has been placed in the current selection process on reducing emissions in ways that are consistent with Government developmental objectives. A quick review of completed TNAs indicates a wide variety of responses some which are more likely to produce reduced emissions and some which, through the "rebound effect," are less likely to reduce emissions.

Technology Needs for Fiji

Table 58: Technology Needs for Fiji

Mitigation	
Energy Sector	Implementation of renewable energy options for the power sector. A 200-300 MW PV system to be implemented between 2020 and 2030 to make the Viti Levu grid close to 100 per cent renewable by 2030. Continuation of existing plans to research geothermal energy, use biomass and put in place additional hydro capacity. For off-grid applications to continue with the present PV program. In addition, there is an urgent need for: o A grid stability study to investigate the ability of the grid to accept large scale intermittent renewables, especially solar PV. o An engineering study to design and cost implementation of the renewable option above with penetration rates resulting from the grid stability study. o Transfer of international mitigation funding to implement large scale renewable options.
Forestry Sector	Continuing the GIZ funded forestry program, in particular, to encourage increasing native species in forest replanting. o A study to find out the funding needed to encourage landowners to plant native species rather than plantation species. o Transfer of international mitigation funding to enable the planting to proceed.
Energy Efficiency	Continuing the Department of Energy initiatives in energy efficiency. o Funding to be sought to provide energy audits for industry and commercial sectors. o Funding to be sought to provide training programs for energy auditing.
Transport sector	Deal with the recent (2012 onwards) dramatic increase in the number of privately owned vehicles by continuing to offer preferential tariffs to non-fossil fuel vehicles. In addition: o A study to investigate modal shifts on high-density routes in particular, Suva-Nausori and Nadi-Lautoka o A study to investigate establishing a project to modify existing hybrid vehicles to plug-in models o Transfer of international mitigation funding to enable mode shifts in transport and vehicle modifications.
Agriculture sector	Focus on a decrease in NO_2 emissions in the agriculture sector. In particular: o A study to investigate a major shift from using inorganic nitrogen-based fertilisers to organic farming methods.
Adaptation	
Environment (Biodiversity/ Ecosystem)	A focus on forestry rehabilitation with an emphasis on mangrove and coastal protection and in addition planting of native species in mainland forest areas. The adaptation needs are consistent with and complementary to the mitigation needs. Existing needs are generally met with the GIZ REDD+ program but in addition to concentrate on: o Putting in place forest protection systems to reduce forest fires. o Planting of drought and fire-resistant species.
Housing	Extensive needs here, highlighted by the recent cyclone Winston including: o strengthening building regulations especially cost-effective measures for rural and outlying coastal areas. o Urgent research and dissemination to promote wider use of traditional building materials and low-cost construction. o Train local builders in new cyclone-resistant technologies and inefficient construction management. o Providing funding for the above measures.
Agriculture	Extensive needs here consistent with mitigation aspects including: o Crop management for droughts, seawater intrusion and increased temperatures. o Strengthening subsistence agriculture and provision of emergency food storage in remote areas and outer islands.
Tourism	As tourism is a cash producing sector it is in the interests of the industry itself to put in place measures to protect their own infrastructure including tourist safety in emergency situations. An obvious adaptation measure would be to encourage the industry to move away from coastal areas but this would be strongly resisted as the industry promotes the sea as a focal point.

Water and Sanitation	**Water is a critical need both for long term human needs and in terms of emergency situations. Cyclone Winston showed this need when in the immediate aftermath of the event, water provision was needed to be provided by external aid assistance. Both long term water delivery in all areas and emergency supplies in outlying and remote areas need to be protected. Sanitation is an important component of health and in particular protecting water supplies from cross-contamination with sewerage, needs to be taken care of.**
Health	**This is an overarching need that is commensurate with the general needs of the country in terms of providing a cost-effective public health service. In terms of adapting to climate change, there will be additional problems in terms of increased tropical diseases and coping with increased temperatures. The other health adaptation measures are generally in terms of coping with emergencies such as cyclones and flooding.**

Technology Prioritisation and Potential Mitigation Technology Options

Electricity Sector

Grid Options: In terms of the time needed to put in large scale renewable energy supplies, it is thought that the current trends in terms of generation mix will in all probability extend for around 5 years, at least until 2020. The current trends are for around 1 per cent increase per annum for hydro, a 0.6 per cent increase for thermal, a 2 per cent increase for biomass and 1 per cent increase for wind and solar. Although Fiji has considerable potential for geothermal development, the resource is not well understood in the country. In addition, the sites on Viti Levu that could feed into the main grid are generally quite small with only two sites between 2MW and 6MW. The Department of Energy and EFL have not been generally supportive of geothermal because there has been little commercial interest in the more than 40 years that it has been considered. It was ascertained in 2016 that exploratory drilling has still not even started. Thus, while interest in geothermal energy should be encouraged, the urgency of a transition to RE demanded by climate change may necessitate an alternate plan that includes grid-connected solar PV. In addition, it is assumed that improvements in energy-efficiency will compensate for any further growth in consumption on the main Viti Levu grid beginning in 2020. This would make the main grid close to 100 per cent renewable by 2030.

The bulk of the financing for the PV grid conversion would likely come from international climate-change funding sources for mitigation, since it is unlikely that such funding could easily be available from current market mechanisms due to the low cost of grid-based electricity in Fiji. However, market-based funding for IPP ventures, if they can be encouraged, would have the advantage of freeing funding from aid sources for other priorities.

Off-grid Options: Off-grid options using PV, on the other, hand are currently economical and can be provided by the market with assistance from the Government in terms of research, training and community interaction.

Contrary to the SE4ALL report suggests that fuel-efficient smokeless wood stoves in rural areas are a good option for recucing of emissions reductions in cooking because they are CO_2 emissions neutral.

Energy Efficiency

The current energy-efficiency program initiated by the Department of Energy should be continued with additional funding obtained from international climate change mitigation funding, as indicated in the NDC. The draft Fiji National Energy Policy (NEP) has put forward the suggestions below:

- Continue to increase public education and awareness of energy-efficiency by providing targeted information to end-users on the range of energy-saving technologies and options available. Develop enforcement protocols where appropriate.
- Extend the current system of energy labelling and minimum energy performance standards to all widely imported electrical appliances and industrial equipment that contribute substantially to energy demand.
- Develop and implement an energy information database, so that demand-side data is collected and analysed, and a verifiable data trail is created upon which energy savings can be verified. This database will be integrated with other supply-side energy information databases where possible.

In terms of a way forward, the barriers that need to be overcome include: training of personnel to undertake energy-efficiency audits across the commercial and industrial sectors and secure up-front funding to put in place the energy audit recommendations.

Transport Sector

Mitigation in the transport sector can be of several types:

- Fuel switching to either biofuels or electric vehicles;
- Mode switching to non-motorised transport (walking and bicycles) or public transport options (buses and trains); and
- Reducing vehicle numbers by introducing quotas, differential tariffs and/or improving vehicle efficiency using fiscal incentives.

The draft Fiji NEP has the following suggestions in terms of mitigation:

- Promote the fuel efficiency of imported motor vehicles in order to reduce petroleum consumption. This includes continuing to enforce age limits for second -hand vehicles and provide import tax incentives;
- Investigate the potential and cost-effectiveness of energy efficiency and renewable energy solutions for sea vessels, including biofuels, solar and sail-assisted sea transport and efficient motors, vessel design, and improved maintenance models to improve the overall efficiency and reduce fuel consumption in sea transport within Fiji; and
- Support the development and implementation of the Department of Transport's land and marine transport policies that encourage a shift towards more energy-efficient forms of land and sea transport.

Biofuels: Fiji has had a long history researching the use of biofuels, starting as early as the 1970s at USP. Unfortunately, the economics of such a transition has always been out of reach because the revenue obtained by selling the source material as is (i.e. as sugar or coconut oil) has always been greater than the equivalent in imported liquid fuels. The transition looked more promising when the price of oil went to US$147 per barrel in 2007, but since then the price of oil has fallen to below US$50 per barrel, making the economics of using biofuels again difficult. The current price advantage could be reversed by a significant carbon tax, but this would be a politically unpopular decision that would be contrary to the present Fijian Government action of reducing the price of transport fuels by lowering the VAT. Nevertheless, biofuels are an option that should be watched as other countries take the lead in biofuel developments (e.g. Brazil).

In this respect, the Fiji Department of Energy has taken the lead to prepare the establishment of Fiji's Bio-fuel Industry Development Programme. The Department recognised that it is scientifically proven that coconut oil and ethanol from sugar have great potentials to meet the fuel demand for Fiji. Results from this preparatory assistance phase would determine the design of project implementation that would maximise cross-cutting benefits on environmental sustainability (through climate change mitigation while ensuring biodiversity conservation) and sustainable development (through financial savings on reduced imported fuels, employment opportunities, and reduced urban migration). The Biofuel Development Unit was approved by the Fiji Cabinet and established in September 2005 with the assistance from the United Nations Development Project (UNDP) as requested by the Government of Fiji. The responsibilities of Biofuel Development Unit are to:

- Establish biofuel standards;
- Biofuel testing trials;
- Coordination of Government and private sector efforts in ethanol and biodiesel production; and
- Coordinate the development of a wider biofuels industry in terms of the policy framework and legislation.

In terms of ethanol production, the Fiji Sugar Corporation (FSC) is currently working with the Department of Energy on a plan to include an ethanol production facility at the Rarawai Mill.

Electric Vehicles: Electric vehicles are an attractive option globally for reducing emissions as they allow the public to continue their ownership of private vehicles but without emissions from the use of such vehicles. The first all-electric vehicle was imported into Fiji in 2015: A Zippee three-wheeler seen below. In terms of promoting electric vehicles, a trial of more conventional models could be pursued by the Government. A clean vehicle expo was also planned for Fiji in mid-2017 to showcase sustainable transport options from various countries.

Hybrid Conversion: Another attractive option would be to set up a conversion facility in Fiji to utilise the current (2015-2016) influx of hybrid vehicles. The number of such vehicles is anecdotally said to be increasing at around 1000 per month (2016) as the duty-free status on second-hand hybrids is due to finish in January 2017, and the rush to secure the cheaper imports has been swamping the ports and the car yards. The battery packs in many of these vehicles are likely to be around 10 years, and so any vehicle older than 2006 is likely to have a reduced capacity battery. There are conversion kits becoming available in the market to convert the hybrid into a fully-fledged plug-in electric vehicle. Such a conversion for private vehicles would be appropriate as taxis usually have too high a daily km travel to facilitate such an action. It might be noted that new hybrids and plug-in vehicles will be still duty-free after the expiry of this tariff for second-hand vehicles in early 2017, but the high cost of the new vehicles has meant significantly smaller numbers are imported.

Improve Public Transport: Fiji has a well-developed public transport system based on buses, minibuses and taxis. As will be seen below, there are currently financial incentives to import fuel-efficient buses into Fiji. Unfortunately, the efficacy of public transport is being hindered by congestion on the roads due to increasing private vehicle numbers and poor road infrastructure. While improving the infrastructure will assist in the short term, it is also likely to increase vehicle usage, which in the longer term will negate the improvements. A better option would be to mode shift to off-road public transport systems at least on the most congested routes such as the Suva-Nausori corridor and Nadi-Lautoka. Fiji has an existing rail transport system on the western side of Viti Levu to service the sugar industry that could be used to extend the system to provide passenger transportation. It is recommended that a formal study be undertaken to investigate this option.

Reducing Vehicle Numbers and Changing Vehicle Types to Energy-Efficient Types

The Government had been moving in the direction of using import concessions to change vehicle types. The SE4ALL report mentioned several fiscal initiatives for the transport sector in the 2009 budget, including:

- Motor Vehicles: To assist low and middle-income earners in purchasing new fuel-efficient motor vehicles, the fiscal duty on new motor cars and other passenger vehicles with the capacity not exceeding 1500cc was reduced from 32 per cent to 15 per cent. The vehicle age limit for used or reconditioned motor vehicles imports was reduced from 8 years to 5 years. These measures will also assist in reducing fossil fuel imports and minimise pollution.
- New Buses: Duty concessions are currently available for all buses with Euro4 and Euro3 engines and for LPG taxis. To improve quality and safety of public service transport, the fiscal duty on new buses for the transport of 23 persons or more was reduced from 32 per cent to 5 per cent, and import excise was reduced from 15 per cent to 5 per cent. All bus proprietors were encouraged to take advantage of this reduction as soon as possible in order to reduce fuel consumption in public transport.
- New Trucks: To facilitate the availability of affordable transport for commerce, the fiscal duty on new trucks of gross vehicle weight not exceeding 3 tons was reduced from 32 per cent to 15 per cent.

Timeline for vehicle Tax Changes in Fiji:

- In 2014 electric vehicles were made duty-free.
- In 2015 all hybrid vehicles were given duty-free status encouraging the importation of these vehicles.
- 2016/17 budget: In 2016 the new budget changed the tax structure for imported vehicles somewhat including an incentive package for those that invest in setting up electric vehicle charging stations.

Forestry Sector

As discussed in the Mitigation Chapter, the forestry sector is currently managed by the REDD+ program. Funding for this program is mostly from the World Bank, GIZ as well as the Fijian Government.

Future Options: The key to longer-term mitigation in the forestry sector is to encourage the planting of native species rather than short term plantation species such as pine and mahogany. Unfortunately, it has been difficult to get landowners to plant such species as they prefer the quicker growing varieties in order to get a quicker financial return. It is likely, however, that some form of financial incentive would be needed to facilitate such a change to planting long life native species. GIZ estimates that by 2030 natural forests will be net a negative in emissions to the tune of around 0.7 million tons CO_2 with an average reduction of around 0.56 million tons over the decade 2020-2030.

Technology Options for the Adaptation Sectors

Environment (Biodiversity/Ecosystem) Adaptation Technology Options

The Fijian Government continues to engage with conservation-focused non-government organisations through Memorandum of Understandings in the implementation of programmes and activities under the National Biodiversity Strategies and Action Plan (NBSAP). This includes, among others, establishment and management of community-managed marine areas; establishment and management of national heritage sites; establishment and management of protected area sites; 'reef to ridge' concept of development and sustainable use of resources; protection of Fiji's flora and fauna and forest conservation initiatives under Reducing Emission from Deforestation and Forest Degradation (REDD+). The achievement of the objectives for these mentioned strategies can only be realised if appropriate technologies are utilised to support their implementation. Managing and sustaining Fiji's environment over the years have been made possible by engaging software and orgware technologies. The development of policies and plans, implementing ecosystem-based adaptation, conducting Integrated Vulnerability and Adaptation Assessment (IVA) and engaging other software and orgware technological options have created an enabling environment for Fiji to manage its land and water-based ecosystems and maintain the biodiversity of these ecosystems.

Ecosystem-Based Adaptation (EBA)

Natural ecosystems benefit people in many ways, from regulating local climates to providing clean drinking water. The benefits supplied by natural ecosystems are collectively referred to as ecosystem services. While these services provide the basis for the livelihoods of many societies and play an important role in ensuring food, water, and energy security, they are also fundamental tools in climate change adaptation. Essentially, EBA addresses the crucial links between climate change, biodiversity, ecosystem services, and sustainable resource management. In this respect, the concept of using ecosystems as a basis to adapt to the impacts of changes in climate has gained momentum in recent years and has now emerged as an important technology in adaptation. Like Community-Based Adaptation (CBA), EBA has people at its centre, and it uses participatory, culturally appropriate ways to address challenges, with a stronger emphasis on ecological and natural solutions.

Fiji's National Climate Change Policy recognises EBA as a technology to build the resilience of communities to climate change and disasters. There is a need for a paradigm shift towards integrating EBA into development, climate change adaptation responses, natural resource management policy and planning processes. In Fiji, the new regional Pacific Ecosystem-Based Adaptation to Climate Change (PEBACC) project that is implemented by the Secretariat of the Pacific Regional Environment Programme (SPREP) uses the EBA approach for community adaptation.

Other Technology Options

Other technology options to be explored to improve the resilience of Fiji's environment include:

- Ecosystem restoration and protection approaches and technologies to restore or rehabilitate ecosystems.
- Sharing and documenting traditional knowledge as a software technology for conservation.
- Carrying out education and awareness programs on the roles and importance of Fiji's ecosystems.
- Development of mangrove ecosystem restoration/ management strategies for the protection of coastal areas from storm surges, erosion and also to filter sedimentation/ siltation from the land.

Table 59: Summary of proposed technology types for environment

Technology type	Hardware	Software	Orgware
Ecosystem Based Adaptation.		√	
Integrated Vulnerability and Adaptation Assessment.	√	√	
Ecosystem restoration and protection.		√	√
Sharing and documenting traditional knowledge for conservation.		√	
Carrying out education and awareness programs on the management of ecosystems.		√	
Development of mangrove ecosystem restoration/ management strategies.		√	√

Housing Sector Adaptation Technology Options

Housing is a basic need and a key indicator of development and social well-being of a nation. Past experience has shown that housing contributes to economic growth and employment, and promotes equity and distribution. Housing should provide an environment that is as safe and healthy as possible. Poor housing conditions can be a major cause of accidents and ill health.

With the projected impacts of climate change and natural disasters, there is a need to re-look at housing designs and to invest in the climate-proofing of homes. Housing locations will need to be constructed away from hazard-prone areas. The following technological options are to be considered in order to build the resilience of the Housing sector:

Table 60: Proposed technology types for the housing sector

Technology type	Hardware	Software	Orgware
Review building regulations to improve standards.		√	√
Use of traditional building materials and low-cost construction technologies and increase the choice of materials available to the builders.	√		
Train local builders in new technologies and inefficient construction management.		√	
Review the building codes and standards prescribed to ensure disaster-resistant construction practices and methodologies are used in the construction of new buildings and residential units.		√	√
Survey of settlements to ascertain the vulnerability of settlements in marginal land to climate change, and take adaptation measures to improve their safety including, resettlement, flood defences, sea walls, dykes etc.	√		
Natural defences against climate change such as restoration of wetlands and marshes, minimise storm and surface water runoff by reducing paved spaces, increasing green spaces etc.	√		
Flood-proofing to reduce or avoid the impacts of coastal flooding on structures. This may include elevating structures above the floodplain, employing designs and building materials which make structures more resilient to flood damage and preventing floodwaters from entering structures in the flood zone, amongst other measures.	√		
Wet flood-proofing measures typically include structural measures, such as properly anchoring structures against flood flows, using flood-resistant materials below the expected flood depth.	√		
A dry flood-proofed structure is made watertight below the expected flood level in order to prevent floodwaters from entering in the first place. Making the structure watertight requires sealing the walls with waterproof coatings, impermeable membranes, or a supplemental layer of masonry or concrete, installing watertight shields on openings and fitting measures.	√		

Agriculture Sector Adaptation Technology Options

The climate change agenda for Fiji focuses on using conservation and environmentally sound agriculture technologies for the best use of land and water resources and prepare for possible climate changes. Identification of technology options for agriculture and food security relied on the TNA Guidebook series for climate adaptation for the agriculture sector. These were refined using national documents, particularly the Fiji 2020 Agriculture Policy Agenda and expert consultations. It resulted in the identification of technology options on Table 61 .

Table 61: Proposed Technology types for the Agriculture and Forestry sector

Sub-Sector	Technology	Hardware	Software	Orgware
Organisation	Modern organised agriculture is being proposed for Fiji, which is to adopt the Rural Transformation Centre (RTC) model from India and Malaysia. The RTC has facilities for information on crops, livestock, and aquaculture products, credit assistance desk by partner banks, and information on new agriculture technology. The RTC also includes a farm machinery pool and Geographic Information System (GIS) based management system to be used in the integrated research, training, production and processing system.			√
Modernisation	Agroforestry in the upland areas where the forestry and agriculture sectors converge. There are two technologies that are going to be adopted. These technologies are the Sloping Agriculture Land Technology (SALT) and Line Planting Technology.		√	
Integration	Develop integrated production, processing, energy, and transport infrastructure support system for agriculture. Central to this agriculture infrastructure system is the food park, with the central facilities to be established in Lautoka in Viti Levu and the second food park is to be established in Labasa in Vanua Levu. Smaller specialised food parks for coconut in Taveuni and for horticultural crops in Sigatoka are being envisioned.	√		√
Sugar Industry	A sugar sector revival strategy is currently underway, which focuses on improving on-farm productivity, increasing cane quality, reducing logistics costs, tapping into opportunities for further value addition, and effectively utilising sugar by-products.			√
Coconut Industry	The new planting and replanting coconut program.		√	
	The intercropping between coconut trees through line planting technique is seen as the solution.		√	
	Together with the replanting program, the coconut industry proposes a radical but affordable technological approach in developing the industry in Fiji by opening a development plant right in the community.			√
	The coconut processing plant uses elements of the coconut plant to convert the meat, water, shell, and husks into different viable products for the world market right in the farms at a sustainable scale of 3000-5000 nuts per day.		√	
Pineapple	Processing right in the community using tabletop juice processing and dehydration are good options to be pursued.	√		√
Root crops	Root crops for export require cold storage for more efficient post-harvest handling.		√	

Sub-Sector	Technology	Hardware	Software	Orgware
Fruits and vegetables	The availability of commercial nurseries that will support the planting of fruits must be put in place.		√	
	The need for tissue culture laboratories that can be even commercially operated.		√	
	In enhancing flowering of mangoes and other fruits, flower inducing technologies must be applied using a sustainable system.		√	
Rice	Rehabilitation of existing irrigation systems.		√	
	Introduction of hybrid rice and quality rice like the Basmati variety is worth exploring both for the tourism sector and export markets.	√		
Beef, dairy & small ruminants	Chilling centres can be expanded to become the RTCs.			√
Kava and other Nutraceutical Crops	Processing support for extraction and processing into different value-adding products like drinks.		√	
Aquaculture	Establishment of aquaculture complex with integrated operations from hatchery to fish processing and marketing.			√
	The proposed integrated fisheries business is a model that can be replicated nation-wide for the culture of tilapia, milkfish and other fish species that are grown in commercial aquaculture that have export market.		√	
Marine and coastal ecosystems	Hard defences are the traditional approach to coastal defence. Examples of hard defences include seawalls, sea dykes, revetments, armour units and breakwaters.	√		
	Soft engineering technologies such as beach nourishment and dune building.		√	
	Promotion of community fish ponds for small scale farmers as a way of increasing the fish resources. Preservation of mangroves areas, coral reefs, and other coastal zones.		√	
	Using high-resolution satellite imagery and Global Positioning Satellite (GPS) technology. Satellite technology is also used to detect harmful algal blooms that can smother reefs and to monitor elevated sea surface temperatures, which can cause coral bleaching.		√	√
	Legal framework to improve watershed management to reduce river bed and bank stability. Legal framework for more rigid development conditions to restrict development on dunes and foreshore areas.			√
	Deployment of modern and efficient surveillance, prediction and information system of climate and environmental key factors at regional and local scales, supporting fishing, aquaculture and ecotourism activities, as well as fisheries adaptive management based on long-term prevision under climate change scenarios.=			√
	Adjustment of the institutional framework (legal, regulatory and organisational) to facilitate EBA for the coastal marine domain at country-level and to implement an Ecosystem Approach to Fisheries (EAF) including artisanal fishing.		√	√

Sub-Sector	Technology	Hardware	Software	Orgware
Forestry	Planting and tending drought-resistant trees with edible fruits to enhance food security and nutrition, reduce erosion and provide an additional source of fuelwood.		√	
	Biotechnology is widely used in forestry such as plant cutting, tissue culture, cross-breeding, and development of native species. Techniques to develop new genes that define resistance to pest and diseases have been applied successfully in Fiji and achieved some results. Crossbred or native species that can tolerate drought and resist diseases have been created.		√ √	
	Local knowledge and associated forest management practices have sustained local and indigenous communities throughout the world under changing environmental, social and economic conditions, long before the advent of formal forest science and 'scientific' forest management. Local forest-related knowledge is usually closely linked to traditional land-use practices, local decision-making processes and governance institutions, and beliefs about the relationships between community members and forest environments.		√	
	An early warning system to protect the forest from fires or burning. The system will help keep track of current climate developments, support seasonal forecasts, and help improve analyses of climate trends and risk factors. This information will be vital to help the Fijian community respond to climate change impacts too.	√		
	GIS applications to support the operational forestry industry. The applications satisfy a range of requirements including strategic planning, tactical planning, database development and maintenance, forest economics, timberlands investment, timber sales and operational activity tracking.	√		
Seeds	Fiji seed policy must be primarily directed toward the establishment of a local seed industry which engages in seed production, explore the production of seeds particularly in disease-free islands of the country for outsourced production, and ensure the availability of seed and planting materials for biodiversity.	√		√
	The nursery and tissue culture laboratory support to ensure the availability of planting materials.		√	
Feeds	Expansion of areas planted to corn, the use of cowpea as a rotation crop after rice and the planting of leguminous crops within the existing cropping systems.	√		
	Sweet sorghum, a grass crop similar to sugarcane which can be used as a feed crop, ethanol crop, and biomass crop is an option in the sugarcane belt.	√		
	The existing feed mill plant in Koronivia must be activated in partnership with the private sector using a toll milling concept.	√		
	Research support to the feed crops industry also includes feed formulation and the trial of improved varieties of the identified feed crops, cowpea for instance.		√	

Other Agriculture Activities

Other climate change agriculture activities focus on the management of natural resources. In areas where soils are prone to water-logging, new drainage techniques can get rid of floodwaters more rapidly; while in dryer villages, particularly the outer island, rainwater harvesting is important. More effective management of soil carbon, precision application of fertilisers and nutrient and the use of energy-efficient machinery all play a part in the community. The primary goal of all the interventions is to help farmers to be prepared and ensure better productivity when facing climate change, thus ensuring food security. More important, however, is that farmers are also contributing to the broad goal of climate change agriculture, which is to decrease GHG emissions.

Fiji must also focus on the training of the trainers. The trainers then must be equipped with knowledge on soil, land, and water conservation technologies, efficient and effective use of fertiliser, agroforestry, and other climate change cropping systems. Farmers from different communities, researchers from different disciplines, non-governmental organisations and other partners must also work together to experiment on the application of different cropping systems. This effort then shows how food security and resilience can be improved in preparation for climate change and at the same time, suggests ways in which smallholder farmers are able to adjust their agriculture practices.

Soil, Water and Fertiliser Technology

Land management technologies - The land use management practices priorities for research, extension and training programs cover balance fertilisation, intercropping, multiple cropping, use of microbial fertiliser, and use of other technologies.

Cropping systems using legume as feed crop - Cowpea (Vigna Unguiculata) is an important grain legume throughout the tropics and subtropics that must be given attention in Fiji because of its value as a feed crop for the livestock and poultry industry. It has some properties which make it an ideal cover crop. It is drought tolerant and can grow with very little water. It can fix nitrogen and grows even in very poor soils. It yields eatable grains and can be used as animal fodder, rich in protein.

Designing cropping systems in such a way that the soil is almost permanently covered with plant canopy is an option, particularly in rice areas and other suitable areas. In arable crops, careful timing of sowing and planting can help to avoid uncovered soil being washed away during the rainy season. After the main crop is harvested, a green manure crop may be sown. On slopes, crops should be grown in contour lines across the slopes (along the contour lines) rather than vertically. This can contribute enormously to reduce the speed of surface water.

Fertiliser and nutrient management - The judicious use of fertiliser, based on site-specific recommendation, is an important policy option rather than subsidising fertiliser. In case there is a program to support the fertiliser needs of farmers, bulk blending, timely application of fertiliser, use of microbial fertiliser, and micro-nutrient management must be incorporated and supported through research.

Forestry and Agriculture Convergence

The physical convergence of the forestry and agriculture sectors are in the upland communities that are now under population pressure for agriculture production. Poor land -use practices however, affect the long term soil fertility due to erosion and continuous crop cultivation. The water and river systems are also affected. Agroforestry is the ultimate solution to address these problems. This strategy eventually becomes the operating system for forestry and agriculture convergence.

Fisheries and Agriculture Convergence

Fisheries and agriculture converge in the use of water and land for aquaculture purposes. The RTCs and the Farmer Field Schools (FFS) can be used in transforming the resources for technology transfer and other support services in profitable aquaculture ventures. Since in most cases, the same farmers engaged in crop and livestock production are also the target groups in the aquaculture ventures, the Ministry of Agriculture must focus on community mobilisation and supplemental technology transfer functions. One business model that the agriculture and fisheries can converge on is the establishment of aquaculture centre that serves as RTC for the aquaculture industry.

Transportation Sector Adaptation Technology Options

Climate change impacts from changes in precipitation and temperature patterns can stress infrastructure beyond design capacity. Changes in temperature averages and extremes will increase the incidence of the road surface, bridge, and embankment damage and failure, while also changing the requirements for maintenance, passenger comfort, and aircraft take-off. Higher moisture can lead to drainage system overload, migration of liquid asphalt, and impact on tunnel foundations. Extreme events (e.g., fires, floods, landslides, mudflows) and accompanying debris can shut down roads and bridges permanently or temporarily. Specific transportation risks include more flooding, which can threaten the safety of roads, landslides, windstorms and inundation of low-lying transportation infrastructure in coastal regions and particularly in the two major islands in Fiji. Most of the transport infrastructure in Fiji, mainly roads, bridges, airports, and wharves are built-in or near disaster-prone areas and are not designed to accommodate the anticipated rise in sea-level and other extreme climate events. The following technological options have been identified that can reduce impacts of climate change and disasters in Fiji.

Table 62: Summary of Technology Options for the Transport sector

Response	Proposed Technology	Hardware	Software	Orgware
Improving the durability of road surfacing material (through the use of warm-mix asphalt or engineered cementitious composite.	Combinations of different materials in warm-mix asphalt can reduce cracking, rutting and other damage caused or aggravated by dramatic increases in temperature extremes and precipitation.	√		
Improving the resilience of ports.	Active motion dampening systems.	√		
Managing transportation with technology.	Intelligent Transportation Systems (ITSs) have the potential to provide adaptation benefits for road conditions monitoring and disaster preparation, management and recovery.	√		
Other Transport Sector Adaptation Options.	Improved bridge conditions in the rural areas.	√		
	Best early warning system for seafarers.		√	
	Climate-proof infrastructures (roads and bridges).	√		

Tourism Sector Adaptation Technology Options

The tourism industry has a key role to play in confronting the challenges of climate change. The spectacular growth of tourism provides both a challenge and an opportunity. The tourism sector itself has responded to this challenge over the past few years and visibly stepped up its response to climate change. There is now a clear understanding that the industry can be part of the solution to climate change by reducing its GHG emissions as well as by helping the communities where tourism represents a major economic source to prepare for and adapt to the changing climate. Tourism plays a substantial role in the livelihoods of these coastal communities and is directly or indirectly exposed to the coastal vulnerability that in turn, increases the effects on poor communities that rely on tourism. The technological advancements that can be considered for the resiliency of the tourism sector are presented in the table below.

Table 63: Summary of the technology options for Tourism Sector

Climate Risk	Proposed Technology	Hardware	Software	Orgware
Tropical cyclone	Cyclone-proofing of buildings.	√		
	Insurance to transfer risk.		√	
	Warning system in place and preparedness (evacuation plan, texting etc.).			√
Coastal erosion and beach loss	Structural barriers are levees, dykes, sea walls, and other artificial barriers built along the coast to hold the shoreline in place or to shape the interaction between the sea and the land.	√		
	Beach nourishment and dune construction.	√		
	Mangrove rehabilitation.		√	
	Use traditional knowledge practices such as weaving together "magimagi" as coastline armour.		√	
	Diversify tourism product away from "the beach", e.g. ecotourism /cultural tourism.			√
Coral reef bleaching	Mangrove rehabilitation to reduce sedimentation.		√	
	Conserve reefs and enhance their resilience.		√	
Reef damage	Artificial reefs	√		
	Marine Protected Areas		√	
Sea flooding/ Storm surge	Setting back of structures, sufficient height of buildings (Enforce the 30 m set-back).		√	
	Natural shelterbelt (e.g. coconut trees)		√	
River flooding	Constructed wetlands	√		
	Land Use Plans		√	
	Dredging	√		
Droughts and water shortage	Rainwater storage facilities	√		
	Water conservation technologies	√		
	Compost toilets		√	

Water Sector Adaptation Technology Options

Climate change impact on water resources can be divided into three categories: (i) too much water (increased flooding), (ii) too little water, and (iii) degraded water quality (because of saltwater intrusion). Fiji's climate is projected to experience more extreme dry and wet conditions, forcing communities to cope with floods and droughts. Both extremes can result in water stress.

Table 64: Summary of technology options for the Water Sector

Response	Technology	Hardware	Software	Orgware
Improving water quantity	Rainwater harvesting with relatively simple technology which comprises a variety of techniques for collecting and storing precipitation in wells, cisterns, or reservoirs.	√		
	Emerging technologies available for treating collected rainwater include nano alumina and photodisinfection.	√		
	UV treatment of water also has the potential to be a very promising technology for water disinfection in the future and should be monitored.	√		
	Surface or aboveground water storage can take the form of reservoirs, cisterns, tanks, or ponds.	√		
	Desalination can make saltwater or brackish water suitable for human consumption, and other uses.	√		
	Water Safety Plans.		√	
	Post Construction Support (PCS) for community-managed water supplies.			√
Improving water quality (through wastewater treatment)	Wastewater treatment and source water protection.	√		
Reducing inland flooding	"Gray" stormwater management.	√		
	Structural barriers to flooding including armoring.	√		

Health Adaptation Technology Options

The country faces many health risks from water contamination and water shortage due to erratic rainfall, food insecurity and increases in water-borne and vector-borne diseases, such as diarrhoea, skin infections, Gastroenteritis, Dengue, fish poisoning, and Ciguatera.

More intense cyclones, floods, heatwaves and drought can add to the direct risks to human health through exposure to extreme events or increase in indirect risks such as deterioration in water quality, reduction in water available for domestic use (thus increasing water hoarding) and decline in food production due to drought. The technologies assessed that can help minimise these impacts, are discussed below.

Lessening the Impact of Changes in Vector-Borne Diseases: An integrated vector management approach has shown significant promise in Asia. Reinforcing and expanding the distribution of long-lasting insecticidal bed nets (LLINs) into the targeted at-risk group (e.g. pregnant women, young children) can serve health intervention in light of climate change impact. Polyester, polyethene, or polypropylene LLINs are treated with pyrethroid insecticides at the time of manufacture. Users are protected not only by the physical barrier but also by the insecticidal action of the net. It is very cheap and easy to use, and about 250 million has been distributed worldwide in recent years.

Biological control may be successful in PICs, especially in Fiji. Current works by the Ministry of Health and Medical Services include Wolbachia and Sterile Insemination Technique(SIT). These techniques, however, would rely a lot on support for medical entomology, technical infrastructure and financial support to effectively sustain the program. The use of the SIT relies on the application of ionising radiation as a means to effectively sterilise insects without affecting the ability of the males to function in the field and successfully mate with wild female insects. Ionising radiation is the sole technology that can be used to achieve these twin goals of sterility induction, coupled with effective field performance. This method is integrated with a whole suite of complementary measures that ensure success in reducing or eliminating vector populations. This complementarity is achieved through collaboration with other specialised organisations and where necessary, using in-house Research & Development. The Wolbachia Technique, on the other hand, uses naturally occurring bacteria, called *Wolbachia*, to reduce the ability of mosquitoes to transmit vector-borne diseases such as Dengue, Chikungunya and Zika. The approach has been successful in laboratory tests and open field trials with dengue-affected communities.

The Wolbachia approach can be implemented in 2 ways, including the *Suppressant Technique* and the *Replacement Technique*. While the suppressant technique aims at causing the Wolbachia to reduce the mosquito population by hindering reproduction, the replacement technique, on the other hand, would cause the Wolbachia to hinder the viruses from growing inside the mosquito and being transmitted between people, without influencing the mosquito population. The method is self-sustaining and has the potential to transform the fight against life-threatening vector-borne diseases.

Incorporating Advanced Information Technology into the Health Sector: As projected climate change, may allow some diseases to spread more easily. The technologies used to detect and prevent disease transmission are likely to be even more useful and beneficial. Disease surveillance systems refer to various types of advanced information and communication devices and applications that can assist health professionals in collecting, processing, interpreting and disseminating data more efficiently to support infectious disease monitoring and response. The following specific types of technologies are needed in this regard:

- Novel data sources, especially sources, mined through the use of new digital or automated collection methods. These include, among others, queries from internet-based search engines and data from social media applications (e.g. Twitter);
- Communication tools (e.g. networks, information aggregators, health-specific search engines, centralised data repositories) for use within the health community;
- Geographical Information System (GIS) for visualising spatial relationships and changes over time-related to disease distribution and risk factors;
- Hardware and software options to support data collection, storage, management and analysis, including point of care handheld communication devices for facility and field reporting, remote sensing equipment, predictive spatial and space-time models and simulation of software and data packages;
- Decision support systems. Tools for storing, managing and analysing disease surveillance data must accommodate a wide range of data types, including entomological surveillance data, pathogen data, and data on control activities (e.g. vaccination and education campaigns);
- Expansion on EWARS (Early Warning Alert and Response System) from pilot sites; AKVO or Qualtrics or Prime utilisation for collecting, storing, managing

and analysing health data; support for tools used in HeRAMS (Health Resources Availability Monitoring System) and WASH in health facilities;

- Technical guidelines and appropriate tools for diagnosis, detection, control, prevention and treatment of diseases (Dengue, Diarrhoea, Typhoid, Leptospirosis), injuries and other food and fish poisoning (Ciguatera) illness arising from climate change;
- Provide active support for entomological surveillance, reporting, monitoring and analysis of mosquito vectors and rodents (this includes modern traps for mosquitoes and rodents and suitable laboratory for the lab protocols); and
- Pursue Early Warning System for Dengue, Leptospirosis, Typhoid and Diarrhoea outbreak with the use of vector data, disease data and climate data.

Protecting Drinking Water Supplies from Contamination: Technologies that can be explored to prevent water contamination after extreme events include: the types of flood-proof sanitary latrines and urine-diverting dehydration toilets, which store faecal matter in waterproof chamber and collect urine separately; pit latrines, including pour-flush latrines, simple(or double) pit latrines, ventilated pit latrines and composting or dry latrines, ecological sanitation (EcoSan) composting latrines, which store urine and compost faeces for use as fertiliser; urine diversion latrines, which separate urine from faeces, allowing the latter to be used as a plant nutrient; and combined-pit latrines, which are shallow and thus more suitable for areas with a low water table.

Other Options: Other technology options that can be explored include:

- Strengthening disaster risk reduction;
- Developing or improving disease early warning system;
- Facilitating rapid and accurate disease notification;
- Integrated vector management;
- Providing clean water, improving sanitation and household disinfection;
- Health vulnerability assessments;
- Prioritise health adaptation activities;
- Climate proof water, health and sanitation infrastructure;
- Vector-borne disease-Vector control and vaccination;
- Water-borne Disease-Molecular screening of pathogens improved water treatment and sanitation;
- Early warning systems are, in most instances, timely surveillance systems that collect information on epidemic-prone diseases in order to trigger prompt public health interventions. However, these systems rarely apply statistical methods to detect changes in trends or sentinel events that would require intervention. Most cases rely on an in-depth review done by epidemiologists of the data coming in, which is rarely done in a systematic way. The World Health Organisation is strengthening the existing surveillance systems for infectious diseases, developing early warning systems based on the new concepts and techniques (EWARS);
- Climate data accessibility for its weekly usage with health and disease data;
- Health Impact Assessment tools and Safe Hospital Index assessment support; and
- Assessment tool for emission through incineration of medical waste.

Key Barriers for Technology Transfer and implementation

- Capital: Accessing capital is limited. The capital costs of renewable energy technologies are generally higher than those of conventional technologies. Also, owing to the risks perceived for new technologies, financing costs will tend to be higher.
- Trade barriers: Although many countries are revising their trade policies in order to liberalise markets, substantial tariff barriers remain in many cases for imports of (emission-reducing) foreign technologies, including energy supply equipment.
- Vested Interests: National interest groups such as powerful extraction and construction companies can influence technology choices in favour of conventional technologies.
- Institutional and administrative difficulties: Such difficulties exist in terms of developing technology transfer contracts, which can be a necessity to qualify regional construction companies as potential partners of the entrepreneurship.
- Regional Cooperation: There is a need for greater regional cooperation among developing countries, both in Research and Development work and in the international commercial contracting network.
- Access to information: Developing countries have, in general poor access to information. It is one thing to recognise that the information and technology desired are available but is quite another issue to gain access to them.

- Differing needs: The needs of the developing countries are quite different from those of the developed countries. Developing countries are generally still focused on large capacities of cheap, reliable power with low technical risk and have new technologies as a lower priority. In addition, most developing countries rate development as a higher priority than reducing emissions.
- Economic incentives: Incentives for donors are weak, mainly when energy demand is scarce and scattered. This barrier can be minimised by the additional potential value gained through Joint Implementation/ Clean Development Mechanism schemes.

Information on Education, Training and Public Awareness

Activities Undertaken to implement Article 6 of the Convention, in particular, the New Delhi Work Programme

A number of activities have been undertaken by the Government and its developing partners that are harmonious to article 6 of the convention. Fiji took centre stage of global climate negotiations in assuming the Presidency role at the Conference of Parties 23rd session. This was a milestone of an achievement for a Pacific Island country that had big shoes to fill in continuing the momentum that was established by the Paris Agreement in 2015. Fiji, as President of COP23, helped guide and pursued outcomes and initiatives in its endeavour to seek climate justice for its people and the Pacific as a whole.

Initiatives in the Negotiation Space

2018 Talanoa Dialogue	This inclusive and participatory process allows countries, as well as non-state actors, to share stories and showcase best practices to raise ambition n climate action.
Implementation Guidelines	Progress was made towards clear and comprehensive implementation guidelines for the Paris Agreement.
Historic Breakthrough in Agriculture	Countries reached agreement on agriculture for the first time. This will help countries develop and implement new strategies for adaptation and mitigation within the sector.
Gender Action Plan	The first-ever action plan for gender was finalised with the aim of increasing women participation in all UNFCCC processes and promote the implementation of gender-responsive climate policy at all levels of governance.
Local Communities and Indigenous Peoples Platform	This platform was finalised to enable participation of indigenous people in the climate negotiations to share traditional knowledge and best practices on reducing emissions, adapting and building resilience against climate change.
Adaptation Fund	Fund replenished with a total of US $93.3 million, exceeding the year's funding target by US $13 million.
Dialogue between Governments and Non-State Actors	Dialogue on non-state actors contributing towards more ambitious NDCs and integrating them into the climate negotiation space.
"Suva" Expert Dialogue on Loss and Damage	Endorsement of the rolling five-year work plan of the Executive Committee (ExCom) which will strengthen the Warsaw International Mechanism for Loss and Damage.
Launch of the Fiji Clearing House for Risk Transfer	Online resource to connect vulnerable countries, offering information on affordable insurance and solutions suitable to them.

Global Partnerships

Launch of the Ocean Pathway Partnership	To address and acknowledge the link between climate change and the ocean.
Launch of InsuResilience Global Partnership	US $125 million contributed to launching the InsuResilience Global Partnership for Climate and Disaster Risk Finance and Insurance Solutions
Bonn-Fiji Commitment	"Bonn-Fiji Commitment of Local and Regional Leaders to Deliver the Paris Agreement at All Levels" a pledge to help raise collection ambition for climate action.
Health Initiative for the Vulnerable	An initiative to protect people of SIDS from the health impacts of climate change. Goal: to increase financial support to climate and health in SIDS by three-fold.
America's Pledge	Report on America's efforts to uphold the emissions reduction target under the PA.

Regional Initiatives

Climate Action Pacific Partnership (CAPP)	CAPP conference on 3-4 July 2017 in Suva for accelerating climate action in the Pacific.
Launch of the NDC Regional Hub	The NDC Partnership is establishing a new regional hub to support the implementation of NDCs in the Pacific.
Blue Carbon for the Pacific	Australia will support efforts to protect and manage coastal blue carbon ecosystems in the Pacific. AU $6 million will be provided to strengthen blue carbon data, knowledge and capacity in the Pacific; support its integration into the National GHG accounting and climate policy.
Pacific Climate Finance and Insurance Incubator (the "Drua Incubator")	Pacific Climate Finance and Insurance Incubator- Drua Incubator, Government of Luxembourg to provide initial funding of EUR 1 million for the initiative.
Rural Electrification Fund	Fiji established this fund programme together with the Leonardo DiCaprio Foundation, Sunergise, Fiji Locally Managed Marine Area (FLMMA) network and Electricity Fiji Limited.

In Country Initiatives

Fiji Water and Wastewater Project	Financing arrangements for water supply and sewerage services project worth US $405 million for more climate-resilient infrastructure. Funded through loans from the ADB and European Investment Bank, a grant by the Green Climate Fund and Fijian Government funding.
Low Income Household Insurance	Property insurance for houses of low build quality. The risk will be underwritten by domestic insurance companies. Livelihoods protection insurance for low-income households whose houses are deemed uninsurable. Supported by ADB, World Bank and the International Finance Corporation.
Sovereign Green Bond	Fiji became the first emerging market – and third in the world – to issue a sovereign green bond to support climate change mitigation and adaptation.
Legal Readiness for Climate Finance and Climate Change Act	Fiji is undertaking a review of its legal readiness to implement its NDC, supported by the ADB. In addition, Fiji is looking at what other legal reforms can be undertaken to further support climate action such as the development of a national Climate Change Act.
GCF Accreditation of the Fiji Development Bank	GCF Accreditation of the Fiji Development Bank (FDB) which will allow the bank to apply for funds up to US $10 million for climate action projects.
Launch of the Fijian NDC Implementation Roadmap	NDC Roadmap focuses on electricity generation, transmission and distribution; demand-side energy efficiency; and energy efficiency inland and maritime transportation. Highlights the short, medium and long term renewable initiatives to achieve 100% renewable energy and reduce CO_2 emissions by 30% by 2030.
Launch of the Fijian National Adaptation Plan (NAP) Framework	Fijian Government is approaching its NAP as a continuous, progressive, and iterative process to ensure a systematic and strategic approach to adaptation in all government decision-making.
Launch of the new Ministry of Waterways	A new Ministry of Waterways has been established to address the growing threat that flooding poses to Fijian communities, a threat that is projected to worsen due to the effects of climate change.
Launch of Fiji's Climate Vulnerability Assessment	In 2017, the Fijian Government requested the World Bank to carry out a Climate Vulnerability Assessment (CVA) of Fiji. The CVA launched at COP23 shows the vulnerabilities faced by Fiji, as well as possible solutions to tackle climate change and boost resilience.

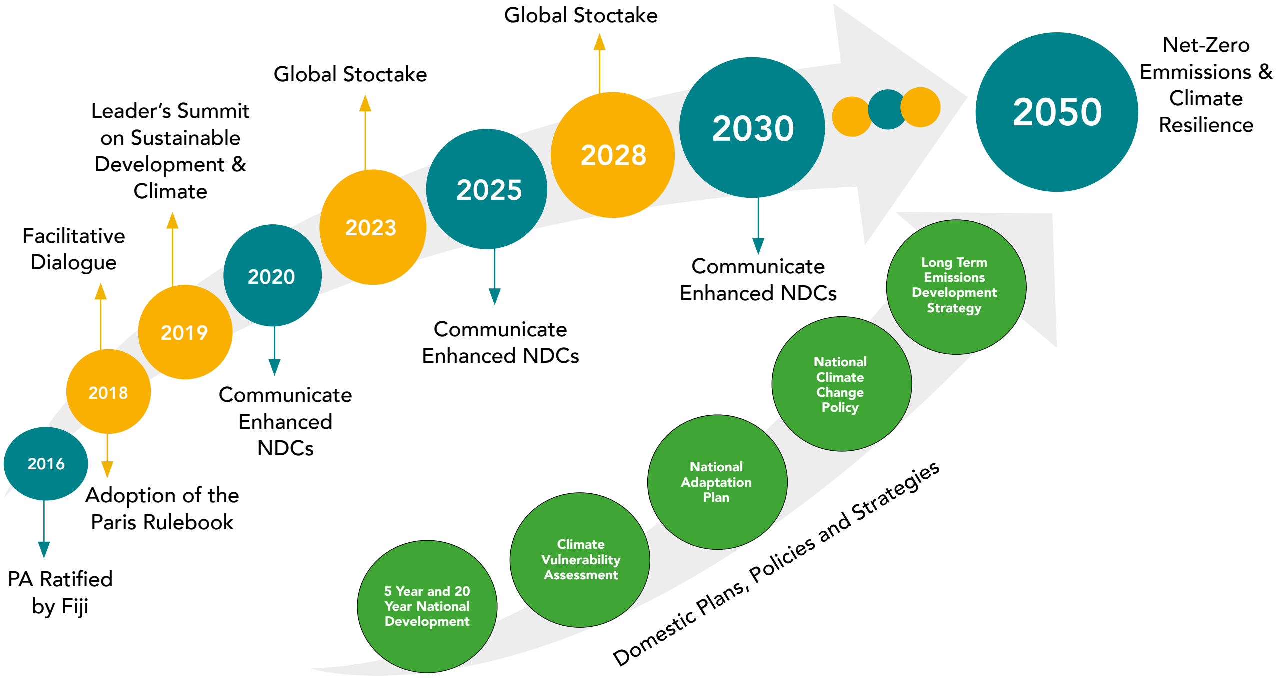


Figure 78: Strategic framework aligned to meet commitments under the UNFCCC

Climate Change Education and Awareness

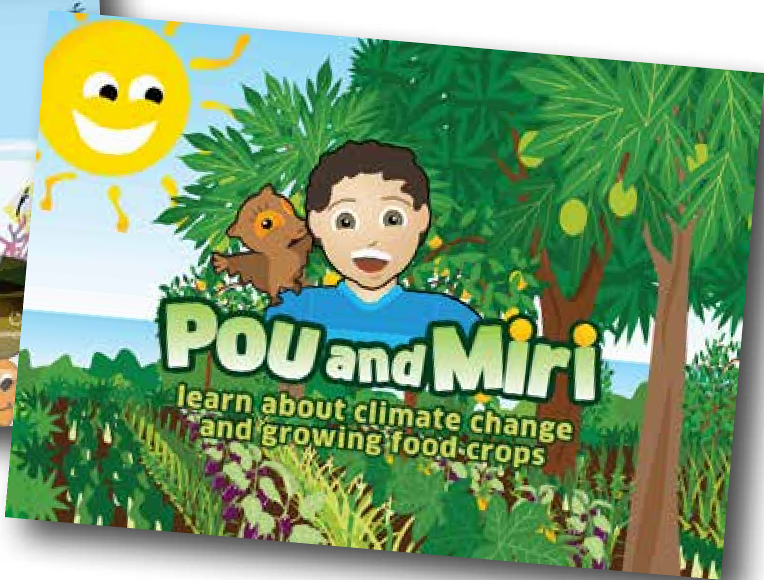
Climate Change Curriculum in Primary and Secondary Schools (Ministry of Education)

Fiji's Education Sector Strategic Plan (ESSP) 2015-2018, aims to provide a "holistic and empowering education system that enables all children to realise and appreciate their inheritance and potential, contributing to peaceful and sustainable national development." In the current curriculum, elements of climate change are addressed in Basic Science (Year 9 and 10), Biology (Year 12 and 13), Physics (Year 12 and 13) and Geography (Year 12 and 13) in secondary education. In Technical and Vocational Education and Training (TVET) environmental changes are addressed in Agricultural Science (Year 9-13).

In 2012 the Ministry of Education (MoE) endorsed a strategy to implement Objective 4 on Training and Education from the National Climate Change Policy (2012) and prior work plans aiming at integrating climate change in school curricula, tertiary courses, vocational, non-formal education and training programmes (including Special Education Schools). Through a series of workshops curriculum development officers have strengthened and integrated relevant content and learning outcomes on climate change and disaster risk management in Basic and Social Science, Commercial Studies, Chemistry, Physics, Biology, English, Urdu, Hindi, Geography, Agricultural Science, Industrial Arts, and Home Economics. The key concepts are introduced in Year 7 and 8, which is later developed in secondary education.

Based on a stock-take of existing and utilised teaching and awareness resources, the children storybook, 'Pou and Miri' has been identified as a useful teaching resource and has been handed over to the Ministry to distribute to all Fijian primary schools (in English and Vosa VakaViti). Other awareness material and activities include:

- An i-Taukei climate change glossary;
- An environmental alphabet poster has been developed with the MoE and Nature Fiji-Mareqeti Viti for all primary school children, showing native animals and plants; and
- MoE, in conjunction with regional SPC/GIZ programme 'Coping with Climate Change in the Pacific Island Region' (*CCCPIR*), has trained 596 primary school teachers in Climate Change Education Trainer of the trainers' programme. The trained teachers are advocates for creating awareness regarding climate change and its effects, the causes, impacts, adaptations and mitigation measures.



Apart from this, MoE has collaborated with SPC/GIZ and several other organisations, including the Australian Government and UNESCO to develop the following resources which makeup toolkits for teachers and are distributed during workshops:

- Resource Book on Disaster Risk Reduction and Climate Change using Traditional Knowledge;
- Picture-based education resource (Flip chart) Learning about climate change the Pacific way and Visual and Teacher Guide Fiji (SPC & GIZ 2014);
- Training material for Climate Change Education (CCE) for Small Island Developing States (SIDS) in the Asia Pacific; and
- 4:47 minutes animation "The Pacific adventures of the Climate Crab" from the Red Cross and the Australian Government's Climate Change Science and Adaptation Planning program.

Fiji Higher Education and Climate Change

The three academic institutes in Fiji play an essential role and contribute positively towards climate change research and development through the various courses and programmes each offer.

USP – The University of the South Pacific

- Postgraduate Diploma in climate change that consists of four 400-level courses.
- MSc in climate change based on a research thesis.
- PhD in climate change based on a research thesis.

FNU – Fiji National University

- Postgraduate diploma programme for Environmental Conservation and Climate Change .

UniFiji

- No specific programs on climate change, however, offers one compulsory course on climate change under the Bachelor of Environmental Science and under Diploma in Environmental Science.

In the build to the COP, the University of Fiji organised awareness sessions with relevant themes to inform and educate the public on climate change issues, and on what the Presidency role would mean for the people, the nation, the region, and world.

Seminar session 1
Theme: Various Adaptation Approaches to Climate Change.

Seminar session 2
Theme: Wave Action and Coastal Hazards in the Pacific.

Seminar session 3
Theme: The crucial function that the world's oceans play in regulating earth's climate as well as the link between sustainable ocean management and its role in mitigating the impacts of climate change on already vulnerable Pacific Island Countries (PICs).

The University also delivered presentations on COP23 and climate awareness at several selected schools and local communities in the Western division.

COP 23

The University of Fiji also holds Eco-contest to create awareness on issues relating to climate and environment in the Pacific by providing a platform for our high school students to learn and share means through which these issues can be effectively dealt with.

Training and Capacity Building

COP Negotiations Training

Training on the UNFCCC negotiating process was provided to the National and Presidency team in the build-up to COP23 and the following negotiation sessions. The training funded through UNDP focused on strengthening negotiators understanding of key issues and how they can effectively part-take in the process. It focussed on developing specific negotiation skills and techniques to lobby and foster national and regional interests.

Green Climate Fund Readiness Programme in Fiji

This project is supporting the Government of Fiji in strengthening their national capacities to effectively and efficiently plan for, access, manage, deploy and monitor climate financing, particularly through the Green Climate Fund (GCF) once it is fully operational.

These activities will be planned and implemented in line with the Fiji National Climate Change Policy. The project will target two important aspects of the GCF approach, access to funds and private sector engagement, both of which will require significant preparatory work before GCF financing will be possible at scale.

The project is financed by the German Federal Ministry for the Environment and Nature Conservation, Building and Nuclear Safety (BMUB) with a funding of US$960,805. The project lifeline is from January 2015 up until December 2018. The implementing partners of the project are the United Nations Environment Programme and the World Resources Institute.

Fiji Women Barefoot Solar Engineers

This initiative, in partnership with the UN Women, Indian High Commission and Barefoot College in Rajasthan India provided the opportunity to women in rural villages in Fiji to become qualified solar engineers. These women are known as “Solar Grandmothers” or “Solar Mamas”. Following the training of the 10 Grandmothers in 2012, the Fijian Government worked together with the Indian Government to start the Bare Foot college program in Fiji. This “Women Solar Engineer” initiative aims to build local capacity and electrify off-grid, remote villages with clean, low-cost solar energy. The initiative at the same time addresses many of the other SDGs, such as: [68]

- Bridging the gender gap by empowering poor, illiterate women;
- Promotes sustainable development outcomes through community ownership;

68 GEF, 2011

- Relieves environmental stress by providing an alternative energy source; and
- Enables improvements in health, education, living standards and quality of life.

Economic Empowerment of Women and the LGBTQI Community in Fiji

Oxfam has been working in Fiji to respond to the growing economic inequality amongst a range of vulnerable populations in Fiji. In collaboration with local NGO partners, Oxfam is supporting women, young people, and LGBTQI people to understand the structures in Fiji that influence decision-making and allocation of resources. The project provides skills-building and mentorship to the target populations and supports access to value chains and markets. A key component of the project is to explore and address socio-cultural factors within the targeted communities that are both barriers and enablers of change to economic empowerment.

Capacity-building activities are also key components of many regional and community-level projects. For example, the USAID Food Security project which aimed to facilitate the development of national and community agriculture-related adaptation response strategies. Capacity-building activities were also carried out under the RESCCUE project to ensure outcomes obtained and management methods introduced remain sustainable. This included:

- Improving knowledge/education, including in law, setting up discussion forums with local authorities, improving the understanding and monitoring of environmental impact assessments;
- Strengthening the provincial Integrated Coastal Management committees; and
- Supporting and co-coordinating national legislation adoption at the provincial level in the provincial policies and sector-based departments.

Information and Networking

Assessment of Current Capacity in Information Communication

While traditional media continues to dominate the Fijian news and information market, websites and other online sources are reaching as many as two-thirds of Fijians, with even higher penetration among young people.

Overall media use: Television and radio are nearly tied for the position of top news and information source for Fijians. 91 per cent of Fijians get at least some of their news and information from television news shows and 90 per cent from the radio.

Thereafter, it's printed newspapers (86 per cent), Internet websites (67 per cent), online social networks and blogs (53 per cent) and printed magazines (36 per cent).

Fijian Government's Digital Transformation Programme (digitalFIJI)

This is a 4-year programme to implement a number of Government applications, enhance the overall ICT infrastructure and build and develop capacity in digital transformation in the Government. The digital Government transformation programme is in line with the Fijian Government's 5-year and 20-year National Development Plan (NDP), which calls for the steady improvement of the quality and accessibility of Government services. A number of initiatives under this programme include:

- Free WiFi hotspot initiative;
- Walesi –digital television platform that ensures that all Fijians have access to the television broadcast, irrespective of where they live; and
- National Framework for Digital Literacy Programme.

Information Sharing

COP23 website – the official website of the COP23 Presidency is a platform to share information about climate change and its effects and learn about the objectives of COP23. It also contains statements and speeches by the COP23 President and innovative climate action initiatives and projects. It is also a medium for communicating particular challenges that climate change presents to Fiji and other vulnerable areas around the globe.

A Climate Change Portal is also under development and is planned to become operational by 2019. The National Climate Change Portal will be an important tool which will feed into the Pacific Climate Portal, which will provide country context information and material. Biennial publication of the climate change newsletter will also continue which will provide key updates on the national level climate change issues and development.

In addition to this, the Pacific Community (SPC) in Fiji also hosts the Pacific Ocean Portal, which provides improved forecasting and real-time data of ocean conditions of any location in the Pacific region.

These are some useful platforms where climate change related information are shared nationally, regionally and globally. Enhancing access to these mediums of communication has been a challenge in the past due to internet network constraints, but this challenge has been improving through programmes and initiative which support enhanced communication and information sharing.

Climate Change Research and Systematic Observations

Fiji's Observational Network

Fiji Meteorological Services (FMS) is responsible for the collection, quality control, processing and archiving of climatological data which are used in a wide variety of global, national and private-sector activities, including the monitoring of climate, climate variability and change.

There are currently 17 climate (single observation at 9 am), 16 synoptic (multiple daily observations) and 35 rainfall-only operational manual meteorological observation stations in Fiji's meteorological network. In addition to these, there are 32 Automatic Weather Stations, 11 telemetered tipping bucket rain gauges and three Airport Weather Observing Stations. Furthermore, there are 24 telemetered tipping bucket rain gauges and 26 telemetered water level monitoring gauges in Fiji's hydrological network. There are three weather RADARS in Fiji, stationed at Nadi Airport, Nausori Airport and Labasa Airport, and one upper air monitoring station. Moreover, a couple of other organisations in Fiji maintain and operate weather observing stations for their own purpose, which includes Water Authority of Fiji, Electricity Fiji Limited, Department of Energy, Natural Waters of Viti Limited, University of the South Pacific and some of the hoteliers. Climate records before 1900 are available for at least six stations or multi-station composites. However, a number of stations have data available from the first half of 1900.

Oceanographic records do not cover such a long time period. Monthly averaged sea-level data are available from Suva (1972–2009 and 1998–present) and Lautoka (1992–present). A global positioning system instrument to estimate vertical land motion was deployed at Lautoka in 2001 and will provide valuable direct estimates of local vertical land motion in future years. Long-term locally-monitored sea surface temperature data are unavailable for Fiji.

Participation in Global Observation Network

The World Meteorological Organization (WMO) has defined a network of stations that make up the core global weather observation systems, the Regional Basic Synoptic Network (RBSN). There are currently 12 stations in Fiji included in the RBSN network (Figure 79). Out of these 12 stations, five are included in the Regional Basic Climatological Network, which is; Nadi Airport, Nausori Airport, Udu Point, Ono-i-Lau and Rotuma. These stations play an important role in providing a good representation of climate on the regional scale, in addition to the global scale. Nadi Airport also contributes to the Global Upper-Air Network observations. Furthermore, Fiji Meteorological Service also contributes to the World Radiation Data Centre in Russia with data from Laucala Bay in Suva and Nadi Airport for research by the international scientific community. Moreover, Fiji also participates in the Comprehensive Nuclear-Test-Ban Treaty (CTBT) observation with a radionuclide station at Nadi Airport.

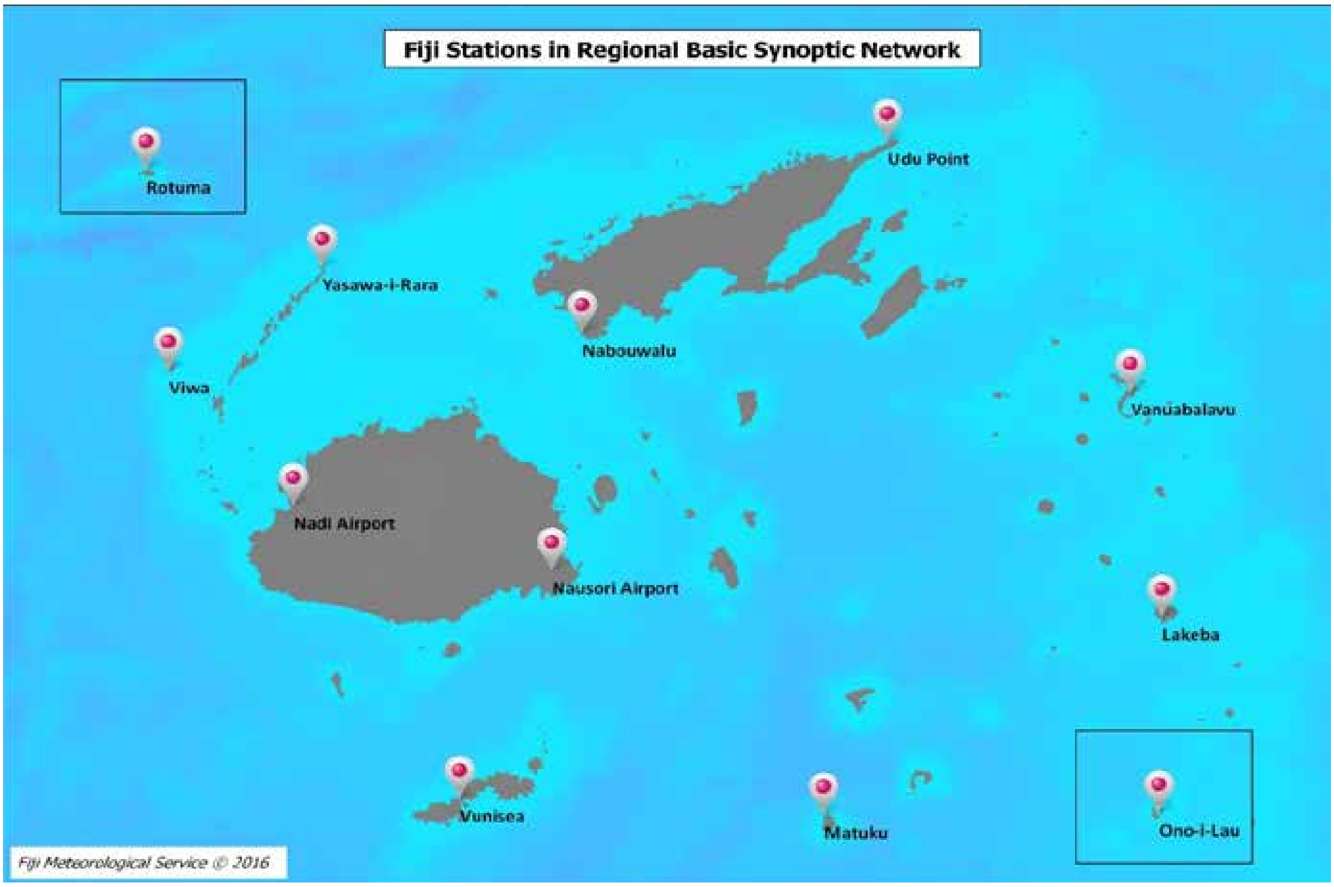


Figure 79: Location of stations in the Regional Basic Synoptic Network.

Research on Climate Change Science

The Australian Bureau of Meteorology (BoM) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO), through the Australian Government-funded Pacific Climate Change Science Program (PCCSP), led the first-ever coordinated research on climate change science in the Pacific and released its landmark publication "Climate Change in the Pacific: Scientific Assessment and New Research" in 2011. This publication was the result of three years of scientific research with the Pacific Islands National Meteorological Services, including Fiji Meteorological Service. This report is an invaluable reference for climate scientists, communities and decision-makers in the Pacific. The PCCSP has filled the climate information and knowledge gap in the region by:

- Collating, digitising and homogenising climate data records for Pacific Island countries;
- Examining past climate observations and trend 21st century based on global climate models;
- Developing a suite of digital tools to improve management, access, modelling and analysis of climate data; and
- Communicating key climate science findings and developing in-country climate science capacity.

Further to work done through PCCSP, research on climate change science of the Pacific continued through the collaboration between the BoM, CSIRO and the Pacific Islands National Meteorological Services under the Australian Government funded Pacific-Australia Climate Change Science and Adaptation Planning Program (PACCSAP). Subsequently, an updated publication, "Climate Variability, Extremes and Change in the Western Tropical Pacific," was released in 2014. This publication provided an updated science-based on further scientific investigations and the new generation of global climate models used in the Intergovernmental Panel on Climate Change Fifth Assessment Report.

Fiji Meteorological Services (FMS) continues to provide the science of climate change to inform various national initiatives on climate change, including adaptation and mitigation projects. More recently, FMS has contributed extensively to Fiji's National Climate Change Policy and National Communications to the United Nations Framework Convention on Climate Change.

In addition to the above research efforts, the University of the South Pacific is also quite actively involved in climate change research through the PaCE-SD program. A number of students have graduated from the University with Doctorate and Master's Degree in Climate Change. Through collaboration with academic and research institutions locally and internationally, a number of research papers on climate change in Fiji have been published in international journals in recent times.

In the past, the Government has also relied on regional organisations such as the Pacific Community (SPC) and the Secretariat of the Pacific Regional Environment Programme (SPREP) to conduct research. Independent research conducted by these institutions has also become a source of information for the Government and other interested parties.

Despite all the above efforts, a considerable gap remains in the scientific understanding of climate change in the region. There is a need for the ongoing delivery of a coordinated, regional programming approach to provide appropriate science-based advice to inform developments and decision-makers. Following the end of the PACCSAP, the Australian Government's funding for climate change research was not renewed. Thus, systematic research on climate change science in the region came to a halt.

Gaps in Climate Change Research

Systematic Observations

There has been a marked decline in the total number of land-based climate observation (measurement) stations in Fiji over the past few decades. These climate measurement stations need to be re-opened and upgraded, and the network needs to be extended. The Fijian Government in recent years has invested a considerable amount of money for Fiji's National Climate Monitoring Upgrade Project (NCMNUP). The main purpose of NCMNUP is to improve and enhance the climate-observing network for Fiji in order to improve or complement studies on climate variability and trends. The Fijian Government has invested more than FJ$1.4 million from 2008 to install a number of Automatic Weather Stations (AWSs) as part of the NCMNUP. However, there remain a lot of data-sparse areas in Fiji.

Fiji has a huge archive of weather data, with data for a number of areas dating back to early 1900s and a few as far back as 1880s. These long set of records are not only a key to understanding climate but can be a cornerstone for accurate climatological predictions and projections. However, a lot of these data are yet to be digitised from its hard copy to useable digital form. The Fijian Government, realising the benefits of the weather data, constructed a purpose-built data rescue and digitisation facility in 2014 for a sum of

FJ$402,767. To this end, the rescue and rehabilitation of observational climate data is expanding the availability of climate data, but requires continnous effort.

The collation of other forms of historical data such as photographs, newspaper records and anecdotal evidence of change, is required to complement the instrumental monitoring of climate change. Given the relatively short duration of the instrumental records, palaeoclimate data also have an important role in extending the climate and sea-level records.

Ocean monitoring in the Pacific Island region, including Fiji, is quite sparse despite the huge proportion of our ocean in relation to land. There are only three sea-level monitoring gauges in Fiji, that is, in Suva, Lautoka and Vatia (Tavua). Some of the areas in which observations lack include: sub-surface properties of the ocean, biological productivity changes and ocean chemistry including acidification. Rescue, digitisation and homogenisation of historical sea-level data are also required to provide a more continuous record of sea-level change. There are even fewer in-situ wave observations in the Pacific Island region. In quantifying the impacts of climate change on the coast in terms of both inundation and erosion, more comprehensive monitoring of shoreline changes and high-resolution elevation surveys are needed throughout the region. To this effect, the Pacific Community and Ministry of Land & Mineral Resources have done some ad-hoc surveys, but there is a need for more systematic assessments.

Understanding Major Climate Drivers

The South Pacific Convergence Zone (SPCZ) is a key climate feature for Fiji. However, the processes governing it are still not fully understood. The El Niño Southern Oscillation (ENSO) phenomena has great influence of year to year variability of Fiji's climate, but there is still a little scientific consensus on how global warming will influence future ENSO events. Continuous research efforts using observational data and improved climate models may improve our understanding of these climate features or drivers.

Climate Change Projections

While climate change projections for Fiji are available through the research work done by the Australian Bureau of Meteorology (BoM) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO), a lot of work is still required to improve projections. One area which requires attention is to improve the science which underpins the projections, for example, a better understanding of processes which governs the SPCZ. This, in turn, is reliant on the availability of quality in-situ and satellite-based observations.

Further effort is required to improve the resolution of Global Climate Models, which can capture large climate variations on small island nation such as Fiji. Greater attention needs to be given to assessing how statistical and dynamical downscaling can complement global climate models. Furthermore, projections of changes in tropical cyclone activities require the use of fine-resolution models which are able to represent small-scale features associated with tropical cyclones.

Locally, there is very limited capacity in the area of climate change projections. Therefore, assistance from bigger research institutions, such as BoM and CSIRO, is necessary to provide the necessary technical guidance and support. A coordinated regionally focused research effort with assistance from advanced research institutions may address research gaps in the area of climate change projections.

CHAPTER 6:
CONSTRAINTS AND GAPS, AND RELATED FINANCIAL, TECHNICAL AND CAPACITY NEEDS

The Second National Communication (SNC) identifies gaps and constraints in terms of the lack of existing frameworks, resources and coordination in addressing climate change. Since the SNC, Fiji has taken a number of initiatives that ensures climate change is mainstreamed into national development planning, setting the basis for climate change adaptation and mitigation activities. This was demonstrated through the formulation of the Green Growth Framework in 2014, the 5-year and 20-year National Development Plan in 2017, National Adaptation Framework in 2017, Fiji's Climate Vulnerability Assessment in 2017 and the current development of the National Adaptation Plan. Whilst adaptation is a key priority, Fiji has also shown commitment in pursuing mitigation, through developing the sector-wide Low Emission Development Strategy and through the implementation of CDM projects.

Financial, Technical and Capacity Needs

The SNC also identifies financial resources as a major roadblock to cater for the technical and capacity needs for adaptation and mitigation activities and long-term investment in research and development. This is an ongoing challenge for the country. However, initiatives such as the Environment, Climate Change Adaptation Levy (ECAL) and the Green Bonds are small windows of opportunity for the country to fund climate change adaptation and mitigation projects, which demonstrates the country's approach to be self-sustaining and the urgent needs for climate action.

Apart from the financial constraints, to implement the interventions in the climate action plans and strategies requires building appropriate implementing capacity. The consideration to conduct a country needs assessment on Fiji's capacity and technology needs for climate actions, identifying gaps, capacity building and technology transfer will be important in bridging the gap between policy and implementation on the ground.

While the National Development Plan serves to mainstream climate change in all areas of development planning and identifies the relevance of different Government programmes to climate change and disaster management, there still exists opportunities to further strengthen monitoring, evaluation and tracking of on-the-ground implementation. This requires stronger inter-institutional coordination and technical capacity across all relevant stakeholders, which includes staff knowledge, training and experience, along with the systems in place required to operationalise climate change policies and strategies.

In light of this, it will be useful to establish data management systems closely aligning to the improvement plan developed under the TNC. A key consideration will be to develop and implement a monitoring/measuring, reporting and verification system to identify the implementation and progress of climate change strategies and policies.

The GEF, Annex II Parties, Multilateral/ Bilateral Contributions

For the preparation of the TNC, GEF provided the financial support of US$500,000 while the Fijian Government was expected to provide an in-kind contribution of US$100,000.

Other than providing support for the TNC, GEF, Annex II parties, bilateral and multilateral institutions have also financially supported climate change activities in Fiji. These include:

- Preparing the iNDC (GEF)
- NDC Roadmap (GGGI)
- Conducting the Climate Vulnerability Assessment (World Bank)
- Conducting the Post Disaster Needs Assessment
- Introduction of Hybrid Power generation Systems in Pacific Island Countries (JICA)
- Feasibility Study for Renewable Energy Project in Taveuni (GGGI)
- Feasibility Study for Renewable Energy Project in Ovalau (GGGI)
- Promotion of Regional Initiative on Solid Waste Management (JICA)
- TC Winston Recovery Support (NZMFAT)
- Upgrade National Disaster Management Office and Emergency Operation Centres (NZMFAT)

The total official development support for the country is presented in the Table 65.

The new foreign policy in 2015 presented the opportunity for a new alliance with non-traditional partners, and the return to parliamentary democracy led to re-engagement with traditional partners.

The Figure 80 shows the total fiscal budget related to climate change and resilience. There has been a steady increase in climate change spending since 2013 and a more sharp increase in 2016 which is primarily due to recovery efforts post TC Winston and further recognising the need for building resilience to future climate impacts.

Table 65: Total Official Development Assistance

ODA	2013		2014		2015		2016-2017		2017-2018	
	($M)	per cent	($M)	per cent	($M)	per cent	($M)	per cent	($M)	per cent
Cash Grants	4.9	3.2	9.5	9.2	6.1	4.4	4.9	3.5	35.6	18.7
Aid-in-Kind	146.9	96.8	94.1	90.8	133.2	95.6	135.8	96.5	155.0	81.3
Total ODA	151.8	100	103.6	100	139.3	100	140.7	100	190.6	100

Source: Ministry of Economy

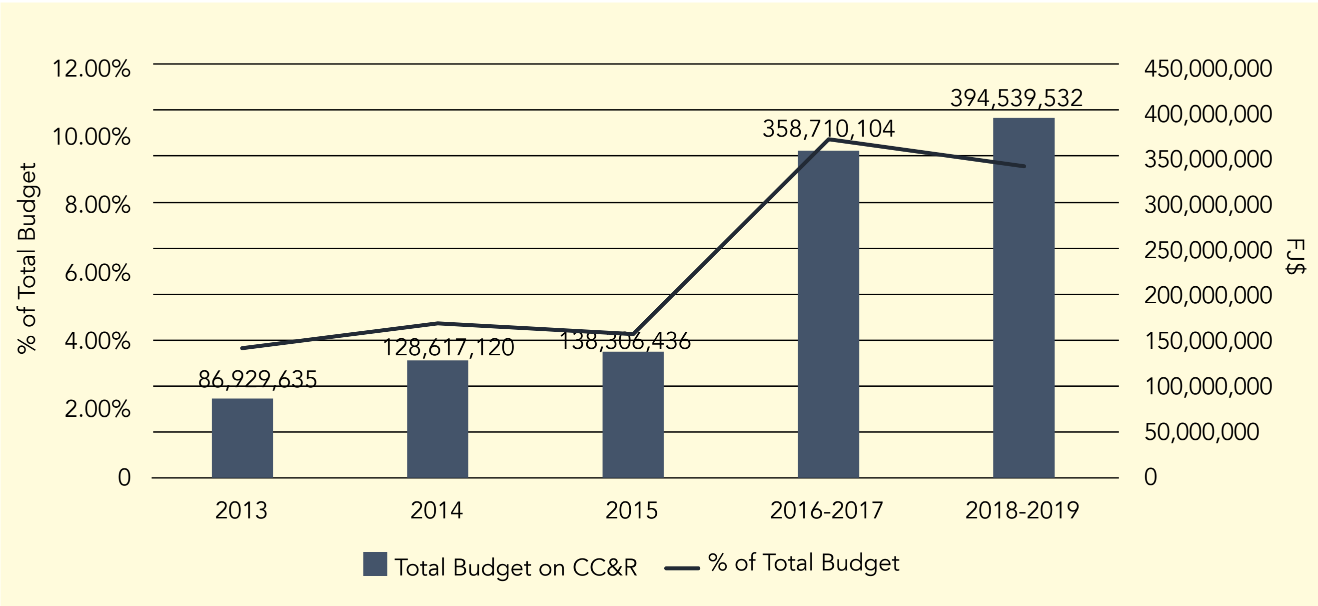


Figure 80: Total Fiscal Spending Related to Climate Change and Resilience

Information on implemented Adaptation Measures

(Programmes containing measures to facilitate adequate adaptation to climate change 2014-2018)

Fiji is at the core of climate change impacts, being geographically placed at the pinnacle of exposure and sensitivity to climate hazards as highlighted in chapter 3. In this regard, adaptation is fundamental to safeguard the nation against the growing threats to its national development and security.

In 2014 the Cabinet endorsed the implementation of the Green Growth Framework, which is a dynamic planning tool to integrate environmentally sustainable initiatives in future development strategies for Fiji. The framework is designed to complement key overarching objectives as well as other Policy initiatives of Government. Also, in 2014, the Government launched a Disaster Risk Management and Climate Change Mitigation programme under the Disaster Risk Management Office to build the resilience of vulnerable communities. This included the relocation of Vunidogoloa village in Macuata and 19 houses on Yadua Island Bua.

In early 2016, the Climate Change Division was transferred to the Ministry of Economy to strengthen the mainstreaming of climate change adaptation and disaster risk management in development process and activities undertaken in Fiji. The unit was allocated $0.2 million for its functioning, and a complementary sum of $215,000 had been provided for the Climate Change Financing initiative. The Fijian Government spending on investments to strengthen resilience has significantly increased from 3.74 per cent of the total budget in 2013 to 9.85 per cent in the 2016-2017 National Budget. Notable projects funded under the 2016-

2017 National budget include:

- Watershed Management project - to rehabilitate flood retention Dams;
- Government is dredging rivers, constructing river bank boulders to prevent coastal erosion and conducting environment impact assessment to mitigate flood risks;
- Strengthening of the early warning system that includes the expansion of the Fiji Meteorological Services to the Northern Division which will improve climate tracking and forecasting; and
- Installation of water level and rainfall telemetry instruments in all hydrological stations to effectively monitor the river levels.

Fiji also successfully co-hosted the United Nations Oceans Conference in 2017 and deposited 17 voluntary commitments to conserve and sustainably use the ocean and marine resources.

Under the 2017-2018 budget, the Government implemented a whole range of climate-change-related initiatives. These include:

- Detailed design for the Nadi Flood Alleviation Project;
- Distribution of Free Water Tanks in Maritime/ Drought-Stricken Areas;
- Rainwater Harvesting Systems for Drought Prone Regions;
- Emergency Repairs – Storm Damages/ Emergency Response contingency funds;
- Reducing Emissions from Deforestation (REDD+);
- Hydro Fluorocarbon (HCFC) Phase-Out Management Plan;
- A levy of 20 cents will be imposed on plastic bags. Plastic bags are recognised globally as a major source of pollution, in particular, non-biodegradable plastics;
- The Environmental Levy will now be renamed as the 'Environment & Climate Adaptation Levy' (ECAL). The rate for the ECAL will be increased from 6.0 per cent to 10.0 per cent;
- The ECAL levy will be charged to luxury vehicles with engine capacity exceeding 3000cc. It will also be applied to the chargeable income of more than $270,000;
- Superyachts will also pay the ECAL of 10 per cent, and the 12.5 per cent Superyacht Charter Fee has been abolished;
- The minimum investment threshold for the tax holiday on 'Electric Vehicle-Charging Stations' will be reduced from $3.0 million to $500,000 to promote investment in this area; and
- Fiscal import duty of 32.0 per cent on vinyl sheet piling used for the construction of seawalls will be eliminated. This is critical to support communities that are vulnerable to rising sea-levels and flooding.

Constraints and Gaps - Adaptation

As addressed in the National Adaptation framework there is lack of a standardised approach to vulnerability assessments which translates to lack of clarity on the extent of how issues of adaptation barriers and limits are incorporated in adaptation and development planning. Notably, the National Adaptation Plan development process has enabled the identification of critical factors that inhibit the potential for strategically implementing adaption measures at national and sub-national levels. These include:

- Information, knowledge and technology barriers: there is an imperative to have a clear understanding of the need for adaptation. This includes strategically addressing key questions; how, when, where and to what extent to adopt, also bearing in mind the associated outcomes and impacts.
- Governance and institutional arrangement: this forms the basis for action, decision-making and the flow of resources to where they are needed. There is, however, factors influencing this flow of work, non-existence of climate change focal points and units in the relevant ministries which add to the issues of insufficient cooperation and coordination. Also, monitoring and evaluation and understanding of climate change adaptation have been a challenge, and thus, there is a need to establish progress reports and indicator for climate change related projects.
- Financial: It is important to ensure that the national budgetary processes adequately allocate resources especially towards disaster recovery efforts as for disaster risk reduction, especially considering that cyclone intensity is likely to increase in the future having similar future financial implications. There is also the need to ensure sufficient flow of finances to the local level especially in rural areas and isolated island. Mobilising finance for the local people is vital to

support adaptation processes, especially to strengthen community-based adaptation.

- Economic barriers: These include the existence of low incomes and lack of investment in adaptation projects because of the difficulty in sustaining returns and reducing investment risks. Moreover, there is a lack of private sector involvement in the implementation of adaptation efforts.
- Natural and biological adaptation barriers and limits: this particularly applies to the deteriorating health of the coral reef systems projected under the different climate change scenarios. This can have serious implications on economic growth, food security and livelihoods, also negatively impacting the fishing, tourism sectors, coastal management and disaster management.

In the **Post Disaster Needs Assessment (PDNA)** conducted after TC Winston, the following recommendations were reported on institutional and policy setup in the context of disaster risk management. The report identified the need to :

- Confirm coordination mechanisms on the ground among ministries, divisions, the private sector, development partners, communities and civil society organisations;
- Establish a volunteer accreditation and deployment mechanism to easily engage the people who want to help in implementing recovery projects;
- Ensure the availability and on-time releases of funds to line ministries for implementing projects; and
- Increase implementation capacity (including from challenges with business-as-usual requirements), as recovery requires a mix of skills (in particular for procurement, financial management and safeguard requirements) that should be made available to support the programme's processes and procedures.

The PDNA also emphasises on the need for strong monitoring and evaluation capacity of the recovery programme for the purpose of ensuring the extent of the application of Building Back Better principle and also to warrant if hazard risk information is used to inform building re-construction and policy development.

Given the on-going focus on building resilience, the Fijian Government has seen it fit to consider tapping the disaster insurance market as a potential means of building up capacity and contingencies for post-disaster financing. Preliminary consultations have been undertaken with the World Bank on a potential financing mix and appropriate modality. Having an insurance cover could increase our financial resilience against natural disasters by improving our financial capacity to meet post-disaster funding needs. Moreover, building capacity within the domestic insurance industry to provide catastrophe risk insurance for buildings will help to reduce the re-building cost faced by the Government and private households while providing incentives to ensure that building codes are followed and assets are maintained to an insurable quality.

Proposed Projects for Financing

Mitigation – CDM Projects

Specific information and detailed knowledge about opportunities, requirements and risks of the CDM are generally lacking among key stakeholders, both in the public and private sector. To create an enabling environment for CDM, Fiji developed its CDM Policy Guideline in 2010 and a CDM Investors Handbook in 2012. However, there is still a lack of appropriate mechanism within the Designated National Authority (DNA) to identify and prioritise investment opportunities. Moreover, the CDM policy guidelines need urgent review and revision as some information is out-dated; for example, the institutional framework for the current DNA set-up. There is also a need for measures to support and promote CDM development under the Fiji DNA and need for funding mechanisms to support initial project ideas or capacity-building programmes.

To date, Fiji has thirteen CDM projects, of which only three have been successfully registered. The rest are at PIN (Project Idea Note) and PDD (Project Design Document) stage. Registered and potential CDM projects hosted in the country are given below.

Table 66: Registered and potential CDM projects

Lead organisation	Project title	Current status	Sector	Estimated average annual emission reductions:
Water Authority of Fiji (WAF)	Kinoya Sewerage Treatment Project	Registered	Biogas	22,000 tons CO_2eq
Electricity Fiji Limited (EFL)	Nadarivatu Hydro-power Project	Registered	Hydro	47, 361 tons CO_2eq
EFL	Vaturu & Wainikasou small scale Hydro-power Project	Registered	Hydro	24,928 tons CO_2eq
Nabou Green Energy Limited	Nabou Green Energy Limited	PIN/PDD	Biomass	
EFL	Qaliwana Hydro-power Project	PIN stage	Hydro	138,023 tCO_2 in the period 2015-2022
WWF	Fiji tourism energy efficiency investment	PIN stage	Energy Efficiency	48,473 tCO_2e in the period 2013-2022
Tropik Wood	Tropik biomass power generation	PIN	Biomass	21,000 tCO_2e/year (147,000 tCO_2e for the first 7-year crediting period)
IUCN	Energy efficient lighting	(PIN)	Energy Efficiency	173,000 tons of CO_2 in the period 2016–2026
Department of Environment	Plant oil power generation for maritime communities (pin)	PIN/PDD stage	Biofuel	818 tCO_2e/year (5,726 tCO_2e for the first 7-year crediting period)
Department of Environment	Methane capture and flaring at Naboro landfill (PIN)	PIN stage	Biogas	15,486 tCO_2e/year (108,403 tCO_2e during the crediting period 2016-2022)
Department of Environment	National Biogas PoA	PIN stage	Biogas	First CPA: 17,233 tCO_2e/year (120,631 tCO_2e in the period 2013-2020)
EFL	National Grid-connected Hydro-power PoA (PIN)	PIN stage	Hydro	First CPA: 57,564 tCO_2e/year (402,948 tCO_2e for the period 2013-2020)
WAF	Sewerage Treatment PoA (PIN)	PIN/PDD stage	Biogas	First CPA - Lautoka Sewerage Treatment : 16,625 tCO_2e/year (116,378 tCO_2e for the first 7-year crediting period)

Energy Sector Projects

The Energy Fiji Limited is the only electricity utility in Fiji and has currently (2018) undergone corporatisation. This re-structuring is to ensure development in all areas of the electricity industry and to improve the efficiency of public service delivery. The Government also has the following Energy and Forestry projects for the 2018-2019 fiscal years.

Table 67: Energy sector project for the 2018-2019 fiscal year

Energy Sector projects	Estimated cost
Energy Development Consultation	20,000
Renewable Energy Development Projects	425,649
Energy Conservation Implementation	135,000
Energy Conservation Assessment	300,000
Upgrade of Gau and Cicia Biofuel Mills	350,000
Upgrade of Buca Hydro Turbine	900,000
Rehabilitation of Solar Home Systems and Diesel Schemes for the Relocated Villages and Reconstructed Homes - TCW	3,818,558
Rehabilitation of Solar Home Systems and Hydro Lines in Kadavu - TC Keni	931,705
Supply and Installation of 2635 Solar Home Systems On-going	566,525
Supply & Upgrade of 700 Type I Solar Home Systems	2,800,000
Supply and Installation of 5000 Solar Home Systems	10,000,000
Supply of Solar Home System Replacement Component On-going	433,127
Water Conservation Awareness Programme	30,000
Collation of Water Statistics	185,296

Forestry Sector Projects

Table 68: Forestry sector projects for the 2018-2019 fiscal year.

Ministry of Forestry	Estimated cost (FJ$)
Fiji Pine Trust - Extension	745,102
Sustainable Management of Vulnerable Forest - Rewa Delta Project	91,935
Reducing Emissions from Deforestation and Forest Degradation(World Bank)	2,499,782
Reducing Emissions from Deforestation and Forest Degradation(REDD+)	400,000
Consultancy Seed Bank	50,000
Research and Development of Wood and Non-Wood Species	150,000
Reforestation of Degraded Forest	700,000
Reforestation of Indigenous Species	250,000
Compensation for Reserves	60,000
Boundary Delineation for Nature and Forest Reserves	35,000
Upgrade of Forest Park	200,000

Constraints and Gaps - Mitigation (NDC Implementation)

With the NDCs in place, the NDC implementation roadmap provides guidelines for its implementation and achieving the target set out to meet the country's commitment to the energy sector. In developing the Roadmap enabling elements, capacity and technical assistance needs were identified, which will be crucial for implementing mitigation actions within the Energy Sub-Sectors; electricity generation and transmission, Electricity Demand-Side Energy Efficiency. These have been identified for short-term mitigation action (2017-2020), Medium-Term Mitigation Actions (2021-2025) and Long-Term Mitigation Actions (2026-2030). Since the SNC, much work has been carried out to address the issues identified, with the NDC roadmap laying the foundation for greater progress in the sector.

The NDC roadmap also addresses governance and institutional arrangements that will be necessary to oversee and successfully implement the NDC actions and at the same address other cross-cutting issues. The current institutional and policy framework for the energy sector, which features overlapping responsibilities and significant gaps in the area of regulation and oversight, requires strengthening to encourage greater private sector participation. The broad enabling elements, capacity building and technical assistance needs in the context of governance and institutional arrangement for the implementation of NDCs are listed below.

- Carry out an assessment of the capacity building and training needs within the key institutions involved in the Roadmap.
- Provide support to initiate the Committees and NDC Implementation Unit (NIU) and, if required, support the coordination and facilitation of the different institutions (especially in the beginning until a process is established).
- To ensure the close alignment of the Roadmap with the Government's strategic plans for the sustainable development and green growth of Fiji.
- Provide training and capacity building to the staff in terms of coordinating the Roadmap and Measurement Reporting Verification requirements and standards.
- Provide support to the Budget and Aid Coordinating Committee on climate finance initiatives and how this funding is treated under the Roadmap.
- Develop enabling elements including new legislation and policy, such as the enactment of a Climate Change Act for Fiji, and other legislation relevant to the Roadmap implementation.
- Provide technical assistance to review and amend the Roadmap, as deemed necessary by the Government.

A key constraint faced by the country is also in terms of Measurement, Reporting and Verification (MRV). The NDC Implementation Roadmap thus captures the enabling elements which include designing, implementing and building capacity for a robust and transparent bottom-up MRV system, including; the review of existing data and reporting, an assessment of data needs, institutional arrangements, a data management system, standards and procedures for MRV, and an evaluation mechanism. More so, it is important to strengthen bottom-up data gathering which may involve new legislation and policy, expanded mandates for the main data collecting agencies and in addition to institutional strengthening through multi-agency activities addressing new sources and process for data gathering and reporting, as well as providing and gathering mandatory data through institutionalising of a command and control mechanism. This is one of the key priority areas under the National Inventory improvement plan.

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Appendix A Methods and Data Documentation

Documentation and Methods and Data Documentation (MDD)

1.1. Category Information

Tables 2.1 through 2.9 below includes the relevant information about categories, including descriptions of each category as it pertains to *Fiji*.

Table 2.1: Category Information- Energy

Sector	Energy
Category	Stationary combustion
Key Category? [Yes or No]	Yes
Category Description/ Definition	Emissions from the intentional oxidation of materials within an apparatus that is designed to raise heat and provide it either as heat or as mechanical work to a process or for use away from the apparatus. (IPCC 2006 chapter 2)
Country Detail	This category comprises fuel use for electricity generation by the national supplier EFL and from other generation, including off-grid generation. Fiji has no known indigenous fossil fuel deposits and all energy sector CO_2 emissions come from imported fossil fuels. In this regards, the importation of liquid fuels is the key source of national data in the energy sector, and this data in Fiji is in the hands of the Fiji Revenue and Customs Services (FRCS). In Fiji, the main use of liquid fuels is in primary combustion engines to produce work. The alternative uses for liquid fuels are for industrial heating, including hot water production and some domestic consumption (kerosene and LPG for cooking and lighting). Virtually no liquid fuels are used for space heating as is done in cooler climates.

Table 2.2: Category Information – Energy

Sector	Energy
Category	Mobile Combustion
Key Category? [Yes or No]	Yes
Category Description/ Definition	Emissions from the combustion and evaporation of fuel for all transport activity (excluding military transport), From IPCC 2006 chapter 3.
Country Detail	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. 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. For marine transport, there are several categories, including commercial transport used for inter-island transport, fishing vessels, tourist vessels and small vessels used for personal and community purposes. Small vessels (vessels under 15m), there are two basic types of engines used in Fiji, 2-stroke petrol combustion models and 4-stroke, with 2-stroke engines making up the vast majority. These vessels are powered with petroleum and premix (or 2 strokes) petrol mix. The larger commercial vessels in Fiji which are mostly under 50 m burn diesel for propulsion and auxiliary power. For domestic air transport, 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. Another 100% locally-owned domestic airline, Northern Air, uses Nausori Airport as its main base operating a fleet of six aircraft (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 full charter service. Other commercials, 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.

Table 2.3: Category Information – Agriculture

Sector	Agriculture
Category	Entric fermentation
Key Category? [Yes or No]	Yes
Category Description/ Definition	Livestock production can result in methane (CH_4) emissions from enteric fermentation and both CH_4 and nitrous oxide (N_2O) emissions from livestock manure management systems. Cattle are an important source of CH_4 in many countries because of their large population and high CH_4 emission rate due to their ruminant digestive system.
Country Detail	The last agriculture census was conducted in 2009, and the next census is scheduled for 2019.

Table 2.4: Category Information – Agriculture

Sector	Agriculture
Category	N_2O Emissions from Manure Management
Key Category? [Yes or No]	No
Category Description/ Definition	Direct N_2O emissions occur via combined nitrification and denitrification of nitrogen contained in the manure. The emission of N_2O from manure during storage and treatment depends on the nitrogen and carbon content of manure, and on the duration of the storage and type of treatment. Indirect emissions result from volatile nitrogen losses that occur primarily in the forms of ammonia and NOx. The fraction of excreted organic nitrogen that is mineralized to ammonia nitrogen during manure collection and storage depends primarily on time, and to a lesser degree temperature
Country Detail	Area fertilised is one of the proposed items for the 2019 agriculture census.

Table 2.5: Category Information – Agriculture

Sector	Agriculture
Category	Rice cultivation
Key Category? [Yes or No]	No
Category Description/ Definition	Anaerobic decomposition of organic material in flooded rice field produces methane, which escapes primarily through air bubbles and by rice plants. The emissions from rice farms depend on various factors such as water regime in farms, number and duration of harvests, soil type, soil temperature and fertiliser use.
Country Detail	Some estimates of methane emissions from rice farms are done in this report to provide a baseline as in future the emissions are expected to grow due to government's national initiative to be become self-reliant in rice production by 2030. Rice farming in Fiji is done more on a subsistence level. The area planted could vary depending on the willingness of farmers to plant rice which is affected by socio-economic status and climate as in northern Vanua Levu the rice farms are mostly rain-fed.

Table 2.6: Category Information – Forestry

Sector	Forestry
Category	Forest land
Key Category? [Yes or No]	No
Category Description/ Definition	Emissions and removals due to changes in biomass, dead organic matter and soil organic carbon on Forest Land and Land Converted to Forest Land
Country Detail	The National Forest Inventory and the formalisation of the Fiji Forest Policy Statement, together with the National Forest Program has provided a framework for the sustainable management of Fiji's forest resources. In addition to the natural forests, there are substantial production forests comprised of pine and mahogany plantations. Fiji forests include natural (indigenous) forests, coconut plantations, commercial pine and mahogany plantations and mangroves. Fiji has a total forest cover of 58% of the total land area, comprising of native forest (900,000 ha), plantation forest (90,000 ha) and mangrove forest (40,000 ha)

Table 2.7: Category Information – Waste

Sector	Waste
Category	Wastewater treatment and discharge,
Key Category? [Yes or No]	No
Category Description/ Definition	Wastewater can be a source of methane (CH_4) when treated or disposed of anaerobically. It can also be a source of nitrous oxide (N_2O) emissions. Wastewater originates from a variety of domestic, commercial and industrial sources and may be treated on-site (uncollected), sewered to a centralised plant (collected) or disposed of untreated nearby or via an outfall. The method for estimating CH_4 from wastewater handling requires three basic steps: • Step 1: Estimation of Organically Degradable Material in Domestic Wastewater • Step 2: Estimation of CH_4 emission factor for Domestic Wastewater • Step 3: Estimation of CH_4 emissions from Domestic Wastewater
Country Detail	In Fiji, most of the industrial wastewater flux is connected to the main sewer lines or discharged into natural waterways, and there is no data available to quantify industrial emissions of methane from wastewater handling.

Table 2.8: Category Information – Waste

Sector	Waste
Category	Biological Treatment of Solid Waste: Methane
Key Category? [Yes or No]	No
Category Description/ Definition	When sludge from wastewater treatment is transferred to an anaerobic facility which is co-digesting sludge with solid municipal or other waste, any related methane (CH_4) and nitrous oxide (N_2O) emissions should be reported under this category,
Country Detail	There are in total 10 sewage treatment plants in Fiji that were considered in this assessment. The Kinoya sewage treatment plant has recently installed a flow meter for the sludge pumped into 2 anaerobic digesters. This may provide useful information and will enable more robust calculations in future. Sludge is only removed at Kinoya Treatment Plant and was treated on-site using an anaerobic digester.

Table 2.9: Category Information – Waste

Sector	Waste
Category	Solid Waste Disposal
Key Category? [Yes or No]	No
Category Description/ Definition	Treatment and disposal of municipal, industrial and other solid waste produces significant amounts of methane (CH_4). In addition to CH_4, solid waste disposal sites (SWDS) also produce biogenic carbon dioxide (CO_2) and non-methane volatile organic compounds (NMVOCs) as well as smaller amounts of nitrous oxide (N_2O),nitrogen oxides (NOx) and carbon monoxide (CO). The CH_4 potential that is generated throughout the years can be estimated on the basis of the amounts and composition of the waste disposed into SWDS and the waste management practices at the disposal sites.
Country Detail	There is only one anaerobic landfill in Fiji called Naboro landfill, which is a major source of methane. This is especially true when the waste composition comprises mostly of organic matter and given the wet tropical climate that causes faster anaerobic decomposition in the landfill to generate landfill gas. All the other municipalities in Fiji collect waste and dump at a disposal sites of varying nature, some are well ventilated, and some are deep and not managed well (Uncategorised SWDs). In practice, 50% of the landfill gas generated constitutes of direct CO_2, but the emission of CO_2 from landfill is not counted as per IPCC guidelines as this gas is of biogenic origin. The Naboro landfill had a weighbridge installed in 2005, and therefore an accurate amount of waste deposited into the landfill was obtained from the Department of Environment and the landfill operator.

1.2. Method Choice and Description

Table 2.10 through Table *2.18* describes the methodology used to calculate greenhouse gas emissions and removals from *categories,* including the equation used its reference, and why this methodology was chosen.

Table 2.10: Methodology for Stationary Combustion

Equation (Describe variables for method used.)	Equation 2.1 Variables: litres x density x calorific value x CO_2 emissions/TJ
Reference	2006 IPCC Guidelines for National Greenhouse Gas Inventories Page 2.11
Describe How and Why this Method Was Chosen	Two methodologies were used, first the "top-down" (reference approach) and second the "bottom-up" (sectoral approach). Good fuel quantity data was available by the only electricity utility provider in the company.

Table 2.11: Methodology for mobile combustion

Equation (Describe variables for method used.)	Equation 3.2.5 Variables: litres x density x calorific value x CO_2 emissions/TJ
Reference	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 3, pg. 15
Describe How and Why this Method Was Chosen	Road transport models were constructed using vehicle number and types from the Fiji Land Transport Authority (LTA) and using estimated fuel efficiency and estimated kilometres travelled. Similarly, transport models were developed for marine and aviation using scheduled trips and flights. This approach was used since data on the fuel sold was not readily available and not provided by the fuel companies.

Table 2.12 Methodology for Enteric fermentation

Equation (Describe variables for method used.)	Equation 10.19, 10.20 and 10.22 Variables: emissions factor for the defined livestock population kg CH_4 head-1 yr (EF), the number of head of livestock species/ category T in the country (N_T), species/category of livestock (T)
Reference	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 10, pg. 10.28
Describe How and Why this Method Was Chosen	Tier 1 – No country-specific activity data EF Enteric fermentation: table 10.10 and 10.11 EF Manure Management: table 10.14 - 10.16

Table 2.13 Methodology for Manure Management

Equation (Describe variables for method used.)	Equation 11.1; Variables: N content of synthetic fertilisers and organic amendments, Fraction of manure managed within each manure management system N_2O emissions from managed soil: Indirect emissions from soil and manure management: To calculate indirect N_2O emissions from fertiliser application due to volatilization equation 11.9 from Chapter 11 of Vol. 4 was used. To calculate indirect emission from manure management equation, 10.27 from chapter 10 of Vol. 4 was used.
Reference	2006 IPCC Guidelines-Chapter 11- N_2O Emissions from managed soils
Describe How and Why this Method Was Chosen	Direct emissions from soil and manure management- Again tier 1 methodology was 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. N_2O emissions from urine and dung inputs to grazed soil were calculated for cattle, pig and poultry by applying an emission factor 0.02 Kg N_2O-N/kg N and for sheep and others the emission factor was 0.01 Kg N_2O-N/kg N. To calculate N_2O emission from manure management Chapter 10 of Vol.4 2006 IPCC guidelines were used.

Table 2.14 Methodology for Rice cultivation

Equation (Describe variables for method used)	Equation 5.1, 5.2 and 5.3 Variables: CH_4 Rice= annual methane emissions from rice cultivation, Gg CH_4 yr-1 EFijk= a daily emission factor for i, j, and k conditions, kg CH_4 ha-1 day-1 t_{ijk} = cultivation period of rice for i, j, and k conditions, day A_{ijk} = annual harvested area of rice for i, j, and k conditions, ha yr-1 i, j, and k = represent different ecosystems, water regimes, type and amount of organic amendments, and other conditions under which CH_4 emissions from rice may vary
Reference	2006 IPCC Guidelines-Chapter 5- Cropland (5.5 Methane emissions from rice cultivation)
Describe How and Why this Method Was Chosen	Tier 1 was applied as methane emissions from rice cultivation is not a significant source, and also country-specific emission factors were not available. To calculate methane emission equation 5.1 in chapter 5.5, Vol 4 of 2006 IPCC guidelines was used. In addition to the total area of rice planted, data was needed for water regime, days of cultivation and the amount of straw incorporated in the soil.

Table 2.15 Methodology for Forest Land

Equation (Describe variables for method used.)	Gain-Loss Method Equation 2.7, 2.9, 2.10, 2.11, 2.12, 2.13, 2.14 Variables: Volume timber harvested, volume fuelwood gathered (whole tree/ tree parts), Area of disturbances(fires, pests, landslides, etc.), forest biomass C stocks by forest type,forest dead organic matter C stocks by forest type
Reference	2006 IPCC Guidelines - Volume 4 - Chapter 2 & 3
Describe How and Why this Method Was Chosen	Two methodologies were used, one for plantation forests and another for natural forests. For plantation forests, good data were available for planting and removals, and country-specific data (tier 3) was available for the carbon content of growing stock. IPCC methodology was used for the plantation forest sector, and the variables were cross-checked against an equilibrium forest in which the total stock over time remained constant. This check gave good data for emissions from the plantation sub-sector. For natural forests, there was reasonable data for removals (legal logging) but not for illegal logging and or firewood collection. There was no satellite data for overall land conversions and nonspecific forest degradation. This lack of data meant that using IPCC 2006 methodology was difficult as no default factors were available. Herold calculated the carbon content of Fiji natural forests at 125 Mt C for 1990 and 118 MtC (432 Mt CO_2) for 2000 suggesting a 0.6% pa decline using IPCC default methodology (tier 1). Payton and Weaver, on the other hand, used sample plots (Tier 3) to calculate 157Mt CO_2 for Fiji natural forests nearly 3 times lower than the tier 1 methodology. A 2010 FAO report suggested a net increase in natural forest stock of around 0.14% pa. The REDD+ program (GIZ) estimated annual degradation of natural forests of around 0.3% per annum. Payton had good data for the carbon content of natural forests (Tier3) which was multiplied by the REDD+ annual degradation estimate to calculate emissions from natural forests. Discussions with NZ forestry experts (Payton and Weaver) and the general conclusion that the uncertainty in emissions was high even with the use of available tier 3 methodology. The figures for natural forests and plantation forests were summed to get total emissions. Note no emissions from other crops, coconut plantations, mangroves etc. were included as this data was not available. In addition, no data was available for the stored carbon in processed wood products was included.

Table 2.16 Methodology for Waste Water treatment and discharge

Equation (Describe variables for method used.)	Equation 6.1, 6.2,6.3 Variables: Biochemical Oxygen demand (BOD); Chemical Oxygen Demand; Country population in inventory year; Total organics in wastewater in inventory year
Reference	2006 IPCC Guidelines - Volume 5 - Chapter 6
Describe How and Why this Method Was Chosen	For the Kinoya Sewage Treatment plant, Tier 2 method was applied because country-specific activity data, that is BOD, was utilised together with default emission factor. For all the other treatment plant since high-resolution BOD data was not available, Tier 1 method was applied whereby default BOD and emission factors were applied. Methane emissions from wastewater treatment and discharge depend on the type of treatment, whether it is aerobic or anaerobic. The IPCC 2006 guidelines also incorporates methane emissions from septic tanks; however, national data on the fraction of the population that uses this type of collection for wastewater treatment is not available. The Kinoya sewage treatment plant is an anaerobic plant that serves the largest population group along the greater Suva area and Suva and Nausori corridor. The sludge is removed at the Kinoya sewage treatment plant and is treated on-site using the anaerobic digesters.

Table 2.17 Methodology for Biological Treatment of Solid Waste

Equation (Describe variables for method used.)	Equation 4.1 and 4.2
Reference	2006 IPCC Guidelines - Volume 5 - Chapter 4

Describe How and Why this Method Was Chosen	Tier 1 Method since country specific data are not available. Data on the amount and type of solid waste which is treated biologically is collected. Anaerobic digestion of solid waste was assumed to be zero since no data are available. Estimate the CH_4 and N_2O emissions from biological treatment of solid waste using Equations 4.1 and 4.2.

Table 2.18 Methodology for Solid Waste Disposal

Equation (Describe variables for method used.)	Equation: 3.1 The amount of waste deposited can be obtained in two ways: *i. Direct amount of waste entering into the SWD sites, obtained from the site weigh bridge.* *ii. The population of the region is known, then waste generation rate could be applied to calculate the amount of waste generated and then this could be applied by the fraction that corresponds to the percentage of waste generated that is normally deposited in the SWD site.*
Reference	2006 IPCC Guidelines – Volume 5 – Chapter 3
Describe How and Why this Method Was Chosen	The estimations of the Tier 1 methods are based on the IPCC FOD method using mainly default activity data and default parameters.

1.3. Activity Data

Table 2.3 shows the activity data used with the methodology described above to calculate greenhouse gas emissions and removals for the categories. Information in this table contributes to understanding the overall quality of the activity data chosen to this estimate.

Table 2.19: Activity Data

Type of Activity Data	Activity Data Value(s)	Year (s) of Data	Reference	Other Information (e.g., date obtained and data source or contact information)	Category QA/ QC Procedure Adequate / Inadequate / Unknown	Are all data entered correctly into models, spreadsheets, etc.? Yes / No (List Corrective Action)	Checks with Comparable Data (e.g., At international level, IPCC defaults). Explain and show results.
Diesel fuel used for EFL grid	95 Million litres	2006-2011	FEA annual reports	FEA now EFL annual reports	Adequate	Yes	Checking kWh delivered against litres consumed compared well with industry figures
Diesel fuel used for off grid generation	8 Million litres	2006-2011			Inadequate	Yes	Reasonable estimate and checked against total diesel fuel used using the diesel model as described on p33 TNC.
Land Transport	108 Million litres	2006-2015	.	For the transport sector data, the number and type of vehicles registered annual was obtained from the Fiji Land Transport Authority. From this a land transport model was produced estimating consumption from estimated vehicle usage (km per annum) and efficiency values. Good data was available for different vehicles classes from LTA, and specific fuel consumption for each class was chosen to give good agreement with total fuel consumption from FRCS. The 60,000 km/annum and 18 litres/100 km is only for commercial vehicles private cars were taken at 10,000 km/annum and 10 litres/1090 km	Inadequate	Yes	Reasonable estimate and checked against total fuel used. Some data was collected informally from taxi drivers, who on average claimed around 200 km per day and some commercial operators who claimed their vehicles travelled around 60,000 km per annum. Separate data was available from the LTA on the fuel types for each type of vehicle.
Marine transport	34 million litres	2006-2011	Fuel usage data published schedules of the main domestic carriers	Marine data was obtained from some shipping companies and cross-checking with the schedules of the main domestic carriers in Fiji which included; Gounder Shipping, Bligh Shipping, Patterson Brothers, Venue shipping and Consort shipping. In addition, allowance was made for tugs, other navigational craft, Fiji Navy boats, tourist shipping and other marine transport accounted elsewhere. Considerable uncertainty, however, was expected for this subsector.	Inadequate	Yes	Compared to the ADB Report "Mitigation Plan for the Maritime Transport Sector in Fiji" (2018).

Type of Activity Data	Activity Data Value(s)	Year (s) of Data	Reference	Other Information (e.g., date obtained and data source or contact information)	Category QA/ QC Procedure Adequate / Inadequate / Unknown	Are all data entered correctly into models, spreadsheets, etc.? Yes / No (List Corrective Action)	Checks with Comparable Data (e.g., At international level, IPCC defaults). Explain and show results.
Air transport	2.5 million litres – avgas 5 million aviation turbine fuels (kerosene)	2006-2011		An air transport model was constructed using website schedules for Fiji national flights and web obtained values for the hourly fuel consumption of aircraft used by the airline. For the aviation sector proxy data was obtained from the national carrier, Fiji Air, flight schedules.	Adequate	Yes	These estimates can be compared to the actual import data from FRCS.
Entric fermentation	Animal numbers Cattle 134 832 Sheep 14 068 Goats 101 196 Pigs 73 698 Horses 27 124 Poultry 3 734 835	2009	The Ministry of Agriculture census of animal numbers in 2009	Data was sourced from agricultural census and annual survey estimates(households, annual reports and commercial farms) and FAOSTAT	Inadequate	No	FAOSTAT database. Comparison to World Bank data for Fiji. The comparison shows that methane estimation is more than the World Bank data, but it is certainly within the uncertainty range of ± 30%. There is a good agreement between the N_2O estimation and the World Bank data for N_2O emissions when taking into account that the world bank data considers AR4 GWP of 310 whereas the revised GWP for N2O in AR5 is 265 (the one used in this assessment).
Rice cultivation	Area Harvested (Ha) 2006-5500 2007-2562 2008-2577 2009-4053 2010-3850 2011-2813		Agriculture census	It was 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. The amount of straw incorporated into the soil was assumed to be on an equal mass basis, that is, the amount of straw is equal to the dry weight of the grains harvested	Inadequate	No	Fiji's 2009 agricultural census lists the total planted area of rice as 3,623 ha, indicating a slight discrepancy from FAOSTAT data.

Type of Activity Data	Activity Data Value(s)	Year (s) of Data	Reference	Other Information (e.g., date obtained and data source or contact information)	Category QA/ QC Procedure Adequate / Inadequate / Unknown	Are all data entered correctly into models, spreadsheets, etc.? Yes / No (List Corrective Action)	Checks with Comparable Data (e.g., At international level, IPCC defaults). Explain and show results.
Manure Management	N-fertiliser application 4047.7 tonnes Urea 515.8 tonnes	2006-2011 (average)	FAOSTAT database	For 2010 the data from FSC for fertiliser application in sugarcane field was also used. Also not necessarily that all the fertilisers bought in particular year were applied. However, there is no means of monitoring exactly how much was applied. The anomalies of high and low data are attributed to most farmers who have stockpiles of fertilisers from the previous year and therefore would only take few bags from FSC. When their stock depletes than they will take more fertilisers hence the observed variation in N-fertiliser and Urea application in tonnes.	Inadequate	Yes	Data and was comparable to the FAO dataset. In addition, urea application data was obtained from the FAO database. The variability in fertiliser application data could be explained by the discrepancy in the sale of fertiliser data and application rate.
Forest land	<u>Natural forests</u> 900,000 ha Forest removal volume 58,000 m^3 <u>Plantation forest</u> Mahogany 39,000 ha Forest removal volume (logging) (10-year average) 64,234 m^3 Pine plantation 49,000 ha Forest removal volume (logging) (10-year average) 330,534 m^3	2005-2014 (average)	- FAO report Fiji Forestry outlook study by Alfred Leslie and Osea Tuinivanua - Hass 2015: Carbon Emissions from Forest Degradation caused by Selective Logging in Fiji - Development of a national methodology for forest carbon stock assessment in Fiji, Ian Payton, 2012	- Fiji Forestry – pers.com. Vakacegu, July 2016 - Forest monitoring capabilities for REDD+ participation: Background and requirements for building an MRV system in Fiji, Martin Herold, SPC/GTZ Fiji National REDD Policy & Scoping Workshop Suva, 27 August – 1 September 2009. - Fiji Hardwood Corporation Fiji Limited - Data supplied by Fiji Pine	Inadequate	No	For the natural forest assumptions were made on the dry matter (dm) content of open and closed forest. (60 t dm /ha is taken for open forests and 195 t dm/ ha for closed forests). These values for dm are consistent with the Payton study of forest carbon stock in Fiji. Volume timber harvested, volume fuelwood gathered (whole tree/ tree parts) – dataset obtained from the annual report, survey reports and research papers. FAOSTAT database used for forestry production and trade) Area of disturbances(fires, pests, landslides, etc) – no data from native forests, forest biomass C stocks by forest type, forest dead organic matter C stocks by forest type- no data.

Type of Activity Data	Activity Data Value(s)	Year (s) of Data	Reference	Other Information (e.g., date obtained and data source or contact information)	Category QA/ QC Procedure Adequate / Inadequate / Unknown	Are all data entered correctly into models, spreadsheets, etc.? Yes / No (List Corrective Action)	Checks with Comparable Data (e.g., At international level, IPCC defaults). Explain and show results.
Waste water treatment and Discharge	Kinoya treatment plant 15.2 – 26.5 kg/yr Population data (as per excel spreadsheet)	2007		The yearly BOD measurements were obtained from the Water Authority of Fiji (WAF). The 2007 census population data was obtained from the National Statistics Bureau, and then a yearly average growth rate of 2%/yr was applied to years 2006 – 2011 to get the population data. The uncertainty of the population data is 5% as stipulated in the IPCC 2006 good practice guidance.			Main activity data: BOD_5 and population data. To get an accurate assessment, it was imperative to know the population that is actually connected to sewer lines and septic tanks. However, the WAF could not provide these details, and therefore, the best practice was to assume that the urban population was connected to sewer lines or had septic tanks that have solid removal frequently.
Biological Treatment of Solid Waste	Kinoya treatment plant 15.2 – 26.5 kg/yr	2007	Census population data		Adequate	Yes	Methane emissions from biological treatment of sludge The only activity data for this category was the amount of organic matter stabilised in an anaerobic digester. To enable calculation sludge removed in wastewater treatment in Kg BOD/ yr was used. The results obtained are negligible and might imply that estimation is incorrect. Unfortunately, the default value of sludge generation is zero. In the absence of total sludge digested in a year it would be impossible to do this calculation using the 2006 IPCC guidelines.
Solid Waste Disposal	The activity data for estimating methane emissions from SWD sites are the amount of waste deposited and the waste characterisation data	2007	Waste characterisation data for the Oceania region was used. The default waste generation rate for the Oceania region was used to estimate the amount of waste generated for all the other SWDs except Naboro landfill.	Some city and town council provided estimated data based on truckloads in the absence of the site weighbridge. These data obtained were not reliable, and hence, approach (ii) above was used to calculate the amount of waste generated for all the other sites except Naboro landfill. For all the other waste disposal sites, the annual waste data was not available, so the amount was calculated with the population data and the default waste generation rate.	Inadequate	Yes	The Suva City Council carried out waste characterisation under a JICA project, but the classification of waste is not consistent with degradable organic component identified in the IPCC methodology to calculate methane generation. Hence this was not used and once again default waste characterisation data for the Oceania region was used.

1.4. Uncertainty

Table 2.5 provides information on the uncertainty associated with several key and non-key category estimates. .

Table 2.20: Uncertainty Estimates Calculated for Categories

Category	Key Category? [Yes or No]	Emissions Estimate (Gg CO2 Eq.)	Relative Lower Bound Uncertainty (%)	Relative Upper Bound Uncertainty (%)	Lower Bound Emissions Estimate (Gg CO2 Eq.)	Upper Bound Emissions Estimate (Gg CO2 Eq.)
1.A.1.a1Grid diesel use (electricity)	Y	223	5%	5%	250	280
1.A.5.a Off grid diesel use (electricity)	Y	22	30%	30%	15	30
1.A.2 Industrial consumption	Y	153	5%	5%	76	230
1.A.4.a Commercial consumption	Y	61	10%	10%	55	67
1.A.4.bDomestic consumption	Y	76	10%	10%	68	84
1.A.3.bLand transport	Y	905	10%	10%	800	1000
1.A.3.d.2Marine transport	N	55	10%	10%	50	60
1.A.3.a.2Air transport	N	18	10%	10%	16	20
4.D.1Domestic Waste-Water treatment and discharge	Y	58	35%	35%	38	78
4.B. Biological Treatment of Solid Waste	N	0.05	35%	35%	0.03	0.08
4.A Solid Waste Disposal	Y	65	35%	35%	42	88
3.A.1Enteric Fermentation	Y	314	30%	30%	220	408
3.A.2 Manure Management	Y	81	30%	30%	57	105
3.C.4.f Direct N2O Emissions from Managed Soils	N	11	30%	30%	8	14
3.C.5Indirect N2O Emissions from Managed Soils	N	14	30%	30%	10	18
3.C.6 Indirect N2O Emissions from Manure Management	Y	61	30%	30%	48	78
3.C.7 Rice cultivation	Y	92	30%	30%	64	120
3.B.1Forestry	Y	380	30%	300%	-760	1140

1.5. Improvements to the Methodology and Data Documentation Analysis

Table 2.8 provides a list of suggested improvements to the methodology and data documentation category-by-category analysis. These improvements will be incorporated into the template in future years.

Table 2.21: Improvements to the Methodology and Data Documentation Analysis

Sector	Category	Potential Improvement
All sectors	All categories	- Emission estimates for previous inventory years were not recalculated applying the same methods and assumptions to ensure consistency for all the sectors. This will be a major improvement for the subsequent GHGI. - Uncertainty assessment was not reported at the category level. A potential improvement for the purpose of transparency could be to specify uncertainty for emissions at the category level. - Reporting templates will also be provided to the sector experts to ensure that all activity data, emission factors and other relevant information are well documented. - It is also important that we report on all source categories where data is available for a complete inventory. This hasn't been the case, and thus, a scoping exercise is necessary to identify relevant data.
Energy		Obtain reliable estimates for fuel usage for the respective sectors from fuel companies and government sources. This will require a systematic approach to ensure that the data-collecting agency collects, updates and maintains it relevant for the purposes of calculating emissions.

Sector	Category	Potential Improvement
Agriculture		Sources for which estimates have not been made due to unavailability of relevant activity data include: - N_2O emissions from cultivation of organic soils and mineralisation of SOM from land-use change; - non-CO_2 emissions from burning of agricultural residues; - N_2O emissions from cultivation of organic soils or organic amendments; - CH_4, CO, N_2O and NOx from the field burning of agricultural residues; (Note: sugar cane residues burned in sugar mills for energy production is not included in the agriculture sector inventory). - Direct N_2O emissions from organic fertiliser application, including manure, on managed soil; - Direct N_2O emissions from urine and dung deposited on managed soil; - Direct N_2O emissions from crop residues on managed soil; - Direct N_2O emissions from mineralisation of soil organic matter in mineral soils during land-use change; and - CO_2 emissions from the application of agricultural lime. None of these N_2O emissions are reported on. Some of these categories can be a significant source of N_2O emissions, especially from manure N and urine and dung N, which can be estimated. Some of these data gaps will potentially be addressed in the next agriculture census in 2019. Inventory team will also need to work more closely with Fiji's agriculture team to produce such estimates. Having identified these and the data gaps below gives the opportunity to relay these limitations to the relevant stakeholders and initiate discussions on means of improvement in data collection. This will thus be shared with government ministries, departments, and other relevant stakeholders.
	Entric fermentation	The major uncertainty in estimating the methane emission from enteric fermentation in ruminant animals, and manure management is the animal population data and this data was onlyavailable for the census year of 2009. The other gap identified was the lack of data on manure management system in Fiji.
	Manure management	For N_2O emissions from agriculture sources, the major limitation was again the animal population number for estimating emissions from excretion and manure management. In addition to this N_2O emissions from flooded rice farms were not calculated as the amount of fertiliser used in rice farms were not documented. Due to the absence of any default values for these two sub-categories and absence of national activity data, the N_2O emissions from the agriculture sector could be slightly underestimated.
	Rice cultivation	The major uncertainty in estimating methane emission from rice farms is the total hectare of rice cultivation and the lack of data on how much area planted is irrigated, rain-fed or simply upland. In the current estimate, it was noted that the area cultivated was assumed to be 50% irrigated and 50% rain-fed and none upland. This is strictly not true as there may be farms that are upland and as such, the methane emission from rice farms could be slightly overestimated. There was no annual data on rice production.

Sector	Category	Potential Improvement
Forestry		The emissions due to disturbances (cyclones, droughts, pests and illegal logging and firewood removals) have not been taken into account and would in all likelihood increase the net emissions. In addition, it must be noted that the uncertainty in the estimates for emissions due to deforestation of indigenous forests, in particular, is very high and will also need further study to narrow down the estimate. Under the IPCC Guidelines, countries must report on emissions from all land-use changes, not just forestry. This will be a priority to include in the next GHGI and to develop a protocol for estimating changes in C stocks across Fiji's landscape. It will also be useful if records of commercial logging in Fiji from both plantation forests and natural forests are compiled accurately. In addition, it is necessary that the assessment of Fiji forests be given high priority to ascertain the emissions profile more accurately. There is also a need to regularly update Fiji's carbon stock to assist emissions calculations for the country using the permanent sample plot methodology. Also noting that the method of reducing the uncertainty in the estimates would be to recalculate the degradation using updated GIS data.
Waste	Biological Treatment of Solid Waste	Data gap or limitation was the population size catered for each sewerage treatment plant. Data supplied by the WAF did not add up to the population statistics for the individual city or town boundaries. The population data supplied by National Water Quality Laboratory (NWQL) actually takes into account the households that are connected to the sewer lines, but this raises serious questions about methane emission from the waste that are collected and dumped by the sewer trucks servicing households that are not connected to the sewer lines. There was no account on what population size was serviced by sewer trucks collecting waste and dumping at the treatment plant. Hence it is only logical that for major cities and towns, the urban population should be taken into account when calculating the emissions.
	Wastewater treatment and discharge	The major limitation for estimating methane emissions from wastewater treatment was the lack of BOD measurements. Although the BOD values for Kinoya sewage treatment plant was close to the default value for the Oceania region, the BOD values from other sites did not agree simply because there were not enough measurements done to calculate the yearly average.
	SWDs	Weighbridges need to be installed at all solid waste disposal sites so that the amount of waste deposited is known accurately. Implement waste characterisation of waste into these four streams: paper and textiles, food waste, garden and park waste and other (non-food) putrescible, and wood and straw waste. The default values for the Oceania region was used in the calculation, but these default values were typically for Australia and New Zealand, which could be different from local waste characterisation. Only Suva City Council, with the help of JICA volunteers, did a waste characterisation study and estimated the % organic component of our waste. However, the individual breakdowns of the organic matter were not known. The default value of zero for methane oxidation was used in this assessment due to non-availability of country-specific data. Soil cover used at Naboro landfill could provide oxidation loss typically in the range of 10%. This is not accounted for in the calculation but is very well within the uncertainty limit. Also, it will be important to include estimations for the burning of the clinical waste considering the that this is a common practice as highlighted in the reported.

ANNEX 1

Table 1 Waste Model Parameters

Parameters	Default values
DOC	0.14
DOC_f	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
Oxidation factor	0
DOC for garden waste	0.2
DOC for paper and cardboard	0.4
DOC for wood and straw	0.43
Methane Correction factor	1 for Naboro landfill 0.6 for uncategorised SWD
Waste generation rate per capita	690 kg/cap/yr
% 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)

Appendix B Community Vulnerability and Adaptation Assessment

B.1 Assessment of elements of exposure (E).

Parameter	Indicator	Korobebe village		Nagado village		Naboutini village		Sabeto village	
		Perceived change	Score	Perceived change	Score	Perceived change	Score	Perceived change	Score
Temperature	Numbers of hot days increased Number of cold days decreased	High (4) Medium (2)	3 (High)	High (4) Medium (2)	3 (High)	High (4) Medium (2)	3 (High)	High (4) Medium (2)	3 (High)
Precipitation	Rainfall has become increasingly unpredictable	Very high (4)	4 (Very high)	Very high (4)	4 (Very high)	High (3)	High (3)	Very high (4)	4 (Very high)
Plant and animal behaviour	Changes in flowering and fruiting of fruit trees like breadfruit and mango. Changes in animal behaviour such as egg laying by chickens	High (3) High (3)	3 (High)	High (3) High (3)	3 (High)	High (3) Medium (2)	2.5 (High)	High (3) Medium (2)	2.5 (High)
Climate-induced disasters	Landslide Drought Fire Cyclone Flood	Very high (4) Medium (2) Medium (2) High (3) NA	2.75 (High)	Very high (4) Medium (2) Medium (2) High (3) NA	2.75 (High	NA NA Medium (2) Very high (4) Very high (4)	3.33 (High)	NA Medium (2) Medium (2) High (4) Very high (4)	3 (High)

Source: SPC and USAID, 2016

B.2 Assessment of Elements of Sensitivity (S)

Parameter	Hazard	Indicator	Korobebe village		Nagado village		Naboutini village		Sabeto village	
			Perceived change	Score	Perceived change	Score	Perceived change	Score	Perceived change	Score
Agriculture and food security	Landslides	Loss of productive lands	High (3)	2.33 (High)	High (3)	2.5 (High)	NA	3 (High)	NA	2.75 (High)
	Drought	Loss of crop production	Medium (2)		Medium (2)		NA		Medium (2)	
	Floods	Loss of productive lands and farm animals	NA		NA		High (4)		High (4)	
	Outbreak of diseases	Production decline	Medium (2)		Medium (2)		Medium (2)		Medium (2)	
	Cyclones	Damage to crops	NA		High (3)		NA		NA	
		Loss of crops	NA		NA		High (3)		High (3)	
Forest and biodiversity	Landslides	Loss of forest cover	High (3)	2.5 (High)	High (3)	2.33 (High)	NA	2.5 (High)	NA	2.5 (High)
	Fire	Loss of biodiversity	Medium (2)		Medium (2)		Medium (2)		Medium (2)	
	Cyclones	Damage to trees	NA		Medium (2)		NA		NA	
	Floods	Loss of forest cover	NA		NA		High (3)		High (3)	
Infrastructure	Landslides	Trails and roads damaged	Medium (2)	2 (Medium)	Medium (2)	2 (Medium)	NA	3 (High)	NA	3 (High)
	Floods	Trails, roads and settlements are damaged	NA		NA		High (3)		High (3)	
	Cyclones	Damage to buildings and public utility	NA		NA		High (3)		High (3)	
Water resources and energy	Landslides	Loss of fresh water (buried)	High (3)	2.5 (High)	High (3)	2.33 (High)	NA	3 (High)	NA	2.66 (High)
	Drought	Reduction of fresh water	Medium (2)		Medium (2)		NA		Medium (2)	
	Floods	Loss of fresh water (contaminated)	NA		NA		High (3)		High (3)	
	Cyclones	Damage to infrastructure	NA		Medium (2)		NA		NA	
		Damage to water infrastructure	NA		NA		Medium (3)		Medium (3)	
Human health	Landslides	Emergence of water-borne diseases	High (3)	3 (High)	High (3)	3 (High)	NA	3 (High)	NA	3 (High)
	Floods	Emergence of water-borne diseases	NA				High (3)		High (3)	
Overall sensitivity score				2.47 (High)		2.43 (High)		2.9 (High)		2.78 (High)

B.3. Assessment of Elements of Adaptive Capacity

Parameter	Indicator	Criteria	Korobebe village		Nagado village		Naboutini village.		Sabeto village	
			Perceived change	**Score**	**Perceived change**	**Score**	**Perceived change**	**Score**	**Perceived change**	**Score**
Human assets	Demography	Old age and children	High (3)	2 (Medium)	High (3)	2 (Medium)	High (3)	2 (Medium)	High (3)	2 (Medium)
	Education	Secondary education and awareness of climate change	Medium (2)		Medium (2)		Medium (2)		Medium (2)	
	Skilled labour	Trained workers	Low (1)		Low (1)		Low (1)		Low (1)	
Natural assets	Land	Land ownership and productivity	High (3)	2.66 (High)	High (3)	2.33 (High)	Medium (2)	2.33 (High)	High (3)	2.66 (High)
	Forest	Availability of products and services	Medium (2)		Medium (2)		Medium (2)		Medium (2)	
	Water	Availability of drinking water	High (3)		Medium (2)		High (3)		High (3)	
Financial assets	Financial institutions	Banks, cooperatives	Medium (2)	2 (Medium)	Medium (2)	Medium (2)	Medium (2)	1.5 (Medium)	Medium (2)	1.5 (Medium)
	Household incomes	Sufficiency for household needs	Medium (2)		Medium (2)		Low (1)		Low (1)	
Social assets	Social institutions	Community affiliations to formal and non-formal institutions	Medium (2)	1.5 (Low)	Medium (2)	Medium (2)	Medium (2)	Medium (2)	Medium (2)	2 (Medium)
	Service providers	Engagement of Government and non-governmental organisations (NGOs) with community	Low (1)		Medium (2)		Medium (2)		Medium (2)	
Physical assets	Infrastructure for services	Access to schools, houses, bridges, roads, electricity, health posts; vehicle availability	Medium (2)	2 (Medium)	Medium (2)	Medium (2)	High (2)	2 (High)	High (3)	2.5 (High)
	Information and communication sources	Access to mobile phones, radio, TV, newspapers, and internet	Medium (2)		Medium (2)		Medium (2)		Medium (2)	
Overall adaptive capacity score				**2.03 (Medium)**		**2.06 (Medium)**		**1.97 (Medium)**		**2.23 (Medium)**

B.4 Rapid Vulnerability and Adaptation Assessment of Communities in Seaqaqa, Vanua Levu

Factors	Sites						
	Nadogo	**Savulutu**	**Navai 2**	**Sevacagi**	**Korolevu**	**Naseva**	**Navudi/Navai/ Rokosalase**
Criteria 1							
Water Resources	4	2	4	4	4	4	4
Health and Sanitation	2	2	2	1	2	1	2
Food Resources and Food Security	2	2	3	3	3	3	3
Energy Resources and Energy Security	5	5	4	4	4	4	5
Criteria 2							
Predominant type of economic system either in the agriculture or fisheries sectors	2	2	2	2	2	2	2
Criteria 3							
Level of community need related to community commitment to addressing climate-induced related stresses in past community projects	5	4	5	4	4	2	5
Criteria 4							
Level of interest shown for the proposed project	2	5	5	5	5	2	5
Criteria 5							
Approximate cost of funding a livelihood adaptation project related to project funding allocation per site or community	2	4	3	4	5	3	5
Criteria 6							
Categorisation of the types of housing structures in the community	5	5	4	5	5	5	5
Criteria 7a							
Vulnerability to inundation, storm surges and projected sea-level	Not applicable for inland communities						
Criteria 7b							
Vulnerability of inland communities to riverbank erosion, inundation and flooding	Not applicable for inland communities						

B.5 Point Score System

A total score of one to five is made for each criterion. The vulnerability score ranges from 1 – very low vulnerability, to 5 – very high vulnerability. The opposite applies when assessing the adaptive capacity.

Description	Very low vulnerability	Low vulnerability	Moderate vulnerability	High vulnerability	Very high vulnerability
Value	1	2	3	4	5

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