ENERGY PERSPECTIVE AND BIOFUELS POLICY PATHWAYS FOR FIJI'S LAND TRANSPORTATION SECTOR

By

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A minor thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Renewable Energy Management

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Declaration of Originality

I, Abhishek Dayal Vinod, hereby declare that the work contained in this thesis is my very own effort and where I have used/ retrieved information, data and work of others I have indicated clearly in the reference section.

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Abstract

Transport is essential in promoting connectivity, trade and other operations, which in effect advances civilisations. Transport is a key factor for economic growth and globalisation, however, modern fossil fuel-based transportation releases greenhouse gas (GHG) emissions whilst contributing to climate change. Fiji has set ambitious targets to achieve net-zero carbon emissions by the year 2050. The road transportation industry is the second most GHG emissions contributor. Achieving the goal is not easy without having mitigation actions in line with people's perspective and policy. This study highlights the need for biofuel production at a large scale to facilitate renewable-powered road transportation industry.

The main objective of the study is divided into two segments a survey analysis and a policy-based approach in transport sector to find out the utilization of fossil fuel in this sector in Fiji, cost and the readiness of the public to adopt newer technologies/fuels such as biofuels. The first part of the survey analysis was done based on the introduction of biofuels for transportation on the basis of people's current knowledge, understanding and perception of fossil fuel usages. The survey was conducted via a structured questionnaire and was distributed to sixty participants whose incomes ranged between 10,000 (FJD) and 70,000 (FJD).

The second part of the study is policy mapping of 14 policy documents, in relation to renewable energy and biofuels in Fiji. The objective is to find possible conflicts and synergies among these policies and strategies to overcome the possible conflicts. For policy mapping, the document analysis approach was adopted to map the 14 policy documents in terms of renewable energy and biofuels in Fiji.

The survey results clearly showed that the people in Fiji are finding it difficult to adapt to or change their lifestyle and shift away from the use of fossil fuels for transportation. In addition, most people who earn less than 30,000 (FJD)

(low income earners), do not know the consequences of fossil fuel usages on the environment and also have limited knowledge on biofuels as alternative fuels. On the other hand, the average to high income earners (earning greater than 70,000 (FJD) owned multiple cars and tend to value their comfort over the detrimental environmental impacts. The policy mapping revealed conflicts in terms of legislations and policies being outdated and not revised on time. Moreover, many of the policies mapped do not have a lot of focus on large-scale biofuels development. Fiji has the potential to progress a lot in the renewable energy for land transportation sector if more robust policy development in combination with behavioural change via awareness is made to the general public that can influence the acceptance of biofuels and other renewables at a greater scale.

LIST OF ABBREVIATIONS

ABRI- Australian Biofuels Research Institute

ADB- Asian Development Bank

ANZ- Australia and New Zealand Banking Group Limited

AR5- IPCC- Intergovernmental Panel on Climate Change Fifth Assessment Report

ARENA- Australian Renewable Energy Agency

ASTM- American Society for Testing and Matters

B5- Biodiesel 5%

BAU- Business as Usual

BC- Black Carbon

BEV- Battery Electric Vehicle

BPD- Barrels Per Day

BSP- Bank of South Pacific

BtL- Biomass to Liquid

CBA- Cost Benefit Analysis

CB- Capacity Building

CDM- Clean Development Mechanism

CFC- Chlorofluorocarbon

CI- Compression Ignition

CNO- Coconut Oil

CO- Carbon Monoxide

CO_2- Carbon Dioxide

CCOF- Consumer Council of Fiji

CH_4- Methane

COP 21- Conference of Party 21

CVA- Climate Vulnerability Assessment

DOE- Department of Energy

DPF- Diesel Particulate Filters

DSM- Demand Side Management

E10- Ethanol 10%

ECAL- Environment and Climate Adaptation Levy Act

EFL- Energy Fiji Limited

EIA- Environmental Impact Assessment

EJ- Exajoule

EMA- Environment Management Act

EN- European Standard

EU- European Union

EV- Electric Vehicles

FAESP- Framework for Action on Energy Security in the Pacific

FAME- Fatty Acid Methyl Ester

FBC- Fiji Broadcasting Corporation

FBoS- Fiji Bureau of Statistics

FCCC- Fijian Competition and Consumer Commission

FDB- Fiji Development Bank

FDoE- Fiji Department of Energy

FJD- Fijian Dollars

FNU- Fiji National University

FOB- Free on Board

FQD- Fuel Quality Directive

FRA- Fiji Roads Authority

FRCS- Fiji Revenue and Customs Services

FSC- Fiji Sugar Corporation

GCF- Green Climate Fund

GDP- Gross Domestic Product

GEF- Global Environment Facility

GGFF- Green Growth Framework for Fiji

GGGI- Global Green Growth Institute

GHG- Green House Gases

GOF- Government of Fiji

H_2- Hydrogen

HC- Hydrocarbon

HEV- Hybrid Electric Vehicles

HFC- Hydrofluorocarbon

HFO- Heavy Fuel Oil

HVO- Hydrotreated Vegetable Oil

IDO- Industrial Diesel Oil

IEA- International Energy Agency

ILO- International Energy Agency

iLUC- Indirect Land Use Change

IPCC- Intergovernmental Panel on Climate Change

IPP's- Independent Power Producer's

IRENA- International Renewable Energy Agency

LME- Latoda Methyl Ester

LCM- Lignocellulosic Material

LED- Light Emitting Diode

LEDS- Low Emission Development Strategy

LNG- Liquified Natural Gas

LPG- Liquified Petroleum Gas

LTA- Land Transport Authority

LTS- Long- Term Strategy

NCCP- National Climate Change Policy

NCD- Non- Communicable Disease

NDC- Nationally Determined Contributions

NDP- National Development Plan

NGO- Non – Governmental Organization

NMT- Non-Motorised Transport

NOx- Nitrogen Oxide

NRE- Non- Recurring Engineering

OAPEC- Organisation of Arab Petroleum Exporting Countries

OEC- The Observatory of Economic Complexity

OECD- The Organization for Economic Cooperation and Development

OPEC- Organization of Petroleum Exporting Countries

PAC- Public Accounts Committee

PEV- Pure Electric Vehicles

PHEV- Plug in Hybrid Electric Vehicles

PIC's- Pacific Island Country's

PM- Particulate Matter

PME- Pongamia Biodiesel

PT- Public Transport

PPT- Petroleum Pricing Template

R20- Renewable Diesel

R&D- Research and Development

RE- Renewable Energy

RED- Renewable Energy Directive

REN21- Renewable Energy Policy Network for the 21st Century

SCB- Sugarcane Bagasse

SDGs- Sustainable Development Goal's

SEFP- Sustainable Energy Financing Project

SI- Spark Ignition

SIDS- Small Island Developing State

SV- Saponification Value

TA- Technical Assistance

TC- Tropical Cyclone

TCTS- Tons of Cane to Tons Sugar Ratio

TFEC- Total Final Energy Consumption

TWIL- Tropic Wood Industries Fiji Limited

UK- United Kingdom

UNFCCC- United Nations Framework Convention on Climate Change

UOF- University of Fiji

USA- United States of America

USD- United States Dollar

USP- University of the South Pacific

USP IAS- University of the South Pacific- Institute of Applied Science

V2G- Vehicle to Grid

VAT- Value Added Tax

VNR- Voluntary National Review

WFH- Work from Home

WWII- World War II

ZEV- Zero Emissions Vehicles

LIST OF UNITS

ha- Hectare

kl- Kilolitres

km- Kilometres

kVa- Kilovolt ampere

kWh- Kilowatt Hour

MB/D- Millions of Barrels per Day

MLN- Million Miscellaneous

MT- Million Tons

Mtoe- Million Tons of Oil Equivalent

MWh- Mega Watt Hour

ppm- Parts Per Million

TWh- Terawatt Hour

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CHAPTER 1
Introduction

1.1 Global perspective of energy usage in transport sector

The energy consumption in the transportation sector increased by about 45% from 2000 to 2017 and remains close to 29% of world's traffic. The greater part of energy usage represents the rising numbers of vehicles on roads worldwide, and the least rise in air and marine transportation. Just a limited proportion of transport energy comes from renewable sources, primarily in the form of biofuels (3% for transport oil) the rest comes from fossil fuels. In 2016, the energy demand for transportation increases as follows: 75% increases in road transport, followed by aviation 11%, sea transport 9.6%, pipeline transport 2.3%, rail transport 1.8% (REN21, 2019). Transport energy conservation policies were more quickly propagated between 2010 and 2017 in high-income countries. In fact, electrical vehicles for passenger's support have grown even more quickly than standard fuel efficiency over this time. Since 2016, funding for commercial cars have increased considerably more than standard fuel efficiency (REN21, 2019).

1.2 Global emissions from the transport sector

According to the International Energy Agency (IEA, 2020), the global emissions of transport have increased by less than 0.5% in 2019 (as compared to 1.9% since 2000) because of improved efficiency, electrification and increased use of biofuels as presented in Figure 1.1. However, 24% of the direct CO_2 emissions from combustion are still caused by transportation (International Energy Agency, 2020). Figure 1.1, also shows that the utilization for biofuels for transport is lowest, which is 1%, while utilization of fossil fuel is the largest component (79.7%). Thus, a shift of focus on biofuels production globally should be thoroughly advocated.

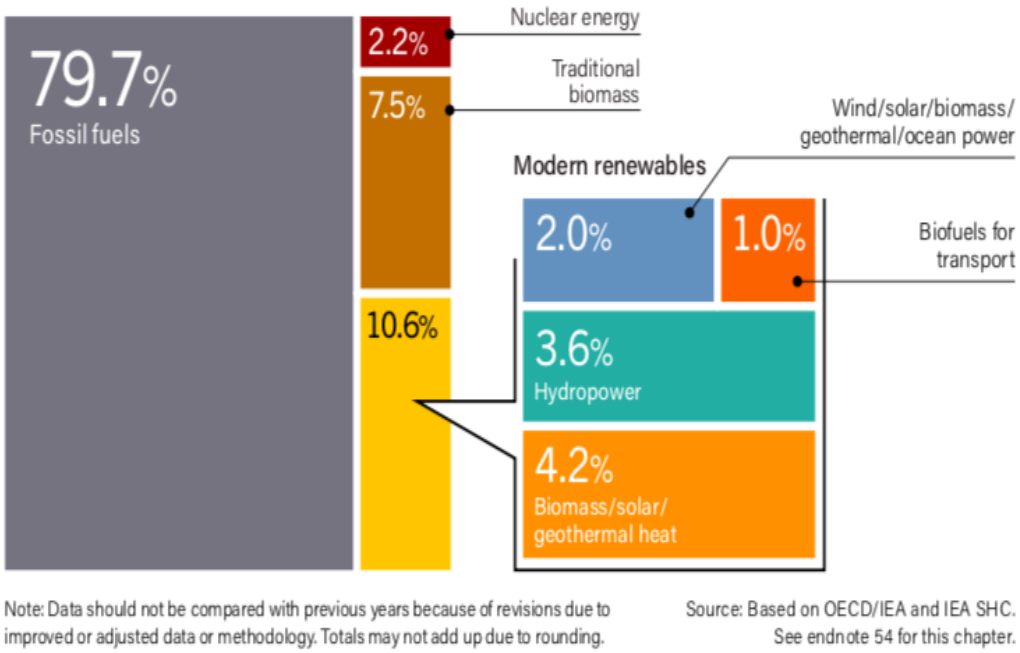


Figure 1.1 Total final energy consumption estimated for renewable share of 2017 (REN21, 2019).

1.3 Current energy situation in Fiji

The energy situation in Fiji is mainly characterized by a heavy dependency on imported fuels. The government is therefore committed to promoting energy production through renewable energy sources in the country to reduce the dependency on imported fossil fuels (Investment Fiji, 2020). The main energy sources in Fiji are for various purposes are (Investment Fiji, 2020):

- Hydro: largely for electricity generation.
- Fossil fuels: for land, maritime and aviation transportation.
- Biomass for household cooking.
- Agricultural residues for co-generation power in timber and sugar mills (Investment Fiji, 2020).

The transport sector is the largest energy user, accounting for about 40% of the energy use and the business, manufacturing and domestic sectors follow up on

the total energy supply. In the last ten years, access to power and renewable energy sources have evolved significantly for electricity generations. The national coverage for electrification has been around 90% (urban at 100% and rural at 80%) in 2014, the recent data presents that Fiji is 99.72% was the electrification percentage in Fiji in 2019 (Macrotrends, 2022). More than 50% of electricity is currently derived from renewable sources, including hydro, biomass, wind and solar energy. By 2030, it is projected to reach to 100% from renewable energy (The Fijian Government, 2019).

1.4 Importance of land transportation in Fiji

The government of Fiji recognizes the importance land transport sector, which contributes approximately 8% of Fiji's GDP, connect people and connect local communities, create markets and promote trade and economic growth. Fiji's transport industry has evolved, developed in recent years, and has played an essential role in the economic and social growth of Fiji and is relatively advanced in comparison to other geographically similar developing countries (The Fijian Government, 2019).

1.5 Non-renewable energy usage by sectors in Fiji

The total number of vehicles registered in Fiji increased annually by 59% between 2001 and 2014. This raised the market for currently imported petroleum-based fuels. In 2021, as demonstrated in Figure 1.2, Fiji imported $541.4 millions of petroleum fuel. This has an impact not only on the economy and on foreign exchange, but also has a negative environmental impact.

Energy for transportation, including maritime transportation accounts for 42% of total energy consumption. Since Fiji consists of 300 islands of which 110 are inhabited, the maritime transportation is a need (Chandra, et al., 2017). Renewable sources like coconut oil and bioethanol can have a relatively large impact in replacing fossil fuel and reducing greenhouse (GHG) emissions. A total of seven biodiesel plants have been commissioned in the islands of Koro,

Rotuma, Cicia, Vanuabalavu, Lakeba, Rabi and Gau, for electricity generation. These plants produce copra biofuel. However, bioethanol production in Fiji is still at the stage of the feasibility study. Molasses is the main by-product of sugar processing and could be used as the feedstock for bioethanol. 82% of the molasses are exported and the remaining 9% are exported and the remaining 9% is used locally. A case study by Chandra et al. (2017) investigated the potential of using sugarcane juice for ethanol is viable for petrol vehicles. There is a need for energy protection and a need to secure a stable future for the sugar industry in Fiji. The interest has been in the local sugar sector and stakeholders intend to harness ethanol form the molasses and convert it to biofuels.

1.6 General characteristics of Fiji's land transport sector

According to the Fiji Sun (2014), a local newspaper, over the last 10 to 12 years the number of motor cars in Fiji has risen dramatically, which has increased importation of fuel for fossil fuels (around 1.2 billion FJD per year). The number of vehicles registered under various categories are shown in Table 1.1 (Maharaj, 2014).With that, the consequences of having increased number of vehicles, and fuel importation of fossil fuel in Fiji is listed below (Maharaj, 2014):

a)) In increased emissions of GHG and Carbon dioxide (CO_2).
b) Increased importation of fossil fuel.
c) Increased pressure on urban and suburban corridors transportation infrastructure.
d) Increased traffic flow.
e) Increased road accidents
f) Increased demand for urban parking space.
g) Augmented burden on drivers
h) Increased traffic, and road congestion.
i) Increased health and non- communicable diseases.

Table 1.1 Distribution of vehicles registered in Fiji from 2012 to 2018 (Fiji Bureau of Statistics, 2020).

Period	2012	2013	2014	2015	2016	2017	2018
All other vehicles	410	428	440	449	446	516	528
Buses	1890	1971	2034	2006	2403	2444	2413
Carriers	302	335	346	376	28	31	74
Goods Vehicle	16,646	17,077	17,610	18,170	17,485	18,397	18,681
Government Vehicles	1313	1327	1508	1349	1524	1596	1988
Private Cars	54,919	59,415	64,988	69,968	79,815	84,558	85,842
Rental and Hire Cars	2096	2178	2436	2632	3017	3829	4040
Taxi	6079	6459	6572	6475	6045 6054	6190	6394
Total	83,655	89,160	95,440	101,450	110,763	117,561	119,960

In addition, the pie chart in Figure 1.2 shows percentage of fuel imported for different usages (Fiji Bureau of Statistics, 2021). The figure clearly shows that in 2021, Gas oil (Diesel) fuel importation was the highest (50%) while Aviation or turbine fuel was the least, due to the closure of the international borders. Furthermore, the use of fossil fuels has a severe and negative impact on human health, notably due to the discharge of particulate matter into the atmosphere. In fact, particulate matter is solely responsible for up to 30,000 deaths globally (Larsen and Olsen, 2022). Conditions such as irregular heartbeat, asthma, with possibilities of cardiac arrest can be caused due to particulate matter released with the use of fossil fuel for land transportation (Alexander, 2021).

As a means to combat emissions, the Public Accounts Committee (PAC) report presented to the auditor general articulated that old and inefficient vehicles with the registration A, B, C, D, E and F to be de-registered and scrapped, yet there are no policies or guidelines as yet (Chand, 2021).

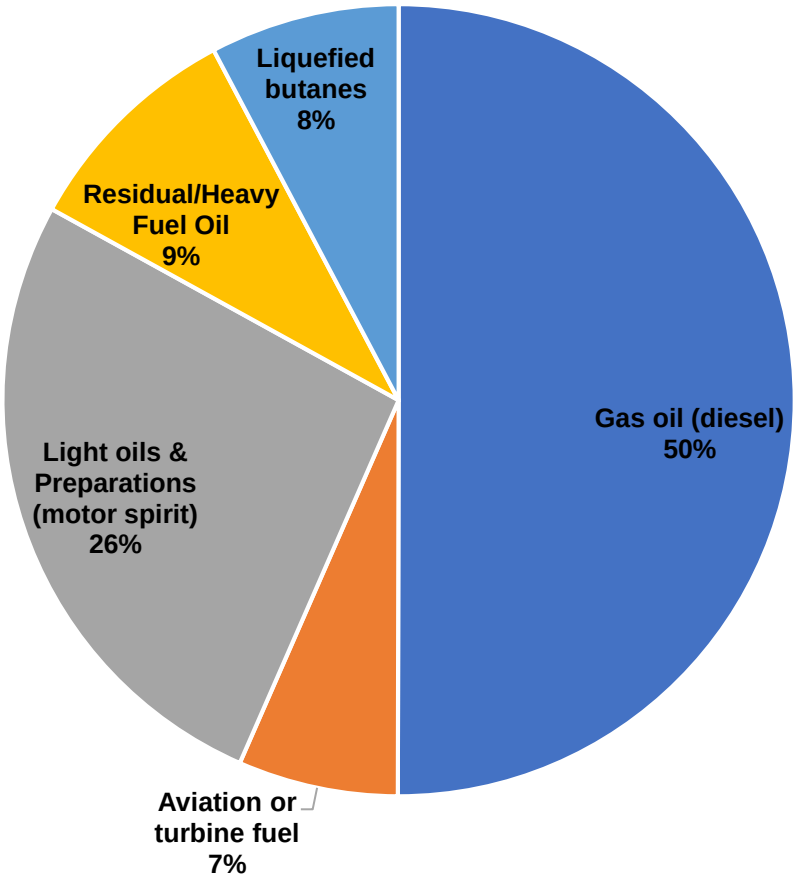


Figure 1.2 Pie chart showing the category and percentage of fuel imported in Fiji in 2021 (Fiji Bureau of Statistics , 2021).

1.7 Actions and goals set for land transport sector

The Fijian government is encouraging the development of the low-carbon transportation, urban growth, building bankable projects, and creating sustainable livelihoods. A project Urban Pathways supports the adoption of the Paris Agreement and the Nationally Determined Contributions (NDC) in the framework of the new urban strategy and the Sustainable Development Goals (SDG's. The local implementation principles are built onto bankable projects, with the intention to create a direct connection between climate change mitigation and sustainable development objectives through access to urban basic services (The Fijian Government, 2019). As such a number of policies

have been developed by the government in close consultation with local and global partners.

1.7.1 Biofuel policies

The Government's goal is thus, to achieve both the commitments of Conference of Party 21 (COP 21) and Nationally Determined Contributions. In corporation of biofuels in the country's energy mix was one of the potential strategies. The challenge remained on promoting the production and distribution of biofuels in the region. The circumstances are not recent and many governments have used the tax incentive mechanism for these outcomes in the past years and approaches to policy should therefore (Singh, 2018):

i) Set targets for biofuel production and use in the country;

ii) Motivate and encourage entrepreneurs to establish a better market for biofuels;

iii.) Develop processing, distribution and use of biofuels with appropriate standards.

Efficient energy policies, laws, and legislation will contribute to achieving the three objectives. Objectives (i) and (ii), could be achieved through the introduction of a new national biofuel programme; promote biofuel development through agreements such as ***tax incentive.*** By establishing and enforcing effective national ***biofuels standards*** and regulations, the third objective could be accomplished.

One aim of fuel application is to ensure that the new biofuels meet the current motor requirements of new cars, and that engine failures do not occur. It is clear that every new energy strategy (policy) will be changed when this broader context is changed:

- Making sure accessible, affordable, secure, modern energy in all countries;

- It is important to note that fossil fuel has an environmental impact;
- Maintaining efficient energy use.

Ensures that the wider picture is taken of energy policies and legislation in general:

- Test the energy supply in the country for everyone;
- Sustain consumers and energy providers;
- Mitigation of climate change and environmental conservation.

1.8 Biofuels industry in Fiji

A 5% biodiesel blend with the help of Land Transport Authority (LTA) and the bus companies was tested in 2007. The experiments included fuel and visibility checks. Mixed findings for buses and cars have been obtained at the end of the testing phase. Subsequently, through thorough research it was found that coconut oil and ethanol are currently the two most important biofuels that could be produced in Fiji which can be used for buses and cars (Singh, 2014). The Department of Energy constructed a research laboratory for B100 at the Walubay Central Plant pool in 2015 in order to enhance the fuel monitoring program, where pure biodiesel and ethanol (B100 and E100) are compatible and tested (Department of Energy, 2020).

1.8.1 *Status of petroleum fuel usage in Fiji*

At present, Fiji uses Euro 2 diesel and unleaded gasoline, which has a sulphur content of ≤500 ppm. It is expected that adopting renewable fuels would substantially decrease GHG emissions and help meet the NDC goals by 2020 (Department of Energy, 2020). However, after the first phases had been conducted in 2007 there has been no further work done on the mixing of biofuel blend fuels in Fiji.

1.8.2 *Feedstock utilized in the research and development for the production of biofuel*

The biofuel system in Fiji is primarily on a pilot scale and focuses exclusively on biofuel derivation from pongamia, coconut and jatropha. Sugarcane, maize, cassava, palms, dilo, biofuels based on algae and cellulosic biofuels are other feedstock attracting interest from stakeholders. Key information about the main biofuel feedstocks are as follows:

- ***Coconut***

  Coconut is the largest biofuel feedstock in the world. Conversely, coconut production in the country generally decreases. In 1991, the total coconut area was 46,764 hectares, which declined in 2009 to 15,009 hectares.

  The coconut production in the country actually focuses on the eastern and northern divisions. The province of Cakaudrove is the largest producer of coconut plantations, home to over 60%.

  Mainly due to natural hazards (cyclones and drought), land lease expired, poor agricultural growth, poor yields (25 coconuts per tree each year), high shipping costs and weak productivity, unfavourable crop price levels, has been the decline of the industry. This and the labour demands have caused farmers to lose confidence in this field (Department of Energy, 2020).

- ***Pongamia***

  The only Pongamia plantation in Fiji is owned by the 'Biofuels International' company. Pongamia was planted in 300 hectares of land, which is to be extended to 100,000 hectares (according to business plans). In the plantation site, the company had plant 140,000 trees, of which only 50,000 survived (the rest were destroyed in a fire) (Department of Energy, 2020).

- ***Jatropha***:

  Jatropha originated in Fiji, the tree's main function is to support vanilla plants. Wainigata Research Station has a Jatropha research site. Seeding was obtained from the site for production review by the local agriculture department office, but no further information about the operation are available (Department of Energy, 2020).

- ***Sugarcane and molasses***

  Sugarcane is the largest agricultural crop in the country supporting the most important sugar industry and is considered the main feedstock for the production for ethanol, which is molasses. Sugarcane production, once the backbones of the Fijian economy, has decreased by some 34% from 3,380,000 tonnes, totalling in 1991, to 2,197,950 tons in 2009. The total sugar cane area declined from 112,192 hectares in 1991 to 57,177 in 2009. The Mana species accounted for more than 50% of total production. The production of sugar in nation's five provinces including main province of Ba is high (Department of Energy, 2020).

1.9 General aim and Specific objectives of the Minor Thesis

1.9.1 *General aim*

The aim of this thesis is to conduct a survey on the transportation modes and renewable energy perceptions and to identify possible conflicts between Fiji's transport policy and the use of biofuels to reduce the fossil fuel consumption for transportation in Fiji.

1.9.2 *Specific objectives*

a) To use the specific example of the Lautoka transportation system in finding out the various methods and modes of transportation.

b) To investigate the use of renewable energy and biofuels such as E10 in Fiji's transportation sector, and the policies, legislations and regulations relating to the production and the use of this fuel.

c) To analyse the current status of energy policies and its relation to other policies are directly linked to the transportation sector.

d) To suggest strategies for resolving possible conflicts between the policies relating to transportation and energy sector with respect to the use of biofuels and renewable energy in Fiji.

1.10 Motivation for the research

In Fiji, the cost of living for a normal middle-class family is very high, due to the current prices in food, clothing, hardware and other essentials of life which a normal human being needs are very expensive. Similarly, the cost of fossil fuel in Fiji is very high due to its remote location. Therefore, Fiji spends a huge sum of money for importing fossil fuels: 1,170.6 (FJD Million) in the importation of fossil fuel in the financial year 2019 from Singapore (Fiji Trades Statistics, 2019). Therefore, if Fiji shifts its focus from fossil fuel importation to the use of E10 and B5 fuel standards it would be very much beneficial (U.S. Department of Energy, 2020). E10 is regular unleaded petrol blended with between 9% and 10% ethanol, and is a safe, reliable, and compatible with the majority of petrol-powered vehicles on the road (New South Wales Government, 2020). B5 is the most common type of biodiesel blended up to 5%, and is highly recommended for Fiji because it is safe, biodegradable, and produces less air pollutants than petroleum-based diesel. However, all this can only be achieved if there is a robust policy in place, for the regulation of biofuels in Fiji. This highlights the role of policy in the effective development of a country's fuel transportation fuel sector.

1.11 Structure of the minor thesis

The thesis consists of 7 chapters; starting the thesis with the introduction, which elucidates evolution of transport, share of renewable energy in the world and Fiji, and emphasis of biofuel production in Fiji.

Chapter 2 includes the background and literature review of the thesis.

Chapter 3 describes the methodology of the thesis.

Chapter 4 includes the detailed analysis of the survey of the questionnaires, the results were discussed and their opinions were examined.

The specifics of the various policies, legislations and regulations are examined in Chapter 5.

Chapter 6 details the potential barriers in the production of biofuels in Fiji.

A set of recommendation and concluding remarks are given Chapter 7 of this thesis.

CHAPTER 2
Background and Literature

2.0 Overview

This chapter elucidates the importance of the transport sector presenting the global fossil fuel consumption and the affiliated costs. Moreover, the international policies on transport, alternate fuels like biofuel emphasis and the SDG goals aligned to the transport sector are presented. Fiji has a lot of potential for biofuels but there has been issues such as food vs energy debate, natural disasters and low copra price. The current role of Biofuels in Fiji and the current milling sites are discussed in this chapter.

2.1 Fossil fuel consumption globally

According to Ritchie and Roser (2019) fossil energy has been the main driver of the change that has been made in technological, social, economic advancement. The role of fossil fuels (coal, gas and oil) in global energy systems remains dominant (Ritchie and Roser, 2019). The consumption of fossil fuel globally is presented in Figure 2.1, including the consumption of coal, gas and oil from 1800 to 2019 in Terawatt Hour (Twh). The consumption has essentially been increasing at an exponential rate.

As the novel coronavirus (Covid-19), shook the entire world, the economic, health, technology and energy supply were all affected drastically. The virus, especially had an acute effect on the markets for oil products as restrictions on foreign travel and regional and local movement prevented the mobility of people and goods, which placed a heavy price hike for goods and services (International Energy Agency, 2020). In addition, the ongoing invasion by Russia on Ukraine the oil prices have sky rocketed the global oil price to over 110 USD per barrel, which is making it difficult for people of Fiji to afford (Kolaczkowski, 2022). Therefore, if biofuel is manufactured in Fiji it would

reduce the cost burden for locals and Fiji would be independent and self-sufficient to cater for fuel needs.

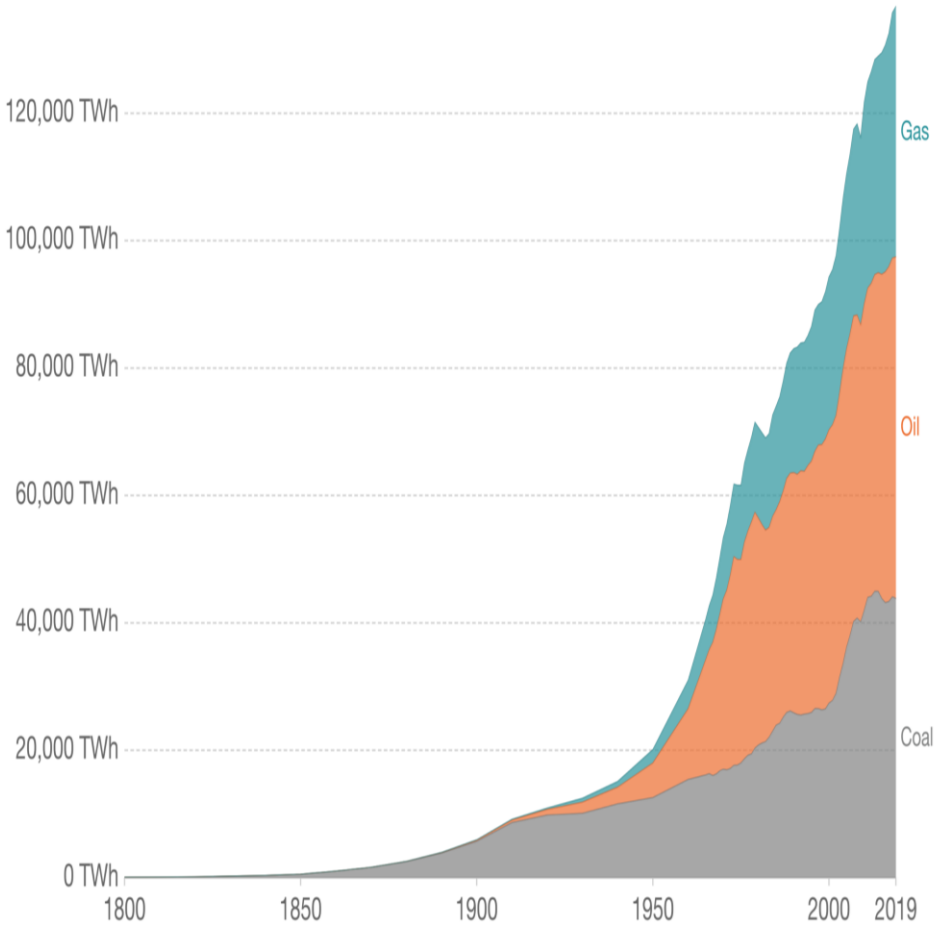


Figure 2.1 Global primary energy consumption by terawatt-hour (Twh) for the use of fossil fuel from 1800 to 2019 (Ritchie and Roser, 2019).

2.2 Biofuel production in Fiji

The Government of Fiji's development priority is to have alternative, less costly and local fuel. High potential sources that has the capacity to satisfy Fiji's fuel demands are ethanol from sugar and coconut oil. There are seven islands that have biodiesel plants operating on a small scale for electricity generation. These islands are Koro, Rotuma, Cicia, Vanuabalavu, Lakeba, Rabi and Gau.

The initial biofuel testing for electricity production and road transportation was conducted in 2007 to determine the feasibility of biofuels in Fiji for both electricity and road transportation (Lee, 2007).

2.2.1 Biofuel testing- 2007

Biofuel testing of coconut diesel of 12% blending trials were done in 2007 in two phases (Lee, 2007):

- ***Phase 1-***

  A total of 32 vehicles were part of this phase, whereby the litres of diesel in a full tank and the corresponding mileage travelled were noted.

- ***Phase 2***

  An alternative coconut diesel made from blending 2% of coconut oil (CNO) for a diesel engine (i.e., 2 litres CNO for 100 litres of diesel). If additional coconut diesel fuel is required, the balance is determined and coconut diesel is added to complete the 2% coconut diesel mixture. Smoke emission checks on coconut diesel fuel vehicles were also performed (Lee, 2007). The coconut diesel which was successful in fuel blending was used in remote islands for electricity generations (Table 2.1) and for transportation. Phase 2 testing is relevant to the thesis because, coconut diesel has been quite successful in the seven maritime islands and can be produced at a larger scale on the islands of Viti Levu and Vanua Levu, and can be utilized for transportation.

2.2.2 Biofuel production and current status at the seven sites

There have been seven maritime locations in Fiji, which has started biofuel production at village/community levels (Table 2.1) for electrification of the villages/ households. These seven maritime locations could be a perfect example to emphasis and encourage large scale biofuel production in Fiji.

Table 2.1 Seven potential sites for biofuel production in Fiji (Department of Energy, 2020).

Feasibility Site	Summary	Current Status
1. Koro Island: The village of Nacamaki	• The village community increases its diverse income base and thus economic resilience by converting the simple production of dried copra into value-adding activities, such as the production of biofuel for the adapted generator, cooking oil, body oil and soap. • Copra, along with agriculture and fishing, is Nacamaki's biggest earner. • Biofuel currently does not play a prominent role in rural electrification in Fiji, even though its potential is considerable. • The energy demand is projected to be about 314,000 litres (calculating at $2.60/ l) per year in Cicia and its neighbouring islands of Vanuabalavu and Lakeba (Cloin and Saula, 2007).	• The estimates demand is between 4500 and 14,000 litres/ year a year in view of biofuel demand and other uses. A 30 Kilovolt ampere (kVA) biofuel-suitable generator is suggested to be installed in the village, as well as electricity metering that ensures a sufficient recovery of electricity. •Biofuels have much more cost-efficient investment cost per (Kilo-Watt Hour) kWh than for example wind energy or solar energy. •Commissioned on 8th September, 2011 and is still operational and produces sufficient quantity of biofuel for the village Nacamaki.
2. Rotuma	• The source is for community or private generators. A need for implementation and the use of biofuels is mandatory. • Funding from the Global Environment Facility (GEF) under the World Bank to promote Sustainable Energy Financing Project (SEFP) (Watling, 2012).	•Rotuma Biofuel Company Ltd. Commissioned on the 14th May, 2011, and is still operational.

<table>
<tr><th>Feasibility Site</th><th>Summary</th><th>Current Status</th></tr>
<tr><td>3. Cicia,
Lau</td><td>• The main development goals are to create modular coconut oil biodiesel production.
• The communities boost their income base and economic resilience by moving from the production of dried copra, as they have done in the past, to value adding activities such as the production of biofuels, cooking oil, body lotions and soap.
• The current electrification of the villages and schools is the result of the program diesel (Ubitau, et al., 2010).</td><td>The Prospects of electricity is as follows (Ubitau, et al., 2010):
<table><tr><td>Diesel Consumption</td><td>56,328 litres/yr</td></tr><tr><td>Operational days generator (assuming power is available everyday)</td><td>365 days</td></tr><tr><td>Average Load</td><td>20 kW</td></tr><tr><td>Coconut oil consumption at current load assuming 365 days operation</td><td>56,328 litres</td></tr></table>•Cicia Biofuel Company Ltd Commissioned on the 8th of September, 2011 and is still operational but does not produce enough biofuel to cater for the people of Cicia.</td></tr>
<tr><td>4.Vanuabalavu,
Lau</td><td>• A biofuel survey was conducted in the villages of Mualevu, Mavnaa, Daliconi, Boitaci, Malaka, Muamua, Namalata, Narocivo, Lomaloma, Dakoilomaloma, Sawana, Levukana, Uruone, and Avea, in Vanuabalavu, the turaga ni koro was interviewed regarding the coconut supply at the island.
• Interviews revealed that biofuels shorten the life of the engine which</td><td>• Vanuabalavu Biofuel Commpany Ltd commissioned on the 15th of August, 2013 and is still able to produce negligible quantity for Vanuabalavu.</td></tr>
</table>

Feasibility Site	Summary	Current Status
	is the negative impact of the use of biofuel (Curuki, et al., 2011).	
5. Lakeba	• ***Yadrana Village***: consists of two coconut oil sheds and other by-products, including soap, lotion and copra meal. • There have been many factors preventing the future location of the biofuel shed at the current site, including availability of space. • The cost of electricity in Lakeba in two villages (Tubu and Levuka), which is connected to the same grid costs $0.22/kWh • The mill produces biofuel needed for the entire island and sells the excess coconut oil and copra meal to existing continental markets (Raju, 2011).	• The current demand of biodiesel on the island is 12,000 litres monthly. The requirement is a combined volume of 9600 litres of diesel and 2400 litres of coconut oil when converted to biofuel. • Lakeba Biofuel Company Ltd, was commissioned on the 16th of August, 2013 and still operational.
6. Rabi	• The 4 villages feasible for biofuel production in Rabi are Tabwewa, Uma, Tabiana and Buakonikai. • ***Copra Feasibility Review:*** On Rabi Island there is no coconut or coconut plantation. Copra farming is restricted to the standing coconut trees available, from which farmers collect dried nuts every day. An approximate 100 to 150 dried nuts per day may be collected by each farmer. Copra is extracted and dried in farm huts near the wood burning dryers (Department of Energy, 2012).	•CNO is for generation of power and not for transportation. •The average current demand for diesel is 4000 litres a month. •The commission of the Rabi Biofuel LTD began on 14th of August 2013, and is still operational.

Feasibility Site	Summary	Current Status
7. Gau and Nairai Island	• Copra production is projected to be 28 tons a month in total on the island. • Copra is sold to Punjas and JayKays by the cooperative. Punjas buys $800.00 per tonne of copra. Copra's freight is deducted directly from the actual copra bill. • Since there are limited car on the island, diesel fuel is mostly used for generators (Velitokaduadua, et al., 2012).	• Diesel is bought at a price ranging from 450.00 to 500.00 (FJD)/200l barrel from Pacific Energy grid. •Freight cost is $28.00 per drum from Suva to Gau. •The commission of the Gau Biofuel Company kicked of 16th of March, 2013, and is still operational.

2.3 Fuel standards in Fiji

As per the Fijian Government, since 1 January 2019, lower sulphur fuel has been adopted by the Trade Standards (Fuel Standards) Amendment Order 2018. The minimum requirements for sulphur concentration in diesel reduced to 10 ppm from 500 ppm. On the other hand, sulphur content in unleaded petrol reduced to 50 ppm from 500 ppm. This amendment was made in consultation with relevant stakeholders, such as fuel companies and the Fijian Competition and Consumer Commission (FCCC), Consumer Council of Fiji (CCoF), government agencies, private sector, fuel importers and other interested parties. The less sulphur fuel would lead to reduced emissions, higher engine life and reduced motor vehicle maintenance costs. The use of less sulphur fuel would increase the time span between the vehicle maintenance and significantly decrease the wear and tear of the engines (The Fijian Government, 2019). Under special circumstances, the importation for the 500ppm fuel is permitted for the re-export purposes.

2.3.1 Biofuels mandate

Diesel can contain 5% biodiesel by volume (max) Fatty Acid Methyl Esters (FAME). However, before mixing, the 5% biodiesel should comply with the biodiesel B100 requirements (The Fijian Government, 2011). When biofuels are produced in Fiji at larger scales these mandates would be quite essential and thus it is important for the local people have an understanding.

2.3.2 Emissions standards

Euro 6 is the sixth epitome of the Directive of the European Union on reducing hazardous emissions from vehicle exhausts. It was adopted on 1 September 2015 and is the most recent European Commission Euro standard. The following statistics from the Society of Motor Traders illustrate the degree to which toxic emissions are limited by the Euro 6 standard:

- Carbon monoxide (CO): 63% reduction in petrol, 82% reduction in diesel since 1993;
- Hydrocarbons (HC): 50% drop in petrol since 2001;
- Nitrogen Oxide (NOx): down from 84 % since 2001;
- Particulate matter (PM): diesel down 96% since 1993

While Euro 4 requirements are the minimum requirement for cars in Fiji, this is just a benchmark defined by the authorities. Consumers can always opt for the maximum possible Euro (Euro 6) standard. Benefits of Euro standard cars in addition to minimising harmful emissions, there are also other benefits of highly rated Euro standard cars, such as Euro 6 cars (Consumer Council of Fiji, 2020).

2.4 Biofuel standards in Fiji

National Biodiesel and Ethanol fuel standards (amendment) Order 2011 Trade Standards (Fuel Standards) states the powers conferred under Section 26 of the Trade Standards and the Decree on Quality of 1992 and following the council's recommendation that the designation of commercial standards for biofuels and ethanol fuel is in the public interest. The order contains a new subparagraph (6) in which it contains that diesel may contain 5% by volume at maximum biodiesel (FAME). However, 5% biodiesel complies with B100 requirements before blending (The Fijian Government, 2011) . To add on, as per The Fijian Government (2011), 'in Schedule 1 of subparagraph 4(1) by enhancing the phrase "European Standards (EN)" before the words "testing method...", was revised in the fuel standard order 2011

2.5 Energy vs Food debate

Biofuels are emphasized all over the world for the following reasons (Guyomard, et al., 2011); environmental concerns, energy security reasons, more saving on foreign currency especially for the Pacific Island Countries (PICs) as they do not produce fossil fuel and fossil fuel importation costs are relatively high, and also rural-sector socioeconomic problems. Biofuel production in Fiji can be quite controversial in terms of food scarcity, but if there is a proper diversification there would be no food scarcity. Biofuels has various branches including; bioethanol, bio methanol, biodiesel (renewable diesel), vegetable oils, biogas, bio- synthetic gas also known as bio-syngas or syngas, bio-oil, bio-char, Fischer-Tropsch liquids and lastly the biohydrogen. The majority of traditional biofuels are produced from conventional farm food crops which require high-quality agricultural land for development, such as maize, wheat and sugar beets, and biodiesel from oil seed. Bioethanol is a fuel addictive/ substitute for petrol (Demirbas, 2008) .

2.6 Fijian government incentives for biofuels

A tax holiday is available for ventures into agricultural commodities processing into biofuels as endorsed by the Commissioner between 1 January 2009 and 31 December 2028. The taxpayer needs to have (Fiji Revenue and Customs Authority, 2018):

- Investment in capital between 250,000 FJD and 1,000,000 FJD for a five-year period;
- Investment in capital for 7 conservative years between 1,000,000 FJD and 2,000,000 FJD;
- For the course of 13 consecutive years, the capital expenditures surpass 2,000,000. FJD (Fiji Revenue and Customs Authority, 2018).

Additional governments initiatives to organizations willing to undertake Biofuel/ Renewable Energy Projects in Fiji:

- Duty free import for the first setting up of factory, machinery and equipment;

- Duty free import of chemicals essential for the manufacture of biofuels;

- The import of all agricultural products is subject to zero tariffs (provided the Ministry of Agriculture has issued a letter of support) (Fiji Revenue and Customs Authority, 2018).

If this incentive is provided to private, foreign investors, or medium and large enterprise biofuels could be manufactured in Fiji, which would be a win-win situation for both the investors and end-users with biofuel production at a lower price.

2.7 Literature Review

Fiji's transport sector needs a deep decarbonisation strategy because it is second most emitter of GHG emissions (The Fijian Government, 2021). There are two

strategies being examined for Fiji's sustainable land transport and future research which included adapting to clean vehicle strategy and mobility management strategy (Prasad and Raturi, 2018). The use of biodiesel in the transportation sector has the potential to lower fuel use by 8.8% by 2040 (Prasad and Raturi, 2018).

A short-term mitigation measure suggested by the Fijian government was to place more emphasis of biofuel production in Fiji (The Fijian Government, 2019). Coconut oil (CNO) and its derivatives, as well as ethanol, are examples of prospective indigenous biofuels or biofuel feedstocks that are being produced or may be cheaply produced in Fiji (Singh, 2014). The viability of biofuels has severely decreased due to climate change impacts. Hence, the success is dependent on incentivizing the production and use of CNO and B20 (Lal, et al., 2022). There has been limited to no work done on fuel blending since 2007 (Lal, et al., 2022), and thus more research and development are required for biofuels in Fiji in particular for the land transportation sector.

The automobile manufacturers are also recognising the significance of high-quality fungible biofuels (European Union, 2022). Fiji has been considering the use of biodiesel B5 (B5 is composed of 95% diesel and 5% biodiesel) mix to replace diesel fuel in the entire transportation sector (Cloin, 2005). In an effort to reduce emissions, the 2017 Nationally Determined Contributions Roadmap proposed for all diesel fuel land transports in Fiji to begin utilising biodiesel fuel by 2021 (Charan, 2019). To support this, the government, in association with Copra Millers of Fiji Ltd., planned to plant around 30,000 coconut trees every year to produce CNO biofuel for land transportation in Fiji (Prasad, 2019).

2.7.1 1st and 2nd generation biofuels

First-generation biofuels are made from crops grown directly in the field, such as grains, maize, sugar beet and cane, and rapeseed (Norberg, 2022). While the second-generation biofuels are prepared from leftover and

waste materials from industries and homes. There is also a lot of used cooking oil and slaughterhouse waste (Norberg, 2022).

Many countries are looking toward biofuels for transportation sector. Hungary assessed that liquid biofuels continue to contribute a minor but growing contribution to global transportation fuel consumption, accounting for around 3% of global road transport fuels (Popp, et al., 2014). However, the study also dwells that there is a threat to food security, and a debate for fuel and food. The study concludes that there should be a balance between fuel and food, also more agricultural production to be done on a global scale so that there is neither shortage for food and nor biofuel for transportation (Popp, et al., 2014).

Successively, a study conducted in India by Malode et al. (2021) pointed that the recent rise and decrease in the price of fossil fuels, as well as the comprehensive move toward green energies, have contributed to an increase in the use of biomass conversion processes. The increased available biomass capacity indicated a necessary improvement in biomass's role in the global energy mix, and the advancement of effective conversion processes permits the chemical transition to better road fuels (Malode, et al., 2021). According to the U.S. Department of Energy, the principal biofuels for land transportation are bioethanol and biodiesel, both of which represent the first generation of biofuel technology (Saad, et al., 2019). The fourth generation of biofuels for land transportation is focused on metabolic engineering of the microalgal genome to optimise biofuel output or reduce costs which is currently researched in the US. Microalgae farming is a crucial component of biofuel production. The study resulted, algae are appealing sources of feedstock for biofuel development, algae has several favourable characteristics, such as fast development and a substantial lipid content. The major constraints appear to be costly infrastructure, operating, and maintenance expenses, the

selection of high lipid-containing algae strains, commercial harvesting, and water evaporation issues (Saad, et al., 2019).

Taking a closer look at the Oceania region, the pathway for Australia's biofuel for land transport development elucidates that the future of biofuel development in Australia must prioritise sustainable, low-carbon, and advancement of 2nd and 3rd of generation biofuels (Thomas and Wright, 2008). The findings reveal that biofuels have the potential to improve Australia's liquid transportation fuel security, but this must not come at the price of food production. Furthermore, current 2nd generation of biofuel technologies are not cost competitive, necessitating an increased Research and Development (R&D) investment (Thomas and Wright, 2008). Azad et al. (2015) suggested that a part of Australia's land transport fuel demand could be met from biofuels. It was found that second generation biofuels have a stronger potential as an alternative transport fuel in Australia (Azad, et al., 2015). The study concluded that despite a vast number of studies were done on 2nd and 3rd generation of biofuels for land transportation, a lot more was needed (Azad, et al., 2015). In comparison study by Hazrat et al. (2015) revealed that Australia's fuel refining utilities were not used up to full capacity which results in higher imports of crude oil (approximately 37%). There were no more technical advanced initiatives being considered to attain self-sufficiency and make the best use of local fuels to reduce fossil fuel imports (Hazrat, et al., 2015). Australia could potentially utilize two types of biofuel which are bioethanol and biodiesel. The study concluded that there is a need for accurate and effective support for the biofuel industry and related polices to possibly reduce Australia's reliance on fossil fuel (Hazrat, et al., 2015).

In addition, a study by ARENA (2017) found out that Australia produced less biofuels for transportation compared to the rest of the world. To contribute Australia's part of the forecasted global average in 2060, the

country's biofuel production must be increased by a factor of 40 to around 20 gigalitres per year (ARENA, 2017). Furthermore, the continued investment in R&D is expected to lower land transportation biofuel costs.

A recent advancement in the techniques in cost reduction and increased reliability in advanced ethanol pre-treatment concluded that local production of land transport biofuels would assist in Australia's trade balance and provide export prospects for countries that lack similar natural resources as Australia for the production of biofuels for fuel purpose (ARENA, 2017). An exploration by Doshi (2017) pursued the support and for more outcomes for microalgae biofuels in Australia for land transportation. Increasing fossil fuel costs promoted exploring microalgae for biodiesel, with the more seminal research for commercial production (Doshi, 2017). This is predominantly attributable to the microalgae biomass's substantial lipid synthesis during cultivation (Doshi, 2017). A high degree of technical replacement between conventional diesel and biodiesel, specifically in blended fuels minimal to no modification of diesel engines are needed (Doshi, 2017).

Studies show that biofuels might be a momentous to very momentous long-term solution to New Zealand's greenhouse gas reduction goals particularly for the transportation sector. The biofuels opportunity is vast, nonetheless timing is critical, especially at high levels of fossil fuel replacement. A study by Kelly (2016) found that there is advancement and support for sustainable transport energy, that is; the utilization of biofuels for road transportation, however, there is still high per-capita fuel demands for transport and inadequate local hydrocarbon sources for biofuel for land transportation (Kelly , 2016). Nonetheless, pathways for a fully sustainable transportation energy system could be technically viable if more investors build confidence in biofuel industry. The study sums up that the key impediments to the development of biofuel industry continues to be the cost barrier and confidence of investors in biofuel

projects (Kelly , 2016). In addition, the R&D for biofuels in New Zealand has minimal contribution of biofuels for New Zealand's road (Suckling, et al., 2018). Biofuel production has the potential to drive regional economic development and job creation (Suckling, et al., 2018). A very recent study by Comendant and Steveson (2021), investigated the pathways for drop-in biofuels are fundamentally comparable to present petrol, diesel, and allied fossil-derived transportation fuels. Drop-in fuels could be manufactured via these four processes; biochemical, hybrid, oleochemical and thermochemical (Comendant and Stevenson, 2021). To assess biofuel implementation by 2025, two scenarios for technical approaches for the production of biomass-based advanced biofuels were assumed. The study found that drop-in biofuels from non-arable forest provide the best and most reliable potential of land transport biofuels. Drop-in biofuels for land transportation are produced from non-food feedstocks, specifically forestry on non-arable land, are the most captivating in the long run, conferring to main outcomes (Suckling, et al., 2022).

Both 1st and 2nd generation biofuels could be utilised as fuel in Fiji at a large scale for road transportation. A study by Kumar (2009) on first-generation biofuels (ethanol) which demonstrated that producing ethanol from molasses or cane syrup in Fiji is likely to be lucrative if done concurrently with sugar production. Other benefits for Fiji included the usage of ethanol in automobiles, which would lower the trade imbalance by substituting for petroleum imports (Stauvermann and Kumar, 2009). Additionally, Fiji also may export any surplus ethanol, which may potentially increase export value dramatically (Stauvermann and Kumar, 2009). The usage of biofuel as a substitute for mineral fuels could be extended to 100% if relevant technology becomes widely available in the near future (Malode, et al., 2021). However, there are many issues that has to be addressed by the government and the stakeholders including land, lease renewals to increase the sugar cane production (Singh, 2014).

An expansion in the number of studies on second- generation biofuels utilizing agricultural residues has been noted (Prasad, 2019). The benefit of using lignocellulosic materials in developing cost-effective biofuels could avoid the “food vs fuel" debate can be avoided (Prasad, 2019). The production of second-generation biofuel could be seen to be viable and economically feasible. This fuel has the added benefit of being able to substitute petrol without requiring engine modifications (Prasad, 2019). In a study by Prasad (2019) found that 488.834,780.40 litres of Pongamia oil per annum can be produced in Vanua Levu, which is the second largest island of Fiji. Though Pongamia oil may be generated locally and processed into a theoretically carbon-neutral Pongamia biodiesel, the life cycle production of such fuels involves emissions to the environment owing to the usage of fossil fuels and other GHG-producing factors (Prasad, 2019). Consequently, a study conducted by Prasad and Singh (2020) found that the benefits of using Pongamia for biodiesel in Fiji is that Pongamia survives well in Fiji’s tropical climate. Another major benefit is that it does not have to debate for fuel vs food because Pongamia oil is not utilized for consumption by people, as Pongamia oil contains certain toxicity, and are not appropriate for human consumption (Prasad and Singh, 2020).

In addition, Jatropha plant oil as alternative for diesel fuel had been trialled during World War II (WWII) (Reddy , 2019). Jatropha thrives in marginal/poor soil conditions and is drought tolerant. Generally, good fuels have a low viscosity, a high energy content, a high saponification value, a high cetane number (CN), and a low iodine value (Reddy , 2019). Jatropha oil produces little smoke and has a high saponification value (SV) (Reddy , 2019). In addition, the oil has a strong oxidizing stability than soybean oil, a lower viscosity than castor oil, a higher freezing point than coconut/palm oil, and a cheaper production cost than ethanol, making it potentially commercially feasible. Jatropha oil has a higher

acetone number (51) than other vegetable oils and petrol and diesel (Reddy , 2019).

Subsequently, a study done by Prasad (2020) suggested that sugarcane bagasse (SCB), molasses, straws and tops from the sugar industry, and hog fuel from the timber industry might all be viable feedstock for biobutanol production for Fiji's land transportation. Butanol's special characteristics make it an effective alternative fuel for land transportation, potentially reducing Fiji's reliance on fossil fuels (Prasad, 2020). Butanol has various advantages such as butanol has lower ignition problems than of ethanol in cold weather, also has lower volatility and it is quite safe when used at higher temperatures (Prasad, 2020). If butanol is produced in Fiji, it could help in achieving the NDC goals and also, contribute greatly with emission reductions by 2050.

The above studies conducted on the 1st and 2nd generations of biofuels for land transportation suggests that Fiji has the ability to produce biofuels at large-scale in both Viti and Vanua Levu. However, literature shows that limited work has been done in Fiji for the first and second generation of biofuels for road transportation.

The key barriers suggested were lack of foreign investors for biofuel industry, as the Fijian economy alone is not strong enough to cater the financial burden (Singh, 2019). The current studies for Fiji is not sufficient and much more research work is needed on both the 1st and 2nd generation of biofuels for transportation. The studies already done in Fiji presents that there is potential for biofuel production in Fiji at large scale if there is adequate investment (foreign or local), latest technological support and lastly the support of the people of Fiji for the production and adoption of biofuels for land transportation.

2.7.2 Policy initiatives for biofuels in land transportation

The impact of biofuel policies in various other countries like Brazil rationalises that ethanol policies in Brazil were initially promoted through government actions in response to the 1973 oil crisis, which caused a petroleum shortage (Janda , et al., 2012). The current ethanol blending obligation for gasoline is 18- 25%. The effectiveness of flex-fuel vehicles, as well as the 18-25% required blend, has allowed ethanol fuel usage in Brazil to replace 50% of petrol for transportation (Janda , et al., 2012). Similarly, in the United States the biofuel policy was mandated in the 1970's. The policies were driven by a variety of goals, including a desire to diminish dependence on imported fossil fuels, decrease GHG emissions, and stimulate demand for domestic agriculture commodities used as raw materials for biofuels (Hochman, et al., 2017). The current US biofuel policy includes three primary mechanisms: output-connected measures, input factor support, and consumption subsidies. While the European Union biofuel policy was developed primarily to meet obligations under the Kyoto objectives for the GHG emissions and to respond to public demand in the EU to address the environmental issues (Giuntoli, 2018).

For the case of Fiji, the Fijian government is committed to make a steady progress in the initiative of biofuel sector and the implementation of strategies were targeted to begin in 2020 (Losirene, 2017), yet due to Covid-19 pandemic brought it to a halt. A key hurdle identified by the Department of Energy is a lack of policy framework and mandate for road transportation (Losirene, 2017). As stated by Losirene (2017) once the policy frame for biofuels is mandated, then the actual groundwork could be addressed such as the technical, economic, and social impacts of the biofuel industry. As per OECD iLibrary (2019), biofuels policies play a vital role in the biofuels market. If biofuel policies are mandated in the Oceania region a huge emission reduction of unleaded and diesel fuels would be noted (OECD iLibrary, 2019). To add on, a study by Lal (2020)

explicitly states that there is a necessity to specifically determine the economic impact of energy policy in the region. Due to an apparent dearth of studies in this area, PICs are unable to clearly articulate the precise macroeconomic consequences of energy policies (Lal, 2020).

2.8 Summary

Decarbonization of the transportation sector necessitates the acceptance of many fuel alternatives at the same time, rather than relying on a single, all-encompassing approach. Based on the findings for the Oceania region (Australia and New Zealand). Australia has the potential to produce bioethanol for petrol vehicles and biodiesel for diesel vehicles. However, currently Australia is not able to produce sufficient biofuel for transportation and further research, investment and technology are needed for the expansion of biofuels for road transportation. Contrarily, New Zealand's current focus is for drop-in biofuels. However, the specific challenges to future fuel development vary, particularly between those impacting drop-in fuels and those affecting other fuels such as cellulosic ethanol, which may face uneven cost competition from first-generation ethanol producers in a falling market. While the USA is currently focusing on producing biodiesel from microalgae, however the cost associated with the production microalgae are relatively high and is in infancy stage.

The outcomes of the studies conducted in Fiji for biofuels (1^{st} and 2^{nd} generations) illustrate that Fiji has a vast potential for investments and productions, yet a lot of research is vital. Fiji has the capacity to produce sufficient CNO-based biodiesel to meet the country's full diesel transportation demands. To add on, there are barriers to advancements of biofuels such as extended timeframes connected with projects and regulatory uncertainty (biofuel policies). Biofuels should be produced in Fiji for the transportation sector as it would help in the reduction of GHG emissions and decarbonizing Fiji. Biofuels productions can be very cost effective and very helpful to the environment as it reduces particulate matter by 47%, hydrocarbon emissions by up to 67% and biofuels would further reduce smog (Mogler, 2022). A

behavioural change of people and a little initiative by the government of Fiji is required to push the emphasis of large-scale biofuel production into action.

CHAPTER 3

Methodology

3.0 Overview

The methodology of this study was divided into two parts. The first was a structured transport survey in Lautoka area on the preferred transportation modes, cost of fossil fuel, environmental and health implications, production and use of biofuels in Fiji. A survey was designed and the details are provided in the Appendix Section (A1). The second phase of the research entailed policy mapping of energy related policies for land transportation sub-sector in Fiji. The policies related to renewable energy and climate change, in relation to the transportation sector that has been adopted by the government of Fiji were also analysed. The methodology adopted for these two phases are presented in this chapter.

3.1 Land transportation and energy survey

In the first part of the research, a survey was conducted to investigate people's perception regarding the transportation sector using a questionnaire. A survey of transportation sector for residents in Lautoka, was conducted to find out the satisfaction level of people with the price and use of fossil fuel, also elucidating on the cost associated with transport sector, environmental impact of the fossil fuel, the potential barriers in transport sector. Respondents were also asked to express their knowledge and views on the production and use of biofuels in Fiji. A total of 60 randomly selected individuals above the age of 18 was the sample size of the survey and the data was collected by means of a questionnaire. This survey was conducted during Covid19.

Prior to the survey, consent from respective individual was sought and the participation was on a voluntary basis. Participants also had the liberty to leave

any question blank, if they were unwilling to answer. Table 3.1 presents a summary of the questionnaire.

Table 3.1 Five parts of the survey sheets and analysis.

Parts	Analysis
Part A: General Information	• Address of household • Total annual income of household
Part B: The Cost Associated with Transportation Sector	• The means of travel (bus, taxi, car-pooling) • The distance travelled per week • Money spent on fossil fuel • Methods in which Fiji could save on transportation cost • Prioritization over specific mode of transport in Fiji • Price satisfaction of fossil fuel in Fiji
Part C: Environmental Impact of Fossil Fuel	• The use of fossil causing environmental degradation • Alternative sources of fuel helping Fiji reach its net zero carbon emissions target by 2050. • Reason why people of Fiji and the Pacific still rely on fossil fuel heavily
Part D: The Potential Barriers in the Transport Sector Efficiency	• Potential barriers in transport sector that hinders the efficiency
Part E: The Production and use of Biofuels in Fiji	• The impact on food crops by the production of biofuel in Fiji (Energy vs Food) • Biofuels a solution for energy crisis • Research and Development in Renewable Energy • Need for development of a new biofuel policy.

3.1.1 Data collection and analysis

Part A of the survey gathered general information of the participants. Primarily, during data collection, the income category was divided in 4 categories and analysed accordingly. The annual income categories and the number of respondents were:

a) 10,000- 29,999 (FJD): 16 Participants

b) 30,000- 49,999 (FJD): 14 Participants

c) 50,000- 69,999 (FJD): 12 Participants

d) >70,000 (FJD):18 Participants

The data collected were analysed using Microsoft Excel. Data was either graphed using a bar graph, line graphs, or tabulated. The advantage of bar graphs is that it can represent a large of collection of data; also allowed for ease of estimating key values and is broadly used in energy field for its simple to understand illustrations (Barcelona Field Studies, 2021). Moreover, analysing data collected from respondents in a table form was chosen for this study because it is easy to find information; finding causal relationships and to efficiently summarise information (Davis, 2021).

3.1.2 Qualitative and Quantitative analysis of the survey

The qualitative and quantitative analysis (Parts B-D of the survey) were to determine the correlations between the annual income of participants to their knowledge on fossil fuels, climate change and renewable energy.

In Part B, the information such as the cost associated with land transport sector in Fiji, money spent on fossil fuel was analysed. The key areas looked at in this section was means of travel, distance travelled per week, prioritization over a specific type or mode of transport which leads to biasness, price satisfaction of fossil fuel in Fiji and keenness to use biofuels.

Part C dealt with questions in relation to the environmental impact of fossil fuel use. The data on this was gathered to find out the reasons for high dependency on fossil fuels in the land transportation sector in Lautoka and Fiji. This section emphasized to collate and analyse data on

the willingness of people to adapt alternate fuel to achieve net-zero carbon emissions. Also, questions on whether the respondents were ready to adapt changes such as introduction of biofuels in Fiji was also investigated.

Furthermore, Part D and E aimed to identify the potential barriers in transport sector energy efficiency that were analysed using bar graph and problem tree approach.

Since the survey was conducted during Covid19 a number of challenges were encountered during the process. In addition, difficulties such as participants not having sufficient knowledge on energy sector or the consequences of fossil fuel use on the environment and the mitigation methods that are adopted by Fiji to combat climate change. Biofuels was all together a new terminology for certain participants, therefore the composition of biofuels, what it is made from, the benefits to the environment of biofuels and the need of a biofuel policy had to be explained to some respondents in order to aid them to fill in the questionnaires provided as the feedbacks were open ended.

3.2 Qualitative policy mapping

To map and examine various policies, legislations and acts that govern transport sector in Fiji, a qualitative policy analysis approach was performed using "Document Analysis" methodology. Document analysis is a method for examining and evaluating documents in order to provide context, raise questions, complement other types of research material, follow change through time, and corroborate other sources (Bowen, 2009).

A list of all policies, legislations and acts was prepared and the scope was narrowed down to the area of interest that is, the energy related polices in land transportation sub-sector in Fiji. For document analysis the 'Qualitative Content Analysis' method used. As a set of tools for the systematic investigation of texts of various types, qualitative content analysis addresses both observable content

and the themes and basic ideas contained in texts as primary content (Maschi and Drisko, 2015). The benefit of qualitative research is the richness of the acquired data, which must be evaluated and categorised in a legitimate and trustworthy manner (Moretti, et al., 2011). According to Graneheim (2004) while addressing the reliability of conclusions from a qualitative content analysis, it is critical to remember that there is always some degree of interpretation when approaching a text (Graneheim, 2004). The specific contents of the various polices, legislations and acts are listed in Tables 3.2-3.4.

Furthermore, information on the use of renewable energy and biofuels in Fiji's transportation sector, and the policies, legislations and acts relating to the production and use of the biofuels (E5 and B10), and renewable diesel were collated and discussed.

3.2.1 Document analysis approach

Document analysis (also known as document review) is one of the most often utilised approaches in policy research, conducting policy research without it is almost impossible (Dalglish, et al., 2020). As Bowen (2009) suggested that skimming the papers to gain an overview, then reading to find relevant categories of analysis for the total collection of documents, and then analysing the body of documents, is one of the widely used approaches in policy research.

To achieve reliable results, a rigorous planning procedure was made before doing document analysis. O'Leary (2017) presented an eight-step planning method that is to be followed in any textual (qualitative research) as follows (O'Leary, 2017):

i. A list of polices were made to investigate: For this study a set of 14 policies were chosen.
ii. Considerations were made on how the policies would be assessed, keeping linguistic and cultural limitations in mind.

iii. The biases were addressed by collecting only the relevant information related to land transport energy sub-sector in Fiji.
iv. The necessary research skills were acquired.
v. Considerations on how to maintain creditability was strategized.
vi. The data searched for should be known for this research, which was the land transport sector.
vii. The ethical issues were considered
viii. A backup plan was devised.

Considering documents as controllable and practical resource, document analysis is a faster and effective method to obtain information. Policy documents are widespread and come in a number of formats, making them a very accessible and dependable data source. Documents contain background information and a wide range of facts, making them useful for placing one's research within the context of its subject or field. Document analysis could also suggest questions that need to be answered or situations that need to be observed, making it a useful tool for ensuring that the research is thorough and critical (O'Leary, 2017).

3.2.2 Qualitative content analysis approach

In addition, the qualitative content analysis does not use statistical analytic approaches. Qualitative content analysis is distinct from other qualitative research approaches, despite certain similarities in feature and techniques (Maschi and Drisko, 2015). The qualitative content is mostly limited to qualitative approach since:

i. The meaning is not always obvious;
ii. Meaning is frequently nuanced, contextual, and best evaluated in a holistic manner;
iii. That any significant or meaningful content may exist only once in a book, but this does not indicate it is unimportant or meaningless.

For these reasons, the qualitative approaches to content analysis was developed. A qualitative research approach can explain the content found in policies, legislation, and acts, investigate the processes or forms of the content distribution, and to construct a conceptualization of the content. Qualitative content analysis involves contextual information and latent content.

3.2.3 Policy documents used in the study

Firstly, 14 policy and legislation documents were collected (Tables 3.2-3.4). Since samples must be rich in information, that is the information extracted from the documents for analysis should contain information relating to land transport sub-sector, hence a subset was created. A third requirement for qualitative research samples is to be comprehensive to factor in possibly contradictory or expanding evidence (Maschi and Drisko, 2015).

Part A has Policies, Legislations and Acts, that bind Fiji's Road Transportation Sector via the Judicial Pathways as in Table 3. 2. Part B is on Roadmap and Policies Developed to Combat Emission Control from Transportation Sector as illustrated in Table 3.3Part C is about Mapping of Policies and Framework Developed in Fiji as aligned to Paris Agreement for a sustainable development (Table 3.4).

Table 3.2 Approach for the Policy Mapping (Judicial Pathways).

Policies	**Analysis**
1) Constitution of Republic of Fiji- 2013	Chapter 2: Bill of Rights - Right to reasonable access to transport - Right to adequate food and water - Environmental Rights
2) Fiji Petroleum Act- 1978	Import and export at assigned location Storage
3) Trade Standards and Quality Control Decree- 1992	The aim of the trade and quality decree The functions of the trade standards and quality control Quality Standards
4) National Biodiesel and Ethanol Fuel Standards (Amendment) Order- 2011	Schedule 4: Trade standards of ethanol fuel

Table 3.3 Approach for the Policy Mapping – Roadmaps and policies developed to combat climate change.

Policies and Roadmap	**Mapping of Policies**
5) The National Energy Policy - 2013	• Energy situation in Fiji for the transport sector • Energy priority by sector • Policies • Conflicts and strategies to resolve conflicts
6) 5 Year and 20 Year: National Development Plan Transforming Fiji 2017- 2036	• Twenty Year Development Plan 2017-2036 • Five Year Development Plan 2017-2021 • Conflict and strategies to resolve conflicts
7) A Green Growth Framework for Fiji: Restoring the Balance in Development that is sustainable for our future- 2014	• The basic objective of the Green Growth Framework • Sustainable transport • Conflict and strategies to resolve conflicts
8) Voluntary National Review: Fiji's Progress in the Implementation of the Sustainable Development Goals- June 2019	• Overview of the Voluntary National Review (VNR) • SDG 7: Affordable and clean energy • Overview of Goal 7 • Opportunities for partnership under Goal 7 • SDG- 12 Sustainable consumption and production • Conflict and strategies to resolve conflicts
9) Climate Vulnerability Assessment: Making Fiji Climate Resilient- 2017	• Transport resilience • Conflict and strategies to resolve conflicts
10)Environmental Management Act- 2005	• Purpose of the Environment Management Act (EMA) • Part 4: Environmental Impact Assessment • Conflicts and strategies to resolve conflicts
11) Maritime and Land Transport Policy- 2015	• National roadmap for democracy and sustainable development • Mitigation and adaptation to climate change • Fuel efficiency and emissions control for vehicle fleet • Conflicts and suggested strategies to resolve conflicts.

Table 3.4 Approach for the Policy Mapping- Mapping of policies and framework in Fiji: Aligned with the Paris Agreement.

Policies	**Mapping of Polices**
12) National Climate Change Policy- 2018	• Overview of the National Climate Change Policy • Resilient development and mitigation of climate change • Pathways • Conflict and strategies to resolve conflicts
13) Low Emissions Development Strategy- 2018	• Overview of the Low Emissions Development Strategy • LEDS Vision • Deep decarbonisation pathway for land transportation • Comparison of scenarios • Land transport • Conflict and strategies to resolve conflicts
14) Fiji Nationally Determined Contributions 2017-2030	• Overview of NDC • Mitigation actions in sub- sectors of energy • Sub-sector transport (Land) • Conflict and strategies to resolve conflicts

The next chapter presents the outcomes of the survey followed by qualitative policy analysis in the respective chapters.

CHAPTER 4

Transportation Modes and Renewable Energy Perceptions for Land Transportation

4.0 Overview

This chapter presents preferred choices of modes of transportation based on the survey outcomes. The general information such as addresses of household, and the income earned per family is presented first followed by the modes of transportation, weekly commute distance, fossil fuel expenses, means of saving on transportation costs (current practices), price satisfactions is detailed out. This chapter presents the outcomes of the Parts A- B of the survey (Appendix A1).

It then presents the outcomes of the **Part C** of the survey which largely looks at the perception of participants on environmental impact of fossil fuel; how the use of fossil fuel in the transport sector causes environmental degradation and climate change, alternative fuel sources and its contribution to net-zero carbon emissions and reasons as to why Fiji and the Pacific Islands depend on fossil fuel. This chapter presents the people's perception towards the biofuel production and usage for land transportation, while the outcomes of **Part D** and **Part E** are presented in Chapters 5 and Chapter 6 respectively.

4.1 Participant information

A total of 60 survey sheets were distributed to individuals of age 18 years and above. Participants were all from Lautoka and earning different incomes. The participants were random and lived in urban, semi urban and rural areas of Lautoka.

4.2 Description of the households

The three major types of the households found in the survey sheets were house, flat and apartment. A total of 53 participants resided in houses, 6 in a flat and 1 in an apartment. A flat is an individual residence with a set of rooms, which is typically one floor, and often for one family. On the other hand, an apartment are rooms designed as a residence but located in a building occupied by more than one household in one singular building and multiple families reside in their designated households.

4.3 Types of household

The type of household mostly used resided by the participants in this survey are mostly personally owned households which is (54), while 6 were communal owned or rented house.

4.4 Total annual household incomes of participants (FJD)

The results reflected that in this survey greatest number of participants were earning more than 70,000 (FJD). Table 4.1 depicts the total annual income per household earned by particular families and households.

Table 4.1 Total annual income of households (FJD) and number of participants involved in the survey.

Total Annual Income of Household (FJD)	**Number of Participants**	**Percentage**
10,000- 29,999 (FJD)	16	26.7%
30,000- 49,999 (FJD)	14	23.3%
50,000- 69,999 (FJD)	12	20.0%
>70,000 (FJD)	18	30.0%
TOTAL	***60***	***100%***

4.5 Modes of transportation

Some participants have more than one mode of transport for traveling in this survey, for instance, participants travelled by bus and car depending on the situations and circumstances. Recently car-pooling, whereby people sharing same route or destination hitch a ride and use one vehicle only, is also becoming common. This method just does not only reduce fuel burden on the car owner, but also assists them with the vehicle repayments (if any) as the car owner charges fare on the basis of normal travel fare from the people traveling sharing the ride. Hence, it can be beneficial for the environment in terms of emissions and pollution as fewer vehicles are used. Thus, it is a win-win situation on both the sides (financial and environment). Nonetheless, due to the ongoing pandemic people are not adopting car-pooling as people prefer traveling in their own bubble (when this survey was conducted Covid-19 was on a peak).

Table 4.2 Preferred mode of transports used by participants and their respective income ranges.

Mode of Transport	***Household income (FJD) and Percentage (%)***							
	No. of respondents in income range: 10,000-29,999 (FJD)	***%*** (Out of 16 participants)	No. of respondents in income range: 30,000-49,999 (FJD)	***%*** (Out of 14 participants)	No. of respondent in income range: 50,000-69,999 (FJD)	***%*** (Out of 12 participants)	No. of respondent in income range: >70,000 (FJD)	***%*** (Out of 18 participants)
Bus	16	100.0%	13	92.7%	8	66.7%	9	50.0%
Car	7	43.8%	13	92.7%	11	91.7%	18	100.0%
Taxi	5	31.3%	4	28.8%	5	41.7%	4	22.2%
Outboard/ Canoe	1	6.3%	1	7.1%	0	0.00%	0	0%
Horse	2	12.5%	0	0.0%	0	0.0%	0	0.0%
Bicycle	1	6.3%	0	0.0%	0	0.0%	0	0.0%
Car Pooling	0	0.0%	0	0.0%	2	16.7%	0	0.0%

As per Table 4.2 generally participants with higher income were less concerned about the environment and the detrimental impacts caused by fossil fuels but were more concerned about their own luxuries. The reason for such behaviour is because people who earn well above of 50,000 (FJD) have a comforting life and these people tend to overlook and forego the effects caused to the environment and tend to be negligence. One of the common actions caused by the participants earning above 50,000 (FJD) is that, a person would not want to take a walk to a nearby destinations such as, grocery store or supermarket but would prefer taking their personal vehicles, because they find it much more convenient and prefer an air-conditioned ride over walking in the hot sun, whilst emissions from the vehicle is neglected and not considered. The pollution and environmental degradation from this are not given much consideration over luxury and comfort.

To counter this, behavioural change is required with planned urban development to allow people to work around easily without the need to battle the heat of the sun. In addition, an introducing Lyft or Uber where people who desire to travel to the same location can go in a shared vehicle, as the most desired mode transportation is Cars in all income levels. Thus, comfort and convenience are not foregone as people can travel in air-conditioned vehicles and environmental degradation would be minimised through lesser emissions of GHG from vehicles.

4.6 Weekly commute distances

The statistics on distance travelled per week in relation to the income levels are shown in Table 4.3, which shows the distance travelled between the participants vary depending on the income earned. It clearly shows that people with higher income levels travel more distances than people earning less. As the income level increases per household there is more travelling which could be either due to work purposes (long distance travelling) or it can either be for pleasure. In

some scenarios households earning above 50,000 (FJD) own more than 2 vehicles.

Table 4.3 Distance travelled per week and income of participants.

Distance Travelled by People (km)	**Income:** 10,000-29,999 (FJD)		**Income:** 30,000-49,999 (FJD)		**Income:** 50,000-69,999 (FJD)		**Income:** >70,000 (FJD)	
	No. of participants	**%**	No. of participants	**%**	No. of participants	**%**	No. of participants	**%**
0- 49km	10	62.5%	1	7.1%	0	0.0%	3	16.7%
50- 99 km	3	18.8%	6	42.9%	2	16.7 %	3	16.7%
100- 149 km	0	0.0%	4	28.6%	3	25.0 %	3	16.7%
150- 199 km	2	12.5%	1	7.1%	3	25.0 %	4	25.0%
200- 249 km	0	0.0%	1	7.1%	1	8.3%	0	0.0%
250- 299 km	1	6.3%	0	0.0%	0	0.0%	0	0.0%
300 km +	0	0.0%	1	7.1%	3	25.0 %	5	27.8%

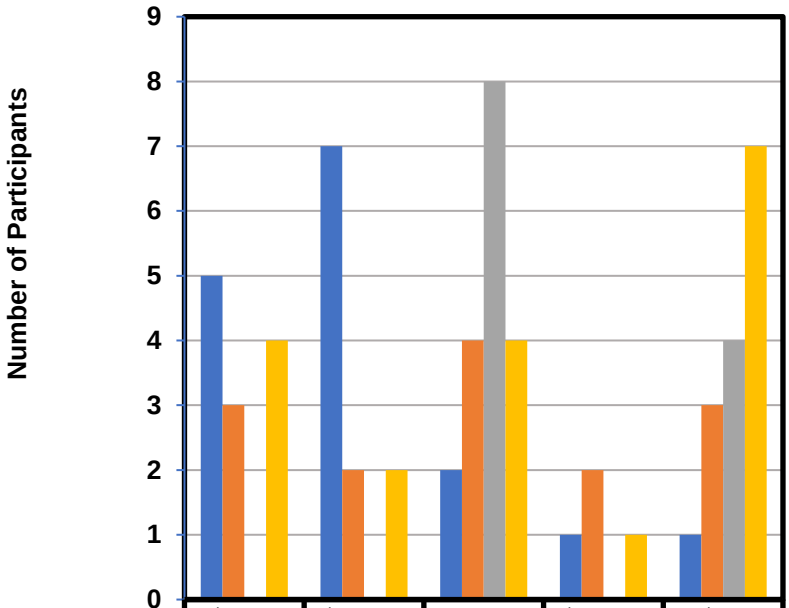
Participants earning higher income (above 50,000 FJD) feel more financially secured to travel longer distances. In addition, in the recent times there are more energy efficient cars with smaller engine sizes requiring less fuel allowing for longer travel distances and at a lower cost. For participants earning above 70,000 (FJD), over 300 km distances were travelled by 27.8% of the respondents. In contrast, participants earning between 10,000-29,999 (FJD), 62.5% participants travel between 0-49km only and none of the participants travelled above over 300 km in a week.

However, with the rising fuel prices globally countries like Fiji tend to suffer a lot. The price of fossil fuel increases each month in Fiji, and such price hikes makes it difficult for people earning below 30,000 (FJD) to sustain a progressive life. Despite high fuel prices people have to travel long distances

either for work or pleasure, particularly after Covid-19 cases started to decline and people were yearning to visit their close-relatives which was not possible due to Covid-19 lockdowns. To combat, the high fuel prices, emphasis on the local production of biofuel for transportation is necessary.

4.7 Fossil fuel expenses

This section elucidates on the money spent on fossil fuel by people in various income ranges as shown in Figure 4.1. It is clear that participants who earn less are quite conscience regarding the money spent on fossil fuel utilization as these people focus more on the basic needs of the family that has to be catered from the money earned.



	$0-24 (FJD)	$25-49 (FJD)	$50-74	$75-99 (FJD)	>$100 (FJD)
10,000- 29,999 (FJD)	5	7	2	1	1
30,000- 49,999 (FJD)	3	2	4	2	3
50,000- 69,999 (FJD)	0	0	8	0	4
>70,000 (FJD)	4	2	4	1	7

Figure 4.1 Weekly expenses on fossil fuel by participants in this study.

On the contrary, participants earning above >70,000 (FJD) spent the most on fossil fuel. This correlates well with the longer distances travelled by the

participants in the higher income bracket. People in higher income levels also own more than one vehicle per family and therefore the cost of fossil fuel is higher. A very good direct positive relation that can be constructed from the results is that participants earning lower are spending less money on fossil fuel, while trying to budget their income for other basic needs. However, this budgeting is actually helping to save the environment from the negative consequences of using fossil fuel. Therefore, people with lower income levels could indirectly be considered more environmentally friendly.

To mitigate the high expense on fossil fuel in Fiji, people should be provided more awareness on biofuels and placing major emphasis on the production of biofuel to reduce the cost of fossil fuel in Fiji for road transportation. Initiating biofuel projects in Fiji would not only reduce fuel burden on families regardless of the income level. Also, more employment would be created and more employment would mean more cash-flow within the nation and substantial amount of economic growth. An initiative by the Fijian government together with more awareness is needed.

4.8 Means of saving on transportation costs (Current Practices)

The bar graph in Figure 4.2 displays the methods used to save money on transportation cost and methods adopted to save money on fossil fuel by people earning various incomes. The use of public transportation was the most common solution used by the participants. Public transports such as buses, taxis, and travelling via vitimini buses (*light commercial vehicles that are used as small- buses for commuting. These small buses can accommodate up to 15 passengers)* were the methods used for commuting by participants. Buses were the most common mode of public transport in Fiji. Alternatively, car-pooling was also preferred.

However, none of the participants stated that biofuel production would save fossil fuel cost and the reasons that were stated was that there would be very high investment cost and a scarcity on food supply would incur for production of bioethanol and biodiesel, and few of the participants had stated that Fiji is not that technologically advanced. Supposedly, a vast number of participants in this study were not aware of

the term biofuels either and a thorough explanation was provided to define biofuel and the importance of biofuel production in Fiji.

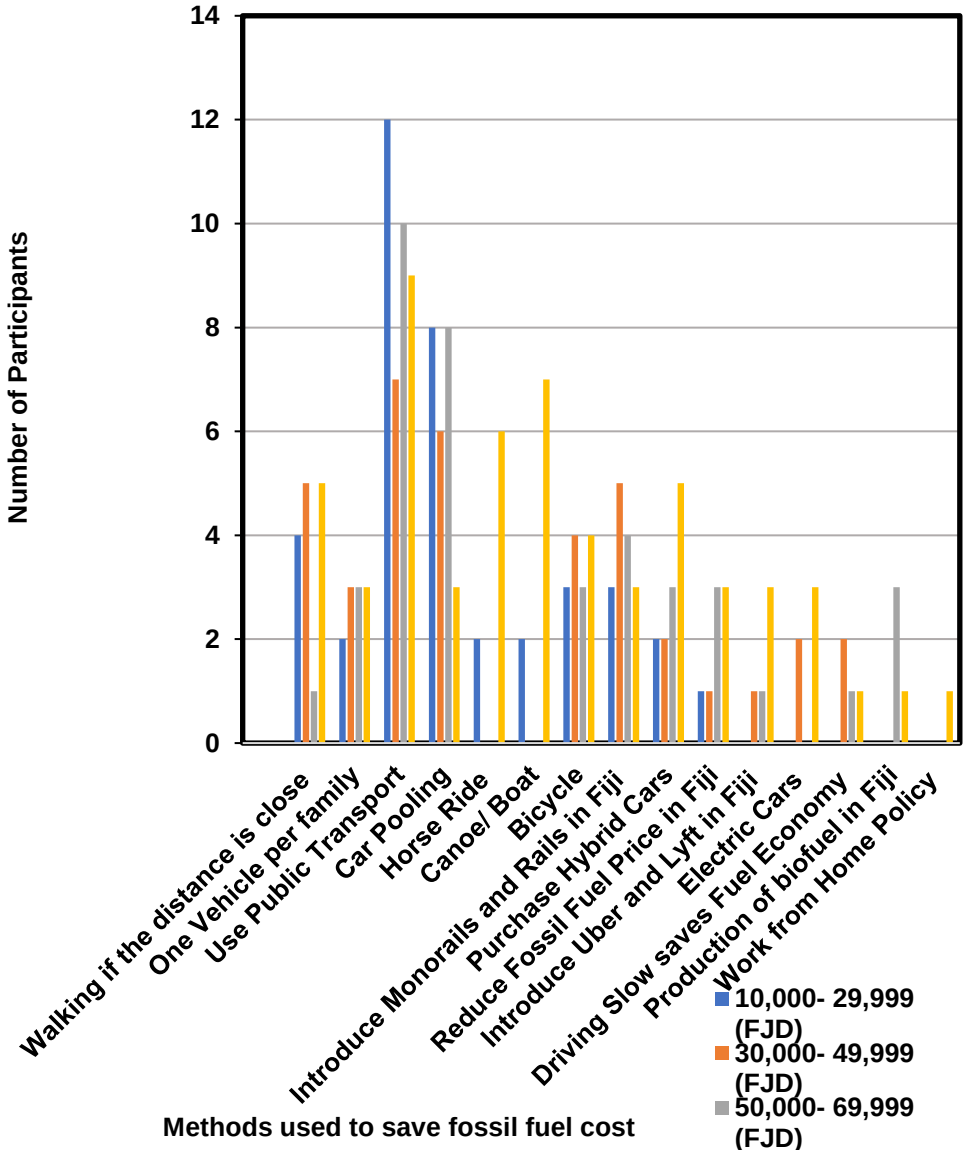


Figure 4.2 Methods used to save fossil fuel cost in land transportation costs.

Consequently, currently Fiji does not have any hybrid buses, fuel efficient buses and buses which are operate on biofuels. The final result would still imply a lot of emissions of CO_2 in the atmosphere and net-zero targets would be difficult to reach, unless Fiji starts producing biofuels which would allow people to use

public transport with lesser negative impact on the environment as biofuels are green energy.

4.9 Price satisfaction of fossil fuel in Fiji

The price satisfaction of fossil fuel in Fiji reveals that participants were highly dissatisfied with the price of fossil fuel regardless of the income levels in Fiji (Table 4.4). It was seen that 66.67% (of 60) participants are not satisfied with the current fuel prices. The key reason for dissatisfaction was that despite an excess of oil productions noted from oil exporting countries and a sharp decrease in crude oil price from 62 USD to 20 USD (Abdullah, et al., 2020), the local pump price escalated. Another interesting point be noted from the Table 4.4 is that participants earning >70,000 (FJD) were also not satisfied from the price of fossil fuel, yet not ready to shift focus on biofuels for transportation or reducing their travel distances.

Table 4.4 Price satisfaction of fossil-fuel by participants.

Income range and total number of participants	**Responses**		**Responses**	
	Yes	**Percentage (%)**	**No**	**Percentage (%)**
10,000- 29,999 (FJD)- 16 people	1	6.3%	15	93.8%
30,000- 49,999 (FJD)- 14 people	6	42.9%	8	57.1%
50,000- 69,999 (FJD)- 12 people	7	58.3%	5	41.7%
>70,000 (FJD)- 18 people	6	33.3%	12	66.7%

4.10 Perception on the usage of biofuels

In terms of biofuel production perception for road transportation, many participants have stated that Fiji is not financially ready to accept or implement this new technology on a large scale. After being advocated and given some knowledge on the benefits of biofuel production and use in Fiji, an average of 91.67% of participants, were for the view initiation of biofuel production would be beneficial. Table 4.5 elucidates on the need for the initiation of biofuel

production in Fiji. As depicted in the results, the lower income levels are more for the biofuel initiation while higher income earners only range above 80% only, because high income earners already lead a successful life and are not ready for any change.

Table 4.5 Initiating the production of biofuels in Fiji and perception of the participants.

Level of income	**10,000-29,000 (FJD**		**30,000- 49,999 (FJD)**		**50,000- 69,999 (FJD)**		**>70,000 (FJD)**	
Number of Participants, Percentage	Number	%	Number	%	Number	%	Number	%
Yes	15	93.8	14	100.0	10	83.3	16	88.9
No	1	6.3	0	0.0	1	8.3	2	11.1
Probably	0	0.0	0	0.0	1	8.3	0	0.0

The initial discussions revealed that biofuels in Fiji needs extensive promotion especially for people with lower income levels. People with lower income in the study conducted did not have much knowledge on biofuel or what green energy actually is. The advantages of biofuel implementation include job creation, a decrease in dependency on fossil fuel, lesser environmental degradation, promotes green climate and closer to achieving net- zero carbon emissions. However, some of them were uncertain with the implementation of biofuel in Fiji because of the cost associated and also many people were reluctant of changes in life and would not like to switch over and learn about newer technologies. Social media advertisement would play a critical role in alerting people on the advantages of biofuels in Fiji.

4.11 Fossil fuel usage vs environmental degradation and climate change

The notion here was to find out the level of understanding people have and their concern for the environment relative to their respective household income levels. The line graph in Figure 4.3 shows responses of participants on the

impact of fossil fuel on the various environmental issues. From the participants earning between 10,000 and 29,999 (FJD), 8 participants stated land, water and air pollution as the primary contributor to environmental degradation, while 7 participants stated emission of GHGs. While the least contributor according to this category of participants was salt-water intrusion and soil becoming unproductive. For participants earning between 30,000 and 49,999 (FJD), 6 participants stated emission of GHGs as the largest contributor. However, 5 participants had stated soot from mufflers, while 4 participants stated environmental degradation as land, water and air pollution, contributing to climate change and sea level rise. The least common responses were ocean warming and acidification, salt water intrusion, crop production is impacted, CFC's and HFC's and acid rain. Moreover, participants earning between 50,000 and 69,999 (FJD) expressed emission of GHGs as the largest contributor (8 participants). Contrarily, impacts on crop production is impacted and melting of glaciers were the least selected responses. Lastly, for participants earning >70,000 (FJD), 16 participants had chosen emission of GHGs, while the least selected were salt water intrusion and acid rain. As per the results analysed people have vast knowledge on the effects of fossil fuel on the environment and the bearings it has. Yet, more advocacy on this issue and more knowledge should be advocated via mass media and internet.

4.12 Adapting alternative energy for land transport sector

Table 4.6 discusses the responses on the introduction and production of alternative fuels like biofuels to help achieve the Paris Agreement target of accomplishing net-zero carbon emissions. However, data shows that many participants were not aware of these goals.

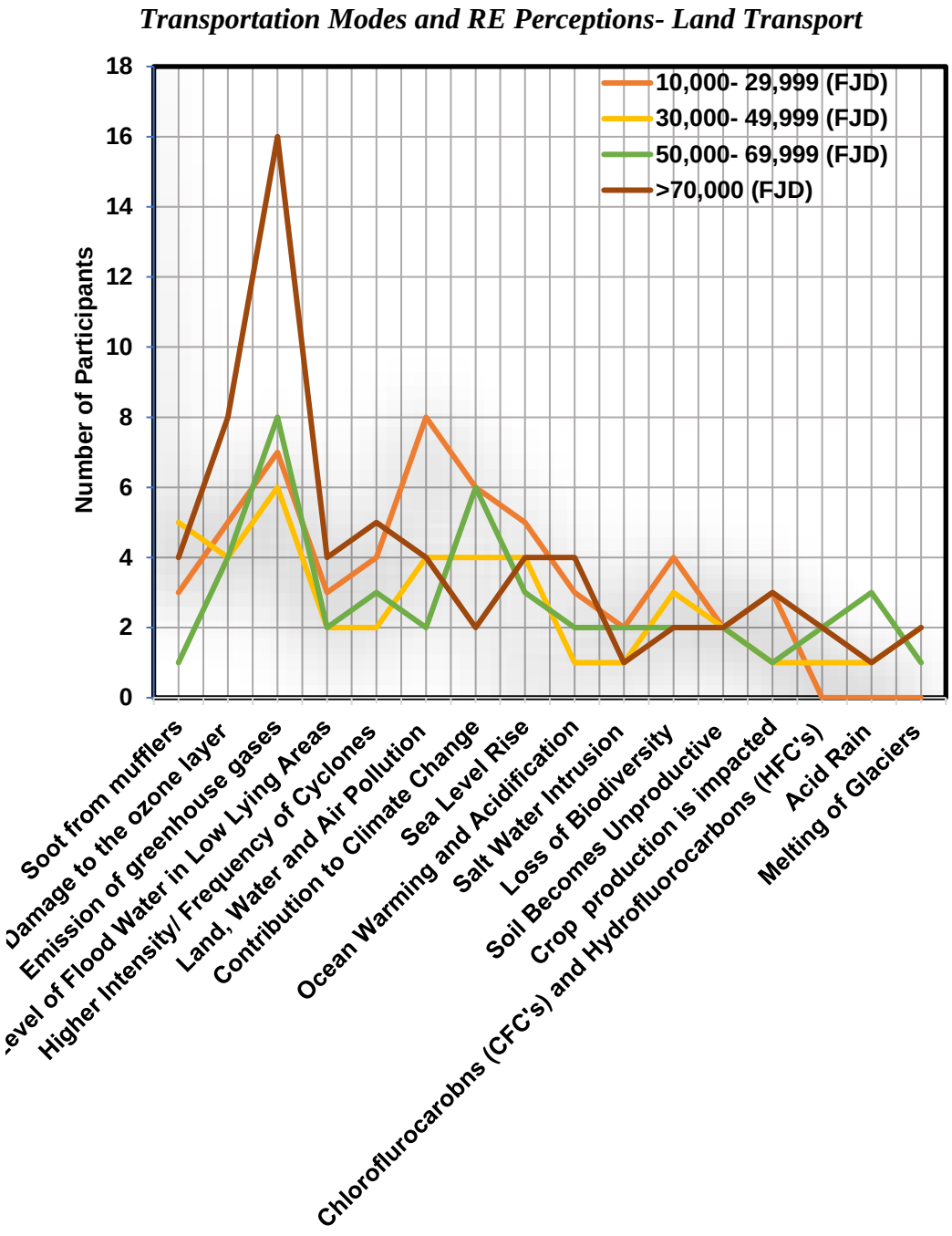


Figure 4.3 Participant responses on the impact of fossil fuel usage on the environment as stated by participants.

Table 4.6 Adapting cleaner, alternative fuels would help reach the net-zero carbon emissions target by 2050.

Income Range	Yes	%	No	%	Probably	%
10,000- 29,999 (FJD)- 16 people	9	56.25%	5	31.25%	2	12.50%
30,000- 49,999 (FJD)- 14 people	10	71.43%	4	28.57%	0	0.00%
50,000- 69,999 (FJD)- 12 people	7	58.33%	5	41.67%	1	8.33%
>70,000 (FJD)- 18 people	15	83.33%	3	16.67%	0	0.00%

As per the results an average of 68.3% participants assumed that when alternate fuels like biofuels are introduced, achieving net-zero carbon emissions would be easier for Fiji. According to participants, The Fijian Government is emphasizing on hybrid vehicles and also has plans to introduce electric vehicles in the near future. In addition, cleaner fuel would emit lesser contaminants in to the environment making the environment cleaner. Furthermore, participants also stated that biofuels are green fuels so there would not be emissions of the GHGs. Correspondingly, participants had mentioned that even though the start-up cost for a biofuel plant maybe costly but in long-term it would be beneficial for the people, the country as they do not have to depend on imported fossil fuel thus could be cheaper with added employment opportunities. Contrarily, the people of older generation are not considerate regarding the environment and are hesitant to adapt or accept to changes. According to them, it would not make any difference because the damage is already done and it would be a huge financial burden to invest in these newer technologies.

4.13 Summary

This chapter revealed that road users need more knowledge and understanding on climate change and how biofuels can be a best possible method to adapt to combat climate change and reducing fossil fuel burden on the people of Fiji. More advocacy regarding the implications of fossil fuel use and cost associated

with the importation of fossil fuel is necessary. Moreover, people do not understand the importance of newer advanced fuels such as biofuels which could aid in mitigating the impacts of climate change, particularly the small island nations.

One of the ways in which Fiji could tackle the increasing fossil fuel prices is via production of biofuels for road transportation. However, people of Fiji must be alerted more on the environmental bearings of fossil fuel utilization, which is a major setback amongst vehicle owners.

CHAPTER 5
Mapping of Policies and Framework for Land Transportation

5.0 Overview

This chapter maps various policies, regulations and legislations pertaining to the transportation sector related to mitigating climate change, and the use of renewable energy sources. A set of fourteen policies are analysed on the use of current fossil fuel and the transition towards-low carbon transportation such the short- term goal is to use biofuels to reduce the use of fossil fuels in Fiji, while the long-term goal is to have fully electric cars in Fiji. This chapter first looks at the perceived biasness by road users at other users (**Part D** of the survey) and then policy mapping is presented.

5.1 Perceived biasness by road users

Certain types of land transportation seemed to be prioritised over the other. Respondents feel that's buses and trucks that are not well maintained or perhaps are not road worthy are on the road providing transportation to people. Table 5.1 shows responses of the participants who feel that there is some form of biasness or prioritization given to buses and trucks over other form, which is Part D of the survey sheets.

The participants perceived that there is biasness towards buses and trucks operating on the roads. An average of 52.5% respondents from the four income ranges agreed to the biasness. A few of the participants stated that hybrid car vehicles such as Toyota Prius tend to over speed without due care. Certain participants suggested that there are illegal operators on the road, which requires further investigation.

Table 5.1 Responses on biasness over a specific type/ mode of transport and the level of income of participants.

Level of income	**10,000- 29,999 (FJD)**		**30,000- 49,999 (FJD)**		**50,000-69,999 (FJD)**		**>70,000 (FJD)**	
Number of Participants, Percentage	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**
Yes	8	50	8	57	7	58	8	44
No	7	43	6	42	5	41	9	50
Probably	1	6.3	0	0	0	0	1	5

5.2 Policies, Acts, Legislations for Fiji's Road Transportation

Part A explores four policies that binds Fiji's road transportation sector through the judicial pathway, however, there is no specific policy that defines biofuel separately in any judiciary documents. The benefits of the judicial pathway are that there are sections on transport and transport use in the documents that are formed by the judiciary.

5.2.1. Constitution of the Republic of Fiji- 2013

- The Constitution of the Republic of Fiji has 12 Chapters.
- Chapter 2 Bill of Rights relates to the transport sector.
- **Section 34** *Right to reasonable access to transportation;*
- **Section 36** *Right to adequate food and water;*
- **Section 40** *Environmental Rights* (The Parliament of Fiji, 2013)

5.2.2. Fiji Petroleum Act- 1978

- **Section 3** Import and Export at Assigned Locations
- **Section 7** Storage (The Parliament of Fiji, 1978)

5.2.3. Trade Standards and Quality Control Decree- 1992

Part I- Preliminary

- **The aim of the trade and quality decree**

This Decree has as its main goal the implementation of uniform standards for goods and services and the quality control of products.

Part II- Administration

- **Section 16** The Functions of the Trade Standards and Quality Control

Part V- Quality standards

- **Section 39** Goods and services that are included in this part and notification of quality requirements proposed
- **Section 40** Quality Requirements Compliance
- **Section 41:** Quality Standards (The Parliament of Fiji, 1992)

5.2.4. National Biodiesel and Ethanol Fuel Standards (Amendment) Order- 2011

Schedule 4 Trade Standards for ethanol fuel

- **Section 1.0 Application**

These trade standards are applicable to ethanol produced, imported, sold or used in Fiji or exported to other countries and to ethanol produced, sold or used in Fiji (The Parliament of Fiji, 2011).

5.3 Roadmap and policies to combat emission control from transport sector

Part B details seven policies developed in Fiji to combat emission control from transportation sector. The listed policies in this part has a section detailing the transport sector in Fiji and the initiation of production biofuels in Fiji.

5.3.1. Fiji National Energy Policy (Draft)- 2013

1. Relevance to the transport sector

a) Energy situation in Fiji for the transport sector

- The transport sector is the largest consumer of imported fuel in Fiji and hence the medium to long-term potential for reducing the import of fossil fuel.
- Attempts to reduce imports of oil by the use of biofuels have been made.

b) Energy priority by sector

Transport

Major issues to be concentrated

- Very heavy reliance on imported fossil fuels.
- While public transportation has improved substantially, access, accessibility and efficiency remain a concern.
- Research on alternative fuels such as biofuel, electricity or gas has been limited to date.

Petroleum and biofuels

Major issues to be concentrated

- The national import bill for petroleum is high nationally.
- The feasibility of biofuels still has to be demonstrated on a larger scale even with many demonstration projects at local level.
- Though national standards E10 and B5 for biofuels have been introduced, local production to date has been limited. As

mentioned in Chapter 2, seven maritime locations have been chosen for biofuel production at village/ community levels for electricity generation purposes only.

c) Policies

i) **Transport**

Priority areas

- Enhance fuel quality in motor vehicles imported- E10 and B5 emphasis on newer generation vehicles (Thomas, 1988).
- Promote the production and implementation of land and maritime transport policies of the Department of Transport that promote changes towards more energy efficient modes of land and maritime transport (Maritime and Land Transport Policy, 2015).

ii) P**etroleum and biofuels**

Priority areas

- Reduce the costs of imports of oil;
- Improving petroleum supply transparency;
- Continue researching potential for rising biofuel production and usage. Charan (2019) mentioned that one of the more promising alternative fuels for transportation in Fiji is biodiesel derived from the transesterification of coconut oil. In 2013, the overall yearly coconut production was 270 million nuts, with a copra yield of 45,000 metric tonnes (Charan, 2019).

Other areas

National biodiesel and ethanol fuel standards continue to be implemented (The Fijian Government, 2013).

2. Conflicts and suggested strategies to resolve the conflicts

a) **Conflicts**

- The FNEP- 2013 policy is still in the drafting stage and relatively very old data are provided, whilst making the policy very outdated.

b) **Strategies**

- A new energy policy has been developed
- A wide public consultation should be conducted when developing a new energy policy to address the specific needs of different sectors.
- The consultation should be in the 3 common languages used in Fiji (Hindi, iTaukei, and English).
- Common people's perception should be initiated and also advocacy on biofuels should be given more awareness.
- There were attempts by Fiji's government to lower carbon footprint and boost energy security by utilising locally produced renewable energy such as biofuel production on large scale (Charan, 2019).
- The potential for creating transportation fuels produced from biomass, specifically coconuts, could be trialled (Charan, 2019).

5.3.2 5- Year and 20-Year: National Development Plan Transforming Fiji 2017-2036

1. Relevance to the transport sector

a) 20- Year Development Plan 2017- 2036

i. Road transportation

- Investment in better and very modern road infrastructure is important.

- Efficiency: At critical junctions where traffic volumes are heavy, traffic lights to be mounted, which could avoid traffic at peak hour traffics.

b) 5- Year Development Plan 2017-2021

Energy

i. Petroleum and biomass

- Fiji fulfils the 500 parts per million (ppm) Euro 2 emission level and transitions to the Euro 5 emissions norm of 50 ppm.
- Government research and development on biofuels and their use in the transport sector has continued.
- Incentives will continue to encourage investment in biofuels (Ministry of Economy, 2017).

2. Conflicts and suggested strategies to resolve the conflicts

a) Conflicts

- NDP focuses mostly on the improvement of road infrastructure than on improving the fuel standards in Fiji or introducing biofuels for road transportation.

b) Strategies

- NDP should have developed a masterplan for biofuels and petroleum as part of their 20-year plan as well. As the main goal is to reach net-zero carbon emissions by 2050. Therefore, biofuel use and production should be emphasized and taken into consideration.

5.3.3 A Green Growth Framework for Fiji: Restoring the Balance in Development that is Sustainable for our future- 2014

1. Relevance to the transport sector

a) The basic objective of the Green Growth Framework (GGF)

The guiding principles of GGF are:

- Reduction of carbon 'footprints' at all levels

- Enhance the use of systematic risk control practices;
- Supporting the establishment of sound environmental audits of past and proposed innovations in order to support not only economic gains but also environmental improvements.

b) Green growth benefits for Fiji:

i) Economic benefits

ii) Environmental benefits

c) Thematic Area 8: Sustainable Transportation:

- ***Introduction of vehicles which are fuel efficient***

- More stable and more fuel-efficient vehicles and help in reducing GHG emissions of greenhouse gases and their negative effect on the Fijian climate.
- The import duty was reduced, for instance, by 32% to 15% for vehicles with a capacity of less than 1500 cc (Ministry of Strategic Planning, 2014).

2. Conflicts and suggested strategies to resolve the conflicts

a) Conflicts

- The GGF largely focuses on socio-economic development, the concentration on fossil fuel and research data implemented in the GGF is secondary, not recent as is was developed prior to the Paris Agreement
- Under section XVII; Chapter 87- 8702 of the Customs Tariff (Preliminary) it states, "new/ old motor vehicle – for transport of 10 or more but not exceeding 15 persons including the driver, there are fiscal and excise duty charged but a VAT of 9% is charged while importation of the transport" (Fiji Revenue and Customs Authority, 2019). A contradiction, while the GGF was prepared in 2014 as the tariff then was 15%.

Mapping of Polices and Framework for Land Transportation

b) Strategies

- Investing more in the research and development of renewable energy sources likes biofuels to reduce, fossil fuel importation.
- More advocacies on environmental protection, through posters, videos and pictures; to alert the people of the detrimental effects of fossil fuels in Fiji and the world.

5.3.4 Voluntary National Review: Fiji's Progress in the Implementation of the Sustainable Development Goals- June 2019

1. Relevance to the transport sector

a) Overview of the Voluntary National Review (VNR)

- Fiji's VNR is an exhaustive analysis of the transformative Agenda 2030 and its 17 SDGs.

b) SDG 7: Affordable and clean energy

Theme for the Goal: ***Ensuring access to affordable, reliable, sustainable and modern energy for all.***

c) Opportunities for partnership under Goal 7

- Reduced fossil fuel dependency

d) SDG 12: Sustainable consumption and production

Theme for the Goal: Ensure sustainable consumption and production patterns.

- **Energy**

  - A combination of regulations, tax policies and grassroots advocacy enabled Fijians to use more energy-efficient and fuel-efficient white goods and vehicles.

- The fuel quality of the nation has also improved, reducing emissions and is currently standardized to Euro IV (Ministry of Economy, 2019).

2. Conflicts and suggested strategies to resolve the conflicts

a) Conflicts

- The VNR also largely focuses on reducing fossil fuel imports; however, the methods to implement is not stated clearly.
- Major emphasis on renewable's stated in the VNR are hydro, solar and wind for electricity generation.
- There is limited or zero mention of biofuel production in Fiji.

b) Strategies

- When policies and frameworks are developed there should be no ambiguity because it creates confusion. If a solution is stated such as investing more in renewable energy; it should be clearly stated which branch of renewable energy because renewable energy is a very broad and uprising industry.

5.3.5 Climate Vulnerability Assessment: Making Fiji Climate Resilient- 2017

9.1 Relevance to the transport sector

a) The transport sector needs tremendous investments to develop a resilient nation (Ministry of Economy, 2017):

- There is a need for strategic planning to avoid the effects of climate change.
- Major costs and policy changes will be needed for the resilience of the transport industry.

- This investment will minimize infrastructure damage (and thus the cost of fixing emergencies.
- The co-benefit of the recovery investments is about 160 million FJD dollars annually.
- The net present value reaches 2.6 billion FJD, which alone benefits from resilience.
- Moreover, such investments will produce substantial benefits in normal times from the reduction in transport time and costs.

2. Conflicts and suggested strategies to resolve the conflicts

a) Conflicts

- The methodology mentioned to support the theme of CVA is not explicit.
- Very limited funding is provided for biofuel development from agriculture and agricultural waste as major emphasis is on the tourism industry.

b) Strategies

- Currently, the production of CNO is the only focused area for biofuel production in Fiji. A wide range of biofuels productions needs to be explored in conjunction with agricultural industries, energy sector and climate change division and the transport sector.
- More crops would mean more employment and more production both for food and fuel, secondly it would also help us reach the goals set for net-zero emission by 2050.
- Agriculture industry can be pivotal in the development of biofuel production in Fiji.

5.3.6 Environmental Management Act- 2005

1. Relevance to the transport sector

a) Purpose of the Environmental Management Act (EMA)

- To apply sustainable use and natural resource production principles; and
- Identifying national issues of concern to Fiji.

b) Part 4: Environmental Impact Assessment

Section 27 Subsection (1)- The Authority must approve on:

- **The process of the Environment Impact Assessment (EIA)**

Section 28 (1)- A development of environmental impact assessment process should be performed.

- **Social impacts of EIA for biofuels**

Some of the social impacts include (The Parliament of Fiji, 2005)

- Livelihood for locals are affected, as reliance on food crops such as corn, sugarcane, and coconut.
- Shifting cultivation could impact agriculture as well as people.
- Negative impact on the locals due to change in lifestyle and some locals are always reluctant to changes as per the survey.
- At times human rights are violated during land acquisition, as traditional customs are violated.
- Disregard of environment concerns for economy (Obidzinski, et al., 2012).

2. Conflicts and suggested strategies to resolve the conflicts

a) Conflicts

- The locals suffer due to any developments as they tend to lose their land and food sources.
- Locals complains of their local customary practices such as a *sevusevu* is not practiced while investors or expertise go for persuading.

b) Strategies

- A socio-economist should be hired when purchasing or conditions of a land sale is taking place. A socio-economist knows how to persuade local people and provide them examples for the benefits of the development taking place.
- A crop diversification in the case of biofuels would not hurt, in fact if there is crop diversification and rotation different food crops can be available for harvest and fuel all through the year.

5.3.7 Maritime and Land Transport Policy- 2015

a) National roadmap for democracy and sustainable development

- The objective is to *'provide a safe, effective, affordable, accessible and environmentally sustainable integrated transport system*.'
- A determination to pursue vigorously private transport financing, especially in the field of land transport.
- The Road Users Levy introduced in 2009.

b) Mitigation and adaptation to climate change

- Promote the implementation of sustainable transport fuel-efficient equipment and motors that operate on biofuels.
- Support the production of domestic biodiesel and bioethanol for the transport sector in collaboration with other agencies.
- Encourage transportation equipment service and maintenance in a way that minimizes carbon emission and consumption.

- Track the domestic fleet of road vehicles, kilometres of travel and fuel consumed to inform annually on fuel weighted by the fleet and fuel quality.

c) Fuel efficiency and emissions control for vehicle fleet

- **Fuel and emissions from vehicles** (Ministry of Infrstructure and Transport, 2015)
  - All newly registered (new and imported second hand) vehicle sold in Fiji must be Euro 4 compliant (or equivalent) and Euro 5 (or equivalent) compliant in five years' time.
  - Petrol and diesel fuels sold in Fiji will be expected to meet similar fuel requirements of Euro 4 and Euro 5.
  - Vehicles imported into Fiji are restricted to less than 5 years of age.
  - Ethanol and biodiesel are developed for the purpose of transporting fuel blending, where they do not shift or limit food crop growth.
  - All lightweight vehicles will be branded under a vehicle fuel economy labelling system.
  - In order to comply with the fitness warrant and undergo on-road checks a Black Smoke Emission Test is required for the vehicles.

2. Conflicts and suggested strategies to resolve the conflicts

a) Conflict

- The mitigation and adaptation methodologies are in the policies. More alignment with the Paris Agreement were adopted in the NCCP in Fiji. However, there has been few implementations or feasibility studies conducted to bring the mitigation and adaptation strategies into action.

b) Strategies

- The mitigation and adaptation strategies could be brought into action by starting up projects such as biofuel productions at small scale in the larger island of Fiji (Viti Levu and Vanua Levu), in this way the feasibility and viability of the mitigation and adaptation actions could be outlined. If these actions are profitable at smaller scale then a large-scale biofuel production can start.
- Importation of vehicles (petrol and diesel) that can run on biofuels.

5.4 Mapping of Policies and Frameworks alignment to Paris Agreement for Transport Sector

5.4.1 National Climate Change Policy 2018- 2030

a) Overview of the National Climate Change Policy (Minstry of Economy, 2018).

Fiji's National Climate Change Policy 2018–2030 (NCCP) outlines Fiji's developmental and climate goals in reducing current and potential climate threats, while optimizing Fiji's long-term growth benefits.

b) Resilient development and mitigation of climate change

i. 100% of national electricity supply from renewable energy sources is to be generated by 2030 and net- zero annual GHG emissions by 2050.
ii. Decarbonizing the transport industry in Fiji.

- **Possible Outcomes**

The transport sector in Fiji is increasing and diversifying the progress of mobility, and equal access to services. It also focuses on reducing local and global impacts on the environment and national exposure to volatility of fuel prices. The progress of the transportation sector is not

aligned with that of the GHG emission targets. Investment in low carbon transportation alternatives and improvements in transportation infrastructure and quality in combination with change of commute behaviour is required in reducing domestic transport emissions to a minimum level (Minstry of Economy, 2018).

- **Strategies:**

  a) Fiji's NDC has been strengthened to reflect ambitious objectives for the decarbonisation of domestic aviation, maritime transportation between and to be backed by national plans and strategies of action.

  b) Increased access to affordable low and non-carbon goods and opportunities for transport and subsidies are public-private collaborations.

  c) Increased annual public spending in public transport, increased opportunities for rural, urban and outer islanders for inclusive, sustainable and low to zero-carbon transport. Transport modes that are carbon-intensive are discouraged and phased-out.

  d) Urban green investment enhances pedestrian experiences and facilities to promote non-motorized transport, reducing the private sector's rise in land transportation (Minstry of Economy, 2018).

c) Conflicts and strategies

Conflicts and the suggested strategies to resolve the discrepancies in the National Climate Change Policy are presented in Table 5.2**.**

5.4.2 Low Emission Development Strategy- 2018-2050

a) Overview of the Low Emission Development Strategy (LEDS)

The LEDS has established four potential low emission scenarios for Fiji, in order to achieve this core objective:

i) A "Business-As-Usual (BAU) Unconditional scenario";

ii) A "BAU Conditional scenario" - This scenario will have greater ambition than "BAU Unconditional";

iii) A "High Ambition Scenario" plans goals beyond the policy objectives already set down;

iv) A "Very High Ambition scenario" projects well beyond those currently identified by policies (Ministry of Economy, 2018) .

The forecasted net-emissions for the projected years (2020, 2025, 2030, 2035, 2040, 2045 and 2050), is shown in Table 5.3 in metric tonnes of CO_2e. A graphical representation for Table 5.3 is presented in Figure 5.1, under Very High Ambition there is huge reduction of CO_2e forecasted for the year 2050, which is -782,767 and if achieved, Fiji would have achieved its set target to achieve net-zero carbon emissions.

Table 5.2 Suggested conflicts and strategies for NCCP (Minstry of Economy, 2018).

Conflict in NCCP	**Strategies to Resolve**
• The NCCP does not talk about the production of biofuels in Fiji as an alternate source of fuel, the major emphasis is to have a net-zero carbon emission for electricity sector. • Since transport fleet requires fuel. Fiji needs to look for alternate fuels or hybrid or electric vehicles in reducing emissions. • ***Under the NCCP- Vision 2030 States:*** Fiji is increasingly less dependent on fossil fuels in its energy and transport sector. However, Fiji's import bills for mineral oils (petroleum products) in 2019 was 1,170,603 FJD in millions (Fiji Bureau of Statistics, 2019).	• Inclusion of alternative fuel initiative with robust feasibility studies for Fiji. • Alternative sources of fuel like biofuels can prove to be a lifesaver for Fiji as it would reduce the burden of import duty on the government and biofuels are green source of energy. • There should be proper feasibility and EIA prior to the development of the project to avoid project failures. • Also need to consider infrastructural development for non-motorised transportation such as bicycles, e-bikes, mopeds etc.

- The LEDS shows that net null emissions could be achieved during the year 2041, after comprehensive stakeholder consultation, study and modelling of various scenarios for each industry, under the Very High Ambition scenario.
- This energy transition includes the adoption of renewable energy for economic, industrial and household use and the transformation into electric vehicle for most of the Fiji land transport systems.

For land transport

- A national plan for electrical mobility;
- Transition to electric and hybrid vehicles and;
- Public transport enhancement and non-motorized transportation networks.

Table 5.3 Total Fijian net-emissions under four LEDS scenarios-all metric tonne CO_2e values (Ministry of Economy, 2018).

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

b) LEDS vision

- Fiji is targeting net-zero emissions of carbon in its economy by 2050.

c) Deep decarbonisation pathway for land transportation

LEDS Pathway to Economy-wide.

The results forecasted under Very High Ambition presents the goal set by the Paris Agreement, which is to achieve net-zero carbon emissions. While the other 3 scenarios outlined are not able to achieve the goal of achieving net-zero carbon emissions by 2050. A summary is provided in Table 5.4 for low emission targets for the transport sector.

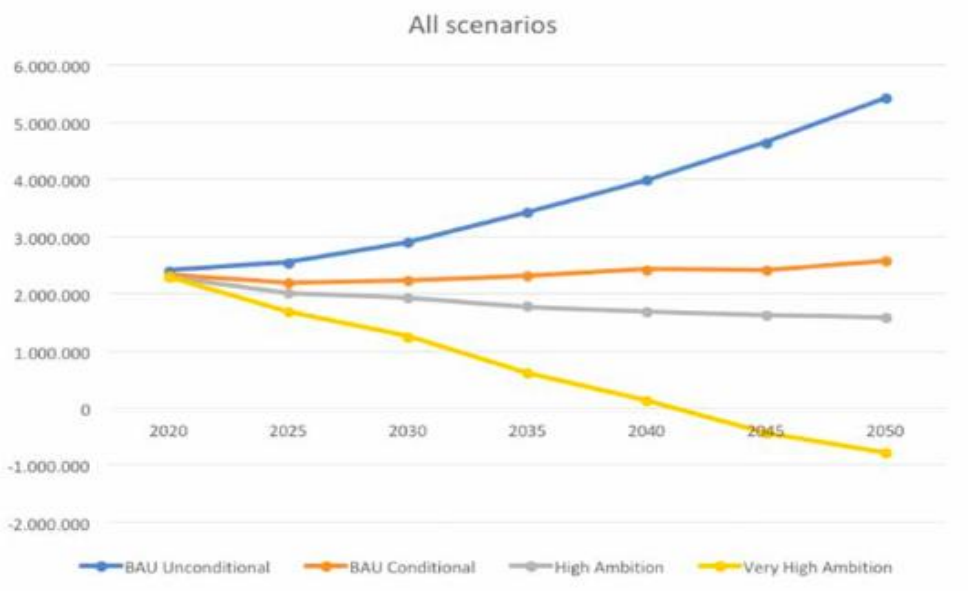


Figure 5.1 Total Fiji's net-emissions under four LEDS scenarios – all values in metric tonne CO_2e (Ministry of Economy, 2018).

Table 5.4 Summary transportation sector low emission scenario-in metric tonnes CO_2e (Ministry of Economy, 2018).

Ambition Scenarios/ Year	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
BAU Unconditional	817,396	937,084	1,112,908	1,277,184	1,416,260	1,531,237	1,623,846
BAU Conditional	801,483	850,057	868,969	829,826	775,607	718,293	672,287
High Ambition	791,991	784,501	768,410	701,325	626,637	549,649	477,104
Very High Ambition	790,929	712,473	640,285	368,761	215,399	60,590	0

The results forecasted looks quite promising and if the forecasted results come into reality, there would be very limited to no carbon emissions. However, more initiative in the alternative fuel for transport sector should take place to achieve these set targets and bringing it to reality.

i. BAU Unconditional scenario

- In this scenario the share of new vehicles sales for cars and taxis will steadily rise to 10% from 2020 onwards.
- Additionally, 20% of cars, 40% of taxis, 70% of buses and 30% of urban vehicles will be electrical vehicles. By 2050, 80% of cars, 50% of taxis and 10% of buses should be Hybrid Electric Vehicles (HEVs), while 20% of cars, 50% of taxis, 90% of buses, and 40% of urban trucks will be HEVs. In this case, all big trucks will still use conventional fuels.
- Fiji will also support biofuels, petrol bioethanol blends and diesel biodiesel blends under the BAU Unconditional scenario.
- By 2020, the scenario is projected to achieve 2% bioethanol and 10% bioethanol in petrol and 5% biodiesel in diesel by 2050.

ii. BAU- Conditional scenario

- The BAU Land Transport Conditional Scenario is designed on the basis of the NDC implementation roadmap to a target of reduction of GHG emissions by 30% by 2030.
- The BAU Conditional scenario includes: promotion of hybrid and electric cars, Public Transport (PT), cycling and biofuel, and the BAU Unconditional scenario.
- This scenario envisages rising the share of new vehicle sales of HEVs in cars, taxis and buses from 20% to 30% from 2020. By 2050, all HEVs with the exception of large trucks will be phased out and 100% of automobiles, taxis, buses and urban trucks and 40% of large trucks will be electric vehicles. The cycling share will also grow from 0% in 2020 to 10% in 2030 and to 20% in 2050.
- In the scenario of the BAU conditional, Fiji will also reach 5% petrol and 2% diesel bioethanol by 2020 and 10% petrol and 5% diesel bioethanol by 2025.

iii. High Ambition scenario

- The key mitigations actions for the High Ambition scenario include, as with previous scenarios, the promotion of hybrids and electric cars, public transport, cycling and biofuels and the upgrade of vehicles in service.
- With 40% of HEV cars in 2020, 50% of HEV taxis and 30% of HEV buses in 2020, the share of new vehicles for HEVs and EVs is steadily growing.
- By 2030, the trend will be 20% for HEVs and 80% for cars, 100% for taxis, 100% for buses, 100% for urban trucks and 40% for large trucks supposedly to be EVs.
- By 2050, all HEVs will be completely removed and 100% of all cars, taxis, buses and 70% of large trucks will be electric vehicles.

- The scenario also accounts for a progressive rise in PT's share to 40% by 2020, 53% by 2030 and 55% by 2050.
- In the high ambition scenario (as in the conditional BAU scenario), Fiji will reach 5% petrol bioethanol and 2% diesel biodiesel by 2020, 10% petrol bioethanol by 2025 and then 5% diesel biodiesel.

iv. Very High Ambition scenario

- In the Very High Ambition scenario Fiji strives to attain zero emissions from the land transportation sector by 2050.
- This ensures that all cars will be scraped after 20 years of service, in addition to taking all mitigation steps, ensuring that all vehicles will be electric by 2050.
- With 50% HEV cars, 60% HEV taxi and 50% HEV buses, this screening aims to steadily increase the share of new vehicles in HEV and EV sales launching in 2020. By 2030, EVs will replace most vehicles with 100% of all cars, taxis, buses and urban trucks, including HEVs (which would be to reduced 0%), and 90% of large trucks with EVs.
- EVs will become 100% of all forms of vehicles by 2050. Furthermore, all vehicle types should have a maximum age of 20 years from 2030.
- The scenario envisages rising the proportion of PT progressively to 40% by 2020, 60% by 2030 and 80% by 2050.
- Under the scenarios of Very high Ambition and BAU Conditional, Fiji will achieve 5% petroleum bioethanol, 2% biodiesel in diesel by 2020; and 10% bioethanol in petrol by 2025 and 5% biodiesel in diesel by 2025.

d) Comparison of scenarios

The estimates of the four scenarios of GHG emission trajectories along with the actual GHG emissions are shown in the Figure 5.2. The conditions under all four scenarios are interpreted for land transport sector, the least promising condition forecasted is BAU Unconditional CO_2e while the most promising forecast is from Very High Ambition where the CO_2e level is 0 and the goal set for 2050 is reached.

Figure 5.2 Scenario comparison for land transport (Ministry of Economy, 2018).

5.4.3 Fiji Nationally Determined Contributions (NDC) Implementation Roadmap 2017- 2030: *Setting a pathway for emissions reduction target under the Paris Agreement*

a) Overview of Fiji's NDC (Ministry of Economy, 2017)

- The energy-specific Fiji's NDC is intended to hit 100% share of renewable energy output by 2030 up from 60% in 2013. Moreover, Fiji will continue to reduce emissions by 10% viz energy efficiency.

- Taken together by 2030, these steps are expected to reduce the overall CO_2 emissions of the Fijian energy sector by approximately 30%.
- This framework includes changes in the supply side and energy conservation in the demand side.

Transportation (137,000 tCO2 a year; US 1,149 billion of dollars):

- *The mitigation initiatives under transportation include the most important CO_2 mitigation (95 $ktCO_2$/yr) contribution schemes for buses and taxi services, private vehicles, lorries and minibuses.*
- *An expanded subsidiary for scrapping old vehicles and recycled materials will be introduced by all vehicle replacement programmes* (Ministry of Economy, 2017).

b) Mitigation actions in sub-sectors of energy

The mitigation initiatives defined in the energy sector are broken down into the following sub-sectors and are planned to be implemented in the short, medium and long term (2017-2030):

- Electricity Generation and Transmission
- Demand-Side Energy Efficiency
- Transport (Land and Maritime)

The Figure 5.3 shows the annual mitigation of GHGs achievable from energy sector, which is estimated to be 627,000 tCO_2 compared to the BAU baseline in 2030.

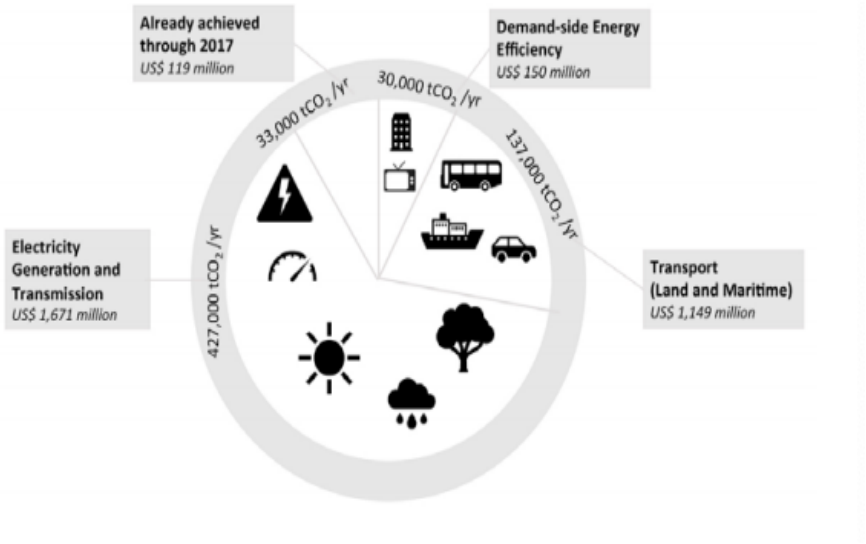


Figure 5.3 Annual anticipated mitigation of GHGs in the energy sector in 2030 and estimated total investment required (Ministry of Economy, 2017).

c) Sub-sector transport (Land)

The mitigation initiatives under the land transport sub-sector roadmap concentrate on ways that can be introduced in the short to medium term, but are consistently carried out over the long term with a measurable effect on the mitigation of GHGs by 2030. A few of these initiatives include replacement schemes for buses, taxis, private cars, lorries and minibuses for trucks, which will introduce an improved sub-industry to scrap new, less efficient vehicles. Key initiatives include the importation and use of biodiesel, and increased fuel-efficient outboard engine use.

Short- term actions (2017-2020):

- T1: Vehicle replacement programme (including Hybrid vehicles and Scrappage)
- Buses, taxis and private cars.
- T2: Vehicles replacement programme (Including Scrappage)
- Lorries (<16t), Minibuses

Medium- term actions (2021-2025):

- T3: B5 Fuel (5% biofuel in diesel)
- T4: Improved maintenance for sea vessels
- T5: Fuel efficient outboard motors

a) **Short-term mitigation actions**

- Short-term mitigation actions for the transport sector concentrate on replacement programmes for land transport vehicles, but include additional regulatory and control actions and liaison with the Land Transport Authority (LTA), FRCS and FCCC.
- It is noted that both the strategies: importation of efficient vehicles and scrapped of old vehicles are included in the fleet's annual vehicle growth (2% annual growth rate assumed between 2017-2030).

i. ***Mitigation action T1: vehicle replacement programme (including hybrid vehicles and scrappage)***

- For newly imported cars, the age limits for imported used vehicles must be combined with European standard fuel requirements. Furthermore, it will include incentives for hybrid vehicles to increase the share of hybrid vehicles in the fleet of buses, taxis and private vehicles.
- Expected 70,000 tCO_2/yr; 11,000 tCO_2/yr (buses); 15,000 tCO_2/yr (taxis); 44,000 tCO_2/yr (private cars): projected GHG mitigation in 2030. Total 42,000 tCO_2/yr; 6,000 tCO_2/a (buses) 11; 9,000 tCO_2/yr (taxis) 12; 27,000 tCO_2/yr (private cars); average annual estimated GHG mitigation between 2017-2030.
- Total projected investment required (vehicle costs only for the Roadmap duration (2017-2030) is 940 million USD in total;
  110 million USD (buses); 60 million USD (taxis); 770 USD million (private cars).

ii. ***Mitigation action T2: vehicle replacement programme (including scrappage)***

- In order to achieve a fleet-wide reduction in GHG emissions, this mitigation action increases the fleet of vehicles (lorries and mini buses) in terms of fuel consumption per km per car. For newly imported cars, the age limits for imported used vehicles must be combined with European standard fuel requirements.
- Complete 25,000 tCO_2/yr; 24,000 tCO_2/yr (lorries <16t); 1000 tCO_2/yr (minibuses). Predicted GHG mitigation in 2030 Max 14,500 tCO_2/yr; 14,000 tCO_2/a (lorries <16t); 500 tCO_2/yr (minibuses): average annual estimated GHG mitigation between 2017-2030.
- Total estimated investment required (vehicle-only cost) over the Roadmap span (2017-2030): 205 million USD total; 200 million USD (lorries <16t) 14; 5 million USD (minibuses).

b) **Medium- term mitigation actions**

With respect to land transport, the mitigation action focuses on the integration of a portion of biofuel into diesel fuel. These initiatives are consistent with the current key climate change and energy policies in the transport sector, but include additional regulatory and control mechanisms and ties with the LTA, FRCS and FCCC. The overall investment and effect on the mitigation of GHGs would largely rely on different criteria which have not been completely achieved in the preparation of the roadmap. The estimates on GHG mitigation and total investment needed are based on the information currently available in Fiji and comparative statistics available internationally.

iii) ***Mitigation action T3: B5 fuel (5% biofuel in diesel)***

- With 95% diesel and 5% biodiesel, all diesel fuel used for land transport will be 'B5' fuel. B5 fuel is presumed to be imported and

supplied through all sub-sectors of land transport (private, public, and commercial).

- It is assumed that B5 will be widely available in Fiji from 2021 to allow for preparation and to ensure the supply of B5 fuel.
- Anticipated 2030 GHG mitigation: 37,000 tCO_2/yr; Average annual expected 2021-2030 GHG mitigation: 35,000 tCO_2/yr.
- Comprehensive anticipated investment needed is negligible (transfer to fuel cost).

Primary elements of enabling, capacity building & technical assistance needs

- Assess B5 (e.g., Singapore, Korea, Australia) import options and Fiji availability.
- To ensure sustainable sources/production, apply international standards or international mark for the biofuel content of B5 fuel in order not to reduce the negative impacts.
- Complete a data assessment divided by sub-categories (to be specified, e.g., category of vehicle, private, commercial, bus, taxi) and in terms of diesel usage, on the fuel consumption and GHG emissions of land transport.

c) **Long- term strategy for electric transportation**

Aspects which need to be evaluated include:

a) ensuring that adequate sources of renewable energy are available throughout the electricity generation system, so that the coverage of electricity transport in the country is technically and economically feasible and does not hinder sustainable development;

b) quantification of the marginal cost of additional renewable energy sources for transport electricity supply in Fiji;

c) requirements for electric vehicle battery recycling and disposal policies/schemes; and

d) assessment of the charging system specifications and of the control of electric transport tariffs.

In order to achieve a gradual transition to electric transport in Fiji in the long term, a low carbon roadmap with specific goals and actions should be established with clear milestones.

d) Conflicts and strategies to resolve the conflicts

The Table 5.5 below presents the conflicts and methods to resolve the conflicts. There could be potentially more conflicts because all policies are made in different Ministries, therefore there are data discrepancies as well. However, Fiji being a small country is doing wonderful with the inclusion of RE in policies.

Table 5.5 Depicts the conflicts and strategies for LEDS and NDC (Ministry of Economy, 2017).

Conflicts	**Strategies**
• Data discrepancies: NCCP states that the global emissions of national carbon dioxide are 0.04%, while LEDS states as 0.06%. • NCCP also states that there might even be cancellations of biofuels in Fiji if there are 100% vehicle conversion to EV's, which means there will be import duties imposed on fossil fuel and no duty in EVs. Focusing on EVs is not the main mitigating method to meet net-zero carbon emissions but placing more emphasis on the production of biofuels in Fiji. • Fiji LEDS states it is quite difficult to attract investments for biofuel plants, as the recovery period would be reduced as forecasted due to a gradual decline in biodiesel in years to come.	• Data consistencies and more coordination is required. • Biofuel implementation should be given a chance in Fiji; however, not starting on a large scale at once but starting small and growing gradually afterwards. • The seven maritime locations of Fijis being the perfect example of the positive value for biofuel production for energy generations.

5.5 Biofuel policies

Biofuel policies are implemented for the development, blending, policy to mandate biofuel plants, protect heritage sites areas, benefits, costs associated are all outlaid in a biofuel policy. Countries like India, Thailand, Australia and various others have biofuel policies (Pelkmans, 2018). Table 5.6 shows whether there should be a biofuel policy for Fiji as well.

Table 5.6 Responses for biofuel policy development.

Biofuel Policy Development	Yes	Percentage (%)	No	Percentage (%)
10,000- 29,999 (FJD)- 16 people	8	50.0%	8	50.0%
30,000- 49,999 (FJD)- 14 people	5	35.7%	9	64.3%
50,000- 69,999 (FJD)- 12 people	7	58.3%	5	41.7%
>70,000 (FJD)- 18 people	9	50.0%	9	50.0%

i) ***10,000 and 29,999 (FJD)****:* the response by participants were equal 50.0% for both the options**.** Participants who stated there is a need for biofuel policy reasoned out that use of biofuels, and regulations on the production of biofuels and the targets that are in the FNEP-2013 were not sufficient for researchers and developers. Also, participants responded that the biofuel policy should address concerns like availability of land or consent from land owners as most land in Fiji are native lands and persuading the *mataqali's* is a major task. Fuel subsidy is another issue to be addressed as biofuel would be locally produced.

ii) ***30,000 and 49,999 (FJD)****:* 35.7% participants were only for the development of the biofuel policy, while 64.3% stated there is no need for a separate biofuel policy. Participants who stated the need for policy development mentioned that biofuels are the new future in transport sector for developing and developed countries, hence appropriate use of resources to prevent over exploitation would be addressed in the policy.

iii) ***50,000 and 69,999 (FJD):*** 58.3% participants agreed for new policy. In addition, 1 participant stated that the framework for the production of biofuels should be mandated to ensure that there are no feasibility errors and financial losses. Moreover, financing and aid for the development of the biofuel's plants should be addressed, the harvesting of biofuels and management of biofuel plants is also required. However, 41.7% participants stated that because a section is designated under the FNEP, and also under the Trade and Merchandise Amendments in the Fuel Standards for Biofuels, no new policy is required,

iv) ***>70,000 (FJD):*** 50.0% of the participants earning in this range agreed for the development for the biofuels policy for the following reasons; the initial cost of implementation and cost of maintenance need to be addresses. A section should be mandated where it would express the solutions to prevent energy vs food debate and how food scarcity would be prevented. In addition, the policy could also state how the price of biofuel would be worked out and how it would be made cheaper than fossil fuels for people of all incomes. Participants stated the new policy framework development would be an additional cost to the country and biofuel productions are less than 1% globally therefore the viability of new polices would be futile.

5.6 A Flow-chart to interlink all fourteen policies

A flow- chart as Figure 5.4, presents all the 14 polices discussed earlier in this chapter. A short summary of those policies, conflicts, the synergy, current status and linkage between all the policies are outlined. All fourteen policies have some short comings and advantages and more emphasis should be placed on the utilization as it is termed as green energy. Nonetheless there is limited work done on the production of biofuels in Fiji for road transport. A biofuel policy should be implemented by Fiji because it would impose all the necessary contents to be addressed in the biofuel production.

Mapping of Polices and Framework for Land Transportation

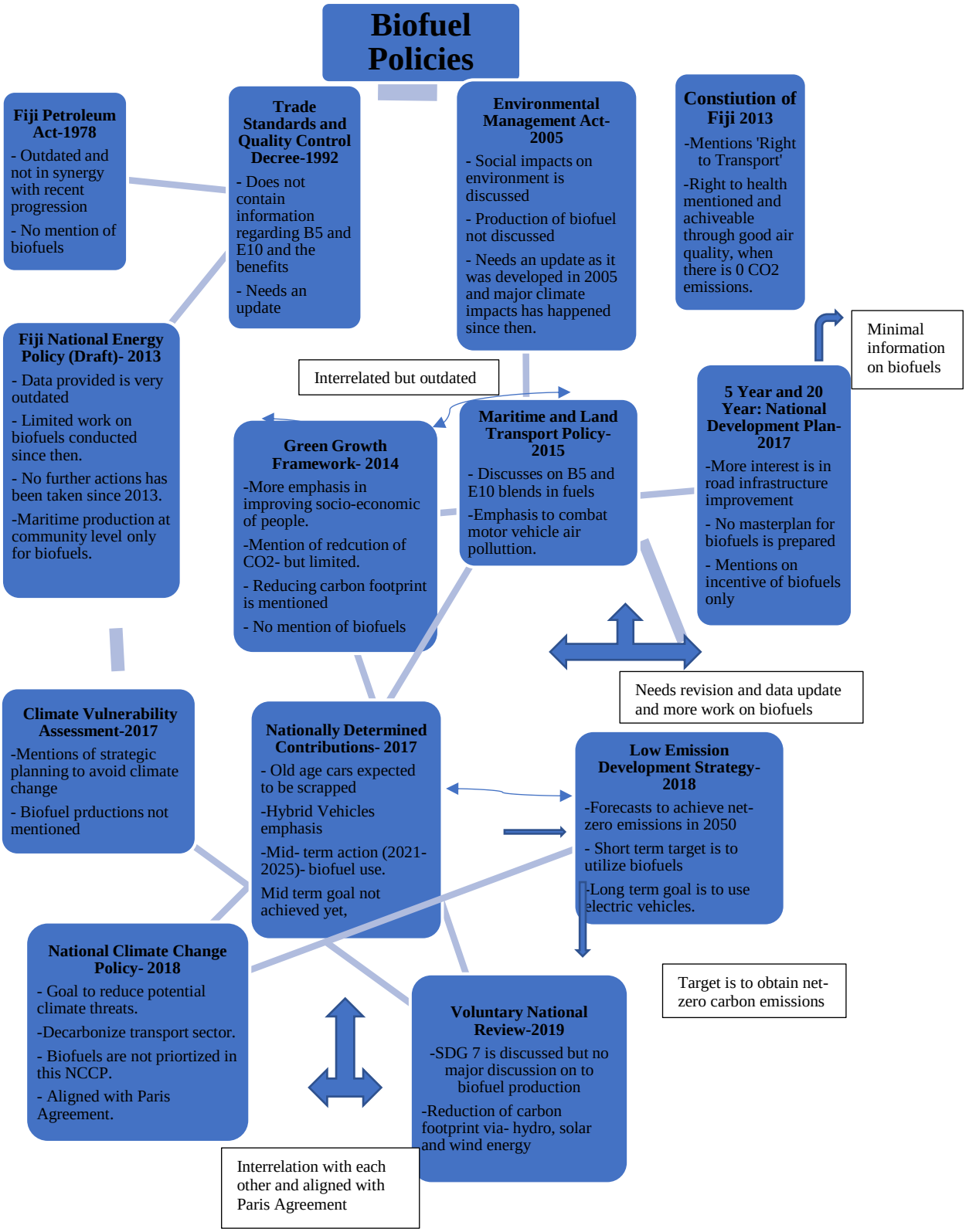


Figure 5.4 The flow-chart discusses all the 14 policies and the interrelated synergies.

CHAPTER 6

Potential Barriers and Challenges

6.0 Overview

This chapter presents the outcomes of **Parts D-E** of the survey, which tries to find the potential barriers in land transport sector efficiency. This included the reasons identified by participants. The barriers were also analysed via literature search.

6.1 Reasons for fossil fuel dependence

People of Fiji and the Pacific Island have to depend on fossil fuel because the Pacific Island Countries (PIC's) do not have oil reserves and also foreign investors are hesitant to invest into RE projects.

Figure 6.1 shows the reasons selected by participants from all four-income categories. Participants largely stated that efficient, reliant and easily accessible to fossil fuel as the common reason for high dependence. Moreover, people are not well aware of new technologies, green energy or renewable energy in transportation sector.

The Figure also revealed that there is a lack of alternative fuels in Fiji, unavailability of land and resources for construction of RE projects, lack of expertise in the RE field and the fossil fuel being a well-established industry, huge profit margins are plausible. Participants earning >70,000 (FJD) indicated that the dependency of fossil fuel is since it is not dependent on weather, and no other options are provided in Fiji yet. In general, from the data obtained, people are lacking ample knowledge on the importance and on the advantages of biofuels in Fiji.

Globally, investments in fossil fuels in Covid-19 recovery packages throughout the world were six times larger than investments in RE. As the global demand continued to rise, investment in new fossil fuels also rose that led to diminishing investment in RE (REN21, 2021).

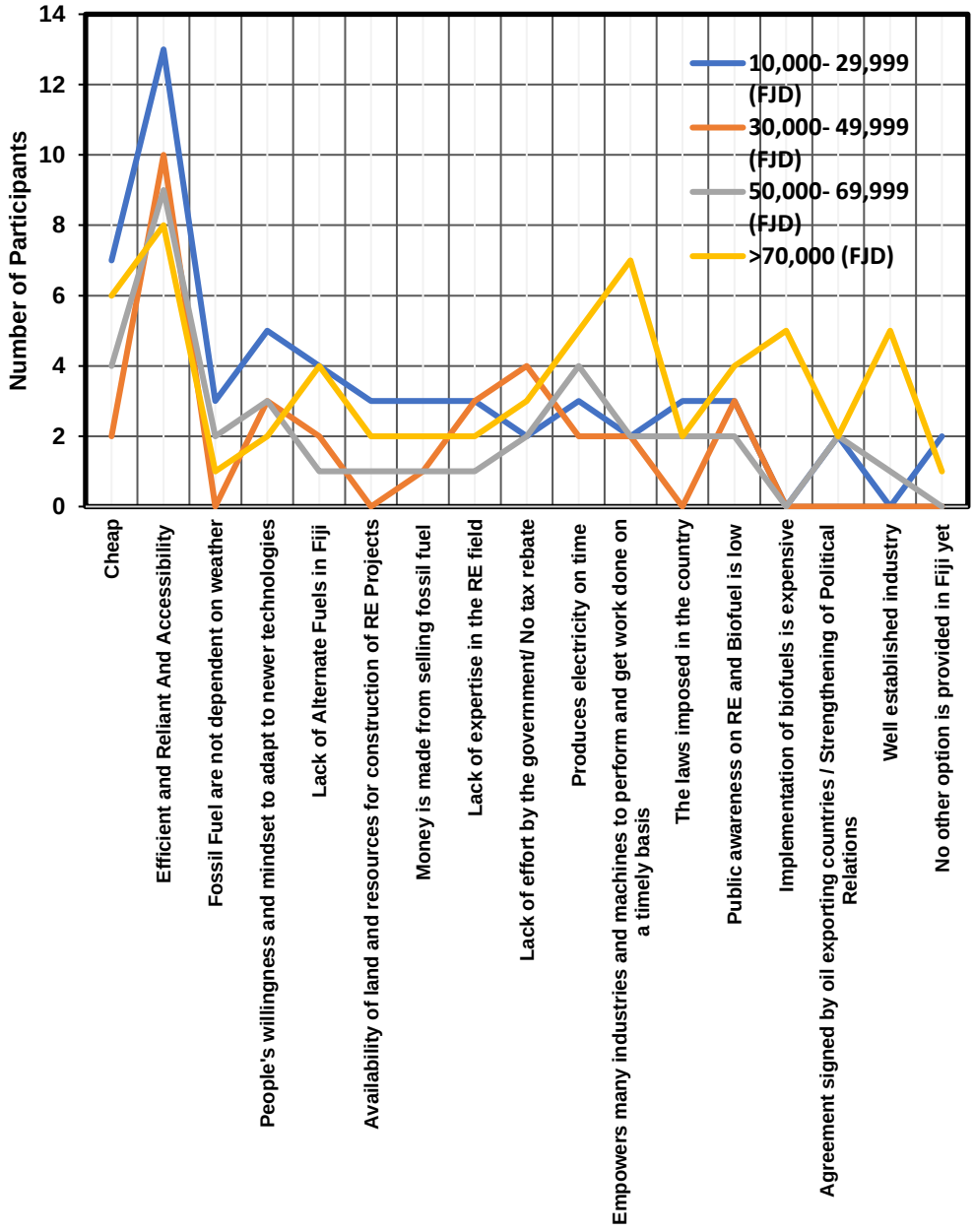


Figure 6.1 Reasons for heavy reliance on fossil fuels in Fiji.

6.2 Potential barriers hindering development

Transport sector has a lot of barriers in Fiji to adapt newer technologies for a sustainable development as presented in Figure 6.2. Lack of financial support is the major barrier in the development of the road transportation sector. When sufficient funds are not allocated, major project developments such as large-scale biofuel production plans are shelved. Moreover, there are not many local graduates in the field of RE and foreigners are brought in Fiji to lead RE projects, which becomes a financial burden for the government and private stakeholders.

The potential barriers in the transport sector that hinders efficiency in the land transport sector are analysed (Figure 6.2). Participants earning between 10,000 and 29,999 (FJD) (i.e., 8 participants) stated lack of proper infrastructure as a contributing barrier. While the least important barrier identified in the efficiency of land transport sector was the poor condition of public transport. To add on, participants earning between 30,000 and 49,999 (FJD), (i.e., 5 participants) stated that the key barrier in the efficiency of the land transport sector was lack of infrastructure, while the least important were non-scrappage of old cars, and a lack of encouragement, communications and management. Furthermore, participants earning 50,000 and 69,999 (FJD), identified three reasons that were; due to a lack of proper infrastructure; authorities doing road checks at peak hour traffic and inefficiency of the government/politics. While the least important barrier was reluctance to scrapping old cars, people's unwillingness to adapt changes and lack of encouragement, communication and motivation.

Fiji being a developing nation is not able to provide enough finances for the road infrastructure improvements and the ongoing pandemic is preventing the investors from providing financial assistance. If sufficient finance is not provided or allocated for infrastructure developments the goals set in the Paris Agreement would be difficult to achieve by the targeted year (2050).

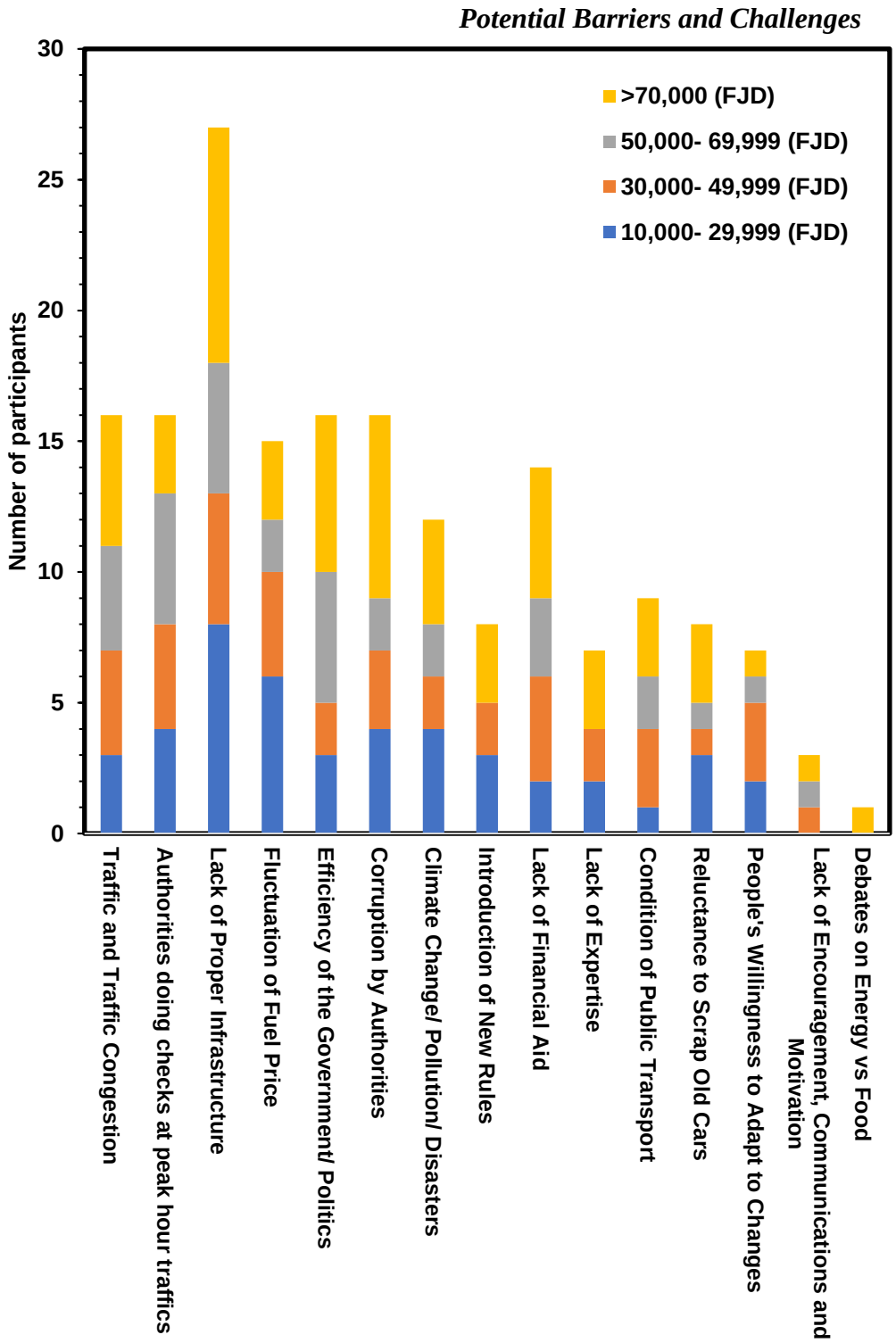


Figure 6.2 The potential barriers in transport sector which hinders efficiency from the results obtained.

6.3 Energy vs Food Debate

A discussion on the impact on local food production with adoption of biofuel options at a commercial scale is very important. The people are petrified whether to produce crops for consumption or whether to produce for fuel thus a debate that is ongoing between energy vs food. This section looks at the responses of the survey followed by critical analysis.

i) ***10-000 and 29,999 (FJD):*** 68.8% of participants stated that there would be a decrease in the food production as Fiji is still a developing nation and some maritime islands together with the bigger islands depend on crops such as coconut, cassava, sugarcane, and maize for food. Conversely, 31.3% participants stated that there would not be any negative impact if agriculture industry is managed well and food and fuel plants are expanded and a balance is made between crops for food and crops for fuel.

ii) ***30,000 and 49,999 (FJD):*** 78.8% of participants stated the same reason as the participants earning between 10,000-29,999 (FJD) as there would be food shortage because Fiji is not fully focusing on agriculture and more emphasis is on tourism sector. Thus, if biofuel productions take place there would be an immense food shortage. In contrast, 21.4% of participants stated that there would not be any effect if there is a proper balance in the crop production for both food and fuel.

iii) ***50,000 and 69,999 (FJD):*** 58.3% of participants stated there would be an impact on food production due to the emergence of biofuel industry as crops would also be utilized for the production of fuel. While, 41.7% participants stated that there would not be any changes if crops production and distribution is managed well.

iv) ***>70,000 (FJD):*** All the 18 participants (100%) stated that there would be a decrease in the food production with the introduction of biofuel

production in Fiji. As food crop would be more extensively used than to feed the growing population. More population would mean more food and thus more fuel as well and Fiji is not economically ready to safeguard both the impending issues.

Pulyaeva, et al. (2020) stated that that the distribution of high-quality arable land in substantial volumes, the issue of land distribution between the energy and food industries would arise. The probability of a significant movement of food producers to the production of products used for raw materials for fuels, that are substantially more profitable, would lead to a higher purchase price for fuel companies (Pulyaeva, et. al., 2020). Due to agricultural producer's desire to compete as suppliers to fuel companies, even a country with considerable land might lack raw resources such as sugarcane, coconut, and corn for the food sector. The advantage of biofuel production only plays a vital role in the emission reduction as it does not contribute to carbon emissions, yet ample studies are a prerequisite for good decision making.

6.4 Biofuels as the solutions for transport sector

Biofuels can become one of the solutions to reduce emissions for land transport use. Figure 6.3 shows the feedback of participants on biofuels as a solution for energy crisis.

i) ***10,000 and 29,999 (FJD):*** 87.5%, stated that biofuels can be a solution to the energy crisis because biofuels emit carbon, allows sustainable development, is a clean/green energy source of energy also the PICs can gain energy independence. However, 12.5% participants stated that biofuels will not be the solution for the energy crisis.

ii) ***30,000 and 49,999 (FJD):*** 85.7% stated it biofuels are safe, cleaner, generates less pollution, and contributes to sustainable development. Even though the initial cost of biofuel implementation would be high, the long-

term use of biofuels in Fiji would be helpful in two ways; Fiji would not have to import fossil fuel thus save a lot on importation and biofuels are greener with less pollution. Nonetheless, 14.3% participants consider harnessing of biofuel in Fiji would be difficult thus not a good solution to resolve the energy crisis.

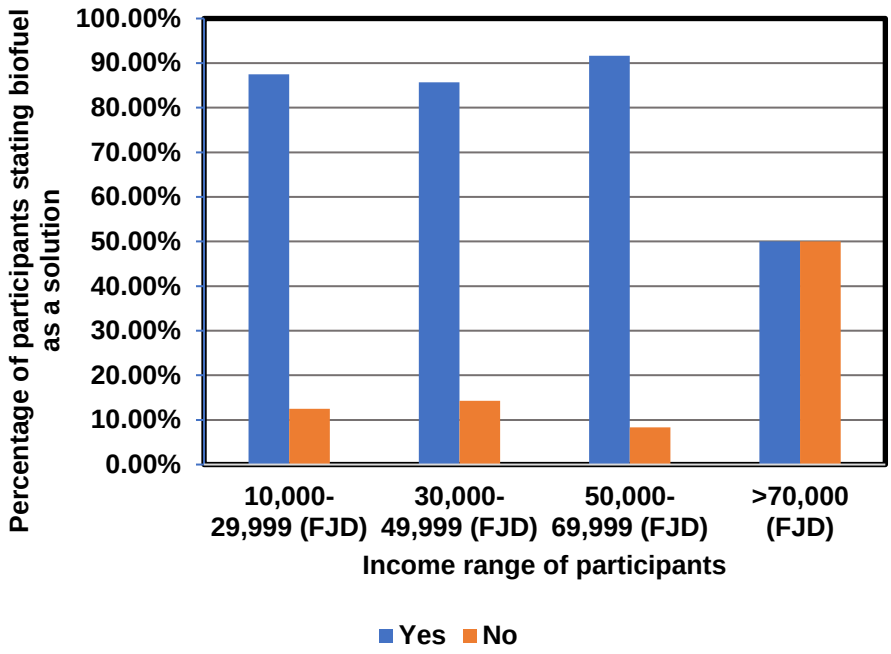


Figure 6.3 Percentage of participations stating biofuels as the solution for transport sector.

iii) ***50,000 and 69,999 (FJD):*** 91.7% participants stated that biofuel could be a life saver because it is a clean source of energy, cheap to produce as it would be manufactured locally, will decrease reliance on fossil fuel, reduce poverty if produced locally, creating more jobs for the locals and price of fuel would be less, but 8.3% participants do not vouch on biofuels stating that it would not be cost effective.

iv) ***>70,000 (FJD):*** 50% of the participants agreed stating similar reasons. While the other 50% stated that the global production of biofuel is only 0.6% thus it is not viable for a developing country like Fiji.

6.5 Research and development of biofuels

For any new technology to be introduced proper research and development and followed by good feasibility studies should be conducted. This section discusses on the need for more investment on research and development of biofuels in Fiji and the results are shown in Figure 6.4.

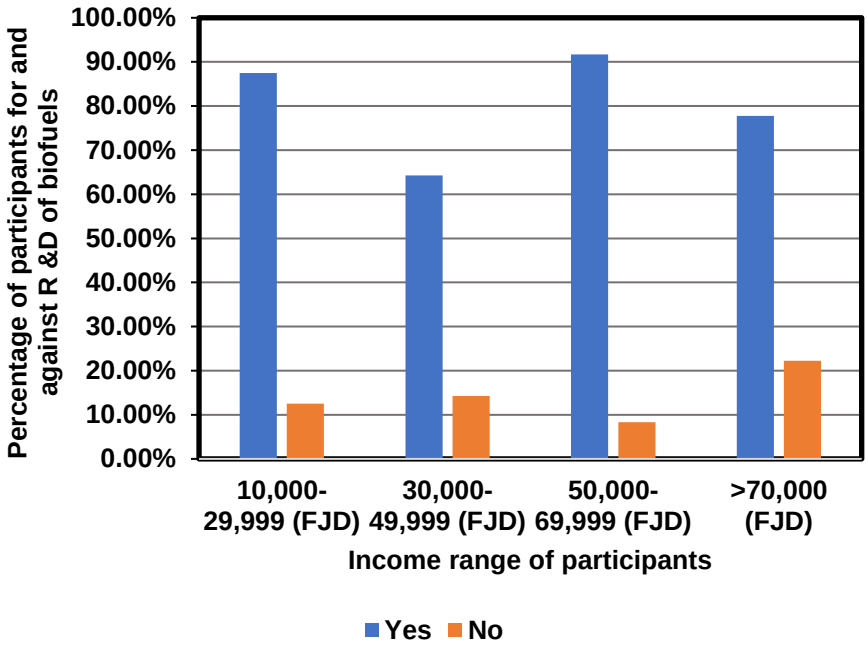


Figure 6.4 The percentage of participations stating the need for research and development of biofuels for road transportation.

i) ***10,000 and 29,999 (FJD):*** 87.5% participants stated that there is a need for R&D in the RE sector since there would be more public awareness and knowledge on RE would be disseminated. On the contrary, 12.5% participants stated Fiji should not contribute to future R&D of biofuels.

ii) ***30,000 and 49,999 (FJD):*** 64.3% participants stated that R&D on biofuels are a good investment because biofuels emit less pollution and any source of energy that is renewable is always considered a clean and environment friendly, also local production would mean cheaper energy. Also, in having better R&D facilities in Fiji, the local graduates who have

knowledge and skills in RE sector would be deemed as an asset to the country. Nonetheless, 35.7% participants stated that there has been enough research done on the area of biofuels.

iii) ***50,000 and 69,999 (FJD):*** 91.7% participants stated that more R&D on biofuels is needed because it would give more advanced knowledge on biofuels and on the latest generations of biofuels. While, 8.3% participant stated that there should not be much R&D on biofuels as the productions on commercial scale globally is very negligible.

iv) ***>70,000 (FJD):*** 77.8% participants stated that biofuels were clean source of energy and affordable would also create job and alleviate poverty, hence R&D was important. Conversely, 22.2% participants disagreed stating that Fiji is a developing country and it is not independent enough to invest in biofuel plants without having foreign investors.

6.6 Problem tree

A problem tree approach was used to analyse the problems faced in the biofuel industry. A problem is shown in Figure 6.5. If more experts are trained with more advocacy in the field of biofuels and RE, then there could be a substantial increase in the percentage of biofuel produced in Fiji. However, there are problems in the development of biofuels in Fiji.

The renewable energy industry in general has not fully grown despite the high cost of fossil fuel. Key barriers for the biofuel development are that banks are reluctant to provide loans. Despite governments and international organisations' support for biofuel production a huge amount is spent on importing fossil fuel. Fiji is keen to improve the situation as it aims for; “Sustainable Energy for All”, to provide more 80% of renewable electricity in the country by 2020 and 100% by 2030. But the purchase of the correct electricity generation equipment particularly for families with low income is limited (The World Bank, 2016).

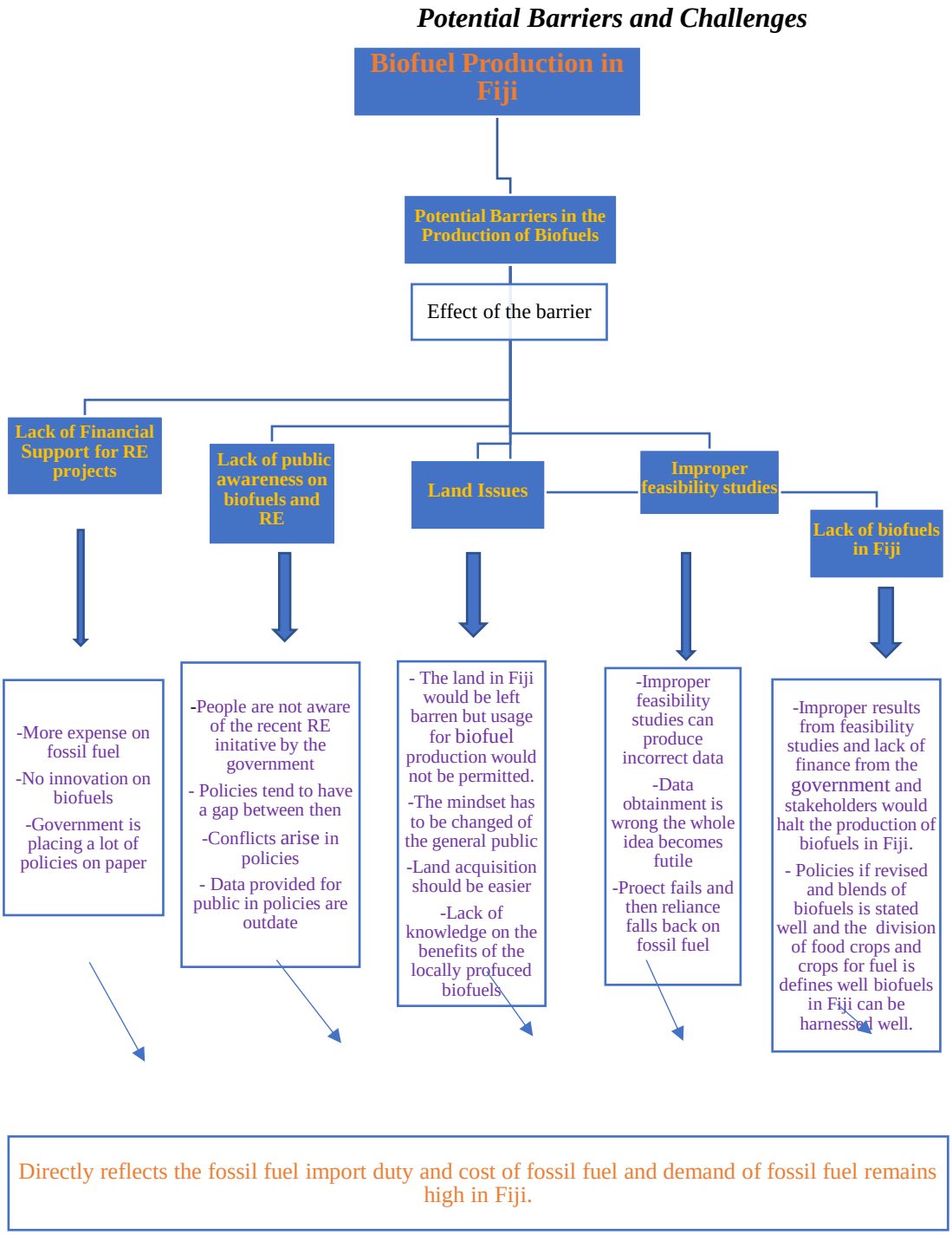


Figure 6.5 A problem tree for production of biofuels in Fiji.

6.7 Solution tree

A solution tree for the problems in section 6.7 is presented in Figure 6.6. The best solution to mitigate the barriers in the production of biofuel in Fiji is through engagement of stakeholders throughout the project and a stakeholder analysis is conducted at all levels.

Any development that takes place has problems associated with it, solutions to mitigate these issues are a must. The above solution tree for biofuel production portrays an insight of the importance of awareness and revision of policies to aid in the emphasis of biofuels to be produced in Fiji. Other solutions could include (Singh, 2014).:

- Fiji can generate B5 biodiesel from coconuts.
- The molasses can be blended into E10 fuel.
- In the near future, Fiji has the potential to become a net exporter of petroleum (SI) and diesel (CI) engine fuels.

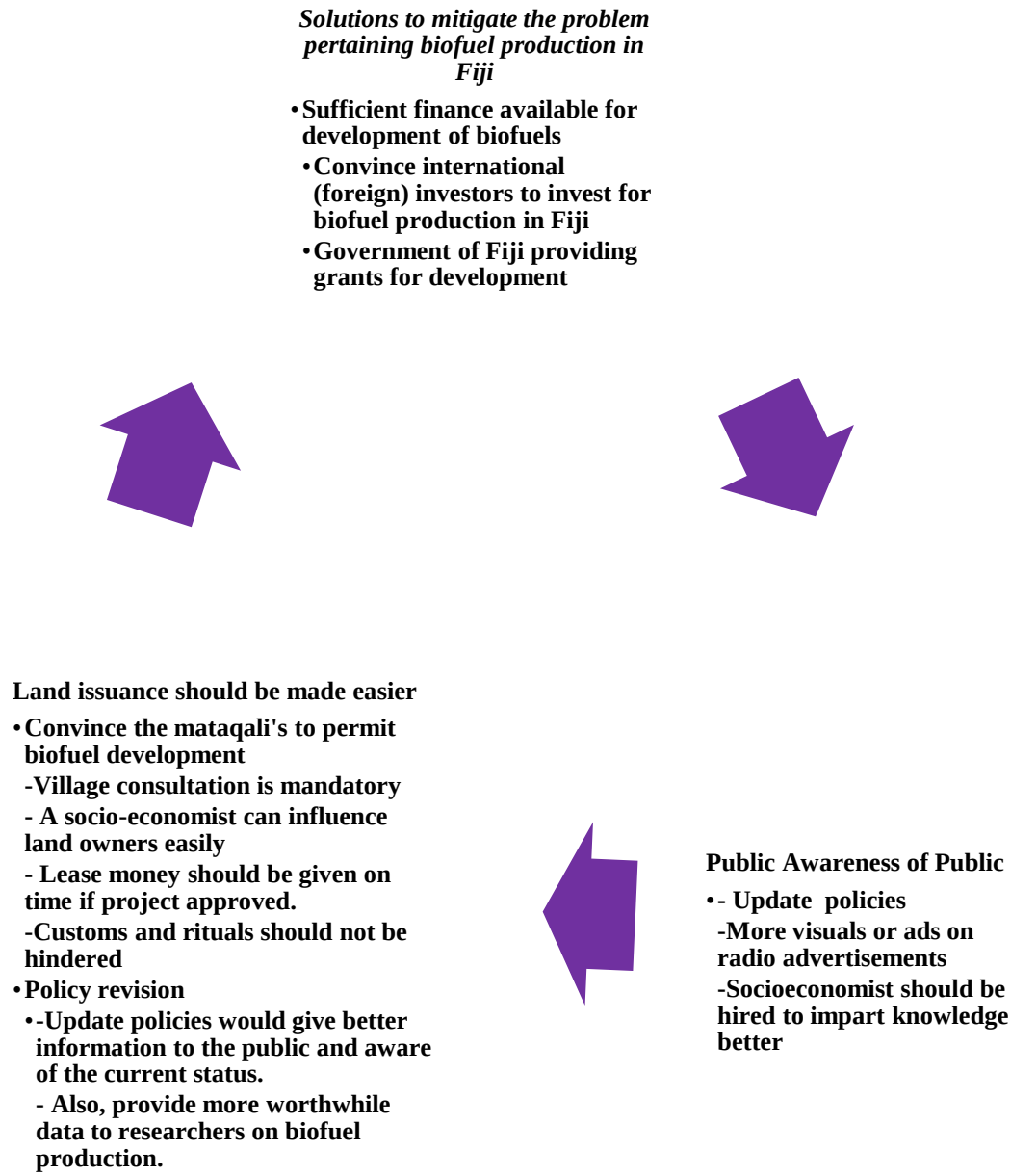


Figure 6.6 Provides a solution tree for the production of biofuel in Fiji.

CHAPTER 7
Conclusion and Recommendations

7.1 Conclusion

In this study, a survey was conducted based on the different household income of sixty participants to determine the people's perception of biofuels for land transportation. It can be concluded from the study that:

- *Lack of acceptance of biofuels amongst vehicle owners*: there is a lack of awareness and insufficient dissemination of information on RE at all income levels. People are not very aware of the implications fossil fuel usage has on the environment.
    - Lower income earners have insufficient knowledge and information on the benefits of biofuels, hence are unwilling to make a transition to the biofuels. This is one of the key barriers in the development of biofuel production in Fiji.
- *Barriers*
    - *Perception Barrier*: Participants also believed that if biofuel production starts, the already suffering agricultural sector will further be affected and there would be a decrease in food production and food supply.
    - *Behavioural Barrier*: People of Fiji are scared to accept and adapt to newer technologies and would like to have the most convenient form of transportation at the expense of the environment.
    - *Policies Barrier*: Policies related to energy needs revision and a new energy policy is under development. More regular policy revisions are needed as new data and information are available to address the evolving climate issues.
        - For instance, the Fiji Petroleum Act-1978 is outdated and does not mention biofuel production and storage.

    - The 5-year and 20-year National Development Plan does not emphasize on the biofuel production.
    - The Green Growth Framework talks on reducing carbon footprint but limited initiative and encouragement on biofuel production is provided.
- Investment: There is an urgently need for more investment in biofuels and other RE.
    - The government of Fiji can provide healthy tax rebates and incentives to investors for accelerated investment in RE.
    - Chances and developmental assistance could be provided to new start-ups that might have innovative ideas, yet lack the financial resources or start-up capital.
- A thorough decarbonization of the transport sector is needed because the transport sector is the second most contributor to GHG emissions in Fiji. There has been 2 mitigation stated in the LEDS, the first being the initiation of biofuel production and biofuel blends in vehicles by 2030, while the 2nd and long-term goal is to have fully electric vehicles on road by 2050.
- *EVs vs Biofuels dilemma*: Fiji also plans to introduce EVs but currently it is not market ready in comparison to developed nations with better EV facilities, technical expertise, financial systems and policies. Fiji needs uplift these (EV facilities, technical expertise, financial systems and policies) in a very short span of time for wider adoption of EVs keeping into perspective that mobility will come to a halt for months if power lines get damaged during severe and frequent tropical cyclones. In addition, more RE needs to be integrated into the grid which has around 60% RE currently.
- *Biofuels Roadmap*: Fiji and other PICs may have a lot of potential for the production of biofuels, however, it needs to prepare a roadmap to put these ideas into actions.

- *Co-benefits of biofuel production and energy independence*: Biofuels would not only reduce emissions of GHG's, but would also reduce the burden of Fijian government in reducing importation of fossil fuel, assist alleviating poverty by creating more jobs.

7.2 Recommendations

i. Public awareness and more advocating on the benefits of biofuels

People of Fiji are not well versed with the benefits of RE technologies. People have a negative perception on the failures of certain RE projects in Fiji. Therefore, proper knowledge dissemination to the general public via seminars, workshops at community level are imperative. Small workshops in villages and *talanoa* sessions are excellent for information sharing.

ii. Use of effective media and simple languages

There are a lot of means to promote Green and Sustainable Energy but the messages are not put across at all levels of people. For instance, a lot of people use Social Media; like Facebook, Instagram, Twitter and so forth, there shall be advertisements where it would portray the negative impact of fossil fuel and the benefits of Biofuels usage. Many people learn more from Social Media than via academic and formal presentations as they have difficulty in understanding the scientific jargons. Thus, if there are more visuals, they would be able to understand better as the saying goes "*A picture speaks a thousand words*".

iii. Thorough feasibility study and cost benefit analysis

A feasibility study is important because it will look at the different aspects of the project and would have a conclusion whether that project is feasible enough to be given a green light. All the possible pros and cons of the project would be identified. For instance, the location of the biofuel plant, how far or close it is to the settlements, how would it affect the livelihood of the people around that community/ or settlement. Furthermore, the

Cost Benefit Analysis would include the cost's associated with the projects and Internal Rate of Returns (IRR) obtained by the production and distribution of the biofuel. If the ratio is not above the investment cost then the project would not be feasible enough. The land availability, feedstock, crop diversification, employment criteria, people's perspective and socioeconomic benefits could also be analysed.

iv. Timely Updating and development of relevant new policies

Revision of energy, climate and other policies is very much important. A dedicated Biofuels policy should be developed and mandated. In addition, the new policy could also set targets by when there would be full utilization of biofuel blends and address issues thoroughly. It could also allow for easier acquisition of land from the land owners for biofuel crops. Lastly, it can also mandate the tax exemptions, holidays and the duty exemptions for the production of biofuels in Fiji.

v. Biofuels provide energy security

Biofuels would aid in providing energy security by diversifying the available sources and providing a component of supply that is not necessarily import dependent, since biofuels would be generated locally. Furthermore, locally produced biofuels are less vulnerable to some energy security challenges, however, biofuels infrastructural damages and supply chain distortion due to extreme weather events needs to be factored in properly.

vi. Biofuels contributes to economic development

Biofuel production would also be a highly appealing proposition in developing nations such as Fiji, where agriculture employs a big portion of the population and biofuels could provide a local job in addition to the local energy source.

vii. Personal net-zero carbon emission or carbon neutral goals

People can try and set personal net-zero carbon emission or carbon neutral goals and start motivating, innovating and accepting RE with open hands, and shift focus from fossils importation to production of biofuels.

Fiji is heavily dependent on fossil fuel and extensively spends on the importation of fossil fuel from oil rich countries. People are very reliant on fossil fuels, simply because they are not aware of the renewable and alternative sources of fuels such as biofuels. Fiji being one of the least contributors to GHG emissions, suffers the most in terms of natural disaster and had experienced detrimental and devastating cyclones in year 2020; namely TC Harold and TC Yasa which both were Category 4 and 5 strengths.

The process of finding alternative mitigation methods to achieve the targets that are set laid out in the Paris Agreement commenced earlier on and the best alternative to reduce dependency on fossil fuel are the transition to RE technologies. The production of biofuel for road transportation has the potential to reduce fuel costs, reduce importation cost of fossil fuels, create jobs and bring about economic growth.

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Appendices

A1- Survey Sheets for Chapter 4, 5 and 6

ENERGY FOR FIJI'S ROAD TRANSPORTATION SECTOR: A POLICY-BASED PATHWAY TO SUSTAINABLE DEVELOPMENT

August 2020

Form No. _____

Name of Volunteer: _____

Date of Survey: _____

This survey is being conducted as a part of a minor thesis for the course REM 407. The data collected will be used only for academic purposes and will kept confidential. Your participation is voluntary. Please indicate to the researcher if you do not want wish any information to be collected about you or your household. Thank you for agreeing to participate in this survey.

Part A: General Information:

1. Address of household:

   _____

   _____

2. Description of residence: a) house b) flat c) apartment d) hostel
   e) other (please stipulate)

3. The type of household:
   a) Regular household b) Group or rented house c) Rented room with a family
   d) Hostel e) Other (please stipulate)

4. Dwellers of household constituent:
   a) Number _____
   b) Total annual income of household (FJD)
   i) 0-4999 ii) 5000-9,999 iii) 10,000- 29,999 iv) 30,000- 49,999
   v) 50,000-69,999 vi) >70, 000

   c) Age and educational level of adult occupants:
   i) _____ ii) _____
   iii) _____ iv) _____

   d) Occupation

   i) _____ ii) _____
   iii) _____ iv) _____

Part B: The Cost Associated with Transport Sector in Fiji:

1. i) Indicate the means of travel (bus, taxi, car, ride with neighbour, others):

_____

_____

ii) Please specify details on personal vehicle usage (if any):

_____

_____

iii) Indicate the distance travelled per week:

_____

_____

2. In Fiji, transport sector has a major influence in the emission of fossil fuel. How much of your personal cash do you spend on the use of transport per week?

_____

_____

3. Suggest methods in which Fiji and its people could save on transportation cost.

_____

_____

_____

4. In Fiji, do you find a prioritization over a specific type of transport mode which leads to bias towards other modes of transport such as (buses, cars, trucks and others), over which Fiji is spending on the development and infrastructure. If yes, please explain why?

_____

_____

_____

_____

_____

5. Are you satisfied by the price of fossil fuel in Fiji? Do you think you could save more money if Fiji starts initiating biofuel production?

_____

_____

_____

_____

_____

_____

Part C: Environmental Impact of the Fossil Fuel:

1. Explain how the use of fossil fuel in the transport sector causes environmental degradation?

_____

_____

_____

_____

2. What is your perception on the use of fossil fuel and its contribution to climate change?

_____

_____

_____

3. If Fiji starts adapting to the cleaner, safer and environmentally safe "alternate fuels", do you think there would a positive change in the climate and would the use of alternate fuels help Fiji reach its target of zero net carbon emissions by 2050? Specify your answer.

_____

_____

_____

_____

_____

4. Do you think the increased intensity and frequency of Tropical Cyclones, Flooding and other weather-related patterns are associated with the use of fossil fuel?

_____

_____

_____

_____

5. Even though fossil fuel is criticized heavily, yet people of Fiji and the Pacific Islands depend heavily on the use of fossil fuel. What are three probable reasons for it?

_____

_____

_____

_____

_____

Part D: The potential barriers in transport sector efficiency:

1. What are the potential barriers in transport sector that hinders the efficiency?

_____

_____

_____

_____

2. Is politics a potential barrier on the transportation sector in Fiji. If yes, please elaborate.

   Yes_____

   No_____

   _____

   _____

   _____

   _____

3. What is the function of the stakeholders in the transport sector, also do they have an influence to be a potential barrier in the development of the transport sector?

   _____

   _____

   _____

   _____

4. How does the government influence the general public, regarding road transportation in Fiji?

   _____

   _____

   _____

   _____

5. Apart from the government, politics and economic barriers in the transportation sector in Fiji, list some of the other potential barriers that you know of that could hinder the development in Fiji's road transportation sector?

_____

_____

_____

_____

Part E: The production and use of Biofuels in Fiji:

1. There has always been an on-going debate between *"Energy vs Food"*. Do you think the production of biofuels will have a serious impact on natural food sources in Fiji such as coconut, sugarcane, cassava, maize and other?

_____

_____

_____

_____

2. People are impending that biofuels is the solution for the energy crisis. Do you agree to this statement? If yes, please explain.

_____

_____

_____

3. If there is more production and use of biofuels in developing countries like Fiji, do you suggest that it would help alleviate poverty?

   _____

   _____

   _____

   _____

4. Do you think Fiji should invest more in the Research and Development of biofuels? If so, please elucidate your answer.

   _____

   _____

   _____

   _____

5. Fiji has developed certain policies relating to Climate Change and Renewable Energy, do you consider Fiji to take a step forward and make a policy relating to Biofuels. If so, what are certain key issues to be addressed in biofuel production in Fiji.

   _____

   _____

   _____

   _____

Thank you for your time and consideration ☺.

A2- Biodiesel requirements in Fiji

Table A Biodiesel requirements in Fiji (Department of Energy, 2020).

Item	Property	Value
1	Ester Content	96.5 (min)
2	Oxidation Stability: Induction Period	6 hrs (min)
3	Total Acid Number	0.50 mg KOH/g (max)
4	Methanol (1)	0.20% m/m (max)
5	Glycerides Mono-glycerides Di-glycerides Tri-glycerides	 0.80% m/m (max) 0.20% m/m (max) 0.20% m/m (max)
6	Glycerine (glycerol) Free glycerine Total glycerine	 0.02% m/m (max) 0.25% m/m (max)
7	Density @ 15°C	860-890 kg/m^3
8	Kinematic viscosity @ 40°C	3.5-5.0 mm^2/s
9	Flash Point	100°C (min)
10	Cetane Number	51 (min)
11	Cetane Index (2)	48 (min)
12	Water	500 mg/kg (max)
13	Water and Sediment	0.05% v/v (max)
14	Total Contamination	24 mg/kg (max)
15	Ash Content	0.01% m/m (max)
16	Sulphated Ash	0.02% m/m (max)
17	Carbon residue [Ramsbottom, on 100% distillation residue]	0.05% m/m (max)
18	Sulphur	50 mg/kg (max) [50ppm]
19	Phosphorus	4 mg/kg (max) [4ppm]
20	Alkali metals (Na + K)	5 mg/kg (max)
21	Alkaline metals (Ca + Mg)	5mg/kg (max)
22	Distillation T90	360°C (max)
23	Copper Strip Corrosion	No.3 (max)

Note:

i. When the amount of methanol is higher than this limit, these requirements will still be met if the flash point meets at least 130℃.

ii. Temperature readings for 10 vol to measure the cetane index. The percentage needs just 50 vol, 90% and 90 vol. percent.

iii. These standards build on the expertise gained from biodiesel fuels made from feed stocks that are widely used in different markets around the world. these standards are based on. The criteria are neutral to output and feed stock

Table B Potential role of molasses in ethanol (Chandra, et al., 2017).

Description		*2010*	*2011*	*2012*	*2013*	*2014*	*Yearly average*
Molasses export[A]	Value (FJS)	23,078,000	30,432,000	14,857,000	15,590,000	17,270,000	20,245,000
	Volume (000 t)	113,000	107,000	67,000	59,000	77,000	84,700
	Price (FJS t^{-1})	204	284	222	264	224	239
Motor spirit import[B]	Value (FJS)	128,634,333	138,428,325	139,557,138	152,578,569	170,028,983	145,845,470
	Volume (L)	101,863,650	96,524,213	94,342,498	102,521,011	115,544,092	102,159,093
	Price (FJS L^{-1})	1.26	1.43	1.48	1.49	1.47	1.43
Molasses ethanol potential[C]	Volume (L)	28,250,000	26,750,000	16,750,000	14,750,000	19,250,000	21,175,000
Motor spirit displacement by E10 blend (molasses ethanol)	Volume (L)	10,186,365	9,652,421	9,434,250	10,252,101	11,554,409	10,215,909
	Price per Litre (FJS L^{-1})	1.26	1.43	1.48	1.49	1.47	1.43
	Savings (FJS)	12,863,433	13,842,833	13,955,714	15,257,857	17,002,898	14,584,547
Balance molasses ethanol[D]	Volume (L)	16,563,635	23,347,579	6,065,750	5,997,899	5,195,591	11,434,091
	Export price (FJS L^{-1})	1.74	1.74	1.74	1.74	1.74	1.74
	Ethanol Sales (FJS)	28,820,725	40,624,787	10,554,405	10,436,344	9,040,328	19,895,318
Industrial cost -molasses to ethanol (excl feedstock)[E]	Cost (FJS L^{-1}	0.322	0.322	0.322	0.322	0.322	0.322
	Conversion Cost	9,096,500	8,613,500	5,393,500	4,749,500	6,198,500	6,818,350
Potential benefit of using molasses ethanol	(FJS)	32,587,658	45,854,120	19,116,619	20,944,701	19,844,726	27,661,515

A&B were obtained from Fiji Bureau of Statistics (2015c). C: conversion rate (250 l/t) was obtained from (Silalertruksa and Gheewala, 2010). D: price of ethanol was obtained from Nguyen and Gheewala (2008). E: conversion cost was obtained from van den Wall Bake et al. (2009), Nguyen and Gheewala (2008), Crago et al. (2010) and Garcia and Manzini, 2012).

A4- Emissions of pollution and future mitigation

Table C Emissions of pollution and mitigation (Chandra, et al., 2017).

Year	*Use of imported motor spirit* (tCO_{2eq})	*Production of ethanol for 10% blending* (tCO_{2eq})	*Use of 90% motor spirit* (tCO_{2eq})	*Use of blended (E10) fuel* (tCO_{2eq})	*Total saving from using E10 fuel* (tCO_{2eq})
2010	296,423	6978	266,781	273,758	22,665
2011	280,885	6612	252,797	259,409	21,477
2012	274,537	6462	247,083	253,545	20,991
2013	298,336	7023	268,503	275,525	22,811
2014	336,233	7915	302,610	310,525	25,709
Yearly average	*297,283*	*6998*	*267,555*	*274,553*	*22,730*

A = Tonnes of CO_2 emission from use of all motor spirit imported in Fiji. B = Tonnes of CO_2 emission from production and use of 10% ethanol extracted from Molasses which will be blended to imported motor spirit. C = Tonnes of CO_2 emission from production and use of motor spirit (90%) that will be blended with 10% local ethanol. D = Tonnes of CO_2 emission from production and use of blended fuel (10% ethanol & 90% Motor Spirit). E = Tonnes of CO_2 emission that can be avoided by motor spirit 90% – ethanol 10% blending.

A5- Standards for ethanol

Table D Standard of the ethanol (The Fijian Government, 2011).

Item	**Property**	**Test Method**
1	Ethanol	99.2% m/m (min [prior to denaturing] 94.2% m/m (min) [after denaturing]
2	Methanol	0.5% vol. (max)
3	Water	0.7% vol. (max)
4	Density	791.5 kg/m^3 (max)
5	Electrical conductivity	500 US/m (max)
6	Inorganic chloride	10 mg/L (max)
7	Sulphate	4 mg/kg (max)
8	Copper[2]	0.1 mg/kg (max)
9	Phosphorus	0.5 mg/L (max)
10	Sulphur	10 mg/kg (max)
11	Non- volatile material	5 mg/100 mL
12	pHe	6.5- 9
13	Acidity (as acetic acid)	0.007% m/m (max)
14	Appearance	Clear and bright, no visible impurities
15	Denaturant	1- 1.5% vol.

A6- Sampling, procedures and recording

- ***Subsection 4.1 Testing Methods:***

  The American Society for Testing and Matters (ASTM) or European Standard (EN) testing methods referred to in Table D shall be used to assess the amount of a substance in ethanol or parameter stated in Table E for biodiesel.

Table E Methods for the test (The Fijian Government, 2011).

Item	**Property**	**Test Method**
1	Ethanol	ASTM D5501
2	Methanol	ASTM D5501
3	Water	ASTM E203
4	Density	ASTM D4052
5	Electrical conductivity	ASTM D1125
6	Inorganic chloride	ASTM D7319
7	Sulphate	ASTM D7318
8	Copper	ASTM D1688 modified
9	Phosphorus	ASTM D3231
10	Sulphur	ASTM D5453[1] (<20ppm) ASTM D2622 (> 20ppm)
11	Non- volatile material	ASTM D381
12	pHe	ASTM D6423
13	Acidity (as acetic acid)	ASTM D1613
14	Appearance	ASTM D4806
15	Denaturant	ASTM D5501

(i) ATSM D5453 is the accepted method for samples containing less than 20 mg/kg (ppm) of sulphur. If it is suspected that samples contain more than 20mg/kg of Sulphur ATSM D2622 is to be used.