DEVELOPMENT OF NATIONAL BIOFUEL POLICY IN FIJI (Context and Status)

MINISTRY OF
INFRASTRUCTURE
& TRANSPORT

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TERM	DEFINITION
Biofuel	*Biodiesel, bio-ethanol and other fuels that are produced from biomass, animal fats, waste cooking oil (WCO) and other mainly used with vehicle, engines, for heat and electricity generation in accordance with national biofuel standard.*
Biofuel feedstock	*Biofuel feedstock is the farm/non-farm stock that can be converted to biodiesel and bioethanol*
Bio-ethanol	*C_2H_2OH which is produced from agricultural plants and other bio sources,*
Biodiesel	*Biofuel which is produced from oily plants, animal fats, waste cooking oil, wastes, and other biomass that are processed into fuel that can be blended with diesel oil. Biodiesel is a renewable fuel consists of fatty acid methyl esters (derived through transesterification of vegetable oils, animal fat and also recycles oil from the food industry with methanol.*
Biofuel Company	*Company that produces, processes, and distributes the biofuel products*
Biodiesel (B5, B10)	*Diesel fuel that has been blended with biodiesel in the ratio of 95 and 90 percent and 5 and 10 percent biodiesel respectively;*
Bioethanol (E5, E10)	*Gasoline that has been blended with ethanol at the ratio of 95 and 90 percent and 5 and 10 percent bioethanol respectively*
Biofuel Feedstock Producer	*Biofuel feedstock producers are farmers or other entities who are engaged in producing feedstock for biofuel production*
Bio-energy	*Bio-energy is the conversion of biomass resources such as agricultural and forest residues, organic municipal waste and energy crops into useful energy carriers including heat, electricity and transport fuels.*

ABBREVIATIONS

ALTA	Agriculture Landlord and Tenant Act
B-5,B-10, B-100	Biodiesel-5%, Biodiesel-10%, Biodiesel-100%,
CC	Commerce Commission
CNO	Coconut Oil
CO_{2e}	Carbon di-oxide equivalent
DES	Dietary energy supply
DoE	Department of Energy
E-5, E-10, E-100	Ethanol-5%, Ethanol-10%, Ethanol-100%,
ePURE	European Producers Union of Renewable Ethanol
EU	European Union
FFPT	Fiji Fuel Pricing Template
FJD	Fijian Dollar
FSC	Fiji Sugar Corporation
GHG	Green house gases
HDI	Human Development Index
km	Kilometre
LTA	Land Transport Authority
MAPI	Ministry of Agriculture and Primary Industries
OEM	original equipment manufacturers
RBF	Reserve Bank of Fiji
RBF	Reserve Bank of Fiji
SE4ALL	Sustainable Energy for All
sq km	Square kilometre
TLTB	iTaukei Land Trust Board
USA	United States of America
USD	United Stated Dollar

EXECUTIVE SUMMARY

The Fiji Biofuel program rationale is drawn from the strategies and goals suggested in National Energy Policy (2013), Green Growth Framework and the National Climate Change Policy. Fiji plans to shift from conventional fossil fuel energy sources (for which country completely relies on imports) towards renewable energy sources.

Currently the country has not defined the scope or policy for the biofuel program but has in place a renewable energy plan which is articulated in various policy and strategy documents.

This report deals with the status of the current biofuel program, assessment of the current business and legal environment in the country for biofuel program promotion, and the existing capacities and opportunities existing in the country for development of a national biofuel program. In addition, the report also quantifies the B-100 and E-100 requirement to meet the biofuel requirement of the country by 2030 and analyzes the existing and potential biofuel feedstock options available to the country to meet the biofuel program targets.

The country retained 248 ML of diesel and 43 ML of gasoline in 2008. In 2012, this increased to 264 ML of diesel and 69 ML of gasoline. Using two different estimations (with multiple scenarios) it is estimated that the diesel demand will reach 454 ML and gasoline demand will be 131 ML p.a. for the year 2030. Assuming that the country will meet its biofuel demand by introducing 10% biodiesel and 10% bioethnaol, the B-100 and E-100 requirement of the country for year 2030 will be 48.69 million liters and 19.28 million liters respectively.

The biofuel program in the country aims to cover entire biofuel chain from plantation to processing and retailing. This would ensure reduced greenhouse gas emissions and diversification of energy sources and in addition, stimulation of developments in agriculture, creation of jobs and saving of foreign exchange.

Fiji's interest towards biofuel has resulted in initiation of multiple activities which are funded by government, further there are subsidy support from the government to promote private investments as well. The Department of Energy (DoE) leads the biofuel initiative in the country. Pilot projects supported by DoE are focused on development and marketing of coconut oil. The copra mills supported by DoE source all the feedstock from communities. Further, Fiji Sugarcane Corporation (FSC) is pursuing production of bioethanol from bagassse.

In order to suggest the biofuel feedstock crop with least environmental footprint and highest economical results, the comparative analysis of selected biofuel feedstock species conducted. The biofuel feedstock species identified for Fiji include,

Potential bio-diesel feedstock crops : Coconut, palm, Jatropha, Pongamia,

Potential bio-ethanol feedstock crops : Sugarcane, Cassava, Maize

The existing biofuel operations in the country are centric around coconut and pongamia for bio-diesel and sugarcane for bio-ethanol. For bio-diesel, government has promoted coconut oil units operating from islands. Investments in these units have been channelized through DoE which also ensures that all necessary fiscal and institutional support is extended to the investors. Pongamia biodiesel program is currently at the plantation stage and the ethanol program of the FSC is currently at the planning stage.

Despite the conducive environment for investors to participate in the biofuel program, several hurdles remain that need to be addressed in order to make the biofuel program successful.

Feedstock production is key to success of biofuel program, also this is the weakest point in the whole supply chain and this is true for Fiji as well. There is no mature market interface existing between

farmers and biofuel producers. Also, biofuel feedstock production is marred with issues such, low productivity etc.

The biofuel production on the other hand is grappling with more serious concerns, despite the doles offered by the government to the biofuel production units in terms of tax breaks and tariff concession, no biofuel is currently produced in the country. On top of it, there is no biofuel production facility in the country that can produce biofuel in the country.

The biofuel program in the country may face a limitation in form of compatibility of the infrastructure and the vehicle engines. Since biofuels have never been retailed in the country at commercial scale, hence the biofuel program managers will have to ensure that the capacity of all the stakeholders involved in the biofuel supply chain would have to be build overtime before launch of a nationwide biofuel program. Stakeholder capacities around the biofuel production to retailing and end use need to be analyzed to measure the existing capacities and make contextual adjustments to achieve desired level of technology upgradaton and expertise to ensure biofuel program success.

The environmental, social and economic impacts of biofuel program in the economy are analyzed to compare various biofuel options available to the country. Clearly, it's critical to evaluate the various biofuel feedstock options based on its overall negative impacts on the ecological, socio and economic parameters. E.g. though copra is seemingly the most clean and beneficial for local economy, but its processing (converting coconut to copra) is highly pollution process. The policymakers will have to emphasize on the evaluation aspects that form the basis of such decision making. The program managers will have to ensure that the biofuel feedstock with the least negatives impacts are promoted in the country.

As far as the food-fuel conflict is concerned, the biofuel program with target of achieving 10% blended fuel by 2030 may create food-fuel conflict in the country if agriculture land is diverted for biofuel feedstock production. The country is import dependent to meet part of its fuel demand, through its self-sufficient in the production of *dalo* and cassava. But the biofuel programs improve rural economy, further this program will also replace petroleum fuel. Hence the country can easily save on forex which can be diverted to import food (already Fiji is import dependent to meet its food demand.

CHAPTER 1

ASSESSMENT OF BIOFUEL DEMAND IN FIJI

This chapter gives an overview of the transport sector in Fiji with specific focus on the land transport. The land transport sector and trends, its composition are discussed in detail along with the renewable energy policy environment in the country. The fuel used in land transport is used to estimate the sector's fuel requirement for next 15 years. This number is used to generate the projections for biofuel required by the country to meet the national target of renewable energy mix for transport sector.

Fiji (officially the Republic of Fiji Islands) is an archipelago of more than 320 islands with one-third of these being permanently inhabited. The total land area of the country is about 18,300 sq km. approximately 93% of nations population resides in the largest two islands viz. Viti Levu and Vanua Levu (ADB, 2014). Notably, almost 47% of the country's population lives in rural areas (The World Bank, 2015).

Further, country's 2/3rd population lives in Viti Levu island, and due to the terrain of the country, most of the population is concentrated in the coastal regions. Of the 14 provinces in the country, Rewa (home to capital Suva) has the highest population density of 370.5 person/ sq km. Wherein, Bua in the northern province has the lowest population density of 10 people per sq km[1] (for visual representation of population densities please refer to Annexure-I).

The economic growth in Fiji has resulted in rapid development of urban settlements. The cities and towns in the country were developed at locations that facilitate business and commerce activities. Thus the cities are being developed on the banks of major rivers or on harbors to benefit from boating and shipping movements (Qicatabua, 2002).

Road network characteristics

The population density and distribution has a bearing on the transport system and road network of the country. The road network in the country is extensive and is approximately 11,000 km in length, characterized by circumferential main roads with feeder road system[2] (see Annexure-II for visual representation of road network of the country).

The road network in the country includes 5,127 km of national roads, of which 1,608 km is sealed (paved) and 3519 km of unsealed (unpaved). The high priority roads make 32% of the road network and such roads make arterial links between the main urban centre's, ports/jetties and airports. The next category of road (secondary road) is 10% of the network which acts as feeder to the main roads. Country roads form the largest network of roads (~55% of road network) that connects the rural areas[3] with major roads and cities.

Road transport sector characteristics

During 2009-2012 about 563,079,671 million litre of fuel was imported by Fiji (of this about 45% was re-exported to other island regions in the region (Unknown, 2014). Of this only about 16% of fuel was used by the land transport sector, considering the distance between islands, sea transport and air transport were the biggest consumers of oil in the country (see Figure 1)

[1] http://www.geo-ref.net/en/fji.htm
[2] http://www.adb.org/sites/default/files/linked-documents/cps-fij-2014-2018-ssa-01.pdf
[3] http://www.transportunit.gov.fj/pdf/2010/SESSION%205%20-%20DNR-%20APISAI%20KETENILAGI.pdf

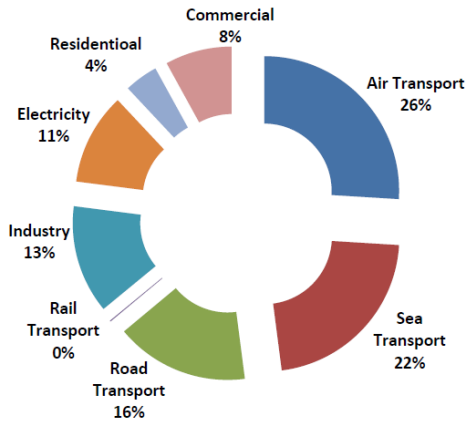


Figure 1: Distribution of fuel users (Fiji Bureau of Statistics, 2014)

The country wide transportation activity as recorded during the period 2006-2010 is represented in Figure 2. Almost half of the transport sector was dedicated to providing supporting and auxiliary services. 31% of the transportation in the country was through air-mode. 17% of mobility demand was met through land transport and the remaining 5% was through sea transport (Fiji Bureau of Statistics, 2014).

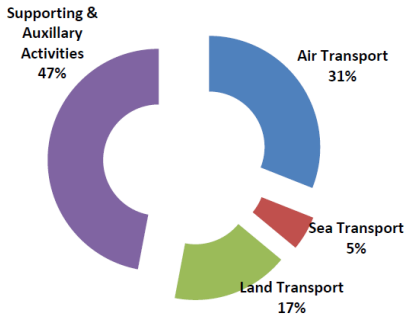


Figure 2: Distribution of transport sector (Fiji Bureau of Statistics, 2014)

Vehicular mix and trend

By the end of 2013, there were 0.18 million vehicles on the roads of Fiji. The vehicle mix in the country is displayed in Figure 2. Private cars constituted 53% of the vehicles in the country. Goods- carriers was the second largest vehicle category (~26%). Buses formed 5% of the vehicular composition and private taxis along with rented vehicles were 9% of the vehicles (see Figure 3) (Fiji Bureau of Statistics, 2014).

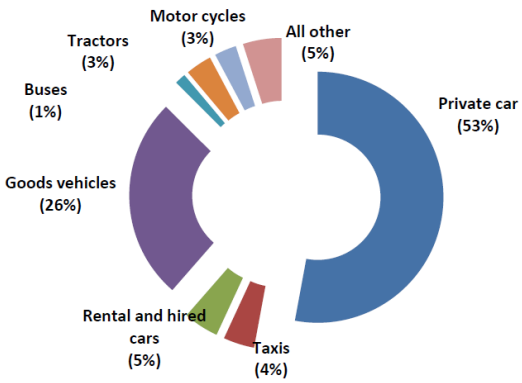


Figure 3: Composition of road vehicles in Fiji (year 2013) (Fiji Bureau of Statistics, 2014)

As reflected by the vehicular growth and its composition, the land transport sector is undergoing transformation to match with the economic growth. The major drivers of the

vehicular growth are the growing population, improving education levels and rising income levels which are resulting in changing lifestyle patterns, which ultimately is also reflected in the investment in the transport choices.

FUEL USE IN TRANSPORT SECTOR

The land transport sector in the country runs on gasoline and diesel, further hybrid vehicles are introduced as well. The rise in the number of vehicles is reflected by the quantity of fuel that is imported by the country. The quantity of gasoline (petrol) has increased by approximately 60% during 2008-2012, wherein during the same period, the quantity of diesel import has remained stagnant (DoE, 2014).

The amount of gasoline and diesel that was consumed by the nation during 2008-2012 is shared in Table 1.

Table 1: Fossil fuel supply (Retained imports) (DoE, 2014)

Year	Gasoline Quantity (million litre)	Diesel Quantity (million litre)
2008	43	248
2009	45	189
2010	78	318
2011	70	276
2012	69	264

PROJECTIONS FOR YEAR 2030

The fuel use data can be used to project the fuel demand in the country for the period 2016-2030.

Fuel forecasting

The fuel use forecasting in the study is based on assumption that the fuel use in the country will grow in coming years (as the country is developing fast) also the emphasis on improved road infrastructure will add to the demand of fuel in the country.

Forecasting Model 1: Based on Historical Fuel Consumption[4]

The diesel and gasoline historical consumption numbers during the period 2008 and 2012 are used to generate fuel use consumption (diesel and gasoline) estimations for the period 2013-2030. To make projections, the fuel use growth rate for the period 2008-2012 is used to generate values for the period 2013-2030.

The following increment rates are considered for estimating fuel consumption for the 2013-2030 period.

[4] Under ideal data condition, the fuel forecasting should be developed using econometric equations derived from historic data for the country. For Fiji, regression models were tested using information available for the country on population, GDP, fuel prices, freight and passenger growth, vehicles on road to develop an econometric model predicting trend and growth of the diesel and gasoline in the country. The data available for the country is not sufficient (<10 data points and sometimes even less) hence the analysis results were too weak to be used in the study.

Considering data limitation, simple growth projections are generated for the country using the fuel consumption data reported in Table 1.

Table 2: Fossil fuel supply (Retained imports) (DoE, 2014)

Year	Fuel consumption increment (in percentage)	Reasoning supporting growth	Reasons supporting growth stabilization
2012-2018	Increment rate 4% p.a.	Rise in income levels of households, rise in tourism	-
2018-2025	Increment rate 3% p.a.	Rise in income levels of households, rise in tourism	Economic growth stabilization, Fuel efficiency will stabilize fuel demand
2025-2030	Increment rate 2% p.a.	Rise in income levels of households, rise in tourism activity	Economic growth stabilization, Fuel efficiency will stabilize fuel demand

For estimating fuel trends for the country, it's assumed that the fuel efficiency in the country will improve by 1 % p.a. in coming years (in EU nations the average fuel efficiency has improved by 16% during last since last two decades[5]). Given the fact that there are no stringent vehicles engine standards in Fiji and road quality is not good in the hinterland, the country's fuel efficiency may improve significantly with introduction of transport sector interventions. Since, Fiji imports all its vehicles hence the engine technology development may impact fuel economy in Fiji without much time lag.

Forecasting Model 2: Fixed rate growth model

Limitations of forecasting models 1 and 2

Both the models are based on short historical trends, and the 2008-2012 data may not be accurately representing the fuel trends in the country. Further, the fuel consumption data may not be accurate. Also, the forecasting does not discount for any economic disruption in the 2013-2030 period.

Estimate of Fuel Demand by 2030

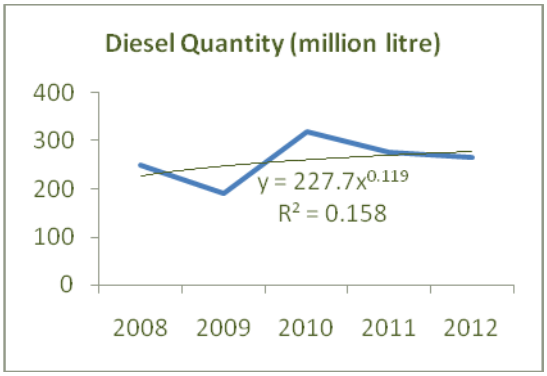


Figure 4: Diesel consumed in the country during 2008-2011 (DoE, 2014)

[5] The transport sector average efficiency factor in EU is 0.9% p.a. (European Environment Agency , 2012). For Fiji

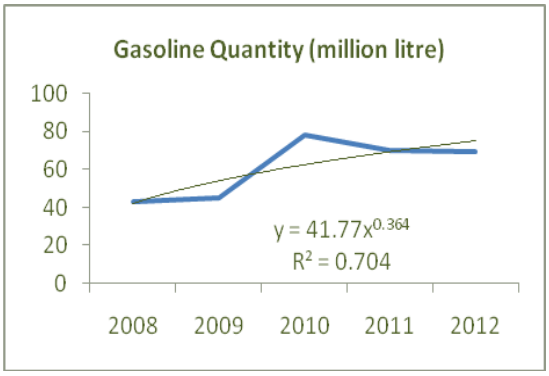


Figure 5: Gasoline consumed in the country during 2008-2011 (DoE, 2014)

A second approach of estimating future trends of fuel demand is applied using 'data trend-line'. The best fitting trend (based on historical fuel consumption data) is identified for both diesel and gasoline.

Equations generated:

1. Diesel use= 227 x (number of year)$^{0.1198}$ - R^2 for this equation is a weak 0.1581
2. Gasoline use= 41.77 x(number of years)$^{0.3648}$- R^2 for this equation is 0.7046

The results of the estimations for diesel and gasoline for all scenarios are presented in Table 3.

Table 3: Diesel & Gasoline Demand Projections (in Million Liters)

Year	Model 1		Model 2	
	Diesel	Gasoline	Diesel	Gasoline
2020	354.38	92.62	309.60	106.47
2025	410.83	107.37	321.91	119.89
2030	**453.59**	118.55	331.51	**131.10**

Based on the diesel and gasoline demand projections from Model 1 and Model 2, it's suggested that the extreme value of gasoline and diesel that is projected by the two models should be considered as the projected value for diesel and gasoline for the year 2030. This approach will help the country meet 10% biofuel blending target irrespective of accuracy of any of the mentioned projected values. Hence, it's estimated that by 2030 the country will demand 453.59 ML of diesel and 131.10 ML of gasoline.

QUANTITY OF BIOFUEL REQUIRED TO PARTIALLY SUBSTITUTE PETROLEUM FUEL BY 2030

Realization of economic risk of total dependency on imported fossil fuels has forced Fiji to focus resources on developing alternative energy sources. Clean and renewable biofuels have been identified as the answer to the problems associated with fossil fuels.

In order to develop a long term biofuel program for the country, an estimation of the quantity of biofuel required by the country is required. This would help policymakers in deciding upon the direction, pace and size of such program.

The quantity of biodiesel required to replace desired order of petroleum fuel replacement will depend on the choice of biofuel feedstock. The calorific value of biodiesel derived from vegetative sources is relatively low in comparison to their petroleum counterparts. In addition there is variation in the calorific value of biodiesel derived from different feedstocks.

A comparison of various biodiesel derived from crops of special interest in Fiji is displayed in Table 4. Clearly biofuel derived from jatropha seed is the closest to diesel. On an average, one gallon of biodiesel will produce 135,004,946.9 joules of energy as compared to 144,943,573.03 joules produced from one gallon of pure diesel (AFDC, 2013).

Table 4: Gross heat of combustion of different biofuels

Crop name	Average Gross Heat of Combustion (J/g)
Diesel	45,580 [6]
Jatropha	39,455 (Da Silva M. L. C. P., Oliveira L. E, 2013)
Coconut oil	35,800 (Hales, 2011)
Pongamia oil	29,442 (Dwivedi, Jain, & Sharma, 2013)

Blending in gasoline is achieved by mixing bio-ethanol. The calorific value of bio-ethanol is comparatively low in comparison to gasoline, one gallon of E-100 (pure ethanol) produces 84,530 BTU energy as compared to 124,340 BTU per gallon achieved using pure gasoline (AFDC, 2013). The biofuel demand calculations are made for projected 2030 demand of diesel and gasoline which is estimated to be 453.59 ML and 131.10 ML respectively.

Based on the calorific value for pure biodiesel (B-100) and pure ethanol (E-100), the amount of biofuel that will be required to achieve the 5% and 10% blending target for the country are calculated using three different scenarios. Scenario-A assumes a modest 5% biofuel blending target which will be met by year 2020. Scenario-B estimates the biofuel required to meet a 10% blending target to be met by year 2025, and Scenario-C estimates a slow-go plath to achieve a 10% blending target to be achieved by year 2030.

All the scenarios are based on the assumption that biofuel goals are achieved by introducing same percentage of bio-ethanol and bio-diesel. For all the scenarios, the estimations are based on supposition that the blended fuel introduction will be gradual (e.g. if 5% blending has to be achieved by 2020, every year 1% additional blended fuel will be made available in the market, i.e. in year 2016, B-100 and E-100 will replace one percent of the fuel, in 2017 B-100 and E-100 will replace 2% of the fuel, wherein by Year 2017 2% blended fuel will be introduced).

Table 5: Biofuel need estimation for Fiji (in million liters)

		Requirement for B-100 and E-100	
Blended fuel as % of transport sector fuel mix –assuming blending percentage is same for bio-diesel and bio-ethanol	Year	B-100	E-100
Scenario A: 5% by year 2020	2020	19.2381	7.83064
	2025	22.0536	8.817652
	2030	24.3490	9.642129
Scenario B: 10% by year 2025	2020	20.9870	8.542508
	2025	44.1073	17.63529
	2030	48.6981	19.28425
Scenario C: 10% by year 2030	2020	12.8254	5.220427
	2025	29.4049	11.75687
	2030	48.6981	19.28425

[6] http://www.ijetae.com/files/Volume3Issue4/IJETAE_0413_08.pdf

Assuming that the country will meet its biofuel demand by introducing 10% bio-diesel and 10% bio-ethanol, the B-100 and E-100 requirement of the country for year 2030 will be 48.69 million liters and 19.28 million liters respectively.

CONCLUSION

Fuel import-export data in Fiji is marred with inaccuracies. Considering the data-limitation, a simple projection for future fuel use is generated. Based on the estimations (subject to multiple assumptions) the land transport sector fuel demand for 2030 is calculated to be 453.59 ML of diesel and 131.10 ML of gasoline. Appropriating for energy contents of bio-diesel and bio-ethanol, volumes of biofuel required to meet the projected biofuel targets for the country are estimated. Based on the calculations the biofuel demand for 2030 is projected to be 48.69 ML of bio-diesel and 19.28 ML of bio-ethanol.

CHAPTER 2

FEEDSTOCK AVAILABILITY IN THE COUNTRY

Fiji is cautiously developing biofuel program for the country. Department of Energy (DoE) is leading the efforts to introduce blended fuel in the transport sector.

The success of national plan to meet the renewable fuel requirement will depend on the amount of feedstock that is developed/ diverted for biofuel production. To replace 10 % of transport fuel by year 2030 with blended fuel, the country would require annual supplies of 48.69 million liters of bio-diesel and 19.28 million liters[7] of bio-ethanol.

The current biofuel program is mostly in pilot stage, commercial interests are displayed in the form of investments in plantations. Going by the current trends, the focus is on deriving biodiesel from coconut, pongamia and palm. For bio-ethanol, sugarcane is considered.

In this chapter, the status of both identified and potential biofuel feedstock availability in the country is analyzed. The production-productivity status and issues of different feedstock crops (both existing and potential crops are analyzed) across the 14 provinces is considered for analysis.

The annual biofuel requirement for meeting country's fuel demand in 2030 is estimated to be 35.6 ML of biodiesel and 19.3 ML of bioethanol[8]. If all the biodiesel oil has to come from palm plantations, 43,338.75 ha of land[9] should be made available to achieve the 10% blended diesell target.

Current biodiesel program is heavily dependent on coconut oil, further there are issues linked to food security, year round supplies of biofuel (biodiesel has a short shelf life). Considering these factors, it's not advisable for Fiji to remain dependent on single source of bio-energy feedstock. The challenges posed by technology, socio-economic status of the country and natural constraints warrant that the country will have to develop multiple feedstock options.

STATUS OF BIOFUEL FEEDSTOCK

Current Feedstock Options

Fiji's interest to introduce biofuel (biodiesel and ethanol) in the transport sector has resulted in multiple projects on biofuel production. Initiated by the government or private entities, multiple biofuel feedstock are considered by the project proponents.

At present, the biofuel projects in the country are focusing on developing and marketing of biofuel derived from coconut. Further there are pongamia and palm oil based bio-diesel projects are in pipeline. For bio-ethanol, sugarcane is considered by the government. None of the projects in the country has attained maturity to deliver/retail blended fuel in the market[10].

Potential Feedstock Options

The biodiesel feedstock species of coconut, pongamia, palm and coconut have been analyzed on availability, distribution, production and productivity parameters in this chapter. For bio-ethanol,

[7] See Chapter 1 for calculations
[8] See Chapter 1 for calculations
[9] Palm Productivity is considered at 4tons/ha and 1kg of palm seed yields 0.28 litres of biodiesel
[10] In the past there have been efforts to market biodiesel, there is not much information on the intervention as the biodiesel marketing soon stopped due to reasons not known.

sugarcane, cassava and maize are considered. The potential bio-energy crops for the country have been identified through:

1. Secondary literature on biofuel in the country;
2. Study of existing agriculture sector crops, productivity and potential in the Fiji and neighboring countries;
3. Technology maturity levels around biofuel development in the region and globally;
4. Inputs from bio-fuel program stakeholders in Fiji.

Based on the inputs, potential crops each for biodiesel and bio-ethanol have been identified for the country. Here it should be noted that biofuel sector is very dynamic and crop preference in future may change depending on technological advancements and research outcomes.

The identified biofuel feedstock species that are considered important for the biofuel program of the country are studied for their availability and productivity in Fiji are summarized in Table 6 below.

Table 6: Potential biofuel feedstocks

Species	Whether currently used as bio-fuel feedstock	Whether native to Fiji	Whether grown at commercial scale	Whether farm / forestry species
For bio-diesel				
Coconut	Yes	Yes	Yes	Farm
Jatropha	No	Yes	No	Forestry[11]
Pongamia	No	Yes	Yes	Forestry
Palm	No	-	-	Farm
For bio-ethanol				
Sugarcane	No	Yes	Yes	Farm
Maize	No	Yes	?	Farm
Cassava	No	Yes	Yes	Farm

1. Pongamia

Pongamia (Pongamia pinnata) is a medium-sized, fast-growing tree or shrub (15–25 m tall). It has been described as briefly deciduous or evergreen with a drooping or spreading branching habit and broad crown (Orwa et al. 2009). The bark is grey or grey-brown and smooth or with faint vertical fissures.

Pongamia grows in humid tropical and subtropical climates. However, it can tolerate a range of different conditions with mean annual rainfall between 500–2500 mm and temperatures of 0–16 °C minimum and 27–50 °C maximum. Mature trees can cope with light frosts, but require a dry period of 2–6 months (Duke 1983; Daniel 1997; Orwa et al. 2010).

The only Pongamia plantation in Fiji is owned by the 'Biofuels International'. The company has planted Pongamia in 300 acres of land and eventually (as per business plans) plans to expand to 100,000 hectares. The company had planted 140,000 trees in the plantation site, of which ~50,000 survive (remaining were lost to fire).

Productivity Analysis

Though pongamia tree is native to Fiji, its commercial exploitation for biofuel production is not tested. 'BioFuel International' with interests in biofuel sector has planted about 140,000 pongamia

[11] Jatropha tree in the country is grown to support the vanilla farming in the country. There are no commercial jatropha plantations (economic benefits from the species are not derived) in the country.

trees. The company has introduced non-native variety of the seedlings due to productivity concerns (Sapp, 2014). In comparison to native variety, the introduced variety (imported from India) has a bigger seed size (see Image 1) and higher oil content.

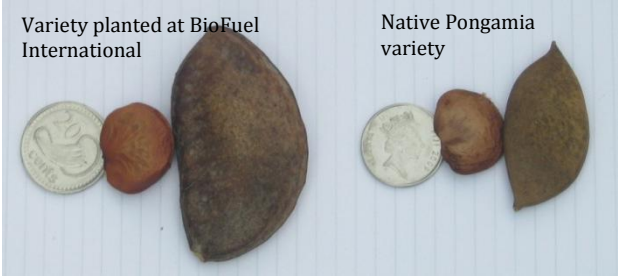


Image 1: Comparison of seeds of Pongamia planted at the Dreketi site and the local varieties (seeds provided by Company Operations Manager Mr Tim Gibbons , not confirmed independently)

2. Jatropha

Jatropha is native to Fiji, the major use of the tree is in supporting vanilla trees. Jatropha test plantation site exists in Wainigata Research Station, it was reported that the agriculture department's local office collected seeds from the site for productivity analysis, but no further details are available on the intervention.

Image 1: Jatropha plantation at Wainigata

Although there are reports of Jatropha farms in the country but their presence remains unsubstantiated (Singh, 2012).

The Wainigata Jatropha plantation was said to be of 284 acres, but during site visit it was observed that what remains of the plantation is a sporadic trees (see picture). During visit to the Jatropha plantation site it was communicated by the agriculture station staff that the Department of Energy (DoE) was collecting Jatropha seeds for analysis, the last collection exercise was carried out in 2011.

Productivity Analysis:

Jatropha is highly controversial species for biofuel program due to its varying productivity numbers. Unlike other biofuel feedstock species, Jatropha has not yet been demonstrated as a crop with reliable performance (SOPAC, 2009). Jatrohpa productivity (seed production per hectare) has shown great variances, a FAO estimate puts productivity between 2-3 tons/ha where more accurate estimations from farms in India and Thailand estimate the numbers close to 1.5 tons/ha.

Table 7: Jatropha productivity in other countries

Country/ climate condition	Jatropha productivity (dry seed)
Semi arid areas	2.0–3.0 tons/ha (FAO, 2010)
India	1. 573 tons/ha (Vietnam Biomass, 2009)
Thailand	1.577 tons/ha (Vietnam Biomass, 2009)

3. Palm

At present palm in not cultivated for commercial purposes in Fiji. The country has been negotiating with companies in Malaysia for developing economically viable palm oil operations in Fiji.

In this regard, Presidio Pacific Palm Limited has displayed interest in developing palm based biodiesel project in the country. As on July 2015, the company has already started a nursery for palm seedlings (land is currently being surveyed for it). It will take another one year to raise the seedlings and additional 2.5-3 years before the palm plantations are mature enough for harvesting.[12]

4. Coconut

Coconut is an important agriculture product and is widely grown across the country. Since the ban on coconut export was lifted in 1998, multiple new companies operating in coconut produce have emerged[13].

In general, coconut production in the country is on decline. The total area under coconut in 1991 was 46,764 hectares, this number declined to 15,009 hectares in 2009. Currently, the coconut cultivation in the country is focused around Eastern division and in the Northern divisions. Cakaudrove province is the biggest producer and home to more than 60% of coconut plantation area (refer Table 8). Out of the total area planted, 14,270 hectares was categorized as bearing area in 2009, a decline from 35,299 hectares in 1991. Using the standard plant density, the area associated with scattered coconut trees was 2,748 hectares in 2009 and in 1991, 3,048 hectares. Consequently the total area reported for coconut in 2009 was 17,757 hectares, a significant reduction from the 49,812 hectares in 1991 (Dept. of Agri., 2009).

The major decline in the area planted has been largely a consequence of natural disasters (cyclones and drought), expiry of land leases, industrial developments, low yield (25 nuts per tree per year), high transportation costs and low profitability due to unfavorable market prices. These factors as well as labour required led to farmers losing interest in this industry (Dept. of Agri., 2009).

Coconut is grown in most of the provinces of the country. And Cakaudrove province has the largest area under coconut plantation, which is more than 50% of the total area under coconut production (for year 2009) (see Table 8).

Table 8: Comparison of coconut production (area wise) in Fiji (Dept. of Agri., 2009)

Province	Area under coconut cultivation
Naitasiri	17.79
Rewa	56.48
Serua	5.27
Tailevu	114.2
Ba	162.39
Nadroga	22.27
Ra	145.42
Bua	3195.54
Cakaudrove	**9117.05**
Macuata	394.28
Lau	1624.65
Lomaiviti	59.66

[12] Quoted from communication with Mr Max Norris (representative of Presidio Pacific Palm Limited)
[13] http://www.go-fiji.com/agriculture.html

Province	Area under coconut cultivation
Rotuma	94.04
Total	15009.04

When it comes to productivity, Lomaiviti province recorded the highest productivity (in 2009). But the poor productivity in Cakaudrove province (at just 0.41 tons/ha) dragged the national average to a low of 0.7 tons/ha which is just 11% of the productivity observed at Lomaiviti province (see Table 9)

Table 9: Coconut production and productivity (Province wise)

Namer of Province	2009 Production (tons)	Tons/ha (year 2009)
Naitasiri	66.4	3.73
Rewa	191.1	3.38
Serua	10.7	2.03
Tailevu	106.2	0.93
Ba	127.7	0.79
Nadroga	26.1	1.17
Ra	251.0	1.73
Bua	939.8	0.29
Cakaudrove	3726.8	0.41
Macuata	108.4	0.27
Lau	4270.2	2.63
Lomaiviti	367.6	6.16
Rotuma	368.1	3.91
Whole country	10560.2	0.70

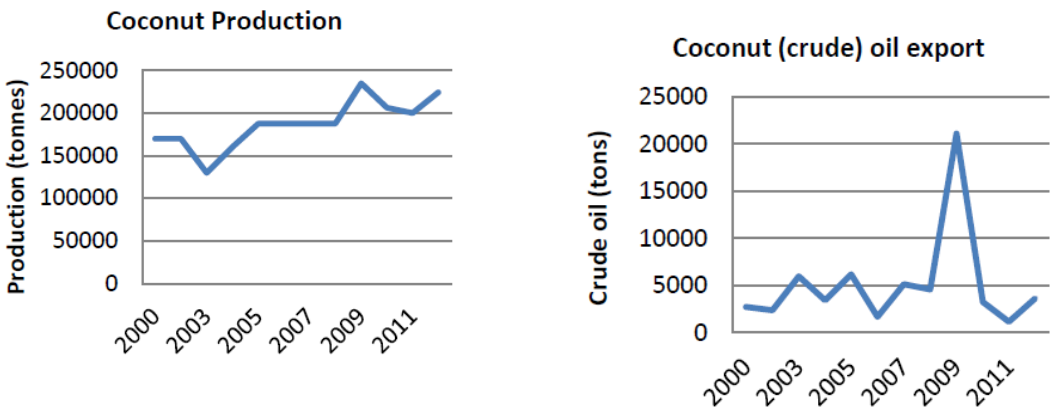


Figure 6: Coconut production and crude coconut oil export figures for Fiji

When the coconut production at the country level is analyzed, there is a clear increase in the production. Whereas the export of the crude coconut oil is on decline (see Figure 6).

5. Maize

Maize is long grown in Fiji. Kernels of maize can be used as an energy feedstock for the production of ethanol fuel.

In 2009, maize was grown in about 535 ha in the country. The production was spread in eight provinces however, the spread of the maize farming is not even, more than 50% was grown in the province of Nadroga. The recorded cultivated areas in other provinces was very low (less than 4 ha) in four provinces. Nadroga, Ba, Macuata and Ra had about 96% of the maize farms and were producing almost 99.5% of country's maize in 2009. In all these provinces, the maize production is catalyzed by both domestic and export market.

Table 10: Area under Maize Cultivation (Dept. of Agri., 2009)

Province	Area (ha)
Ba	132.15
Bua	2.44
Cakaudrove	13.47
Macuata	61.07
Nadroga	**294.62**
Ra	26.65
Serua	1.27
Tailevu	3.81
Total	**535.48**

Since 2006, the production of maize is on rise. New varieties too are introduced in the country with assistance from the Ministry of Agriculture[14].

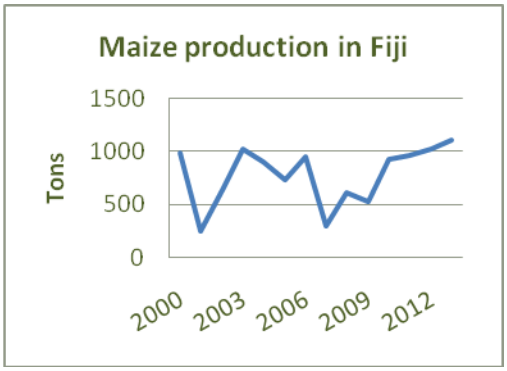


Figure 7: Maize production trend in Fiji (Dept. of Agri., 2009)

Productivity Analysis:

The highest yield in the country was reported from Nadroga province, at 1.98 tons per ha. This was about 32% higher than the country's average maize productivity. From Table 11 it's clearly evident that the average productivity of the maize in the country is very low. Based on the 2009 production numbers, it can be inferred that per hectare productivity of maize can be easily improved in all the provinces.

[14] http://www.pacifictradeinvest.com/wp/?p=796

Table 11: Maize production and productivity in the country (Dept. of Agri., 2009)

Namer of Province	2009 Production (tons)	Tons/ha (year 2009)
Ba	151.6	1.15
Cakaudrove	2.2	0.17
Macuata	30.7	0.50
Nadroga	584.6	1.98
Ra	31.5	1.18
Whole country	800.6	1.50

6. Sugarcane

Sugarcane is the most important agriculture crops and supports the most important industry (sugar) in the country. 90% of the sugarcane in the country is produced in the land owned by the indigenous Fijians (and farmed by Indian origin residents)[15].

Sugar cane production used to be the backbone of Fiji's economy; however, it has declined by around 34% from a total of 3,380,000 ton in 1991 to 2,197,950 ton in 2009. The total area under sugarcane has decreased from 112,192 hectares in 1991 to 57,177 hectares in 2009. Over 50% of the total production was from the Mana variety (Dept. of Agri., 2009).

Sugar production is concentrated in five provinces of the country and Ba province being the biggest producer (see Table 12).

Table 12: Area under Sugarcane Production in Fiji (Dept. of Agri., 2009)

Province	Planted area (ha)
Ba	27640.00
Cakaudrove	204.21
Macuata	17031.94
Nadroga	6443.53
Ra	5856.38
Total	**57176.06**

As described in the introductory paragraph, majority of the sugarcane plantations are owned by individuals and households (~64%). The remaining plantations are either captive plantations of sugar companies or are with cooperatives (See Figure 8).

[15] http://www.go-fiji.com/agriculture.html

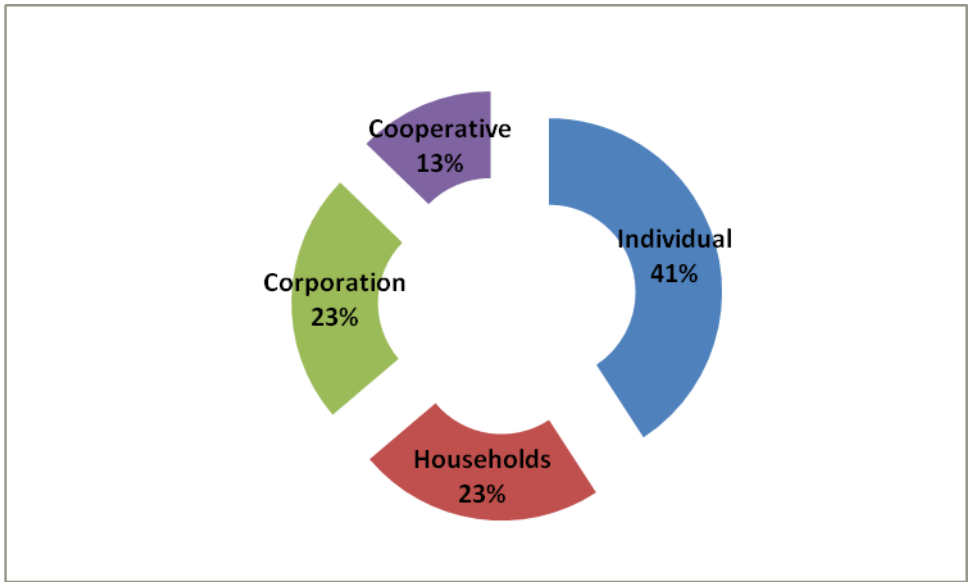


Figure 8: Sugarcane plantation distribution (Ownership wise)

Production and Productivity Analysis:

Production has been affected severely because of floods, drought, production inefficiencies in the mills that affected the level of sugar extraction, the amount of unharvested cane, loss of access to higher priced markets as a result of changes in the world trading environment and expiring land leases which resulted in an increase in the number of farmers leaving the industry.

The sugarcane production in the country is reported from 5 provinces (Table 13). Ba province is the lead producer of sugarcane. In 2009 the province produced ~52% of the country's sugarcane.

Table 13: Production and Productivity of Sugarcane in 2009

Sugarcane	Production (tons)	Productivity (tons/ha)
Ba	1139808.05	41.24
Cakaudrove	13495.82	66.09
Macuata	570948.24	33.52
Nadroga	216047.44	33.53
Ra	257648.08	43.99
Total	2197947.63	38.44

Despite being the leader in production, the Ba province is not the leader in productivity. Per hectare sugarcane productivity is highest in Cakaudrove province at 66 tons/ha with Ra province being the second. In all, the country's average sugarcane productivity is 38.44 tons per ha. Compared with global leaders of sugarcane production, the average productivity of sugarcane in the country is low (Table 14). In fact, the productivity in the Cakaudrove province is although highest in the country, but it still lower in comparison to the national averages for the top ranking countries.

Table 14: Comparison of Sugarcane Productivity of Fiji with Other Countries

Country	Productivity (tons/ha)
Australia	85.1
Colombia	84.1

Country	Productivity (tons/ha)
Usa	77.5
Indonesia	73.1
Thailand	66.4
Fiji	38.44

7. Cassava

Cassava is one of the root crops grown throughout the year at subsistence and commercial level; it takes three to twelve months to mature.

Cassava (*Manihot esculenta*) is an important crop supporting sustenance of the farmers especially the Ethnic Fijians. The cassava plant is long known and grown in the country mainly for local consumption; as food, liquor processing and livestock feed. Cassava demand has been on rise due to demand from the exporters. The result is that many were now ploughing their unused land for cassava farming (Malo, 2012).

Koronivia Research Station (KRS) in Fiji has identified 28 cassava varieties that are grown in the country (Bijay & Singh, 2013). Cassava is drought tolerant and also can be grown in less fertile land, hence cassava is also grown on marginal lands. Since cassava can be harvested to correspond to household needs and market opportunities. Hence, cassava is also termed as "pro-poor" crop (Fahrney, Keith, 2010). Cassava roots provide a rich source of calories and the leaves are rich in protein for both humans and livestock. There are programs in country that support the cassava farmers in channelizing their produce for export. The Agriculture Marketing Authority (AMA) liaises with local institutions to ensure that the market signals reach the farmers (Department of Information , 2012).

Fresh and frozen cassava has found potential markets in Australia and New Zealand where large Pacific Island communities exist.

Cassava growing areas in Fiji:

Cassava in Fiji is grown in all the provinces but it's slowly losing ground to other crops. Total area under cassava declined from 17,800 ha in 1991 to 15447 ha in 2009. In 2009, about 58000 ton of cassava was produced in the country (Dept. of Agri., 2009).

The area planted under cassava declined from 17,800 hectares in 1991 to 15,447 hectares in 2009. The main cassava producing provinces were Naitasiri, Tailevu, Ra and Cakaudrove. Central Division proved to be the major cassava producing area with a total of 5,564 hectares planted (36%) of the total. In 2009, 58,772 ton of cassava was produced with a value of FJD 21 million (Dept. of Agri., 2009).

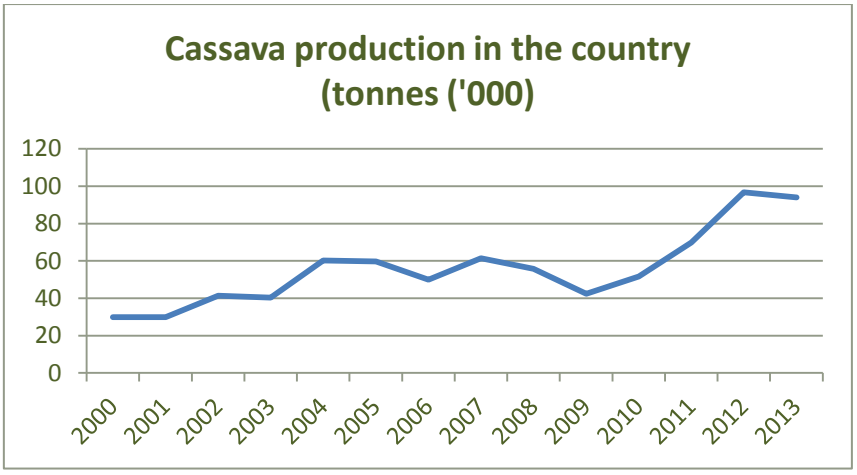


Figure 9: Cassava production in Fiji[16]

Productivity Analysis:

The cassava productivity in the country is low at 3.8 tons/ha. The maximum productivity for year 2009 was observed in Lau province. The average yield for the country was 3.80 tons per ha and in 10 provinces the productivity was higher than the national average productivity (Table 15).

Table 15: Cassava production and productivity (Department of Information, 2012)

Namer of Province	2009 Production (tons)	Tons/ha (year 2009)
Ba	3419.5	2.52
Bua	1271.8	2.29
Cakaudrove	4173.6	2.05
Kadavu	621.8	4.83
Lau	1550.3	8.65
Lomaiviti	1543.5	7.04
Macuata	2056.1	1.35
Nadroga	2712.0	1.69
Naitasiri	15787.9	7.86
Namosi	1570.2	5.96
Ra	4610.4	2.05
Rewa	3148.7	7.32
Serua	3696.2	6.17
Tailevu	12409.6	5.48
Rotuma	200.1	5.05
Whole country	58771.6	3.80

Comparing the Cassava productivity in Fiji with other countries it can be inferred that the average cassava productivity in the country was very low. This also indicates that there is high potential of improving average cassava yield in the country (Table 16). The introduction of high yield cassava varieties can improve the production considerably.

[16] http://www.factfish.com/statistic-country/fiji/cassava,+production+quantity

Table 16: Cassava productivity in other countries

Range of productivity (globally)	25 -60 ton/ha/ year (Franken, 2010)
FAO Estimates	5-12 tons/ha for low yielding and 40-60 tons/ha for high yielding varieties (FAO, 2004)
Thailand	17 tons/ha (Kuiper, Ekmekci, Hamelinck, Hettinga, Meyer, & Koop, 2007)

SUMMARY OF STATUS OF BIOFUEL PRODUCTION AND PRODUCTIVITY

The information on the current production status and productivity of biofuel feedstock (currently used for biofuel development and the favored potential options) was collected through primary and second research.

Exiting biodiesel feedstock options coconut, pongamia, jatropha and palm were analyzed on production, productivity through primary and secondary research. Pongamia is a new crop and has not started yielding fruits commercially. Its productivity cannot be commented upon, but during the field visit the farms were found to be in healthy condition. Similarly, jatropha too could not be commented upon due to lack of information on plantations in Fiji. The plantation visited was a small patch of couple of bushes of jatropha and the stakeholders (staff of agriculture station) were not confirmed about the productivity of the tree.

Coconut species in the country have failed in meeting the productivity expectations. Various stakeholders commented upon reduction in the supplies of copra due to reduced productivity of coconut trees.

Among the bio-ethanol species, sugarcane is grown in large tracts. There is high economic dependency of farmers and industry on sugarcane crop hence it's not marred with productivity and production concerns as its grown on fertile farm land and farmers/industry ensure all necessary inputs required to support the crop. In addition the FSC also provides research and extension support to sugarcane farming.

The other bio-ethanol crops are maize and cassava, the net production of both the crops have although risen in the country but the productivity remains low.

CHAPTER 3

STATUS OF BIOFUEL INDUSTRY IN FIJI (JUNE 2015)

First discussed in 2006 as solution to country's energy problem. Although, biofuel is not yet introduced into the economy but the biofuel program has since evolved; government supported interventions as well as private investments have resulted in action in the direction of biofuel development in the country.

The first and only attempt of producing and selling biofuel was reported in 2011. The 'Flour Mills of Fiji' was producing biofuel and selling it to public. The company soon stopped its operations. From interaction with the officials working with the parent company it was understood that the company was selling blended fuel in the Lami which is an industrial zone outside Suva city of Fiji (information on biofuel quality, quantity and sales is not available). The company stopped operations as it was not making profits selling blended fuel, also there were reportedly complaints by the consumers.

There are no other reported attempts to manufacture or sell biofuel in the country. The Department of Energy (DoE) has supported establishing nine diesel processing units in remote islands. The units operate independently (in guidance and supported by DoE) and produce filtered coconut oil (CNO).The units also have fuel blending facility where CNO is blended with diesel to be supplied to villagers.

PONGAMIA BASED BIOFUEL BUSINESS

There is only one company with business interest in Pongamia for production of biofuel. The 'Bio fuels International' operating from Bua Province, Drekiti in Vanua Levu, Fiji is a foreign owned company (registered in Fiji). The company started in 2010 with five acres of plantations, in 2015 their plantation site has expanded by 1000 hectares and eventually the company wants to develop a 100,000 ha Pongamia plantation in Fiji. The company hopes to initiate biofuel production by year 2016.

Current status of biofuel production:

At present the company is focusing on feedstock production and expansion of farmland under Pongamia cultivation. The company has secured approval from Fiji's Foreign Trade Investment Board to build a bio-fuel refining plant in Dreketi (Bua Province) for production of high quality biodiesel.

The proposed biodiesel site at Dreketi was visited, but no inference could be made from the machines (unassembled oil milling machines were lying on the site) available on the refinery site.

	Image 1: Biofuel International's biodiesel processing site at Dreketi (Bua Province)
	Image 2: Biofuel International's biodiesel processing site at Dreketi (Bua Province)

Business strategy:

The company plans to produce pongamia is large tracts of land through community participation and produce bio-diesel from the pongamia seeds to be sold in Fiji and outside.

For biofuel feedstock production, the company has partnered with communities. The company has entered into agreements with farmers. The company provides high quality Pongamia to the farmers, inturn the farmers will be selling seeds to the Biofuel International at company prescribed rates.

Starting from three farmers in 2010 in (Nasarawaqa and Lekutu), the plantations under pongamia have reached to 1000 ha in 2015. The farmers own and raise the plantations (seedlings and other support provided by the Biofuels International) and get paid for labor work in the plantation areas.

All the expenditures incurred in the plantation management is borne by the Biofuels International, and the company has plans and commitment to buy pongamia seeds from the farmers once the trees mature.

The company plans to sell biodiesel to Fiji markets. Apart from providing for Fiji's domestic usage, Bio-fuels International has contracts secured to provide to agriculture in the US (California growers in Northern Ca.) more than 250 million litres of refined bio-diesel annually derived from these plantations.

COCONUT OIL CENTRIC BUSINESS

There are multiple CNO companies operating in Fiji. The CNO industries can be divided into two subsets, (i) CNO companies managed and operated by DoE on behalf of Government of Fiji, (ii) Privately owned CNO companies.

Government owned CNO companies: A total of nine such units exist in Fiji, operating from small islands, these units are located at (i) Tarakua (Cicia island, Lau Eastern Division), (ii) Nacamaki(Koro island, Lomaiviti, Eastern division), (iii), Rotuma (Rotuma island), (iv) Nasaqalau (Lakeba Island, Lau), (v) Mavana (Vanuabalavu, Lau), (vi) Rabi, Tabiang, (vii) Moala (Moala Island) and (viii) Yaroi, (Matuku Island).

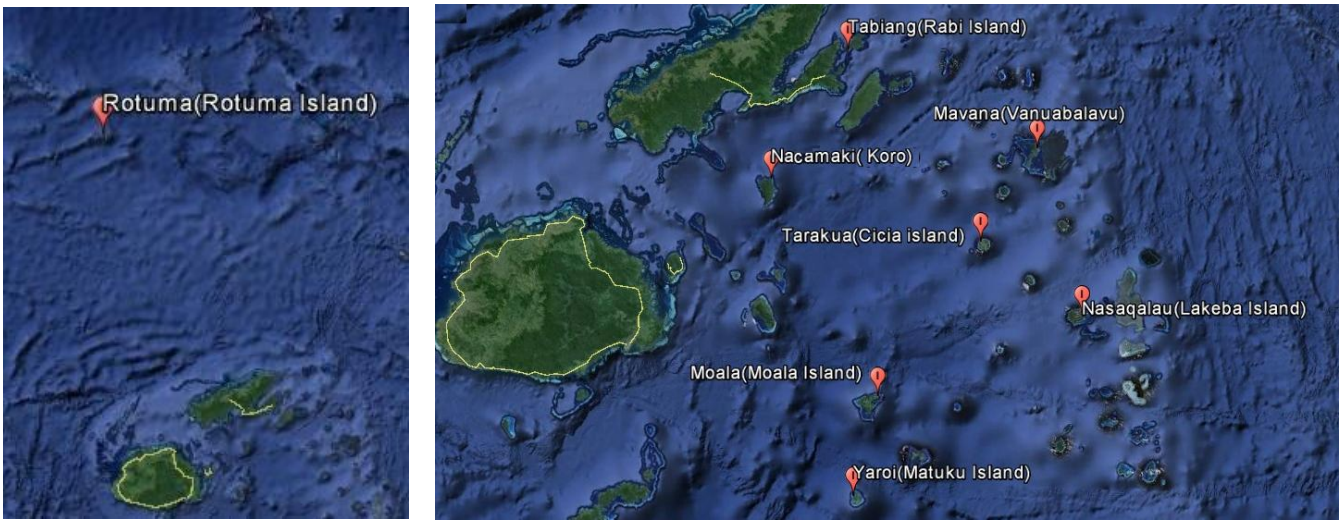


Figure 10: Geographical distribution of Government owned CNO industry in Fiji

These mills operate from small islands, geographic spread of the eight mills is displayed in Figure 10. As is clear from the figure, these mills operate in remote locations. Sourcing copra from surrounding areas, the mills produce CNO. CNO is sold directly as oil to bigger companies, or is mixed with diesel (20% CNO and 80% diesel) to be sold as fuel which is used in running diesel generators.

Owned and managed by the DoE, the processing capacity of these units is similar (generating ~1500 lit/ day in a 24 hour shift).

In addition there are private sector copra millers operating in the country. These companies produce virgin coconut oil, and edible and non-edible coconut oil. Three such companies were visited, none displayed interest to invest in biofuel program and all were struggling to operate their facilities at peak capacity due to supply constraints.

PALM OIL BASED BIOFUEL BUSINESS

Currently there are no palm plantations in the country. A private entity Presidio Pacific Palm Limited has displayed interest and committed for developing an integrated palm energy project in the country . The goal is to participate in the biodiesel program of the country.

The company has already leased land for raising nursery and is in advance discussions with iTaukei Land Trust Board (TLTB) for leasing 10,000 ha of plantation land. Further, the company has plans to lease another 7,000 ha from third party planting mode.

The company has not shared plans on the biofuel processing activity.

Business approach

The company will be raising the palm plantation in about 17,000 ha of land. Of this 10,000 ha will be land taken on lease by the company, and the remaining land will be community land. The company envisages producing more than 380,000 MT of palm from the farms in Fiji.

The goal is to develop an integrate energy project where a biodiesel plant of capacity of 100,000 MT will be installed and power projects 28.4 MW of thermal power plants (running on palm oil and waste biogas).

ETHANOL BUSINESS

The sugarcane production in the country is managed by Fiji Sugar Corporation (a public sector company). The company has four production facilities. Of the four facilities, three (Lautoka , Rarawai and Penang) are located in Viti Levu and one facility (Labasa) operates at the Vanua Levu island)(see figure 11).

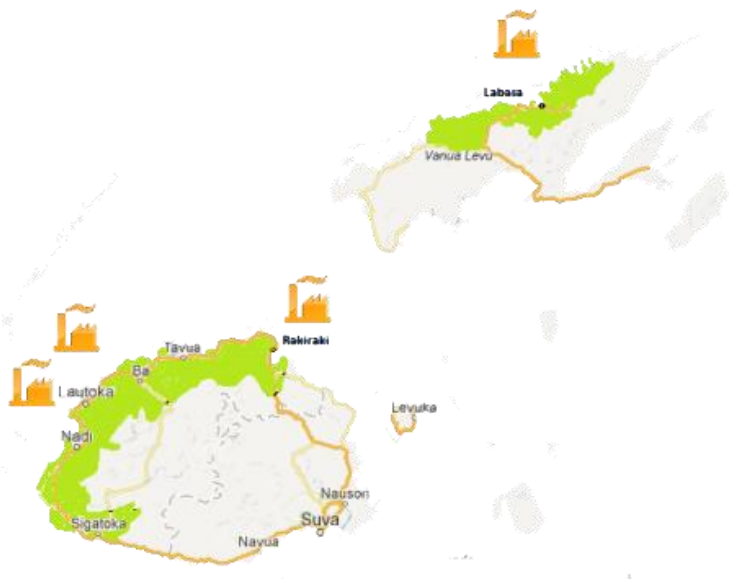


Figure 11: Locations of cane processing facilities of FSC (Image source: http://www.fsc.com.fj/FSCMap.html)

The four mills crushed about 1.83 million metric ton of cane and produced 226,000 metric ton of raw sugar. In year 2014, FSC witnessed an increase in cane production (14.3%) resulting in a 25.6% increase in sugar production (compared to 2013 crushing season figures).

FSC plans to establish an ethanol production plant at Rarawai milling facility and produce approximately 13 million litres of ethanol. The company plans to supply. The feasibility study for the project is complete and FSC has secured financing for establishing the plant which is expected to be commissioned by year 2016[17].

CONCLUSION

The biofuel program in the country is yet to gather momentum. Despite absence of clear market indicators, investors have displayed interest in investing in biofel program. This is an encouraging sign for the policymakers.

[17] http://www.fdoe.gov.fj/index.php/energy-security/biofuel/ethanol-production

CHAPTER 4

BIOFUEL COMPATIBILITY

Biofuels have not been fully accepted by the fossil fuel industry due to technical issues associated with the storage, transportation and usage of blended fuel. The physical and chemical property of the blended fuel is different from pure gasoline or diesel, and may pose compatibility challenges during the blending, storage, distribution and end-use (combustion). This section provides the basic information on the challenges associated with biofuel blends and also provides information on the compatibility aspects of the fossil fuel industry in Fiji.

The blends of bio-diesel and bio-ethanol have different chemical and physical properties compared to pure diesel and gasoline. This actually can pose problems and sometimes raise serious compatibility issues. The biofuel program (of introducing E-10) in Germany faced resistance from the car owners due to compatibility issues (Hawranek & Neubacher, 2011).

Compatibility issues with biodiesel

Water contamination is a real concern with transportation and usage of bio-diesel. Since biodiesel is a hygroscopic material, hence it has tendency to absorb water from its surrounding[18]. The presence of water may lead to certain problems including suspended water (absorbed by bio-diesel) leading to changing quality specification of the fuel. The presence of water may lead to formation of fatty acids in the fuel which may cause chemical reactions in the tank/pipelines resulting in corrosion. Most importantly, if the water absorption crosses a threshold limit, it may separate out from the oil forming a layer on the bottom of the storage tank which may lead to corrosion of metal[19].

Because of these reasons, biodiesel storage, transportation and usage requires precautions and some degree of retrofitting so not to damage the equipment and machines.

The various compatibility concerns associated with bio-diesel are mentioned in Annexure IV.

Compatibility issues with ethanol

Similar to bio-diesel, bio-ethanol and gasoline blends too are not very stable if not handled carefully. Bio-ethanol attracting water/moisture can lead to phase separation in the blended oil and multiple issues can crop up include corrosion of storage tank systems. The phase separation in bio-ethanol results in formation of two separate layers, the top layer is formed of the petroleum fuel with a small amount of ethanol; the bottom layers contain water and ethanol. Such phase separated fuel when used in engines can pose serious damage. (see Annexure V for more details).

COMPATIBILITY ISSUES OF FUEL SYSTEM IN FIJI

The biofuel/blended fuel compatibility with existing fuel storage, transportation and retailing system was not studied in detail. The information on compatibility has been collected through stakeholder consultation.

[18] For this reason, water presence in blended fuel is tolerated and European EN (14214) and ASTM 06751 standards have set a limit of 0.05 gm per kg of biofuel.
[19] http://www.gov.mb.ca/ia/energy/pubs/biodiesel_storage_and_handling.pdf

The interaction with Pacific Energy Oil Company revealed that most of transportation fuel transportation and retailing infrastructure in the country is decades old. The petroleum fuel supply chain in the country has not been upgraded by the oil companies due to various reasons, including low profit margins. As per the Pacific Energy Oil Company, the existing petroleum fuel management system may not be compatible to switch to biofuel program.

Further, the biofuel program would require expansion of storage capacities at the terminals and oil dispensers. The oil company was of the view that the existing oil dispensers don't have extra land area to expand their capacity.

BIOFUEL COMPATIBILITY OF VEHICLES IN FIJI[20]

Vehicle engine manufacturers or original equipment manufacturers (OEM) typically provide commercial warranties on the vehicles components including engines. Engine manufacturers also determine what implications, if any, the use of biodiesel blends has on the performance of engines and commit warranties accordingly clearing indicating the fuel that is to be used (or not) including the biofuel blending compatibility of the machine.

The engine manufacturers after testing the engine performance with multiple blended fuels, provide guidelines on the fuel best suited for the vehicle. Currently most of the engine manufacturers indicate on whether the vehicles is compatible with blended fuels or not, also is specified the upper limit of blending suitable for the engines.

Vehicle compatibility status

The vehicle data of Fiji is analyzed to measure the compatibility of vehicles with various blending percentage (both bio-diesel and bio-ethanol blends). To check the vehicle compatibility, only vehicles that have been manufactured post 1990 were considered (assuming that older vehicles no longer are in condition to ply on roads). As per the data provided by LTA on vehicles registered in Fiji, approximately 95,000 vehicles manufactured after 1990 have been imported in the country. In order to check vehicle compatibility with varying order of bio-diesel and bio-ethanol blending, the vehicle manufacturer's fuel use guidelines were checked. Information on the model and make of approximately 95,000 such vehicles is available. Of these about 41,000 thousand vehicles run on diesel and another 48,000 run on gasoline.

1. Biodiesel compatibility of vehicles

There are approximately 41,000 diesel vehicles registered in Fiji that have been manufactured post 1990. The vehicles are studied for bio-diesel compatibility based on the fuel recommendation provided by the vehicle manufacturer. Of these, the manufacturers don't suggest use of blended fuel for 19,000 vehicle, further no information (on blended fuel tolerance) is available for 12,600 vehicles.

The compatibility of vehicles is displayed in Figure 12 below, only about 23% vehicles are compatible with B-5 and B-20. There is no information available on the blended fuel tolerance of 31% of the vehicles.

[20] All analysis in this section are based on primary data on vehicles from 'Land Transport Authority'

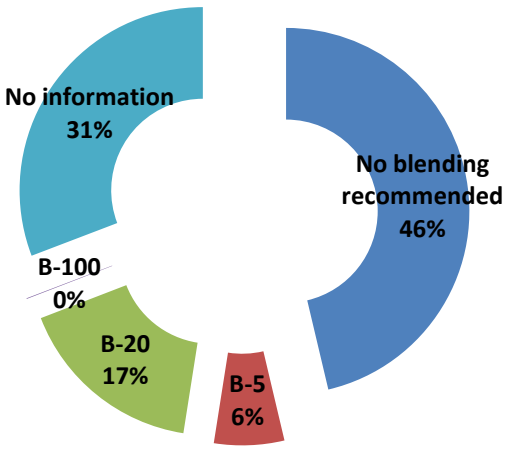


Figure 12: Biodiesel compatibility of vehicles imported in the country (engine make-post 1990)

2. Ethanol compatibility of vehicles

There are approximately 48,000 gasoline driven vehicles imported in the country that have been manufactured post 1990. Based on the vehicle model details provided by LTA office, the vehicles have been checked for their compatibility with blended fuel. More than half of the total vehicles (~26000) are compatible with E-10, wherein about 44% of vehicles are non-compatible. Further, no information is available on ethanol compatibility for approximately 1100 vehicles.

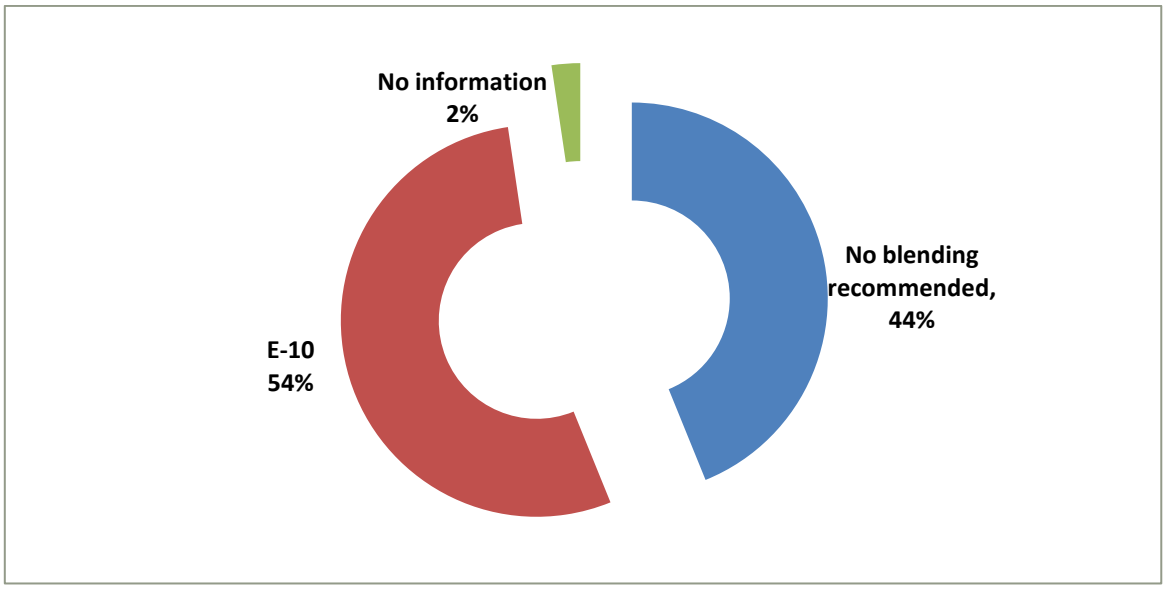
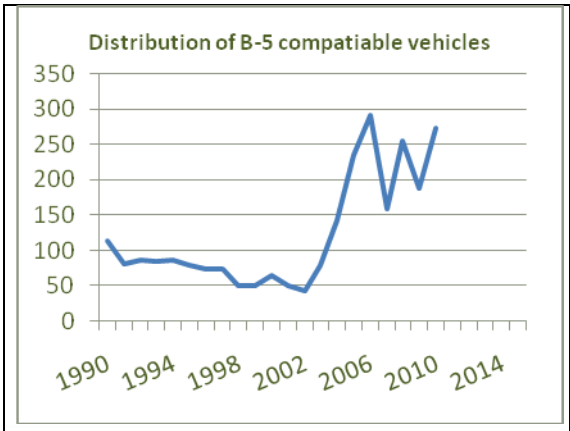
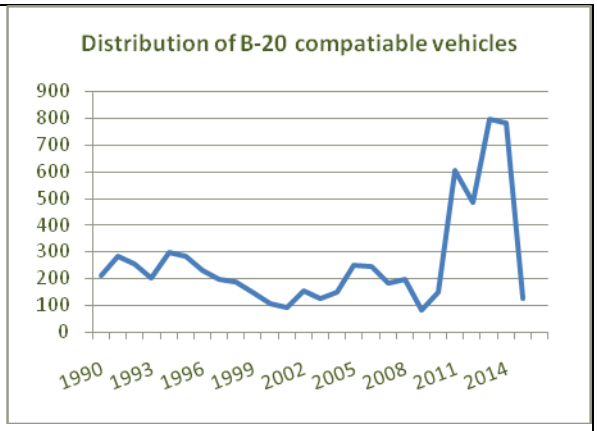
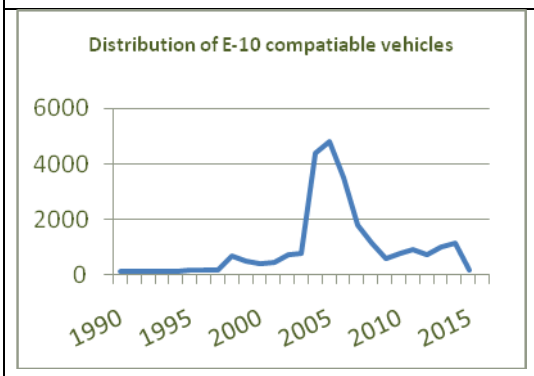


Figure 13: Blended gasoline compatibility of vehicles imported in the country (engine make post 1990)

The data made available by LTA is also analyzed based on the year-wise distribution of vehicle compatibility with blended fuels. The results are displayed in Figure 14.







The B-5, B-10 and E-10 compatible vehicles are displayed in the adjoining figures and arranged as per year of make of engine. It's evident from the figures that the blended fuel compatibility of the more recently produced vehicles is higher.

Figure 14: Blended fuel compatible vehicles on roads of Fiji distributed w.r.t. year of engine make

Clearly, a larger number of vehicles manufactured in recent years are compatible with blended fuel. This is significant information for biofuel program of the country.

COMPATIBILITY CONCERNS FOR FIJI

Fuel system and vehicle compatibility are critical concerns that need to be addressed by the authorities in Fiji to successfully design and launch the biofuel program in the country.

The petroleum companies are unsure about the compatibility of their fuel storage, transport and dispensing systems with blended fuel. Part of the system is very old (especially the storage facilities) and needs retrofitting, upgradation and possibly replacement to make it biofuel compatible.

All the vehicles in the country are imported, new as well as used vehicles are sourced to be sold in the country. Biofuel compatibility of vehicles is currently not promoted through fiscal instruments though promotional rebates are extended to other clean vehicles[21]. The result is that the number of vehicles which are imported in the country are not necessarily biofuel compatible. Currently about 23% of diesel and 54% of gasoline vehicles support some degree of blending (information on OEM fuel blending tolerance is not available for 1/3rd of the diesel vehicles).

In current form the fuel system and vehicle biofuel compatibility does not support full-fledged biofuel program. In order to introduce biofuel blending in phased manner, the country will have to develop biofuel policy and introducing matching regulations to control import of vehicles (favoring the ones with high biofuel compatibility) and slowly expand biofuel supporting fuel infrastructure and dispensing system.

[21] Information from 'Fiji Revenue and Customs'- Public Circular N. 14 of 2013

CHAPTER 5

POLICY ENVIRONMENT AROUND BIOFUEL PROGRAM IN FIJI

Domestic policies in the country are scanned and reviewed to analyze the regulatory environment that governs the biofuel energy sector, including processes and functions around biofuel feedstock production, feedstock extraction, biofuel processing-refining and usage (including retailing).

The assessment focuses on identifying relevant policy components and associated regulations that can help make or break biofuel energy program. Most importantly the analysis focuses on defining boundaries of different policies providing guidance on sector imperfections that need to be addressed through policy guidance.

The steps followed to review of policy, regulatory environment include:

1. Mapping and identifying biofuel energy sector relevant domestic policies and regulations,
2. Review and analysis of policies/regulations, considering their appropriateness in governing the biofuel sector,
3. Gap analysis: Identifying aspects of biofuel sectors that are not governed by the current set of policies.

IDENTIFICATION OF POLICIES AND REGULATIONS

The relevant policies/regulations were identified through a preliminary scanning of policies of concerned ministries and departments. The biofuel energy linked processes (e.g. biofuel feedstock production, processing, procurement, sales and usage) were considered for selecting policies/regulations of interest. Further, discussions with stakeholders were carried out to zero-in on all relevant policies, various regulations and national action plans and programs that are connected (directly or remotely) to biofuel energy sector in the country.

The following policies have been evaluated to analyze their role in governing the biofuels energy sector and their impacts on sector performance. The logic for selecting these policies/regulations is also explained.

Table 17: Polices/regulation evaluated for biofuel sector governance aspects

Policy	Ministry/department	Connect with biofuel energy sector
Proposed National Energy Policy 2013-20[22] **(Petroleum and biofuels directive)**	Department of Energy	The policy provides directives on the use of biofuel in the transport sector. The policy also prescribes for fuel standards, energy security and environmental friendly measures for the fuel used in the country.
Section 7 of the Commerce Commission Decree 2010	Fiji Commerce Commission	Regulation of pricing of public utilities and price controlled items
Environmental Management Act (EMA) 2005	Fiji's Department of Environment (DOE)	Mainly due to the reason that it governs any activity or undertaking likely to alter the physical nature of the land in any way(includes the construction of buildings or works)
Climate Change Policy (2012)	Climate Change Unit within the Ministry of Foreign	Mainly due to the fact that the policy defined mitigation and adaptation

[22] Policy awaiting approval by cabinet

Policy	Ministry/department	Connect with biofuel energy sector
	Affairs and International Cooperation (MFAIC)	approaches. The biofuel program results in sequestration as well as mitigation (renewable energy in the transport sector) Agriculture based interventions and sugarcane specific guidelines.
Fiji Forest Policy (2007)	Ministry of Fisheries & Forests	Role of forestry in creating a sustainable rural environment, employment and income opportunities[23].
Immigration Act	Department of Immigration	Inflow of skilled workers is governed by the Immigration Act of the country.
Foreign Investment Act 1999 and Foreign Investment (Amendment) Act 2004 and the Foreign Investment Regulation 2009	-	Mainly because it controls the inflow of funds in the country.
Customs Act No.11 of 1986 Revised in 2010	Revenue and Customs Authority	Mainly because it controls the inflow of vehicles and machinery in the country.
Rural Land Use Policy (2005)[24]	-	An overarching policy that governs rural land use to achieve poverty alleviation goals of the country.
Land Transport Act 1998[25]	Ministry of Works Transport & Public Utilities	Mainly because this act prescribes the type and standard of fuel and fuel systems to be used by motor vehicles and emission standards for motor vehicles.
Fiji Green Growth Framework (2014)	Ministry of Strategic Planning	Mainly because it identified biofuel as a potential renewable energy theme.

REVIEW OF POLICIES AND REGULATIONS

In the following section various policies/regulations that influence the biofuels energy sector are analyzed to understand the policy clarity and limitations with respect to biofuel energy.

The various features of existing policies and regulations are identified under the four broad processes of biomass sector management; these include biofuel feedstock production, biomass extraction (for processing) and processing, biofuel energy marketing and usage. In addition, policy conflicts and policy gaps too are highlighted.

MAIN FEATURES OF THE EXISTING POLICIES AND REGULATIONS[26]

Biofuel feedstock production in the country is governed by multiple policies/regulations. Since agricultural, forestry and agro-forestry products, byproducts and residues could be used as feedstocks for biofuel production in Fiji (Voegele, 2011), hence policies that govern the agriculture and forestry are applicable for biofuel feedstock production as well (depending on land type that is used for growing biofuel feedstock).

The energy sector in the country is guided by the National Energy Policy (NEP). The work of the Department of Energy shapes the energy programs in the country. Specific to renewable energy, the stated objective of NEP is to conduct research, promote and utilize renewable energy options in the country.

[23] http://theredddesk.org/countries/policies/fiji-forest-policy-statement
[24] http://theredddesk.org/countries/policies/rural-land-use-policy-2005-fiji
[25] Land Transport Act 1998 (document)
[26] Details on relevant policies/regulations and actions plans is provided in Annexure-ii

The renewable energy strategy for the country has set ambitious target of achieving 90% renewable energy goal for the country. The sector specific goals are not set, but specific to biofuel sector, fuel standards have been defined. The only standards for renewable energy that have been accepted by Government thus far are standards for bio-fuels (E-10 and B-5 biofuel standards). These voluntary standards accepted by Cabinet in 2011 and form the basis for bio-fuel blending and sale (ECAL, 2013).

Fuel pricing, which also has implication on blended fuel pricing, is governed by Commerce Commission (CC) in the country. Established under Section 7 of the Commerce Commission Decree 2010, the commission is responsible for fair trade practices in the country. Further, policy also regulates the pricing control of public utilities and price controlled items[27]. Periodic prices are released for retail and bulk sales (the price indications are region specific where geographic boundaries are clearly defined)[28] (Fiji Commerce Commission, 2012).

The commission reviews the fuel pricing in the country (this is based on components in the agreed 'Fiji Fuel Pricing Template (FFPT)'. The prices are communicated to Minister for Industry, Trade and Commerce for approval and Gazette notified (Fiji Commerce Commission, 2012).

The biofuel feedstock production and biofuel production is regulated for environmental performance of the operations. The Environmental Management Act (EMA) 2005 provides the framework that ensures sustainable land and water resource management in the country.

The Government's strategy to curb petroleum imports has been to encourage the development of indigenous local energy resources and investigate the potential to replace fuel imports with locally produced biofuels. There are incentives extended to the biofuel program in the country. The incentives are in the form of concessions on the duties that are levied on the inputs and tax breaks to support investment in the biofuel sector. The diesel which is used for blending with biodiesel has a duty of only $0.05/L compared to the normal duty of $0.18/L. Concession of $0.13/L is provided. Also there is a 10 year tax holiday is available to a taxpayer undertaking a new activity in processing agricultural commodities into bio-fuels (Nakavulevu, Promoting Renewable Policies in Fiji).

Biofuel usage in the country is not governed by any policy. Although there are blended fuel regulations in the country but the production of biofuel has not yet attained the stage where it can be introduced at the commercial retaining outlets. Hence the absence of regulation to promote blended fuel usage.

POLICIES SUPPORTING BIOFUEL OPTION IN TRANSPORT SECTOR

The Fiji Biofuel program rationale is drawn from the strategies and goals suggested in the proposed National Energy Policy (2013), Green Growth Framework and the National Climate Change Policy.

Fiji plans to shift from conventional fossil fuel energy sources (for which country completely relies on imports) towards renewable energy sources.

Currently the country has not defined the scope or policy for the biofuel program but has in place a renewable energy plan which is articulated in various policy and strategy documents.

The proposed National Energy Policy has defined renewable energy targets for the country to reduce petroleum fuel dependency in the country. The policy has set targets for adding renewable energy supplies to the total energy demanded by the country. Further, the Green Growth Framework proposes of bringing down the total fuel used by the road transport sector (by 22% of the baseline).

[27] http://www.commcomm.gov.fj/category/price-control-order/
[28] http://www.commcomm.gov.fj/wp-content/uploads/2015/04/Fuel-Price-Control-Order-April-2015.pdf

The proposal is to improve vehicular fuel efficiency and develop and demonstrate alternative fuel sources for land transport (Ministry of Strategic Planning, 2014).

Table 18: Targeted reduction in share of imported oil used in transport sector

Year	2010	2020	2030
Proposed percentage of imported oil used in land transport sector	42% (Baseline)	32%	22%

Further, the Sustainable Energy for All (SE4ALL) report (which is endorsed by the cabinet) proposes the use of biofuel. SE4ALL summarizes the biofuel targets for the whole economy (use of biofuel in the land transport sector is not defined). The biofuel program goals are defined as **biofuel replacing the liquid fuel** in the country (DoE, 2015).

Table 19: Biofuel targets for Fiji (DoE, 2015)

Year	2011 (Baseline)	2015	2020	2030
Percentage of biofuel consumption in total liquid fuel supply	0%	0.76%	1.11%	2.37%

The strategies for climate change mitigation pronounced in the Climate Change Policy of the country is to integrate climate change issues in national planning, budgeting and implementation processes. With particular focus on biofuels, the policy emphasizes on assessment and utilization of appropriate renewable energy including biofuel to reduce vehicular emissions (Government of the Republic of Fiji, 2012).

This demands for exploration of non-conventional energy sources to meet fuel demand of the transport sector. Promotion of biofuels as energy option for transport sector thus becomes important for achieving the goals set in the National Energy Policy. Also, biofuel program will help in introducing greener fuel which will help achieve the goals set in the National Climate Change policy.

In this context, the proposed National Biofuels Policy provides the framework for the development of bio-diesel and bio-ethanol program. The biofuel policy for the country is guided by the socio-economic context of the country and takes lessons from the biofuel programs implemented domestically and internationally.

The country has plan to introduce biofuel consumption in the country. The country plans to replace approximately 2.37% of the liquid fuel by biofuels (DoE, 2015).

GAPS IN THE EXISTING POLICIES/REGULATIONS[29]

Policy assessment framework:

The biofuel sector policies are analyzed using a 4x4 matrix. The aspects of policy that are captured in the policy assessments are (i) Biofuel feedstock production, (ii) Biofuel feedstock processing, (iii) Biofuel production/processing, and (iv) Biofuel standards and retailing.

Table 20: Polices Policy/Regulatory mapping of biofuel sector in Fiji

	Biofuel feedstock production	Biofuel feedstock processing	Biofuel production/processing	Biofuel standards & retailing
Fiscal/ financial incentive	-	Tax incentives exist	Incentive system exists	-

[29] Refer to Annexure-iii for details

	Biofuel feedstock production	Biofuel feedstock processing	Biofuel production/processing	Biofuel standards & retailing
Financing support	-	-	Incentive system exists	-
Technology development and deployment		-	-	-
Environmental externalities management	The national forest management policy has provision for sustainable management of forests	-	Environment Management Act governs the production processes	Fuel usage related externalities are not managed
Quality standardization	-	-		Fuel standards exist The country has not specific the fuel standard to be followed(as blended fuel is not retailed)
Pricing	Feedstock prices for selected crops are regulated (e.g. Copra and sugarcane)	-	-	Fuel price control exists in the country

Although there are multiple policies existing that govern certain aspects of biofuel sector in the country, there are some concerns which are not addressed by any of the existing policies/regulations, these include:

Biofuel feedstock production- The incentive mechanism to support biofuel feedstock production don't exist. Also quality aspects (e.g. productivity) are not regulated. Further, there are no provisions for managing/controlling the prices of the feedstock (which may be required to rule out exploitation of farmers).

Biofuel feedstock processing: No policy directive to govern aspects linked to biofuel feedstock processing in the country. There are biomass processing projects, but these initiatives by design are project driven.

Biofuel production/ processing: The country policies don't support technology development support (although deployment support exists). Further, quality standardization of the fuel produced at this stage is not regulated. But any fuel to be retailed by any company is regulated by the DoE.

Biofuel usage: There is no policy in the country to motivate or govern technology usage or technology standards of biofuel end use. The current approaches and programs around biofuel end use are often project driven and not specific to transport sector.

CONFLICTING POLICIES/ REGULATIONS[30]

Generally, there are no conflicting policies that could be identified. But there are certain policy and project specific aspects activities that could create conflicting situations:

[30] Refer to Annexure iii for details

Pricing control (for retailing of fuel) may demotivate the investors as the prices of blended fuel will depend on the choice of the biofuel feedstock. A price cap on blended fuel may favor certain biofuels which are cheap to produce. Further, regional variance in biofuel feedstock production will need to be incorporated in the retail price of the blended fuels.

CONCLUSION

Multiple government departments and institutions, bound by varying mandates are responsible for management of various aspects of the biomass (and biomass energy) sector.

It is clear from the policy analysis presented in the chapter and the sector mapping for gaps and conflict analysis (presented in previous section) that the biofuel sector in the country is loosely governed. There are issues that do not come under the scope of any of the existing policies, viz. technology aspects, product quality, processing, technology development etc.

In order to develop biofuel policy for the country, it will be imperative to address the sector gaps and provide for motivations to support the sector growth.

CHAPTER 6

BUSINESS ENVIRONMENT ASSESSMENT

The success of the biofuel program in the country depends on the public-private business partnerships that are developed through the program implementation strategies. This chapter highlights the business environment that exists in Fiji, and analyzes it with respect to the existing and envisaged biofuel programs for the country. The analysis focuses on the impacts of business environment on biofuel sector and its performance and growth.

Fiji is a middle income country (most developed among the Pacific island economics). Fiji's economy has been steadily expanding, during 2014 the GDP growth rate was 4.2% (lower compared to GDP growth of 4.6% achieved in 2013). The current economic growth trajectory is the longest witnessed since its independence in 1970. The progressive investment environment in the country has resulted in unprecedented growth in private sector investments, in 2014 flow of private funds was approximately 13 % of the gross domestic product (ADB, 2015).

The biofuel sector is evolving in the country and domestic as well as international funds are getting invested in the plantations and processing units. Existing business approaches and the business environment is described in the following section.

ANALYSIS OF BIOFUEL CENTRIC BUSINESS MODELS

There are multiple entities engaged in biofuel program (directly and indirectly). The government supported (and promoted) copra mills are guided by the biofuel program philosophy (of introducing blended fuel in the country) of the Department of Energy (DoE), wherein other entities are purely guided by business motive.

The private entities with interest (and investments) in biofuel program include Biofuel International, Fiji Sugar Corporation (FSC) has shown high interest in establishing an ethanol plant to supply ethanol to the Fiji markets (and export).

In Fiji, mature biofuel business models are yet to emerge. On the biofuel feedstock production, the only plantations that are mature enough are coconut based. Due to lack of feedstock, the interfaces between feedstock production and processing facilities are yet to be established.

Evaluating the business model adopted by the companies is important because it can help identify the gaps before the whole program is scaled up.

STRUCTURE OF EXISTING BUSINESS MODEL

Figure 15 summarizes the existing arrangement of complete biofuel production process. This arrangement incorporates three stages namely feedstock production, feedstock processing to biofuel generation and biofuel distribution and retailing.
Following sections outlines stage wise description of existing arrangement. In the remark boxes, the favorable aspects of the national biofuel program re marked with a check sign (√) whereas the non-conducive aspects are marked with a cross sign (X).

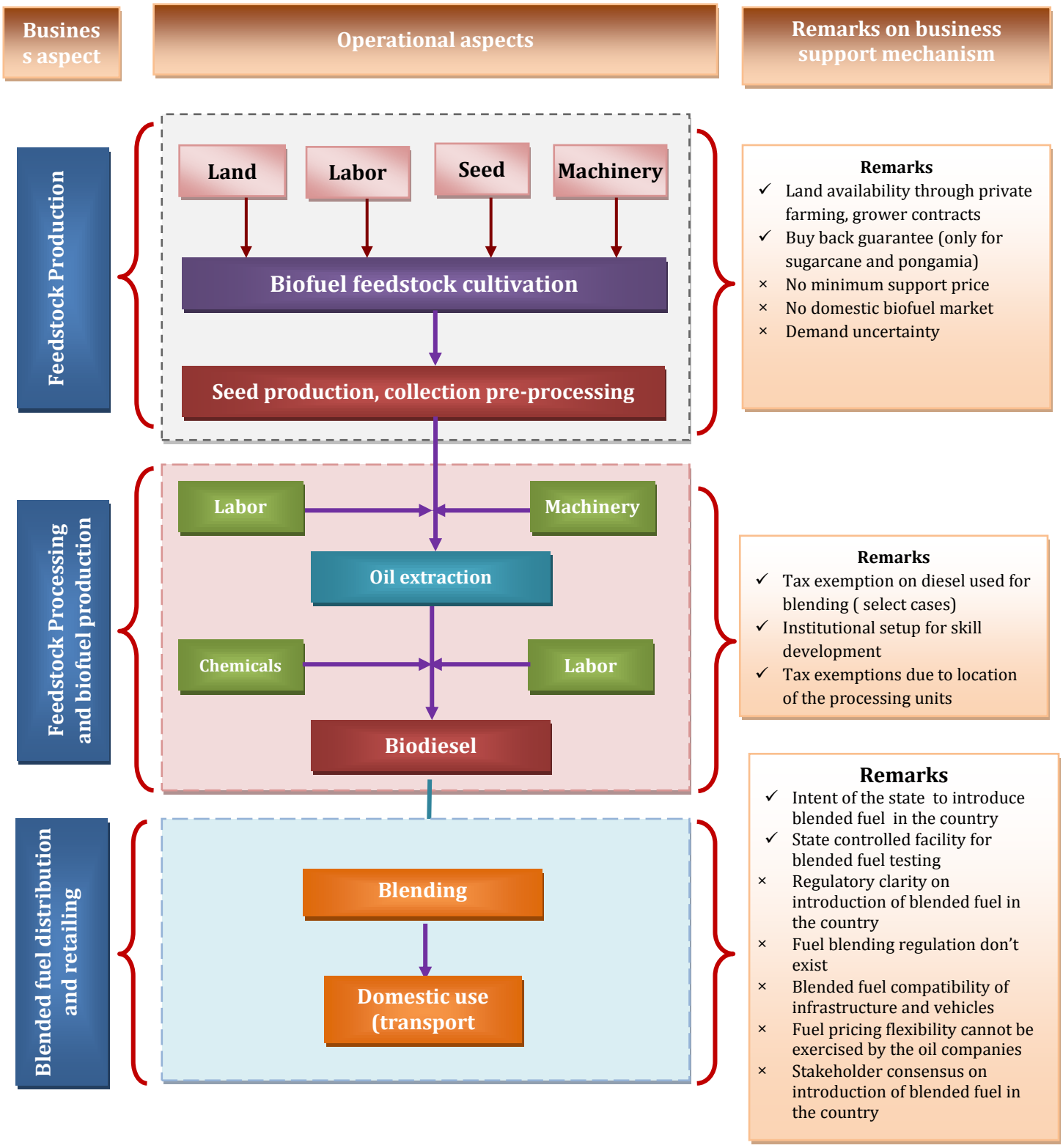


Figure 15: Existing arrangement of biofuel generation in Fiji and related issues

The details of various aspects of biofuel program are described in the following section.

- **Biofuel- feedstock production**

The feedstock production stage includes activities ranging from feedstock production, initial processing and its sales to the biofuel processing unit.

In Fiji, the current feedstock species include sugarcane, pongamia and coconut.

Sugarcane production: Sugarcane in the country is grown by Indian and Fijian farmers, further there are sugarcane farms under control of FSC as well. FSC procures all the sugarcane and has an elaborate arrangement of railroads to transport cane from farmlands to the milling units.

Currently sugarcane quality control measures are not in place and FSC makes payments purely on quantity procured from the farmers.

Coconut production and processing: Coconut production is carried out by the local farmers to be sold to the oil mills post processing. The farmers themselves or the market intermediary dry the coconut to convert it to copra.

The oil millers only buy copra (dried coconut) from the farmers and the price of the produce depends on the quality of copra. High moisture content and presence of fungus reduces the quality of the produce.

Pongamia: The pongamia plantation in the country is still immature and no sales of pongamia seeds have ever taken place. The farmers involved in the pongamia farming (through Biofuel International) have got into contractual agreement to sell whole of their produce to the company for converting it to oil.

There is no farm level processing required for pongamia seeds, the fruit along with seed coat is to be sold to the company.

- **Feedstock processing and biofuel production**

As of July 2015, the country does not produce any biofuel (B100 or E100). The copra mills produce CNO and part of it is mixed with diesel to be sold to run the diesel generators. The coconut oil produced by the unit is filtered to remove any sedimentation before mixing with the regular diesel oil.

The state offers tax benefits to the copra milling units in the form of general exemptions applicable to any investments that are made in the priority zones (refer section 6.2.2). Also the government has made provision of extending tax wavers on the diesel that is used by the units for blended fuel production.

- ***Biofuel production, processing and retailing***

The blending fuel is not mandatory in the country, hence its neither produced/sold in the country neither its introduction considered by the oil companies.

In order to develop a blended fuel market, DoE introduced voluntary B-5 in the country to check technology readiness and commercial commitments. But there have been no efforts by the private investors and entrepreneurs to make available blended fuel in the market.

Currently no biodiesel or ethanol is produced in the country. It is reported that in 2011 'Flour Mills of Fiji' was retailing biodiesel but it appears that the sales were restricted to the vehicles owned by the company (refer to picture). Further, over time the company stopped selling blended diesel.

The other entities that are catering to the fuel demand by blending purified coconut oil with diesel (a 20% blend is prepared and sold)

Further, the coconut oil produced in the coconut oil mills facilities is mixed directly with the diesel and sold as 20% blend to be used in the diesel generators operating in the rural Fiji.

REVIEW OF EXISTING BUSINESS ENVIRONMENT

1. Review of land management system in the country

The land in Fiji is managed by two institutions, namely Department of Lands & Survey and the iTaukei Land Trust Board (TLTB). The Department of Lands and Survey manages all government

owned land, whereas TLTB is responsible for management of all the iTaukei land (or the native land). Under the Fijian law, iTaukei land cannot be sold (except to the state). Hence, for all residential, agriculture, and other commercial purposes, iTaukei land is leased to the developer[31] on a fixed term lease.

Specific to agriculture purposes (scope of biofuel program), lands leases are managed under the Agriculture Landlord and Tenant Act (ALTA). Mutually satisfactory agreements are to be reached between land-owner/s and tenants to make land available for commercial purposes.

With respect to the (potential and existing) biofuel feedstock programs

- The coconut trees are grown in private and village commons, no land contracting is required for the coconut farming as the feedstock is sourced directly from the farmers.
- Pongamia plantation is raised on land which is owned by the farmers, and a 'grower contract' is signed with the farmer. Biofuel International enters into a contact with farmers to buy the produce.
- There are multiple land holding arrangements for growing sugarcane. Under the most common system, farmers grow the crop in leased land and supply the crop to the FSC. In order to economize and revive the cane supplies, FSC has entered into sugarcane cultivation by contracting large tracts of land.

2. Tax environment in the country

In the country, favorable taxing environment exists to support the investments. Income tax exemptions are extended to companies established in the tax-free regions during the notified period (for tax free zones refer to Figure 16). The extent of exemptions is decided based on the capital investment mobilized in the region.

Duty Exemptions: Exemptions on import duty on raw materials, machinery and equipment (including parts and materials) are provided to support establishment of the business in the Tax Free Region. In addition, income tax exemptions are available which vary depending on type of investment (Fiji Revenue & Customs Authority, 2015).

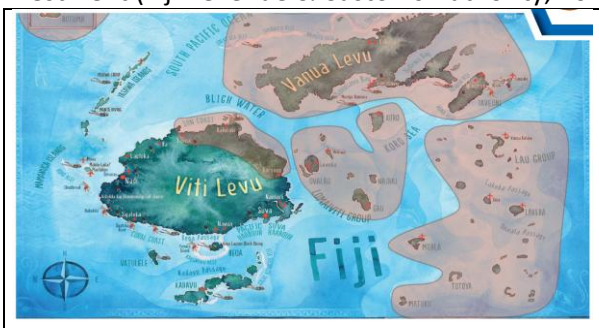


Figure 16: Economic Zoning in Fiji (Fiji Revenue & Customs Authority, 2015)

Zoning in the country (Fiji Revenue & Customs Authority, 2015)

As depicted in the adjoining map, the shaded regions depict the tax free region in the country. Which include Vanua Levu (included Taveuni, Rabi, Kioa and other islands generally included for government's administrative purpose as being in the Northern Division), Rotuma, Kadavu, Levuka, Lomaiviti, Lau; and East of Viti Levu (Korovou-Tavua region).

Tax exemption for biofuel production (Fiji Revenue & Customs Authority, 2015)

In Fiji a 10 year tax holiday is offered to biofuel producers (who derive fuel from agriculture commodities). The conditional tax relief is offered to companies who employ at least 20 people and make capital investment of USD 1,000,000. The tax relief is conditional and can be only availed by project proponents who invested during the 1-Jan-2009 till 31-Dec-2018 p

Further, relief is offered for the biofuel producers in the form of duty free imports of machinery and chemicals required for biofuel production.

[31] http://www.investmentfiji.org.fj/pages.cfm/for-investors/key-infrastructure-services/land.html

A special tax-exemption is offered to copra mills (mills promoted and supported by DoE). The mills are exempted from any taxes on diesel, which is to be mixed with CNO to be sold for use as fuel in diesel generators.

3. Bank financing

Introduced in February 2012, the Reserve Bank of Fiji (RBF) requires commercial banks in the country to lend out a minimum of 2.0 percent of their deposits and similar liabilities in the form of loans to the renewable energy sector. This was in line with the government policies to simulate renewable energy programs in the country and promote substitution of the imported fuel (RBF, 2012).

Table 21: Investment in renewable energy sector by banks in Fiji

	Jan 2013	Jan 2014	Jan 2015
Total renewable energy loans (USD)	84.3 m	185.1 m	241.6 m
Investment in Renewable Energy Sector (USD)	7.9 m	3.0 m	0.0 m
Surplus / (Deficit) (USD)	4.7 m	89.1 m	120.0 m

The Reserve Bank of Fiji has focused on creating an economic environment that is conducive to investment and growth. In order to help businesses, the apex bank has helped keep the bank lending rates low. Further, the bank also favors the passive approach for liquidity management[32].

Specific to agriculture sector, the RBF introduced an Import Substitution Facility to try to assist large scale commercial agricultural businesses to obtain credit at concessional rates of interest[33]. At the same time, the bank financing rates in the country have become more favorable to the industry. The interest rates have steadily declined post 2007. As depicted in Figure 17, the bank rates have sharply declined from 9% p.a. in 2007 to about 6.2% p.a. in 2014.

Figure 17: Bank interest rates[34]

Specific to the biofuel program in the country, of all the enterprises and corporations visited, FSC was planning to avail bank loan to diversify its production line and produce bio-ethanol. None of the other entities approached during the study had availed any financing from Fiji based financial institutions.

CONCLUSION

The business environment in the country with respect to biofuel sector is highly encouraging. Since none of the private entities have benefitted from the benefits extended by the government, hence at this stage no comments could be made on the effectiveness of the government incentives on promoting biofuel sector in the country.

[32] http://www.bis.org/review/r110511c.pdf
[33] Ibid
[34] http://www.tradingeconomics.com/fiji/lending-interest-rate-percent-wb-data.html

CHAPTER 7

SOCIAL AND ENVIRONMENTAL IMPACTS ASSOCIATED WITH BIOFUEL PROGRAM

Fiji is pursuing a transition in the transport sector fuel management by introducing a country wide biofuel program. Projects centred on coconut and pongamia feedstock has been initiated wherein palm and bio-ethanol focused actions are to start in coming years.

There are environmental and social impacts associated with biofuel program. It is important to ascertain and quantify impact of biofuels on the country's socio-economic and environmental system. The impact assessment of the biofuel program is required not only to contain the negative externalities and design offset program, but most importantly to provide inputs to the policy makers and program managers to select biofuel feedstock species with minimal consequences on society, economy and environment.

The analysis in this chapter focuses on; (i) the socio-economic impact assessment of biofuel - feedstock derived from food and forestry crops; the impact on macro-economy and rural economy in the country is analyzed. (ii) The environmental impacts of the biofuel program to discuss the impact of program on soil quality, biodiversity, water resources, tree cover etc.

Biofuels are a direct substitute to the polluting fossil fuels. Being of renewable nature, they have the potential to bring down the greenhouse gas emissions (GHG) effectively. Further, the biofuel program has economic spillover effects as the biofuel supply chain extends all the way from remote villages (biofuel feedstock production centres) to blended fuel selling outlets. Managed properly, biofuel program can ensure green fuel supplies and raise income levels across the feedstock and fuel supply chain.

Biofuels also have associated drawbacks, the raw material development and procurement process can sometimes pose serious environmental and economic problems. Across the globe, biofuel programs have been assessed for their impact on the local ecology and society. In this section, the socio-economic and environmental impact assessment of the biofuel feedstock (existing feedstock and potential biofuel crops) is carried out. The analysis is based on the data/ information collected during field visits and supported by secondary information.

METHODOLOGY AND APPROACH

Assessment of the socio-economic and environmental impacts of the biofuel program in Fiji was carried out through primary and secondary research. The primary data collection was based on interaction with farmers and industries that were either engaged with the existing biofuel feedstock production program or are involved in farming of crops that are potential feedstock for biofuel production in the country.

ENVIRONMENTAL IMPACTS OF BIOFUEL PROGRAM

The impact of biofuel program is assessed on two parameters, micro level impacts of biofuel-feedstock production on local ecology and macro level environmental benefits of replacing fossil fuel with biofuel.

Micro Environmental Impact-

1. **Impact on soil quality:** Biofuel feedstock production requires plantation of oil-seed producing species. Introduction of non-traditional or alien plant species can change the soil character of the land. The impact is severe if soil is treated with agro-chemicals (to make it suitable for introduction of new species). The impacts on the soil can be either be negative or positive depending on the quality of intervention.

   Inputs from field visits:

   Pongamia farming: During the field survey, aspects of impact of the biofuel crops were captured through discussions with project promoters and farmers.

   The farmers reported that in the plantation locally blended fertilizer was being used which has a positive and lasting impact on the soil quality and its pH levels.

   Further, there are positive impacts of Pongamia plantations for it being a nitrogen fixate species.

   Impacts of sugarcane farming: Sugar making is Fiji's oldest industry, and it's a "very small holder" focused industry. There are multiple studies that have established sugarcane farming's impacts on local ecosystem.

   The sugarcane plantations in the country are affecting the water bodies. This is due to the fact that the farmers grow sugarcane up to the water bodies, also sedimentation and waste flowing from farms into the water bodies has a lasting negative impact on the ecosystem. Due to this practice the health and biodiversity of river systems and coastal areas is being negatively impacted (Hartemink, 2008).

   Fertilizer overuse also has lasting impacts on the soil quality. Overuse of fertilizer in sugarcane farms has resulted in acidification of soil acidification (Hartemink, 2008)[35].

2. **Impact on forests and biodiversity:**

   Fiji's supports over 2600 vascular plant species (of these 1600 species are native to the country), similarly 90 native species of birds, bats, frogs and reptiles are found in the country[36].

   Clearing of land for agriculture (both commercial and subsistence) has resulted in major losses of forests in the smaller islands as well as the drier and lowland rainforests of the higher islands has faced the pressure. It is conservatively estimated that 70,000 hectares of forest has been lost in the past 15 years and that forest loss continues (Lees, 2007). The loss of forests has also put the flora and fauna under stress.

   A biofuel program designed on sound environmental principles can help the community move strategically from seasonal crops to tree species in areas threatened by population pressure and deforestation. This would help reduce damage to soil and also improve the green cover over time. Coconut, jatropha are such species that can not only provide economic returns to the farmers but also improve the forest conditions. Further, these species are not only source of biofuel feedstock but second as fuel, thus help reduce pressure on the local forest resulting in improved forest health. All these features actually may result in improved biodiversity of flora and fauna in the vicinity. In cases where biofuel feedstock production also adversely affect the biodiversity if it is introduced in areas under

[35] due to applications of sulphate of ammonia at rates averaging 150 kg/ha/year, nitrogen at rates of 150 kg/ha/year (Hartemink, 2008)

[36] Nearly half the bird species are endemic, and a third of the reptiles are. Endemism in invertebrates runs very high. Marine endemism is significantly lower

food crops, or are developed after clearing land. In addition, chemical use to enhance farm productivity can have negative impacts on the local biodiversity.

Pongamia farming: In the process of feedstock production, large tracts of land are put/planned under monoculture. This can negatively affect the biodiversity, further the leaves and seeds of the tree are not edible, further suppressing the biodiversity by not supporting bird and insects[37] .

Copra production: Coconut farming does not have any associated negative implications on ecology. But coconut drying (copra production) has high ecological footprint[38].
Coconut is processed (dried) to produce copra which in turn is sold to millers. The coconut pieces are dried using small village based (wood operated) kilns. During field visits it was observed that it required about two quintals of wood to produce one quintal of copra. Considering the emissions associated with the burning of wood, the environmental footprint of copra production can be very high.

Image 3: Coconut processing plant (for production of copra)

Macro Environmental Impact-

GHG reduction potential: Biofuels are considered a solution to climate change. Biofuels are although carbon intensive, yet they are carbon neutral because the carbon that is captured during the fruit development process is only released back during combustion process. There are also associated indirect carbon emissions (from feedstock production, transportation and processing) and emissions of other harmful pollutants, can be significant.
Various studies have shown that GHG emission reduction from using bio fuels instead of crude oil derived fuels results into GHG reduction of 45-65%. The activities which lead to GHG emissions in biofuel production are use of fertilizers, pesticides, energy in transport of crops to biofuel production facilities, energy consumed in biofuel production facilities and transport of biofuels to point of application etc which results in net GHG reduction between 45%-65% (where 45% is the worst case scenario).

[37] Information collected during field visit
[38] Information source: Site visit and interaction with farmers involved in copra business

Conservatively, assuming the GHG emissions through use of biofuels will be 45% the net GHG emissions reduction from use of biofuel is derived using the equation mentioned in Table 22.

Table 22: Parameters and equation to calculate GHG reduction potential from use of biofuel

	Biodiesel	Bioethanol
Biofuel CO_2 lifecycle avoidance factor[39]	45%	45%
Net avoided CO_2 eq.	Energy in TJ by B100*Ton CO2 /TJ by crude oil derived diesel*Biofuel CO2 Lifecycle avoidance factor	Energy in TJ by E100*Ton CO2 /TJ by crude oil derived gasoline *Biofuel CO2 Lifecycle avoidance factor
Emission factor of replaced fuel	Emission factor of Diesel= 74.1 TCO_2/TJ	Emission factor of Gasoline= 69.3 TCO_2/TJ

The volume of biodiesel and bioethanol required to meet the 2030 biofuel targets of 10 % blending for the transport sector are calculated to be 35.59 million liters and 19.28 million liters respectively (refer to Chapter 1). Using the equations and values from Table 22, the most conservative estimate for GHG emission avoidance is arrived at.

Table 23: Avoided CO_2e by replacing 10% of conventional fuel with biofuels

	Biodiesel	Bioethanol
Avoided fuel/p.a.	33.151 ML of diesel	13.11 ML of gasoline
Avoided tCO_2/p.a.	53,940.35	9,631.63

45.359

The biofuel program of the country has the potential of a total GHG avoidance of 63,571.35 ton of CO_2 equivalent if 10% of the conventional fuel gets replaced by biodiesel and bioethanol.

Apart from this, if tree species are planted to generate biofuel feedstock, additional benefits from carbon sequestration can be achieved.

SOCIO-ECONOMIC IMPACTS

The biofuel feedstock production process has huge socio-economic repercussions for the rural economy. The social and economic impacts of the biofuel program are analyzed at micro and macro levels.

Micro level socio-economic impacts

1. **Impact on income:** Theoretically biofuel feedstock is just another cash crop for the farmers. If the risks associated with production and marketing of the feedstock are low, the farmers will be able to improve their income.
   The biofuel program can help boost the rural economy. The biofuel feedstock production, its procurement and processing will help develop jobs in the rural setting and also improve the capacity of the people engaged in such program, improving their employability.
   In Fiji, the impact of Pongamia Pinata plantation in Bua province reportedly has a positive impact on wage rates. Prior to introduction of biofuels, there were limited employment opportunities. The workers were getting USD 10 per day during the inception phase, the daily wages have climbed to USD 20[40]. Further, the farmers selling copra have benefitted

[39] Conservative factor (lower number of the range 45-65% is considered for calculations)

[40] Although the project is just started and biofuel production is yet to start, the Bio Fuels International claims that the income from pongamia will be six times compared to income from sugarcane.

due to presence of CNO milling facility in Rabi (Tabiang) as now they have multiple buyers for their produce. [41]

2. **Market Exposure:** The biofuel feedstock is to be sourced from the natural resource stock of the country; be it forests or agriculture. In cases where biofuel feedstock is procured from producers in villages (farmers and villagers), there are two scenarios; (i) the private entities get into contractual agreements with the producers to buy feedstock; (ii) no contractual arrangement in place for marketing of produce.
   The biofuel feedstock producers can benefit from the buy-back arrangement agreed upon with the biofuel producers. But under free market conditions, farmers are exposed to the price risks.
   In case where there is buyers' monopoly (in case of Pongamia, alternate uses are not possible, buyers enjoy monopoly as the alternative use of seed is limited and there may be no other buyers of the seed) farmers' risks are very high. If supply is more than the demand, the buyers can manipulate the price of the seed and can easily buy it close to the break-even point (at price where the sellers cost is just meeting the investment). Since price discovery for seller is impossible (there are limited buyers) hence the seller loses.
   In case of sugar, the buy-back arrangement is institutionalized. Although FSCs monopoly exists, but the farmer welfare and benefits are well guarded by the system (which is influenced and also partially controlled by the state).
   The case is different for coconut based activity as the demand for copra is high. But high demand doesn't necessarily translate to high prices of copra. The farmers have to sell their produce to the nearest miller in order to get the maximum margin. The high shipping costs discourages exploring markets to bargain for higher rates.
   This situation has a long term repercussions for the biofuel program, as the biofuel feedstock buyer rather than focusing on his operational efficiency can still manage to maintain margins by procuring at the lowest possible prices.

3. **Food security:** Biofuel feedstock production is land intensive arrangement. To meet the biofuel targets of the country for 2030, at least 31,687 ha of land will be required (if Palm is used as feedstock crop) to meet the biodiesel requirement. Biofuel demand will put pressure on the existing land use. The demand for agriculture inputs will rise and other inputs will become scarce/costlier, constraining the food production of the country.
   (a) Land diversion:
   The biofuel program squeezes the land availability. The financial concerns drive the choice of crops that the farmers finally opt for. The decision of farmers or private biofuel producers to produce biofuel feedstock crops in the agriculture land may result in marginalization of cultivation of staple crop varieties.
   It is conservatively estimated that 70,000 hectares of forest has been lost in the past 15 years and that forest loss continues (Watling and Chape, 1992).
   (b) Impact on farm input costs:

   Farm chemicals use

   Through field survey it was established pongamia producers in Fiji were using bio-fertilizers to improve the farm productivity. Further, the coconut farmers were using no fertilizers.

   Thus, other crops (including food crops) don't have to compete with the biofuel feedstock plantations for the fertilizers and other chemicals.

[41] Information source: field survey

But the case may be different when large scale palm plantations are introduced in the country depending on the company's strategy (whether the palm plantations use bio-fertilizers or use conventional farm-chemicals for plantation management).

Labor: The commercial feedstock cropping (current and potential) is labor intensive. During the field surveys impact of labor supply and demand and wages were discussed in villages. Further, the copra production is labor intensive (labor is required to operate the kiln as well as gather wood).
Apart from labors involved in the feedstock production processing, the biofuel program has generated demand for skilled labor.
Notably no negative impact on either wages or labor supply-demand mismatch was observed during the field survey.

Macro Socio-economic Impact:

1. **Economic cost of support to biofuel program:** The biofuel programs are often supported by subsidies and tax benefits to bring the blended fuel at par with market prices of conventional fuels.

   Subsidy or direct tax benefits (exemptions) can be extended to the stakeholders engaged in the biofuel supply chain. E.g., in United States of America (USA), farmers receive direct financial support for growing biofuel crop. Wherein, currently in Fiji, CNO producers are receiving direct tax breaks.

   In current Fiji biofuel program, tax exemptions are extended to the biofuel producers (e.g. tax exemption on diesel used for blending with CNO) to reduce the marginal cost of production. This in turn helps the producer sell the blended fuel at prices comparable to that of market rates of diesel. In this case, the sellers and the buyers gain from the operations. Whereas the ultimate losers are the taxpayers as they have to bear the subsidy burden (in this scenario environmental externalities from biofuel program are not considered).

   Considering the simple '*producer subsidy model'* the net losses to the taxpayers are more than the gains to the buyers and sellers.

2. **Impact on fuel import bill:** Fiji imports 100% of its petroleum fuel, hence the biofuel program can help reduce the net oil import bills of the country saving foreign exchange; the money that can be diverted for either welfare programs or biofuel programs.

   Biofuels programs can help create jobs:

   The spillover impacts of the biofuel program will have a larger impact on the welfare of the rural community and can boost the rural economy.

   The production of feedstock and its conversion to biofuel requires greater quantities of labor compared to that required for extraction and processing of fossil fuels, this is due to the fact that biofuels are more labor intensive than other energy technologies for each unit of energy delivered (Rajagopal & Zilberman, 2007).

   The biofuel program also produces demand for skilled workers and managers. An estimate by European Producers Union of Renewable Ethanol (ePURE) suggests that for every 100 million litres of bioethanol produced, approximately 1.500 jobs are createdin developed economies (CropEnergies, 2011).

   The spillover impacts of the biofuel program will have a larger impact on the welfare of the rural community and can boost the rural economy. Since biofuel feedstock development is an important part of the whole process, hence majority of these job additions will come up in the rural sector, which can help boost the rural development.

For quick comparison, the environmental, social and economic impacts of biofuel program in the economy are captured in Table 24.

Table 24: Comparative analysis of environmental performance of various biofuel feedstock crops

	Coconut	Jatropha	Pongamia	Palm	Sugarcane	Maize	Cassava
Environmental Externalities							
Impact on soil quality	Improves soil quality	Improves soil quality when grown in slopes	Improves soil quality due to nitrogen fixation properties	Excessive use of chemicals has negative effect on soil quality	Excessive use of chemicals has negative effect on soil quality	Neutral if grown in non-forested areas	Continuous (without rotation) farming of cassava can reduce soil productivity in areas under shifting cultivation
Impact on biodiversity	Positive impact if grown in unstocked forests	Negative impact due to promotion of monoculture, further the tree does not support animal life	Negative impact due to promotion of monoculture, further the tree does not support animal life	Negative impact due to promotion of monoculture	Negative impact (due to use of chemicals)	Neutral if grown in agriculture fields	Neutral if grown in agriculture fields
Impact on forest cover	Positive impact if grow in unstocked forests	Positive impact if grown in unstocked forests	Negative impact	Negative impact	Negative impact	Neutral if grown in non-forested areas else negative impact	Neutral if grown in non-forested areas else negative impact
GHG sequestration	Carbon sequestration possible	Carbon sequestration possible	Carbon sequestration possible	-	Neutral	Neutral if grown in non-forested areas else negative impact	Neutral
Economic Externalities: Benefits to Farmers[42]							
Impact on income	Positive impact but the prices have fallen over time	Potential of rise in income. No evidence found in country as jatropha plantation don't	Rise in income reported.	Potential of rise in income. No evidence found in country as Palm	Sugarcane is a cash crop and important income source for the farmers in Fiji. The dropping sugar prices are	Potential of rise in income. No evidence could be collected from	Potential of rise in income. No evidence could be collected from Fiji.

[42] From field surveys and secondary data on Fiji

		exist.		plantation don't exist.	reflected in low prices of sugarcane.	Fiji.	
Market	Multiple buyers of produce	Product not introduced in Fiji markets	Monopoly market (only one buyer)	Product not introduced in Fiji markets	Monopoly market but prices regulated by government	Multiple buyers of produce exist	Multiple buyers of produce exist
Food security	Negative if grown by replacing food crop	Negative if grown by replacing food crop	Negative if grown by replacing food crop	Negative if food crop is diverted for biofuel	Negative if grown by replacing food crop	Negative if food crop is diverted for biofuel	Negative if food crop is diverted for biofuel

It's evident from the table that all the biofuel feedstock species have associated negative and positive externalities with varying order of impacts on the social, ecological and economic setting.

CONCLUSION

Clearly, it's critical to evaluate the various biofuel feedstock options based on its overall negative impacts on the ecological, socio and economic parameters. The policymakers will have to emphasize on the evaluation aspects that form the basis of such decision making. The program managers will have to ensure that the biofuel feedstock with the least negatives impacts are identified and promoted in the country.

CHAPTER 8

BIOFUEL AND FOOD SECURITY

In this section, food security issue in Fiji is analyzed and possible impact of biofuel program on national food and nutritional security is analyzed. Insights for biofuel policy are derived to contain food and fuel conflicts in the agriculture sector dominated economy of Fiji.

The commonly accepted definition of food security, 'the ability of all people at all times to have both physical and economic access to a sufficient amount of safe and nutritious food which meets their dietary needs and food preference for an active and healthy life[43]' is applied to Fiji context to analyze the food security concerns of the country with respect to the biofuel program proposed for the country.

On the basis of Human Development Index (HDI), Fiji ranks 88 out of 187 countries (reference year 2013). With a score of 0.724 the country falls in the high human development category (UNDP, 2014).

Despite high performance on HDI, a large population in the country lives in poverty. As per the Department of Statistics, during 2008-2009, 31% of people in the country were living below poverty line and of these 43% were living in rural areas (Bureau of Statistics, 2010).

Specific to food insecurity, the country witnessed improvement in food consumption in the urban areas whereas deterioration was witnessed in the rural areas (see Table 23). Also, the expenditure on food items in the country is low compared to other pacific island countries. Most importantly, the rural household's food self-sufficiency has gone down by 20% between 2002 and 2009 (Narsey, 2012).

Table 25: Percentage of population with food expenditure below 'Food Poverty Line' (Narsey, 2012)

	2002-03	2008-09	Change (percentage points)
Rural	59	64	7
Urban	61	56	(7)

The important observation around food security issue in the country is that imported food items are replacing the domestically produced food items (in both rural and urban areas) (Narsey, 2012)

FOOD SECURITY OVERVIEW IN FIJI

Fiji being a small island nation is exposed to factors that have bearing on the food security of its residents. The most prominent factors include, (i) small size (geographically and economically) of the country, (ii) remoteness and (iii) vulnerability (Sharma, 2006). The three factors in combination leave the country dependent on imports to meet the domestic demand for certain products. Further, the spread of population within islands makes the communication (transportation) costly, increasing the economic cost of goods and services, including food items. Also being surrounded by sea, the country is always exposed to the natural disasters like cyclones, hurricane among others. All these factors have implications on the performance of the agriculture sector[44].

According to the 1996 World Food Summit[45], food security represents "a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious

[43] http://www.fao.org/docrep/005/y4671e/y4671e06.htm
[44] (E.g. Cyclone Ami (in 2003) caused a loss of F$66 million for the agriculture sector alone (Sharma, 2006)
[45] http://www.fao.org/docrep/005/y4671e/y4671e06.htm

food that meets their dietary needs and food preferences for an active and healthy life". To analyze a country's food security three aspects are to be considered, these include food availability, food accessibility, and food utilization/absorption.

1. Food Security Indicators

The indicators of food security are:

- Food availability in terms of food production and food imports/exports
- Food consumption in terms of average per person dietary energy supply (DES)

2. Vulnerabilities

There are multiple risks faced by the agriculture sector in the country. Fiji is exposed to significant risks associated with climate vagaries in the form of drought caused by El Niño effect in the Pacific. Further, climate change impacts are visible in the region. Analyses of trends in extreme daily rainfall and temperature for the period 1961 to 2003 show significant changes in the climatic conditions. Long-term climate change is likely to increase the frequency and intensity of climate extremes such as tropical cyclones (Mudaliar, 2009).

Also, the coastal agriculture is projected to get affected by rising sea level (affecting the agriculture area availability and productivity due to inundation, seawater intrusion into freshwater lenses, soil salination) (Mudaliar, 2009).

These shocks cause a loss of natural resources and a negative impact on livelihoods. The number of households affected varies with intensity of shock and livelihood strategy.

Food production of key staple crops

The dietary preferences of rural and urban Fiji vary a lot. In rural areas the staple diet consists of roots and tubers (*taro*, cassava, *dalo* among others). The protein sources include fish and meat. In urban areas the staple diet is very different and consists of rice, wheat and bread. The protein sources are similar to rural areas but also include milk and milk products (Sharma, 2006). In the following section, the demand and production of various staple food items is analyzed to assess the food-self-sufficiency of the nation.

Rice is one major crop in the country and most common staple food across ethnic groups, the country has long tradition of growing rice. Although the country was producing 75% of its rice in 1975, but the scenario change rapidly and in 2014 almost 85% of the rice demand of the nation was met through imports (Economic Planning and Statistics Division, 2012).

Table 26: Self sufficiency of 'rice' in Fiji (Economic Planning and Statistics Division, 2012)

	2005	2006	2007	2008	2009	2010
Import (kg)	25,405,055	25,739,578	32,757,624	49,754,072	30,612,502	44,123,603
Export (kg)	146,933	215,452	167,627	870,093	781,542	788,540
Production (kg)	15,189,000	12,732,240	14,869,500	11,594,800	11,637,460	7,683,600
Self sufficiency ratio	38%	33%	31%	19%	26%	15%

From the above table it's clear that the rice production is fast declining in the country. The situation is alarming as the country is heavily dependent on imports for food that forms a major percentage of individual's diet (an average Fijian consumes about 62 kg rice every year) (Economic Planning and Statistics Division, 2012).

Apart from rice Fiji is also 100 per cent dependent on imports to meet the local demand for wheat and maize (there is no local production of these crops in the country) (Mudaliar, 2009).

Cassava being one of the staple foods, is grown throughout the country. The production by the Central Division is very high (almost 72% of the national production) due of the demand from the big urban centers (Economic Planning and Statistics Division, 2012).

Table 27: Self sufficiency of 'cassava' in Fiji (Economic Planning and Statistics Division, 2012)

	2005	2006	2007	2008	2009	2010
Import (kg)	0	0	0	0	0	0
Export (kg)	1,799,063	1,714,305	1,709,949	1,800,526	2,522,199	2,257,945
Production (kg)	59,648,000	50,021,100	61,379,000	55,773,000	42,332,200	51,690,200
Self sufficiency ratio	103%	104%	103%	103%	106%	105%

From the data presented in the table above, it's clear that the country is meeting 100% of the cassava demand and is also able to export the food to other countries.

Taro (also known as *dalo*) is the most consumed root crops in the country. Planted commercially for meeting local demand and for exports, the area under *Taro* production is expanding. The root crop is grown all across Fiji and central division is the major production centre. The country was producing around 70,000 tons (annually) of taro, and its exports averaged around FJD22 million during the 2007-09 period (Sharma, 2006).

Table 28: Self sufficiency of '*dalo*' in Fiji (Economic Planning and Statistics Division, 2012)

	2005	2006	2007	2008	2009	2010
Import (kg)	0	0	0	0	0	0
Export (kg)	9,959,468	11,434,808	11,949,411	10,795,807	9,482,284	10,513,355
Production (kg)	83,751,000	76,155,720	61,662,170	74,008,600	69,863,300	60,283,000
Self sufficiency ratio	113%	118%	124%	117%	116%	121%

From the data presented in the table above, its clear that the country is meeting 100% of the taro demand and is also able to export the food to other countries. Further, the trends indicate that the local production as well as consumption of taro is in decline.

FOOD DEMAND-SUPPLY GAP ANALYSIS

In terms of total daily calorie intake as an indicator of food security, the U.S. Department of Agriculture recommends the following daily calorie intake (see Table 27).

Table 29: Estimated daily calorie intake of humans

Gender	Sedentary (Kcal)	Moderately active (Kcal)	Active Kcal)
Men	2,000 to 2,600	2,200 to 2,800	2,400 to 3,000
Women	1,600 to 2,000	1,800 to 2,200	2,000 to 2,400

On an average, it could be assumed that the calorie intake is 2,500 per day for men and 2,000 calories for women; further, the average could be assumed at 2,250 Kcal/head for the population in general.

Food Balance Sheet (FBS) data for 2007 indicated that an average Fijian was consuming a whopping 3411 thousand calories (kcal) per day, this was almost 50% higher than the recommended daily intake of calories. To put this in perspective, an average Fijian (in 2007) was consuming an average of 56 kg of rice; 68 kg of cassava and 56 kg of *dalo* to meet his/her food requirement (Martyn, 2011).

For food security, Fiji is heavily dependent on imports. In 2007, almost 62% of the calorie demand of the country was met through imports, of this rice and wheat were the largest contributors (34%), wherein locally produced root crops (cassava and *taro*) were providing only 11% of the calories country demanded (Martyn, 2011).

Though the nation is able to meet its food demand. But over dependency on imports is an issue that the future agriculture/food security should try to address.

POLICY OVERVIEW – FOOD SECURITY AND BIOFUEL

In 2010-2014 Primary Industries Strategic Development Plan provides a framework for development of agriculture and allied sector in the country. The Plan also mentions introducing industrialization and modernization in agriculture sector (including livestock) to increase agricultural productivity (which has implication on food security) and encourage commercial agriculture for local consumption as well as exports.

The goal of the previous Ministry of Agriculture and Primary Industries (MAPI) plan specifically targets reduction of imports of food items by promoting local food production as substitutes for imported food items (Martyn, 2011).

BIOFUELS AS DRIVER FOR IMPROVING FOOD SECURITY

In order to ensure energy security and sustainable development, the Fijian government promotes the development of renewable energy as an important component of the national economic development. Currently the country does not have any policy to govern the biofuel sector. Considering the food security concerns, it's necessary that the policy developed for the country addresses issues pertaining to fuel-food conflicts (the agriculture and food security priorities of the country are communicated by the fact that use of cassava for biofuel production is not encouraged).

1.1.1 Biofuel Program Strategy in Fiji (Welfare features)

The biofuel program strategy to substitute part of transportation fuel with that of domestically produced biofuel would not only reduce the fossil fuel import bill and enhance energy security but also improve other welfare activities such as agriculture sector development, rural development as well as poverty alleviation, substantially. A qualitative assessment of the welfare features associated with biofuel program include:

Agriculture sector development

The increasing demand for biofuels has to be met through increased production of biofuel feedstock crops. Enhanced biofuel feedstock crop production may be achieved by: i) improving crop yields per hectare; ii) increasing the area of land that is farmed; iii) increasing farming efficiency and reducing wastage; iv) bringing underutilized land under commercial farming plan or iv) a combination of these. As discussed in Chapter-2, farm productivity in the country is low compared to other nations. There is scope for improvement in yield, and there are rightly guided programs (e.g. introducing high yield pongamia is one such effort). Here, inputs of fertilizer, improved farming practices, and crop breeding may help.

As crop productivity per unit of land is increased, less land will be required to supply the required quantify of biofuel feedstock. The farm productivity efforts will have repercussions for the whole of farm economy in the country.

The same logic is true for food crops as well, there is scope of improving the food crop productivity in the country. This idea is supported by the observation that global agricultural output has increased by 140% since the 1960s for only an 11% increase in cropland area (The Royal Society, 2009). Higher agricultural yields will also reduce pressure on the land and forests, thus providing country an opportunity to diversify rural livelihood system.

Improvement in current farming and distribution practices could help increase efficiency and reduce wastage. Pre and post harvest losses in developing countries, where little pesticide or herbicide is used, can account for 20-40% of the potential harvest due to pests and pathogens (Hutton, 2010) Hence, there is room for improvement. Access to farm technology will help increase yields (e.g. the Brazilian experience suggests that this can be achieved through the selection of better crop varieties and irrigation) (Peskett, Slater, Stevens, & Dufey, 2007).

Rural development

There is a potential for biofuels to contribute to rural development if biofuel feedstock production and processing (level of processing depending on technological advancement and controlled by policy measures to ensure rural economy gets its due share in the economic growth fuelled by the biofuel program) is carried out by small and medium farmers. Farmers can be made the drivers of socially responsible biofuels development by encouraging them to grow biofuels alongside their food crops. Small scale and locally sustainable, village-based biofuels development will benefit small farmers by realizing the micro-economic possibilities of energy crops. This innovative approach implemented in Mali (International Research Center for Energy and Economic Development, 2013) on an experimental basis has been very successful in achieving the goals. However, a potential land-use shift to biofuels could undermine food security if farmers find that it is significantly more profitable than the production of food crops (a clear case of diversion of coconut for non-edible oil production). Such a threat, however, might be minimized by introducing pro-food production land-use policies that limit biofuels production land ratios. This will serve the goal of energy independence that is equitable and will be a win-win situation for all sectors of society, the environment, and the government.

Poverty alleviation

International experience on biofuels has revealed both positive and negative social and economic externalities associated with biofuel feedstock production. On the positive side, biofuels production systems have helped improve household welfare through the small-scale out-grower schemes or cooperative schemes, especially for typical smallholder crops (suitable for biofuel production), that are most effective at raising poorer households' incomes.

At the same time, International experience (e.g. Jatropha based biofuel approach in India) has also revealed that unplanned biofuel can add to large scale monoculture on the cultivable or forest land leading to uncertainties on how biofuels will actually contribute to rural prosperity. Similarly, large corporations have raised palm oil plantations in SE Asia after cutting down forests. In both cases, the rural population has suffered as natural resource quality has degraded. If these trends continue, in fact, biofuels production might lead to increased rural poverty as small farmers increasingly lose their land and forests to large investors.

For poverty management purposes, it is recommended that the government of Fiji explore opportunities to engage small farmers/poor villagers in the production of biofuels. If smallholder/cooperatives yields can be improved rather than expanding cultivated land, the schemes can generate pro-poor outcomes. This supports the view that biofuels could help low-income countries overcome their dependence on oil imports while also reducing greenhouse gas emissions and increasing farmers' participation in the growth process (AGRITRADE, 2013)

Therefore, it is recommended that investments into biofuels should have clearly defined objectives and must include environmental and social impact assessments. There is need to map and conduct an inventory of land uses before allocating land for biofuels cultivation. Laws should be enacted that provide for protection of farm and pasture land to avoid illegal land alienation and displacement. Policies relevant to biomass and land inventories as well as legal protection of the smallholders and herders will safeguard the interest of the farmers and protect them from unintended consequences.

CONCLUSION

Food and biofuel feedstock require common resource inputs including - land, water, labor and agro-chemicals. The challenge is to increase the supply of biofuel feedstock while not constraining or diverting the land and other resources that support food-crop cultivation. Focusing on ecological conservation, sustainable production methods and food security, the biofuel policy can be designed in manner that reduces and minimizes the fuel-food conflict.

The following points would need to be kept in mind while designing the biofuel feedstock production strategy for the country:

- Focusing on feedstock crops that do not divert the resources away from food items;
- Producing biofuel feedstock on marginal and underutilized land;
- Increasing land-productivity, introducing multi-cropping, mixed cropping for sustainable yield improvement;
- Reducing loss/waste in biofuel feedstock supply chains, to enable more products to get to the markets.

ANNEXURE

Annexure-I

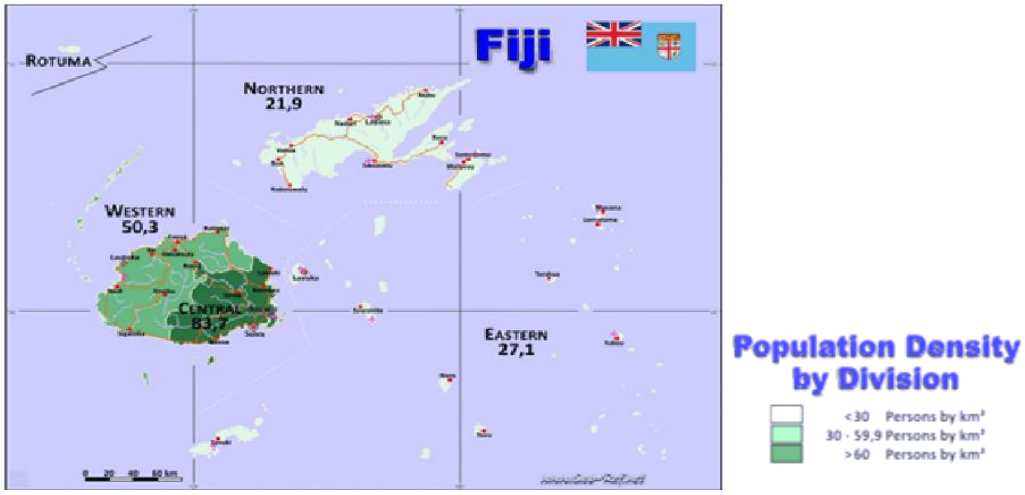


Figure: Fiji- Population density by division (Source: http://www.geo-ref.net/en/fji.htm)

Annexure-II

Figure: Road network (Viti Levu island) (Source: Document Fiji Islands Road Assessment Additional Information[46])

[46] http://www.transportunit.gov.fj/ntcf.htm

Annexure 3

Road network: Fiji (Source http://www.mapsofworld.com/fiji/road-map.html)

Annexure IV

Solvency impacts: B-10 dissolves sediment accumulated in tanks or engines, which can plug filters. Blends of B20 and less minimize the solvent effect, but minor filter plugging could result in the first couple of weeks of use. The solvency effect should not be an issue for blends of B5 and lower.

Material compatibility: B100 can degrade, soften or seep through some hoses, gaskets and seals. The soft metals often found in fittings, such as brass, copper, tin and lead, can be found on some tanks, and vehicle models before the mid 1990s. Blends of B20 or lower minimize most issues of material incompatibility.

Storage ranks and dispensing equipment: Most tanks designed to store diesel fuel can store B100 with no problem. Tanks with lead solders and zinc linings are to be avoided. Any biodiesel affected metal should be replaced with stainless steel, carbon steel, or aluminum.

Transportation: During transportation it has to be taken care of that moisture/water does not come into contact with biodiesel.

Annexure V

Specific issues associated with E85

The storage and distribution of E85 has a much more significant potential adverse effect on storage tank system components that are in continuous contact with E85, and can potentially contaminate vehicle fuel tanks. E85 can corrode soft metals such as aluminum and zinc and the more cathodic metals such as brass, copper, and lead. It can act as a scouring agent that can loosen internal deposits and sludge. E85 can accelerate an existing corrosion in steel tanks. Not cleaning the tank properly before introducing E85 can lead to loss of product.

E85 is not compatible with many plastics, and certain resins used in older, lined tanks. E85 can impair the operation of Automatic Tank Gauges and probe floats, and destroy the sealing ability of some materials such as cork, rubber, and leather. Phase separation can occur, and filter maintenance is an important issue because improperly sized or efficiency rated fuel filters may allow contaminants and corrosive element from the tank to enter the vehicle fuel system during fuel transfer.

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