Sustainable Biofuels in the Pacific -An overview

J. Cloin [1] & G. Vaïtilingom[2]

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Abstract

The Pacific region has great potential for the use of biofuels for transport and electricity generation however Island States must strike the right balance between food security, energy security and ensuring sustainable livelihoods during the associated transformation of their energy and agricultural sectors. This paper provides an overview of technical, economic and agricultural issues involved in striking this balance.

Introduction

Around the world, there is a great sense of urgency about the introduction of alternatives to fossil fuels. Driven largely by concerns of dwindling resources, global warming and other environmental concerns, renewable types of energies such as wind, solar, hydro and biofuels are perceived by many to be able to replace the role of fossil fuels in our economies. In the Pacific Islands, the sense of urgency is even felt stronger than in most other parts of the world, through their remoteness, their small size and relatively high fuel prices. Sometimes biofuels have proven to be more readily available than fossil fuels in extremely remote places.

The resources required for effective biofuel utilisation appear to be abundant in many Pacific island countries: humid tropical environment and an abundance of sunshine. There are however also restraining factors, such as the limited availability of land and water resources, with potential negative impacts on food security. Especially in countries consisting of low lying atolls there is almost no idle land, coupled with infertile coralline soils and possibly long spells of dry weather; this makes any form of agriculture very difficult [SPC/IFAD, 2008]. As a result, many atoll communities already face problems in maintaining food security and eating a balanced diet. Considering using part of those same resources for fuel production potentially has a detrimental effect on food security. On the other hand, plantations used in the past century for exporting copra, can become a source of cash or readily available energy for communities, if sufficient attention is given to sustainability issues such as land and water resource management, depletion of soil nutrients, while sufficient amounts of quality land are devoted for food production.

Another potential detrimental effect of biofuel production lies in the 'commoditising' of staple food products, for example in case cassava is used for the large-scale production of ethanol as a petrol replacement. In this case, the interests of individual farmers (high prices for their produce, traditional way of farming) are diametrically opposed to the interests of the distillery, which requires low prices for its viability.

Figure 1: Farmer cutting copra: the use of coconuts for local fuel can have positive economic impacts to the rural community. *(Picture: Cloin, 2007)*

[1] jan.cloin@gmail.com
[2] gilles.vaitilingom@cirad.fr

Traditional small scale production methods do not fit with the requirements of high volume, low-price demands of a biofuel facility. Even though a biofuel facility can be an opportunity (creation of agricultural jobs, local fuel production), it can also be threat (depressing prices on local produce market) to rural populations.

The above observations make it imperative that any biofuel policy considers both local and national food security, energy security and take into account the changes in the agricultural sector and the energy sector, while promoting sustainable livelihoods where possible.

Biofuel global developments

Since 2000, global interest in biofuels was boosted by rising energy prices, strife for energy independence, promoting agricultural development and concerns about global warming. Especially liquid biofuels are popular, as they seemed to be able to partly or wholly 'replace' common fuels such as petrol and diesel in cars and generators.

To achieve a vibrant biofuel sector, many countries provided full or partial exemption from excise tax; eco-tax or value added tax as well as mandatory blending of biofuels. Most countries promoting biofuels had measures in place or implemented them between 2000 and 2005, while blending quotas have been adopted only more recently [IEA, 2008]

Total world oil demand is currently at 4,600 bn litres, while biofuels (produced mainly in US and Brazil) only constitute of 60 bn litres, or 1.25% [FAO, 2008]. This explains why fuel market developments have a much higher impact on food commodity markets than the other way around. The world food commodity prices have increased by 60% in 2006 and 2007, even though the exact impact of biofuel production on the increase in food prices is unclear. Estimates vary between 3% (US Department of Agriculture) and 75% (World Bank). Other concerns include the lack of greenhouse gas emission reduction related to (especially) ethanol from maize and the destruction of indigenous forests for large scale palm plantations in Malaysia and Indonesia.

The ambitious EU biofuel production targets (20% in 2020) that were set in 2007 have stimulated growing public concern surrounding the impacts from increasing biofuel production on land use change, agricultural product prices, deforestation and water use. There is now growing consensus to decrease the EU targets to more modest levels such as 10% in 2020.

Production and utilisation of biofuels in the Pacific

During the past 3 years, despite the increase in price paid for coconut oil on the world market, there has been an economic case for the use of coconut oil as a diesel replacement (Figure 2). This has not happened on a very large scale, but isolated cases around the Pacific have made use of their locally available vegetable oil to replace imported fuels.

For example, Vanuatu utility UNELCO has been running one of their 4 MW generators up to 25% on coconut oil and has four biofuel projects in the outer islands, with one operating on 100% coconut oil. A significant number of cars have also been modified to run on filtered coconut oil. In Papua New Guinea, entrepreneur Matthias Horn is using coconut oil in cars and generators, with the PNG National Fisheries College experimenting with various applications, including a fishing boat [NFC, 2006]. The Solomon Islands has a few cars and generators operating on coconut oil driven by the efforts of John Vollrath. The country has great potential for biofuel, due to the large-scale palm plantation and through coconut plantations, especially in the outer islands.

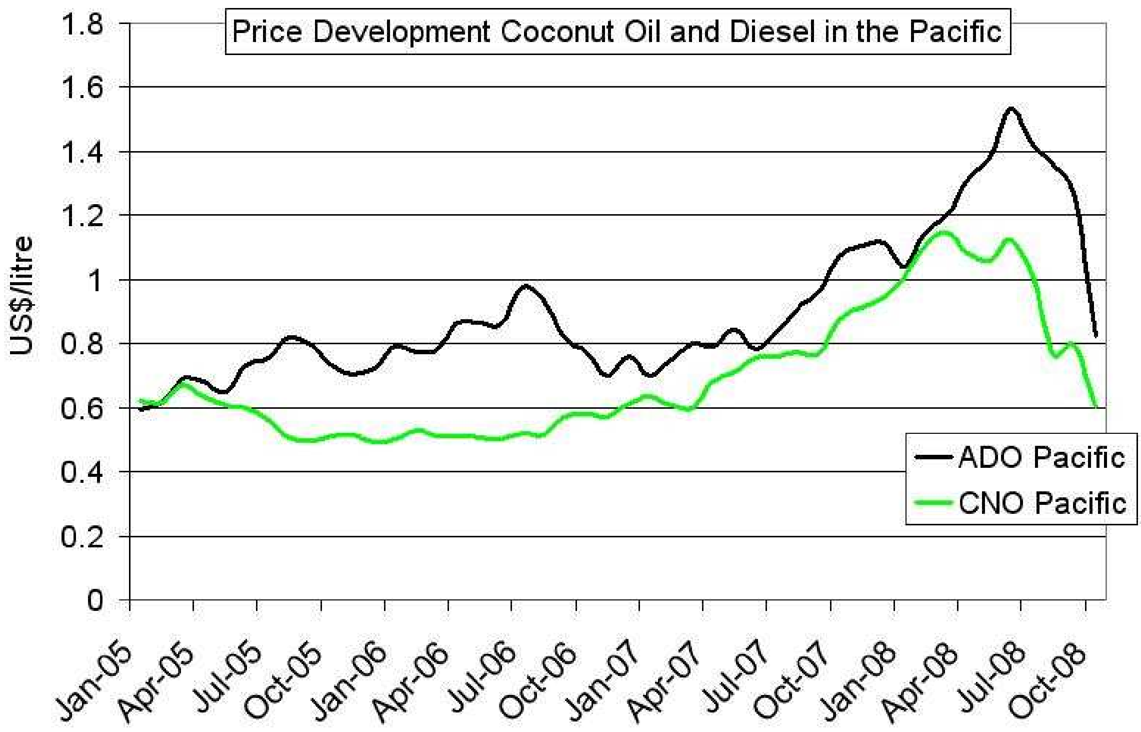

Figure 2: Price development coconut oil and diesel in the Pacific 2005-2008 (Source: PPIACO price index, Coconut Industry Authority of the Philippines)

Fiji has a number of entrepreneurs proposing to produce biodiesel from waste oil, Jatropha oil Pongamia nut oil.

There are also plans, in various stages of development, to produce fuel-ethanol from molasses and cassava in PNG and Fiji.

Various feasibility studies have been carried out for rural electrification based on biofuels in Vanuatu, Fiji, Marshall Islands, FSM [UNDP 2007, 2008; SOPAC 2007] for small communities, but many are not (yet) operational.

The main reasons for the slow uptake of biofuel activities in the Pacific are due to:

a) Isolation

Isolation of islands and countries as a whole cause ideas and innovations to move slowly. Even though in isolated cases coconut oil and ethanol have been produced and used successfully, the applications spread only slowly around the region.

b) Small size

Many biofuel applications, especially ethanol and biodiesel production, require large scale factories in order for them to be competitive with fossil fuels. Most markets in the Pacific Islands do not have this size, while export is costly as well.

c) Lack of supporting policies

All countries in the world where biofuels have taken off as a source of energy, have had or still have supportive policies for biofuel introduction. Most countries in the Pacific do not have an active policy, let alone tax or investment incentives.

d) Perceived technical risk

Due to some technical failures and uncertainty under what conditions various types of biofuels can be used in standard / modified engines, users are reluctant to experiment.

e) High Opportunity Cost of Labour

Even though there is rural poverty in most Melanesian countries with absolute low wages, many communities in the Pacific value the time spent on preparing crops for biofuels in addition to other agriculture activities very highly. This decreases the economic opportunities for biofuels.

Technical Challenges for Biofuels in the Pacific

Second generation Biofuels (coming from wood, straw, dedicated crops,…) are believed to reach the market in 15 to 20 years from now with a forecast substitution capacity of 25 % of the world oil consumption. However, all projected "biorefineries" are designed as very large scale units to be competitive with fossil liquid fuels and might not be applicable to the Pacific region.

First generation Biofuels (biodiesel from vegetable oils and bioethanol) are used as additives to petroleum product at national level and mainly for transportation. But in many developing countries and small countries at the local level, they can provide a source of fuel in favour of existing activities, rural electrification and maybe sustainability of food crops. Technical constraints to consider are different for these two levels.

Pacific island countries are relying on imported equipment and have not yet developed the capability to adapt internal combustion engines design for biofuel utilisation. Therefore characteristics and particularities of biofuels have to be carefully assessed and taken in account.

Two kinds of biofuels are considered in the Pacific: Coconut Oil (pure plant oil or esterified as Biodiesel), and Ethanol from sugar cane or others sugary products (like toddy) and starchy crops.

Coconut Oil

The viscosity of Coconut Oil is almost ten times higher than that of diesel fuel at 40°C. This leads to poor fuel atomisation and results in incomplete combustion. More serious are the extremely high flashpoints of vegetable oils and their tendency for thermal or oxidative polymerisation leading to the formation of deposits on the injector nozzles, a gradual dilution and degrading of the lubricating oil and the sticking of piston rings. As a consequence, long term operation of most pure vegetable oils or blends with diesel eventually leads to engine breakdown.

It is however possible to use vegetable oil in the Pacific as a fuel.

a) In standard Diesel engines by either:

- adapting the "fuel" and making Biodiesel (esterification with methanol or ethanol).
- using pure vegetable oils or mixtures under internal thermal conditions allowing their complete combustion (two tank systems)
- using IDI engines (Indirect injection system)

b) In specifically designed engines modified to burn vegetable oils.

Ethanol

Ethanol characteristics are close to those of petrol. It is a flexible fuel with a natural octane number higher than petrol. A blend of ethanol enables a petrol engine to reach better efficiency and lower level of pollutants at the exhaust. Care must be taken with acidity which can lead to an increased wear of injectors and injection system.

Ethanol can be used in two ways:

a) Hydrated ethanol (hydrous ethanol at 95 % vol. containing 5 % water):

- In blends with petroleum fuels:
  Hydrous Ethanol is not soluble in petrol at the doses usually

recommended as motor fuel (5 to 20%) except in the presence of a particularly effective additive to avoid phase separation of the two fuels.

- Pure hydrated ethanol:
  The use of ethanol 95 as sole fuel is possible in spark ignition engines. Brazilian cars during the 80's were able to run on pure ethanol containing up to 10 % water. Adpated diesel engines can run if a procetane additive is used in ethanol.

b) De-hydrated ethanol (ethanol at 99 % vol.):
   Blends with petroleum fuels are stable and usable. When ethanol blends above 10% are used, engines must be monitored and when blends exceed 22%, engines must be modified. But care must be taken with humidity in tanks: at 3 % vol. of water there is phase separation of the petrol on top and hydrated ethanol at the bottom. In Pacific humid climates the use of an additive is a necessity.
   Note that it is also possible to use de-hydrated ethanol in mixture with diesel fuel. Tests have been carried out on a bus fleet in Chicago involving an 80% diesel, 15% ethanol and 5% additive. Cuba is using 2 % anhydrous sugar cane ethanol in mixture with diesel in sugar factory trucks.

- Pure de-hydrated ethanol:
  The use of ethanol 99 as sole fuel is possible in spark ignition engines as well as adapted diesel engines with a procetane additive in ethanol.

Economic potential for biofuels in the Pacific

The economic case for biofuels plays at the macro-level, improving the balance of payment by decreasing imports; it also plays at the micro-level enabling communities to use local resources to avoid dependence on fossil fuel purchase.

At the macro-level, world market prices for fuel, biofuel commodities and exchange rates determine the economic case for nations, while at the micro-level, local transport costs and taxes determine the degree that communities can benefit from utilising biofuels.

The crash of the commodities market that followed the recent turmoil in the credit markets worldwide, is a good example of the volatile nature of these price levels. From March 2008 to October 2008, the price of palm oil has fallen from €1,000 to €340 per tonne, a decrease of 66%. Even though in the same period crude oil fell a mere 60% from US$147 per barrel to US$60 per barrel, it is very difficult to assess the long term impact of import substitution on the balance of payments.

The same is true for tax incentives at the national level; as the fiscal resource base of most Pacific island countries is very thin, it is very difficult to make a clear-cut case for biofuel tax exemption. Incentives for local use of biofuels must be scaled down over time to avoid erosion of Government income especially in economic challenging times. Mandatory blending does not have this disadvantage, but will increase fuel prices across the board, hurting only the consumers of fuel.

Biofuel impact on rural livelihoods

Rural livelihoods concern the capabilities, assets and activities that provide a means of living to rural people [Cahn, 2002]. While a simple economic analysis on the use of biofuels can identify an opportunity for financial earnings of a community, the whole of the way people live, their value system, traditions and beliefs must be taken into account. Basis of the rural livelihood approach is that a newly introduced activity (such as biofuel production and utilisation) must be based on the resources locally available, must fit in the way of life and, most importantly must have an added value for the community involved, differentiated by gender.

Biofuel impact on food security

Food security relates more to people's access to food rather than whether there is enough food available. It is built up of a) the availability of food; b) the access to food (distribution, price); c) stability of food (supply, price) and d) the way people use their food (nutrition).

In terms of availability, the impact of biofuel can be negative if it uses land or resources that would otherwise have been used for food production. On the other hand, it can stimulate investment into certain crops / agricultural practices that leads to increased availability of food.

Food prices can increase due to resource competition. This decreases the access poor people have to food; for farmers the effect will be positive, as they receive more for their crop. The closer linkage to fuel markets has shown to give agricultural commodities higher volatility, thus decreasing stability of food prices. Biofuels can affect people's health if its production competes for water. Alternatively, small-scale biofuel production may reduce the reliance on other traditional fuels such as wood, which would provide more time for other activities, particularly for women and children, and reduce the health risk of using traditional fuels. [UNESCAP, 2008]

Biofuel impact on the environment

In terms of effects on the agricultural sector, if the cultivation of energy crops replaces intensive agriculture, impacts can range from neutral to positive; if it replaces natural ecosystems or displaces other crops into protected areas (in most cases in the Pacific), the effects will be mostly negative [ODI, 2007].

The impact on the environment of biofuels can be measured in a number of ways. Most important is the energy balance, which measures the required inputs [MJ] to produce biofuels as compared to the useful outputs [MJ] that is obtained during use. The highest energy balance can be achieved with straight vegetable oils (such as oil palm and coconut oil) and ethanol from sugar cane. The energy balance of ethanol from Sugar Cane in Brazil is estimated at 9 (i.e. 9 units of energy available from 1 unit of energy input), whereas the energy balance of ethanol from maize in the United States is 1.5. Rapeseed oil in Denmark has an energy balance of 11 while the energy balance of coconut oil as a pure plant oil in the Pacific has been estimated at over 15 [SOPAC, 2007].

A second measure of impact on the environment is the impact on greenhouse gas emissions, which is determined on the basis of the fuel that is replaced versus the emissions related to the production of the fuel. It can be argued that the carbon emitted during use will be absorbed again by the plant if sustainable agriculture is being used.

In addition to these important indicators of environmental impact, there are number of considerations such as the effluent of ethanol production and the side products of biodiesel production that must be disposed of wisely.

The introduction and enforcement of appropriate technologies, regulations and standards can help to mitigate most of these problems, but will be slow to materialise where policy environments are weak [ODI, 2007].

Agricultural Challenges for Biofuel in the Pacific

The main agricultural challenges in the Pacific are land availability and the impacts of climate change. It is important biofuel production and consumption take these two constraints into account, by making the islands in the region more resilient instead of more dependent on imported items and/or a higher degree of sensitivity to changes in the global markets and weather patterns.

A model for additional income generations for small scale farmers comes from Tanzania, Africa [Diligent, 2007] where a Jatropha plantation forms the basis for biodiesel production plant. In addition, small farmers can sell their Jatropha nuts, a crop from their natural hedges, which never had any value to them. They now increasingly intercrop Jatropha with their various crops.

Agricultural Guidelines for Biofuel Policy in the Pacific

The introduction of biofuels has an important role to play to increase energy security and independence, next to agricultural development and diversification in the Pacific region.

Policy decisions to promote biofuel use on the outer islands with high fuel prices and low volume of consumption must be based on resource-based management with at the centre stage the sustainable livelihoods of island communities.

In addition, large scale plantations and conversion plants have an important role to play to achieve economies of scale and likely cost effectiveness with fossil fuels.

For this to be achieved, Governments should consider supportive measures that can be phased out over time. This can include tax exemption, mandatory blending of biofuels, investment incentives and public-private partnerships into (large scale) biofuel applications. In addition, land use allocation must be reviewed, ensuring effective use of land for sufficient food and fuel.

How to promote Biofuels in the Pacific

Frequent interaction between communities and co-ordinated training efforts can lead to faster diffusion of ideas; biofuel applications will have to be tailor-made to fit the smaller markets and supportive policies have to be developed at a national and perhaps regional level to attract investment and certify products for consumers; adopting standardisation can further decrease perceived technical risk. Biofuel applications should incorporate robust mechanisation to decrease labour inputs as much as possible.

Conclusion

The biofuel revolution is fast approaching. Biofuels will play a major role in the future of the Pacific islands energy and agricultural sector. It is not clear to what extent the poor farmers will benefit from this revolution. The challenge is to ensure a balance between food and biofuel production and the creation of income opportunities for small scale farmers.

Pacific island countries that consider biofuel as part of their energy and agricultural long term development strategy should conduct their own national assessments critically, guide investment opportunities and protect the poor from adverse impacts.

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Definitions

Biodiesel: is acceptable in most diesel engines as a fuel replacement up to 100%. It is usually produced from vegetable oils that have been treated chemically in a process called esterification.

Biofuels are products from biological origin that have been converted into liquid, solid or as form, depending on the raw material base and the technology employed, for energy generation. *Liquid biofuels* are used for heating, cooking, lighting, transport and power generation. Bioethanol, bio-diesel and pure plant oils are the most common forms of liquid biofuels. *Solid biofuels* are plant matter such as wood chips, and other solid or woody biomass, that can be directly used as fuel. Two of the most widely used forms are wood chips and bagasse - the fibre remaining when sugar cane is crushed to remove the cane juice for sugar production. *Gaseous biofuels* include biogas, which is produced by digesting organic waste and is generally used for cooking, lighting and power generation at the village level. [CTA, 2007]

Ethanol: an alcohol that can be used up to 10% in standard engines, up to 25% in adapted engines and up to 85% in specially designed petrol engines. Ethanol is usually produced by distilling alcohols to a purity of 95% (hydrated) or up to 99% (hydrated). For fuel uses, ethanol is often denatured (mixed with petrol) to avoid abuse (human consumption) under a low tax regime.

Sustainable Livelihoods: A Pacific livelihood comprises the capabilities, assets and activities that provide a means of living: a *sustainable* livelihood works within a traditional and cultural context adapting to and coping with vulnerability, while maintaining and enhancing assets and resources [Cahn, 2002]

SPC Member Country *	Potential[3]	Biofuel Policy	Active Use[4]			
			Eth	CNO Elec.	CNO Veh.	Bio Diesel
American Samoa	Low	unknown	N	N	N	N
Cook Islands	Low	NO	N	N	N	N
Federated States of Micronesia (FSM)	Low	NO	N	N	Y	N
Fiji Islands	High	draft	Stu	Y	Y	Stu
French Polynesia	Low	unknown	N	Y	Y	U
Guam	Low	unknown	N	N	N	Y
Kiribati	Medium	draft	N	Stu	Y	N
Marshall Islands	Medium	draft	N	N	Y	N
Nauru	Low	NO	N	N	N	N
New Caledonia	Low	unknown	N	Y	Y	Stu
Niue	Low	NO	N	N	N	N
Northern Mariana Islands (CNMI)	Low	unknown	N	N	N	N
Palau	Medium	NO	N	N	N	N
Papua New Guinea (PNG)	High	draft	Y	Y	Y	Stu
Pitcairn Islands	Low	unknown	N	N	N	N
Samoa	Medium	NO	Stu	Y	Y	Stu
Solomon Islands	High	draft	N	Y	Y	N
Tokelau	Medium	YES	N	Stu	N	N
Tonga	Medium	draft	N	N	N	Stu
Tuvalu	Low	NO	N	Stu	N	N
Vanuatu	Medium	YES	N	Y	Y	N
Wallis and Futuna	Low	unknown	U	U	U	U

N: No, Y: Yes, Stu: (Has been) under study, U: Unknown.
** This table will be updated during the workshop by the participants from the respective countries.*

[3] Potential: taking into account land availability, land quality, wage levels and scale opportunities.
[4] Acitve use, including recent experiences