Enhancing the sustainability of tropical island communities by improving self sufficiency in liquid fuel supplies

by

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Abstract

The goal of the recent UN's Global Conference on Sustainable Development of Small Island Developing States was to prepare a strategy for sustainable development specific to small islands. At the UN's Earth Summit in Rio in 1992 small islands were designated as a vulnerable group warranting special international attention. The objective is sustainable development.

Coconuts represent a naturally sustainable resource ideally suited to island environments. They are one of few plants that tolerate poor sandy soils with saline water, and which survive frequent cyclones. Coconut products (cream, juice, fibre, wood, shell) are used extensively by local households. In the form of copra (dried chunks of coconut flesh) coconuts are a significant oil-seed crop and the major source of cash income for many islands. However, copra cannot be used locally. It has to be exported and the processed coconut oil (CNO) imported. Such re-imported oil is very expensive and not available to the local population. Thus many of the potential uses of coconut oil are forfeited. Critical among these is its potential use as a substitute for liquid petroleum fuels.

This paper discusses the implications of new processes of Direct Micro Expelling (DME) CNO at a village level and shows that widening the choice of technique for CNO extraction could have a profound impact on the sustainability of remote island communities.

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1. SUSTAINABILITY AND STABILITY

Volume 31 of the *Development Bulletin* (July 1994) of the Australian Development Studies Network on "Managing Resources in the South Pacific" makes dismal reading. The politicisation of public sector management and administration on the one hand and the scarcity of managerial skills at all levels of government are recurring themes in many papers. Amid the many uncertainties facing island states, there are known trends. Critical among these trends is the rate of population growth: many of the Melanesian island states have among the highest rates of population growth in the world. Almost irrespective of the size of the total population, rapid growth rates impose enormous stress on any country as it seeks to match rising aspirations for better social services in health care and education plus infrastructural developments in transport and communications. The difficulties in providing such services are compounded in countries where the degree of monetisation of the economy is limited. Here, administrative services tend to be rudimentary so that in addition to catering for the rapidly growing population, a catching-up process needs to take place for the current population. Such catching-up is too slow for youth who are no longer satisfied with traditional semi-subsistent lifestyles. These normal problems of the development process can be exacerbated by the relative remoteness and isolation of the individual island communities. Many youth seek a way forward by migrating to urban centres where paid employment is not expanding. Frustrated aspirations often lead to crime. Add to this the existing managerial inadequacies and it becomes easy to despair.

Hovering in the wings is the issue of sustainability. This has two dimensions: the international and domestic. On the international front, Agenda 21, the global action plan adopted at the UN's Earth Summit in Rio in 1992 designated small islands as a vulnerable group warranting special international attention as they will be the most effected if the sea level rises from global warming. The UN's Global Conference on Sustainable Development of Small Island Developing States was the first "follow-up" to the Earth Summit. It was held in Barbados over April/May 1994. Its goal was to prepare a strategy for sustainable development specific to small islands based on the Barbados Declaration. This is an early test of the "global partnership" formed at the Earth Summit, by which rich and poor countries agreed to act together to pursue sustainable development - that is, economic development that meets present needs without jeopardising the welfare of future generations by undermining the environment on which all life depends. The lack of will and commitment by the international community to effective action is symptomatic of the lack of political significance of the island states. Indeed action is only likely when islands actually start to "sink".

On the domestic front the issue of sustainability is also complex. Many conflicting agenda surface in the attempt to formulate policies. Such conflicts are a part of any interaction

between interest groups, and their resolution is the central purpose of any political system. However, typical political policy debate has a short time horizon. 'Sustainability', 'greenhouse effects', and 'rising sea levels' are long term issues with great uncertainty attached to the many parameters. Agenda on these issues have to consider a set of alternative long-term scenarios. The further out in time any scenario goes, the greater the cone of uncertainty and the easier it is for current decision-makers to avoid hard choices. However, in the South Pacific we are not just dealing with the niceties of debate, decision making and implementation. Rather, the complexities are compounded by ineffective and unstable governmental structures. Many issues of excessive logging and fishing are well understood but monitoring - let alone policing - compliance with national forestry and fisheries policy is virtually non-existent (*Sydney Morning Herald* 17/1/95, p.10). Oversize bureaucracies in national capitals are currently incapable of preventing colonial-type resource plundering. Until national governments become more focussed, attempts to encourage sustainability will have to rely on local communities and enhancing their capacity to manage the resources over which they actually exercise control. This is a prime motivation of the Kandrian-Gloucester Integrated Development Project (KGIDP) in the West New Britain (WNB) province of Papua New Guinea. This is a joint project of the PNG and Australian governments and is largely funded by AIDAB.

2. LOCAL RESOURCES - THE SIGNIFICANCE OF COCONUT

One of the early tasks of the KG project was a set of socio-economic baseline surveys. Typical among these surveys was that in the Kove area. In the sample villages, 93% of households had bearing coconut palms (an average of 413 palms/household - representing about 2½ hectares). Sales of copra during the previous year accounted for 79% of cash-crop income. More families had copra as a source of income than any other activity. However, wages, village business, and remittances generated more income in total for the villages, although few were involved in these activities (KG Project, 1993). These survey results are typical in their portrayal of the significance of copra in the South Pacific. Other surveys present very similar stories (e.g. Jones *et al* 1988). Removing and drying coconut kernel to make "copra" has been the primary source of income for coastal people in the South Pacific for generations. Many still depend on copra sales for school fees, taxes and to purchase the basic necessities of cooking oil, soap, some basic foods, and fuel for lighting and boat engines.

Coconuts are a naturally sustainable resource and their significance for village life is far greater than being merely a cash crop. Coconut palms are ideally suited to island environments. They are one of few plants that tolerate poor sandy soils with saline water, and which survive cyclones. Coconut palms bear a bunch of fruit each month for about 65 years of their 70± year life span. They require minimum maintenance. They are one of the few tree crops for which there are no economies of scale. About 90% of the 45 billion coconuts produced per year in the world are grown by about 10 million smallholder farmers. For island people, **coconuts are a way of life.** They call the coconut palm the "Tree of Life". It provides shade and shelter, food in a variety of forms (cream, water, juice, sugar), fibre, wood, fuel and artefacts. It is the traditional crop of the indigenous people, so traditional that they barely know how to express its importance in their farming systems and in their diet. In many places, coconuts continue to be planted to match increases in population.

As a cash crop, copra production has lost its attraction. Over the last 50 years competition from other oilseeds has unsteadily eroded copra prices at about 2% per year ("unsteadily" because copra prices are extremely volatile. Over the last decade, CIF Rotterdam prices have ranged from a low of US$ 150/ton (mid-1986) to $540/ton (early-1985).[1] Of 42 primary commodities analysed by the World Bank, copra was the 38th most unstable and coconut oil was worst of all (World Bank, 1990, p. 181). Smallholder coconut farmers in the South Pacific are sensitive copra prices (Fleming and Jones 1989). At low prices, copra production drops and large numbers of nuts are abandoned where they fall. The loss of their prime source of cash income is one of the factors encouraging landowner groups to sell off logging concessions to their rainforests.

The importance of the coconut in the islands is recognised by international institutions. The Asian Development Bank noted in regard to the Solomon Islands that:
Nothing could benefit the rural economy more and no benefit could be transferred to the smallholders faster than an increase in the value which they receive for their coconut sales. (ADB 1983)
In regard to Vanuatu, the opening sentences of the Executive Summary of the 1993 report of the French agricultural research organisation CIRAD (successor to IRHO) on the coconut sector, read:
Copra plays a fundamental role in the Vanuatu economy and in income distribution. Given the limited use of [purchased] inputs and the efficiency of domestic marketing circuits, copra production enables greater distribution of income to rural inhabitants than any other agricultural activity, which is a major social factor. (de Taffin et al for CIRAD 1993)

Although coconuts represent a **continuous sustainable resource**, low and highly unstable prices mean that this resource is grossly under-utilised. Coconut palms provide a continuous sustainable source of nuts and fronds. When they stop bearing, the timber becomes available. The constant supply of nuts has the potential to provide processing plants with consistently high throughput (Etherington 1991). This conveys an enormous economic advantage over processing highly seasonal crops. With this in mind, what has the international response been to the management of this sustainable resource?

3. INTERNATIONAL RESPONSES

Price support has been one approach. The instability in international copra prices (about a declining trend) has a particularly severe impact on countries such as Vanuatu where copra production represents 5 to 10 per cent of the GDP depending on the year and on fluctuations in world prices. The impact of the price fluctuations on the rural economy have been offset for a number of years by STABEX funds from Europe. STABEX funds can be used for investment purposes within a sector. The long run implication of using these funds only for supporting the price to growers depends on whether the growers have been using the funds for consumption or investment purposes. The issue has, however, become academic since these funds have run out. The system could not contend with the continually declining price trend. Copra is still the country's main export, accounting for 30 to 50 per cent of total export revenue. Thus the declining copra price impacts the terms of

trade. This in turn impacts domestic savings (Jayaraman 1993). A similar pattern has been true in PNG (Jolly *et al* 1990) and the Solomon Islands.

Surprisingly, **supply enhancing projects** have been another response. The Australian Centre for International Agricultural Research (ACIAR) has had a coconut improvement project going for over seven years. A senior CSIRO scientist working with the program explained its objectives:

> "This project aimed to increase the productive potential of coconut palms in the region. . . . It was argued that there was some really poor material growing around the islands and new hybrids would give a big boost to yield potential. . . . In the event it appears that it doesn't matter if new strains or hybrids are higher yielding because overall there is a great surplus of coconut production. That surplus is the result of the very poor price for coconut products on the world market." (Foale, pers. comm 1993/12/21).

While the project achieved some significant goals, it and similar supply-increasing projects by the French in Vanuatu and the European Community at Taveuni in Fiji have been total failures in meeting their prime objective of increasing rural incomes. Recent studies with the blessing of the Consultative Group on International Agricultural Research (CGIAR) (Persley 1992) and the World Bank (Green, ed. 1991) continue to support action plans aimed at increasing coconut supply. Their prime focus is on embodied technological change which requires that the new varieties be planted for there to be any benefits from the research. If the planting does not take place, there can be no return on the millions of dollars spent on these research programs (Etherington 1993). These studies have given scant attention to improving the demand for coconut products (Etherington 1988, 1991). This is surprising since the copra industry and its processing methods are legacies of the age of empire when raw materials were shipped from the colonies to centralised, large-scale, metropolitan processing plants. Processing technologies have changed little since.

4. ALTERNATIVE POLICY OPTIONS

What do you do with a crop which has enormous cultural significance, has so many non-monetary uses, is a critical stabilising factor for the environment but whose monetary value has declined so markedly over the last fifty years? The 1993 CIRAD report on Vanuatu posed four policy questions which are relevant throughout the south-west Pacific.

- Should copra be crushed locally and the oil and meal exported?
- Should technically advanced processing of desiccated coconut or coconut cream for small niche export markets be adopted?
- Should exporting be the key strategy or is it possible for some import substitution with coconut oil to be undertaken?
- Specifically, is it technically feasible and economically viable for the local substitution of coconut oil for petroleum products?

If the answers to these questions are all negative then the implication is that the cash-income aspect of coconuts will simply continue to decline and the crop revert to its subsistence status of pre-colonial times. If this is the only scenario then other sources of income will have to be found or the rate of urban drift and emigration will increase. The implications for the sustainability of Pacific island communities is very serious indeed..

The first two questions have been the subject of numerous studies in almost every country of the South Pacific (see Wall 1986). The CIRAD report quickly dismisses them either as being directly uneconomic (copra crushing) or because of the risks of being undercut by more technologically sophisticated economies. In either case, Vanuatu suffers the "structural disadvantage" of its distance from world markets and the scattered nature of the archipelago.

It is in posing the last two questions that the CIRAD report is radical. It effectively turns the export disadvantages on their head and looks at the natural protection of domestic markets given by isolation.

> 'Vanuatu's geographical position - insular, with a scattered archipelago - undoubtedly increases the cost of CIF operations for exports, but also increases the costs of imports. For example, petroleum products are already expensive by the time they arrive in Vila or Santo, and the fact that they are transported to the islands in 200-litre drums leads to a further massive increase in price. What was a structural disadvantage for exports becomes a structural advantage if . . . products can be used on the local market to replace certain imports. This is even more advantageous if the products are used on the islands: copra is no longer subject to the cost of either international transport or transport between the islands (32% and 16% of the cost of CIF operations respectively), whereas the imported product is subject to both types of costs and reaches the islands at a very high price.' (de Taffin et al. 1993, p. 34)

The lack of local processing is reflected in the high prices of edible CNO on domestic markets. For example, the copra production of the northern Cook Islands is shipped to Tahiti and then transhipped to Auckland. The copra is crushed and refined in Auckland. Rarotonga (capital of the Cook Islands) buys its CNO from New Zealand. This oil has to compete with vegetable oils totally produced in New Zealand (or Australia).

Two corollaries follow if the "structural disadvantages" are to be transformed to local advantage:

1) it must be possible to produce the oil locally without a large copra mill, and
2) there must be imported products for which coconut oil is a good or at least acceptable substitute.

CIRAD presents two small scale oil production options (see also ILO 1983):

A) Modest mills using hot coconut oil as the drying medium for fresh copra and then expelling the oil using small but conventional mechanised screw-press expellers.

B) Manual expelling using a heavy duty Bielenberg oil-seed ran press.[2]

5. DIRECT MICRO EXPELLING

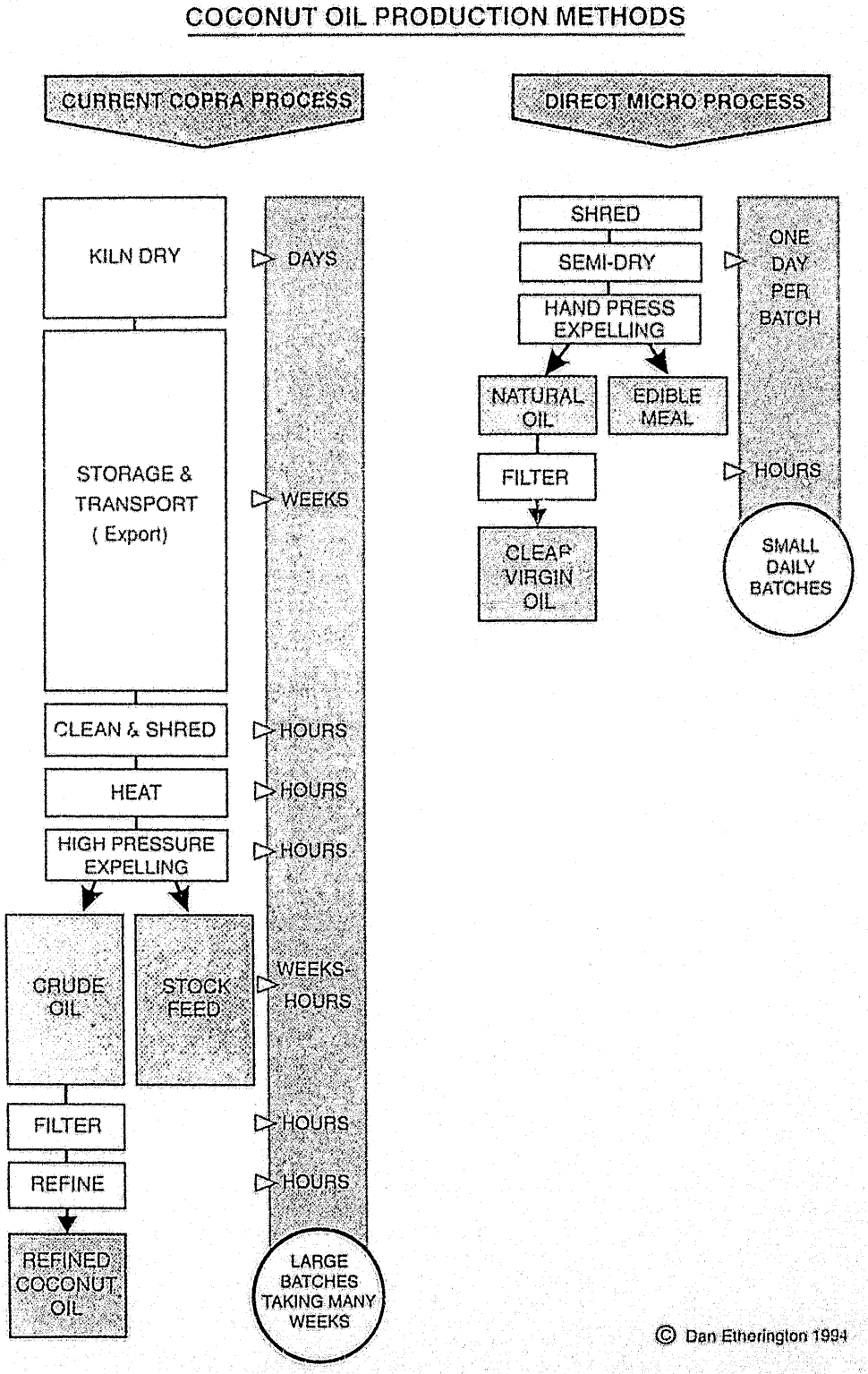
The author has, with a network of colleagues, developed an alternative process (Etherington et al. 1993, Morton 1993) which is partly based on some original British research at the Natural Resources Institute (NRI) (Hammond et al. 1991). **Direct Micro Expelling** (DME) uses partially dried grated coconut to produce a cold pressed oil on the same day the nut is opened. It by-passes copra production entirely. The technique makes use of the fact that with the right moisture content, oil is preferentially expelled at relatively low pressure. In the NRI experiments, the pressures were in the range of 700 kPa to 3.5 MPa. Screwpress expellers typically generate pressures in excess of 70 MPa. Low pressure expelling allows for the production of a water-clear, aromatic oil which is vastly superior to crude copra oil.

The re-discovery of low pressure expelling (it is based on observations of a village technology used in Tuvalu - Timmens, 1978) should spawn a whole generation of very simple, inexpensive manual expellers suited to villages and households. No longer is high pressure the binding constraint. The choice of technique for CNO extraction has been increased significantly. The particular manual press developed by the author weighs less than 15 kg and has a throughput of 15 to 30 kg copra-equivalent/hour. The capital costs is a fraction of alternative systems. The press can also be used for the domestic production of coconut cream.

Figure A illustrates the contrast between the time taken for the production coconut oil from copra and Direct Micro Expelling. The former involves building up large batches over many weeks. Storage and shipping involve further delays with deterioration of the copra quality and loss of oil before expelling and refining takes place. There appear to be many potential advantages to DME:

1) Processing the flesh immediately after it is extracted greatly reduces the growth of micro-organisms and contamination of the raw material.
2) Drying is much more efficient when using shredded coconut meat. Whereas copra takes from one to four days to dry (depending on the type and efficiency of the drier used,[3] shredded coconut can be dried in twenty minutes to 4 hours (Banzon et al 1982, p. 206, UNIDO/APCC 1980/1982 Part 4, p.22). Furthermore, in this direct processing the optimum moisture content is much higher than for copra, and solar drying can be used instead of kilns. Hot air dried (HAD) copra is typically processed in batches of at least 1,000 nuts. DME can handle batches from 10 to 300 nuts/day. Such tasks can fit in more easily with daily village routines.
3) Pressing hot, dehydrated coconut saves the reheating required in a copra mill.
4) The direct process gives a clear natural coconut oil with a negligible free fatty acid content. This virgin CNO is a final product with a long shelf-life. It is directly edible and **requires no further processing.**[4]
5) Production is not contingent on the timeliness of shipping services. Irregularity of fuel supplies is a major problem for schools and hospitals in remote island locations.
6) The international market for copra is very unstable. There is virtually no local market for copra *per se*. By contrast, cold pressed virgin coconut oil will find a ready local market as a cooking oil, cosmetic and possibly as a fuel.[5]

Figure A



7) The co-product of the direct process is an **edible** high protein meal.
8) Finally, the scale of operation is similar to typical South Pacific smallholdings with two to five hectares of coconut and, as with coconut production itself, there are few economies of scale.

6. LOCAL, "LIQUID FUEL", MARKETS

The local market for cold-pressed coconut oil (CNO) will probably start at the household level as a body oil. CNO is widely used for this **cosmetic** purpose for feasts and celebrations ("singsings"). The current local market price for this body oil made by the 'kitchen method' of boiling coconut cream, is about US$ 4/litre in Melanesian countries. **Cooking** oils vary in price by type and quantity but US$ 3/l is quite typical. Expanding domestic soap production also becomes a real possibility.[6]

However, such markets, while valuable, are strictly limited. For example, in Vanuatu, the substitution for imported cooking oils would only take up about 500 tons of copra equivalent (t.c.e.) per year. Undoubtedly the largest, and most rapidly expanding, local oil market is for liquid fuel - kerosene and diesel. Again using Vanuatu as an example, the CIRAD report calculates that a 30% penetration of the diesel market in Vanuatu would account for about 6,000 t.c.e. In fact, the amount of copra diverted will depend critically on the technical efficiency of oil extraction. If at a village level the average extraction rate is only 70% of the available oil, then 6,000 kilolitres of automotive diesel oil (ADO) (about 1/3 of the market in 1992) would be obtained from about 13,000 t.c.e. which is about 50% of smallholder copra production in Vanuatu. Such a switch in the market away from traditional exports would represent a radical shift.

The CIRAD estimate, however, may be conservative since it assumes that the market shares of the various petroleum products remain constant. The possibility exists for there to be an increasing penetration into the petrol market if marine diesel engines become more popular. **Table 6.1** compares the capital and operating costs of two-stroke and diesel outboard engines. If the engines last three years and are operated for only two hours per day for 300 days/year, the overall costs of the diesel will work out at about half of those of the equivalent petrol driven engine.

What is true of the diesel market could also impact the smaller kerosene market. Kerosene is primarily used as a lamp fuel. Simple coconut oil lamps have been used in Sri Lanka and India for centuries and adaptions for these could be used instead of hurricane lamps. But of possible greater significance is the work of Oliver Kennedy at the University of Wollongong. Kennedy has developed a retro-fit device that allows a pressure lamp to be operated on 100% coconut oil. There is a need for similar work to be undertaken on kerosene fuelled cookers. Studies in Fiji have shown that both these items have very high income elasticities of demand (Siwatibau, 1981).

Table 6.1 Comparative Costs of Diesel and 2-Stroke Outboard Engines

Assumptions

Outboard Engine		Capital costs US$	Fuel Consumption l/hr
Diesel	27-hp	6,500.00	13
2-Stroke	40-hp	2,500.00	26

Fuel	US$/litre	Discount rate
ADO	0.53	0.05
Petrol	0.74	
2-stroke oil	3.00	
Lube oil	3.00	

Diesel Outboard

Hours/year 200	Years 1	2	3
Capital Cost	6,500.00	0	0
Maintenance	500.00	500.00	500.00
ADO	1,381.65	1,381.65	1,381.65
Lube	15.00	15.00	15.00
TOTAL	8,397.65	1,898.65	1,899.65
PV of Costs	8,306.34	10,028.47	11,669.46

Summary

Hrs/year	PV of Costs US$
200	11,669
300	14,252
400	16,835
500	19,417
600	22,000

2-Stroke Ourboard

Hours/year 200	Years 1	2	3
Capital Cost	2,500.00	0	0
Maintenance	500.00	500.00	500.00
Petrol	3,833.39	3,833.39	3,833.39
Oil	312.00	312.00	312.00
TOTAL	7,146.39	4,647.39	4,648.39
PV of Costs	6,924.18	11,139.50	15,154.95

Summary

Hrs/year	PV of Costs US$
200	15,155
300	21,480
400	27,806
500	34,131
600	40,456

Of all vegetable oils, coconut oil is technically the most suitable as a direct substitute for diesel fuel. Numerous studies in the Pacific, SE Asia and Australia have shown this.[7] The significance of the "liquid fuel" market for the coconut industry lies in the fact that it is a rapidly expanding market where the long term relative price trend is likely to be upward. Thus, the technical suitability of coconut oil as a fuel, the expanding fuel market, the abundance of the coconut resource in many remote locations, and trends in relative prices, all encourage an examination of the economics of substitution.

7. THE ECONOMIC CASE

There have been numerous studies of the economic potential for vegetable oil fuels. The University of Upsalla, Sweden and the University of Idaho, USA are two major centres that have conducted many studies on the economics of agricultural fuels. Hickenbotham (1988) examined the economics of vegetable oils as fuels for two scenarios. An increase of 2.6 times in conventional diesel fuel prices was required in the US for vegetable oils to compete as diesel fuel substitutes. The social costs of mandating 1% to 5% of vegetable oil use as fuel was about $2/gallon giving a total cost of over $3/gallon compared to 1981 retail price of diesel of $1.06/gallon. Thus vegetable oil-based fuels are not now viable alternatives to diesel fuel in the US. However Gavett & van Dyne (1992) show that using existing facilities with the US government agricultural set aside programs could result in biodiesel at $0.59/gallon. Such biodiesel burns cleaner than diesel fuel and meets new stringent environment constraints.

In a similar studies, Goetzke (1988) concludes that rapeseed oil is not economically practical in Germany, and that rapeseed oil prices would have to sink far below the world price for diesel fuel for its use as an energy fuel to be encouraged by the EC. Zaffaroni, Kaufman & Pratt (1987) review the Brazilian vegetable oil production, test results and options for use in diesel engines. With current international prices, use of vegetable oils as substitutes for diesel oil is not feasible in Brazil. Caringal (1989) explored the development and economic analysis of rapeseed methyl ester and Johansson and Nordstrom (1982) found that crude rapeseed (lobra) oil was priced only 15% higher than diesel fuel in May 1982 implying a narrowing of relative prices.

McCombs (1985) analyses the potential of small farms in Latin America to produce vegetable oils and ethanol as substitutes for petroleum based fuels and fertiliser, including an economic analysis of strategy options. While none of the systems can compete with current international diesel prices, he gives a qualified defence of a pro-biofuel policy. He sets research priorities and a framework for selecting pilot farms which can start commercial production of liquid biofuels.

The situation in remote islands is significantly different from large conventional analyses. Hammonds & Smith (1987) explore the economics of small scale vegetable oil expelling and note that the results are highly site specific. Jael (1991) states that there are many islands in the Philippines where coco-methyl ester will compete with diesel fuel because high transport costs. This too is the argument of CIRAD in relation to Vanuatu.

Tables 7.1 and **Table 7.2** illustrate the potential for the Solomon Islands and Vanuatu respectively. The basic assumption is that the cost of producing coconut oil locally with low-pressure expelling techniques is not too different to producing hot-air-dried (HAD) copra. The tables also reflect the potential significance of price fluctuations. Data are from 1992 during which year the copra price rose sharply. The rural Copra Buying Centre price for copra in the Solomons moved from SI$ 0.30/kg to 0.44/kg during the year while the price of diesel was steady at SI$1.50/litre (SI$300/200 litre drum in rural areas - vs $224/drum at major ports).

Table 7.1

Implied Price of Coconut Oil and Actual Diesel Prices[a], Solomon Islands 1992 (US$/litre diesel equivalent)			
Expeller Efficiency %	CNO March	Diesel	CNO August
60	0.29	0.51	0.43
70	0.25	0.51	0.36
80	0.22	0.51	0.32

[a] Assuming that the cost of extracting CNO is the same as for making copra. Assuming 65% oil in the copra, conservative CNO recovery rates, a density of CNO of 0.942, and a thermal differential between CNO and diesel of 0.85 and converting to US$ at an exchange rate of SI$ 2.94 : US$.

Table 7.1 shows that at all extraction efficiencies and commodity prices, there is an economic incentive to produce CNO as a diesel fuel substitute.

In Vanuatu, the situation is similar. The August 1992 beach price for HAD copra was 25,000 Vatu/ton (or 15,000 V/ton for smoke-dried copra). This was the highest price for 3 years. In 1991 the quarterly prices ranged from 18,000 to 21,400 V/ton and were above the f.o.b. prices due to the operation of a stabilisation fund. F.o.b. prices in 1991 ranged from 14,000 to 22,850 V/ton. The March 1992 f.o.b. price was 32,400 V/ton. (The exchange rate was US $ 1.00 = 110 Vatu). Undertaking the same exercise as in **Table 7.1**, we have the following relative prices:

Table 7.2

Implied Price of Coconut Oil and Actual Diesel Prices[a], Vanuatu 1991-2 (US$/litre diesel equivalent)			
Expelling Efficiency %	CNO Sept 91	Diesel	CNO Sept 92
60	0.47	0.59	0.65
70	0.40	0.59	0.55
80	0.35	0.59	0.48

[a] No allowance is made here for additional costs of extracting the coconut oil

As the efficiency of oil extraction improves, the cost of CNO declines. According to the 1991 Vanuatu Smallholder Agricultural Survey, the overwhelming reason given for not making copra in 1991 was the low price of copra (GOV 1991). In terms of relative prices, there is less incentive for people in Vanuatu to want to substitute CNO for diesel than in

the Solomons. Yet even in Vanuatu it should be worth expelling CNO locally to displace diesel fuel if the extraction efficiency is great than 70%.

In both cases, the diesel fuel price sets a floor price for CNO. However, this "floor price" will only come into effect after the higher priced markets for cosmetic and cooking oil have been satisfied.

8. CONCLUSIONS

In this paper, it has been argued that providing villages in the South Pacific with a technology that enables them to extract CNO at a local level, can enhance their incomes and improve the sustainability of their communities. **Figures B** and **C** illustrate the potential impact of modifying coconut processing technology in such a way as to enhance such sustainability. **Figure B** shows the "aid-dependency", migration, resource-removal, nature of the island economies relying on copra as their major source of income. **Figure 2** shows the potential for improved sustainability and enhanced incomes that might flow from the local production of CNO. Having viewed the technology, Foale wrote:

> ". . . You have a relatively simple technology that can be delivered at a totally novel level into the target group. This could be taken up by individuals and households with the prospect of generating a steady flow of cash income in direct proportion to the effort expended, at least up until the present surplus of coconut production over use had been accounted for. Provided the market developed to absorb this new supply of fuel, food oil and raw material for value-adding, there would be new life and energy injected into the economy at the grass roots. This has, in my view, the greatest potential for economic and social benefit of any rural technology that has ever been proposed for the South Pacific. (M. Foale, pers. comm. 1993/12/21)

While the focus of this paper has been on the potential of the domestic market, some islands might also be able to export their oil because it is a high quality, high-value, low-bulk commodity. The relative isolation of many of the islands gives domestic production a significant degree of natural protection - protection that can be used to enter the local fuel market. Politically and economically, the most isolated island in the South Pacific is Bougainville which has been subjected to a trade embargo for four years. The embargo has forced the community to use coconut oil in precisely the ways suggested in this paper: as a lighting fuel and as a diesel substitute. In doing this, Bougainville has had to use a far more labour intensive technique to produce the oil than Direct Micro Expelling.[8]

How long will it be before other islands follow suit by using this abundant renewable resource, much of which is currently going to waste? Does Greenpeace Pacific have such a strategy in mind when it talks of a fossil-fuel free Pacific? Is this a suitable strategy for the Sustainable Development of vulnerable Small Island Developing States that was the focus of the Barbados Conference in April/May last year? If the micro production of coconut oil becomes a reality, could it provide the basis for self-sustaining improvements in living standards? Can imports be switched from consumables to investment goods and consumer durables and exports to a higher value-added component? Indeed, is a move from the scenario shown in **Figure B** to that given in **Figure C** possible?

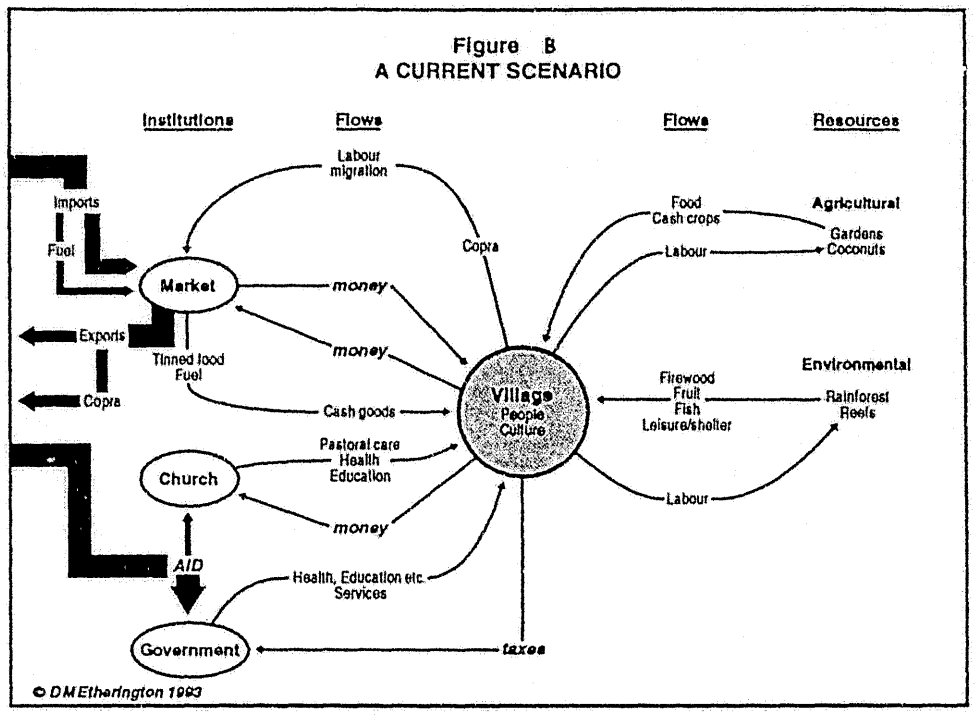


Figure B
A CURRENT SCENARIO
Institutions
Flows
Flows
Resources
Labour migration
Imports
Fuel
Market
money
Exports
Copra
Tinned food
Fuel
money
Copra
Food
Cash crops
Agricultural
Gardens
Coconuts
Labour
Village
People
Culture
Cash goods
Firewood
Fruit
Fish
Leisure/shelter
Environmental
Rainforest
Reefs
Pastoral care
Health
Education
Church
money
Labour
AID
Health, Education etc.
Services
Government
taxes
© DMEtherington 1993

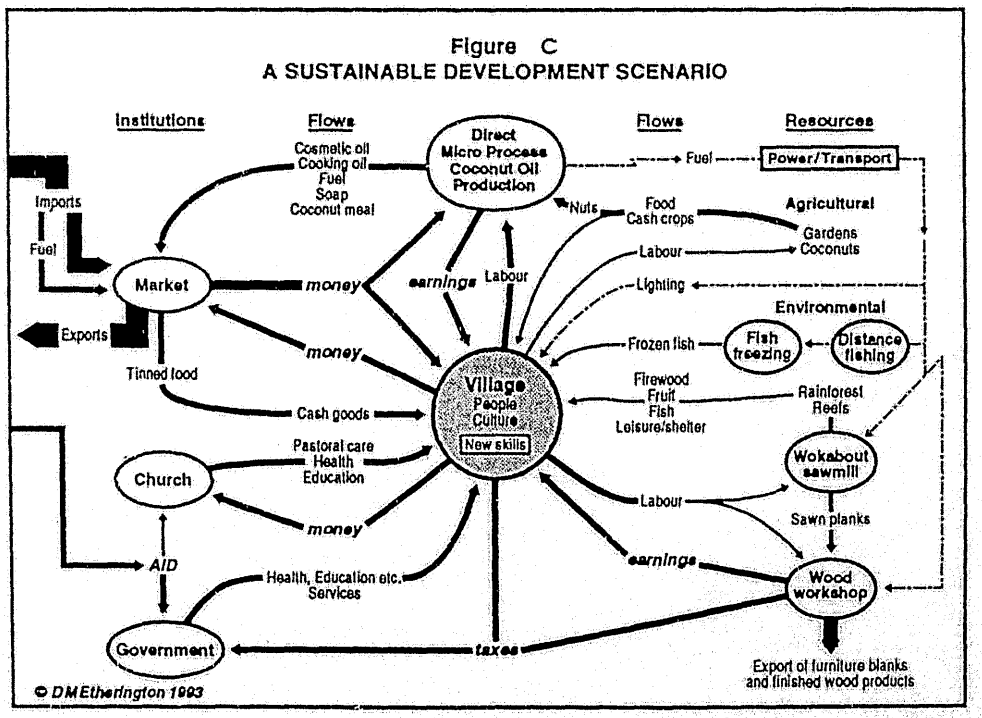


Figure C
A SUSTAINABLE DEVELOPMENT SCENARIO
Institutions
Flows
Flows
Resources
Direct
Micro Process
Coconut Oil
Production
Cosmetic oil
Cooking oil
Fuel
Soap
Coconut meal
Fuel
Power/Transport
Imports
Fuel
Market
money
earnings
Labour
Nuts
Food
Cash crops
Agricultural
Gardens
Coconuts
Labour
Lighting
Exports
money
Tinned food
Environmental
Frozen fish
Fish
freezing
Distance
fishing
Village
People
Culture
New skills
Cash goods
Firewood
Fruit
Fish
Leisure/shelter
Rainforest
Reefs
Pastoral care
Health
Education
Church
Wokabout
sawmill
money
Labour
Sawn planks
AID
Health, Education etc.
Services
earnings
Wood
workshop
Government
taxes
Export of furniture blanks
and finished wood products
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1. Current copra prices are again relatively high at around $450/ton.

2. The budget costs of trial units (without buildings) are given as US$ 87,000 (10,425,000 Vatu) and US$ 10,000 (1,200,000 Vatu) respectively. The throughput of the two systems is 100 to 150 kg/hour and 10 to 20 kg/hour on a copra equivalent basis.

3. The indirect-heat "Kukum" drier used by smallholders was developed in the Solomon Islands in the 1950s. This drier requires three days to dry a 1000 nut batch of copra (300 kg to 400 kg). During this time the kiln is fired for two eight hour periods and uses about 500 kg of dry fuel (wood, husks and shell, fronds etc). Copra drying can be dangerous since one is using fire to dry a good oil fuel. Driers often catch fire and are destroyed.

4. Further processing might be undertaken for special uses. Natural, virgin oil that has not been subjected to chemical processes may have 'health food' attractions. It should also have the attraction of not requiring as much processing as copra oil.

5. To increase company profits, an estate manager on Kar Kar Island PNG, made batches of superior grade solar dried copra and immediately expelled the CNO. This CNO would be similar to directly expelled CNO. It found a ready local market and is now being exported in 200 ml bottles to Australia as a cosmetic oil (D. Hill, pers. comm. June 1993).

6. The author's "conversion" to the potential of domestic markets came as a result of visiting a village soap maker in Mozambique in 1992. This entrepreneur had the coconuts, the soap-making technology and a ready, proven and reliable, local market. His only problem was that his source of CNO dried up when the local copra mill closed down for rehabilitation. In spite of valiant attempts, he could not produce sufficient oil from a bench press using a 50 tonne hydraulic jack.

7. The extensive literature is reviewed in Etherington & Hagen 1993. Jamieson & Thillainadesan 1987, Kaufman 1984, and Thillainadesan 1989 provide important studies in the SW Pacific. The most recent exposure of the potential of this fuel was in the ***Energy Challenge*** competition held at the end of November 1994. The University of Wollongong entered a standard Toyota Hi-ace van with a 4 cylinder, 2.4 litre diesel engine running on coconut oil. The criterion for the competition was the lowest Greenhouse Gas Index. This Index was devised by the NRMA. The CNO entry came third out of 40 vehicles entered and was only narrowly beaten by two diesohol-fuelled semi-trailers. An added bonus to the use of coconut oil as an automotive fuel is that it is a very much cleaner fuel than diesel.

8. Bougainville is not unique in the use of CNO in a "war" setting. The Tamil controlled areas of Sri Lanka have been reported to be using CNO to run all their diesels - including captured tanks.

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