Integrating Economics into Resource and Environmental Management

Some Recent Experiences in the Pacific

Padma Narsey Lal and Paula Holland

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FOREWORD

Standard economic classes in schools and universities often cover subjects such as macro economics, trade, micro economics and political economics, and many graduates go onto specialize in such subject areas. By comparison, resource and environmental economics as an area of specialization is less recognised in the Pacific. Few Pacific island governments employ resource economists or use economic analysis to inform how their natural resources can be best used. This is despite regular calls by Pacific Leaders to include economic considerations in environmental or economic development efforts.

We all know that Pacific islanders rely on limited resources and other natural endowments for their economic, social, cultural and spiritual wellbeing. In recent years, there has been a move from a subsistence lifestyle built on renewable, biodegradable and/or locally accessed natural goods and services to one using non-renewable, non-biodegradable and/or imported goods and services. This has generally necessitated increasing access to higher incomes such that there has been an associated increase in pressure on natural resources to meet this by, for example, increasing fishing or logging levels. Together with unsustainable levels of waste resulting from non-biodegradable products and increasing community sizes, many Pacific communities now face declining environmental quality and decreasing local reserves of some local resources such as fish. Efforts to control these situations have been conventionally dominated by a ‘preservation’ or ‘don’t touch’ management ethos. However, this ignores that communities ultimately need some access to natural resources to meet basic needs in a changing world. There is therefore an increasing acceptance that human development cannot occur through preservation, but must include sustainable resource use, too.

Resource and environmental economics can help in this endeavour by increasing understanding of human behaviour in an environment like the Pacific where resources are not infinite. Through this improved understanding of behaviour – and through assessment of human values for resource use – economics can also provide critical information to enable policy makers to compare different resource use scenarios and form robust polices.

Nonetheless, few graduates in the region appear to think about careers in economics related to the area of resource and environment management, or think about the relationship between households, sectors or trade, and resource allocation. The result is an extremely limited capacity in resource and environmental economics, generally in the Pacific region.

In response to this, IUCN-Oceania organized a small gathering of those practicing resource and environmental economists that were available in 2007 to form an informal network of people interested in resource and environmental economic issues. Following this in September 2009, IUCN-Oceania hosted Experiences in the Use of Economics in Resource and Environmental Management: a Pacific Resource and Environmental Economics Practitioners’ Workshop. The workshop brought together the known resource economists operating in the Pacific who were able to make themselves available at the time to discuss current issues and share experiences. The workshop participants presented key technical papers covering a wide range of thematic areas as well as practicalities and challenges of undertaking resource and environmental economic analysis in the region. These papers have been peer reviewed and compiled to form these workshop proceedings.

I am delighted to endorse this volume of the workshop papers which I am certain will become an important reference for people interested in applying economic analysis to inform resource decisions at all levels. I also congratulate the workshop participants who have decided to formalize the network to launch the Pacific Resource and Environmental Economics Network (PREEN). The PREEN will help support Pacific islands to critically assess and plan for sustainable development. With case studies such as this and an effective network of economists working to promote sustainable resource use in the Pacific, let us trust that environmental management in the Pacific is one step closer.

Taholo Kami

IUCN-OCEANIA REGIONAL OFFICE
(ORO) DIRECTOR

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CHAPTER 1

Introduction

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In 2009, IUCN-Oceania Regional Office in partnership with SOPAC and SPC established the Pacific Resource and Environmental Economics Network (PREEN). The PREEN was established in response to a need by the small but growing group of practitioners in the Pacific for a professional body to share information and access peer support to conduct natural resource and/or environmental economics in the region. The number of practitioners has risen as more governments and organisations in the region recognise the value of using economic information to improve resource management by informing policy options, underpinning advocacy and/or improving the transparency in decision making.

Resource and environmental management has conventionally focused on command and control strategies for managing the environment together with education and awareness strategies. Management efforts have not usually directly considered economic dimensions of people's behaviour and decisions though. Conversely, environmental conservation decisions often did not include livelihood or opportunity cost considerations associated with protected area declaration and management. Where government agencies did appreciate the role and relevance of economics, they often did not have the resources to employ dedicated natural resource economists in their administration. In any event, there are few trained resource and environmental economist available in the region, even to serve as consultants.

For those few natural resource and environmental economists that do operate in the Pacific there are few opportunities to meet professionally to share ideas and/or forums through which they can support each other. By necessity, many of the resource economists operate in isolation as they often are attached to scientific organisations, and where resource economics activities are often additional to the main focus. While the body of practitioners has increased slowly over time, the opportunities for them to share lessons and co-learn have nevertheless been limited.

The establishment of the PREEN is thus a significant development in the region to enable practicing economists to support each other in their work and share their experiences. Equally important is the opportunity for the PREEN to enable increased awareness in the appropriate use of resource and environmental economics in the Pacific and act as a collective set of expertise to help mainstream resource and environmental economics in resource and environmental management.

With the hosting of the first PREEN workshop at IUCN-Oceania in 2009 (see Annexes 1 to 4) it became apparent that the diversity of natural resource management issues being tackled using economics in the Pacific is wide. Yet, its nature will not come as a surprise to readers who understand some of the most pressing resource and environmental issues in the region today. Contained in this document is a subset of papers presented at the Inaugural PREEN Workshop that highlight:

- the diversity of policy issues and the types of resource and environmental economics projects/initiatives recently completed/currently underway in the region, and whether the initiatives were supply or demand driven, as well as policy implications and the impact the projects had, if any;
- diversity in methodological approaches adopted, even to address similar policy questions, as well as methodological and data challenges faced by resource and environmental economists and how these were overcome; and
- key challenges faced in developing and conducting such projects, and lessons learnt, including the encouragement of tangible policy outcomes and/or behavioural changes.

Although the papers presented at the workshop do not reflect economic analysis applied to every resource or sector in the Pacific, they nevertheless highlight critical contemporary issues for islanders in which economics can make a contribution. The papers also demonstrate that policy outcomes can be very different when resource and/or environmental economics information is incorporated to decisions than when they are not.

The papers presented to the workshop and subsequently, peer reviewed are grouped thematically in these proceedings.

Section I

Given the current preoccupation of the world with climate change, it will come as no surprise that Section I of these proceedings reflects economic activities underway in the region concerning disaster risk management and climate change adaptation. In Chapter 2, Economics of Disaster Risk Management, Holland et al. summarizes a variety of case studies in Fiji and Samoa recently undertaken to advocate for appropriate investment in flood avoidance or mitigation. The case studies highlight not only the potential benefit from investing in mitigation, but also the challenges in overcoming data gaps in the Pacific.

In Chapter 3, Vulnerability of the Fiji Sugar Industry to Disasters - An Economic Assessment of the 2009 Floods, Lal assesses the economic costs associated with the 2009 floods on the sugar belt in Fiji using the standard 'with and without' assessment. This case study highlights not only the costs of natural disasters in the region, but also the vulnerability of households to poverty as a result of such events. This paper also emphasises inconsistencies in methodologies and data types used to estimate economic costs of disasters in different projects that make it difficult to compare between studies as well as between events even in the same country.

In Chapter 4, Economic Cost Assessment of Climate Change, Lal reviews recent projects that assessed economics of climate change in the Pacific to highlight key methodological and data issues and challenges in the region. This paper highlights the need for robust scientific information about climate change scenarios as well as the effects of climate change across sectors and communities, standardized methodology and consistent use of concepts of values to determine costs and identify appropriate adaptation measures.

In Chapter 5, Impact of Climate Change on Samoan Agriculture, Manley and Sugano, present work in progress on the likely impact of climate change on land rent values, or Ricardian rent. Among the other important aspects of this work, they demonstrate the gaps in data that Pacific practitioners face in conducting such analyses. They also provide a practical example of some of the limits to economic frameworks in assessing some resource problems in the Pacific.

Section II

With limited incomes in a developing region and a high reliance on imported fuels, countries are experimenting with the adoption of different renewable energy technologies. Section II provides a number of studies recently conducted on biofuel-based renewable energy technologies. The papers presented demonstrate that, although there are many technically feasible biofuel technologies currently being promoted in the region, these technologies are either not always economically viable in Pacific islands, or that they must be designed with specific caveats in mind.

Thus, in Chapter 6, Economic Feasibility of Coconut Biofuel, Martin assesses the economic feasibility of coconut-based biofuel and demonstrates that coconut-based biofuel energy as a source of transport fuel may not become the norm. Key reasons they demonstrate include the limited supply of copra, declining returns to labour in copra production and the importance to communities of where they spend their time (socioeconomic opportunity cost of labour).

Likewise, Singh in Chapter 7, Economic Feasibility of the Tailevu Biofuel Project in Fiji, demonstrates that although coconut biofuel is promoted under CADT technology as a diesel fuel substitute, it will remain economically unviable unless specific key conditions are met, including diesel prices being consistently higher, initial capital costs paid for by donors, initiatives based on using the 'whole of nut' and other value-added products and machinery being regularly maintained.

By comparison, Stauvermann and Kumar in Chapter 8, Technical Diversification in the Fiji Sugar Industry, illustrate using macroeconomic analysis that large scale sugarcane-based ethanol production could provide positive economic returns to Fiji in the future, provided key institutional and production conditions are met and the declining state of the sugarcane production and the sugar industry as a whole, is also addressed.

Section III

The third cluster of papers in these proceedings examines the broader issue of mainstreaming resource and environmental economics to key resource and environmental management decisions. Thus, in Chapter 9 Economics of Tuna Management, Ram-Bidesi reflects on the management of tuna in the Western and Central Pacific through a review of some recent economic studies on key policy questions facing the countries. She notes the key economic drivers that appear to compel the fishing industry to overfish, despite decades of in-country 'management' and bilateral negotiations with distant water fishing nations. In light of her review, she also suggests that resource accounting and valuation techniques could provide useful insights into framing the Pacific Island Countries' (PICs) positions for negotiations in reaching agreements amongst the various interest groups.

In Chapter 10, Socio-Economic Assessment of Pacific Coastal Management, by Connor discusses how resource and environmental economics analytical framework can help understand influences and impact of various human activities and factors in the context of a catchment containing a continuum of environments from ridge (upland environments) to reef (coastal and marine) environments. He notes that such an understanding can help develop appropriate strategies for managing impacts on coastal zone environments.

In Chapter 11, REDD-Based Carbon Financing for Fijian Forests, Manley uses the opportunity cost concept to examine whether REDD-based carbon financing can provide sufficient incentive to avoid or reduce the extent of deforestation and forest degradation in Fiji. She compares the expected gross returns from agricultural activities, such as taro and kava production, to that from what could be achieved through the voluntary Carbon market trade through avoided conversion of virgin and secondary forests. Carbon financing alone cannot, she concludes, provide sufficient incentives for not converting forests to agriculture, even with the assumption that the institutional requirements for REDD and C-trade were met.

In Chapter 12, Economic Feasibility of Aggregate Mining, Holland et al. demonstrate the use of cost benefit and cost effectiveness analyses to inform key policy choices concerning coastal aggregate mining in atoll nations. They note that, given the threats to wellbeing of people from coastal mining and availability of limited number of alternatives to coastal aggregate mining, a rigorous analysis of options can help countries make informed choices as well as minimise other environmental impacts associated with some solutions. The paper, using three recent case studies from Tuvalu, Kiribati and Marshall Islands, demonstrates how economic benefit cost analysis and/or cost effectiveness assessments, supported by good scientific information, can be used to inform key policy choice in relation to coastal aggregate mining.

The last chapter in this volume, Chapter 13, Mainstreaming Economic Considerations in Waste Management Decisions, by Lal, demonstrates, using waste management case studies from Tonga and Tuvalu, that even where resource managers accept the role and relevance of resource economics in policy formulation, mainstreaming these considerations to decision making is constrained by limited capacity. This paper highlights the need for a basic understanding of the economic dimensions of waste throughout a project cycle and notes that this can be acquired relatively easily through 'hands on' targeted short training courses.

Overall, the papers presented in this proceeding highlight lessons learnt and key challenges in applying resource and environmental economics in the Pacific. Some of these challenges may be overcome using appropriate project design and hands on capacity development in the future. However, other challenges are likely to persist because of some basic data gaps, including incomplete scientific understanding and/or poor baseline information. These will be key challenges for effective decision making – and for economic practitioners – to face in the future.

SECTION I

ECONOMICS OF DISASTER RISK MANAGEMENT AND CLIMATE CHANGE ADAPTATION

Picture reproduced with the kind permission of SOPAC Survey Team, Fiji Floods.

CHAPTER 2

Economics for Disaster Risk Management

Paula Holland, Angela Ambroz and Allison Woodruff

INTRODUCTION

It is a long accepted fact that the Pacific is one of the most natural disaster prone regions in the world. Key natural disasters threatening the region include earthquakes, tsunamis, volcanic activity, landslides, cyclones and flooding. The impact of the disasters is wide ranging. At a humanitarian level, natural disasters in the Pacific have reportedly directly affected more than 3.4 million people and led to more than 1700 reported deaths in the region (PNG not included) since 1950 (Betterncourt, et al 2006). At a development level, they reportedly cost the Pacific islands region US$2.8 billion in the 1990s (in 2004 terms – Betterncourt, et al, 2006). At the national level, these losses can be devastating. The 'big ocean, small islands' context contributes to environmental, economic and social exposure in most developing Pacific island states. Further, the small size of most developing Pacific island economies means that disaster can have a disproportionately high impact on their economy compared to other countries. Accordingly:

- Cyclone Heta which hit Niue in 2004 sustained immediate losses in 2004 amounting to over five times that of GDP[1];
- The 2007 earthquake and accompanying tsunami that hit the Solomon Islands cost the country around SI$700 million – or 90 per cent of its 2006 recurrent government budget (ADB, 2007); and
- During disaster years, Samoa reported average economic disaster costs of 46 per cent of annual GDP (Betterncourt, et al 2006).

These are only the direct (and preliminary) estimates of the costs of disasters and are based in immediate losses such as the destruction of infrastructure and crops. However, natural disasters also indirectly impact economic growth further by removing access to infrastructure (e.g. inability to get produce or producers to markets) and lowering economic capacity (e.g. loss and/or disruption of educational opportunities). Accordingly, Fairbairn (1996) confirms that '… the direct damage to a country's productive base and associated macroeconomic instability can deal a substantial blow to ongoing efforts by these countries to achieve longer-term sustainability and improvements in living standards'.

Pacific islanders clearly recognise the importance of planning for and dealing with natural disasters, adopting in 2005 the Pacific Disaster Risk Reduction and Disaster Management Framework for Action 2005 – 2015: Building the Resilience of Nations and Communities to Disasters (Madang Framework). This regional strategy outlines the major policy imperatives recognised as needed, both nationally and regionally to address disaster. Additionally, through the Pacific Plan which is the overarching strategic development policy document for the Pacific region, the need for improved 'disaster risk management' practices and policies are emphasized by Pacific island countries as a way to enhance sustainable development.

[1] Total damage inflicted by Cyclone Heta was estimated at NZ$89.1 million (Government of Niue 2004). GDP statistics for Niue in 2004 are not available (Statistics Niue, personal communication, June 2008) although GDP in 2003 is reported as NZ$17.3 million (Statistics Niue, undated).

Disaster Risk Management

Disaster Risk Management (DRM) is the term given to activities that aim to reduce the risks associated with natural disasters, and/or address the ability of a society to respond to them. Conventional DRM activities in the Pacific reflect 'disaster management' (DM) which, when regarding natural disaster as inevitable, focuses on dealing with disaster occurrence as effectively as possible. Activities commonly include, for instance, preparation for disasters, response (emergency relief, rescue work, medical assistance, recovery, etc.) and rehabilitation. By comparison, current international thinking about DRM puts an increasing emphasis on 'Disaster Risk Reduction' (DRR) or mitigation activities that proactively reduce the likelihood that disasters will occur – or at least will lessen the scale of their impact. Accordingly, investment in DRR and mitigation is a key issue in the Madang Framework which recommends among other things:

- Reducing underlying risk factors by, for instance, promoting risk sensitive resource use policies and practices such as implementing appropriate building codes;
- Effective, integrated and people-focused early warning systems by, for instance, establishing effective monitoring and early warning systems, and delivering effective communications and awareness raising.

Despite the recommendations of the Madang Framework, investment in DRR or mitigation receives a lower priority in the Pacific than DM. This is likely to have much to do with the perception of natural disasters as a humanitarian issue, compelling governments and donors to focus scarce funds on immediate crises rather than planning for the future. However, investment in DRR or mitigation is also likely to be obstructed by the fact that the benefits are sometimes slow to appear – that is, it is a short-term investment for long term gains. Ironically, those benefits may be difficult to discern since they exist as averted costs.

The combined effect is that it can be difficult to persuade hard stretched national governments – or international donors with competing interests – to mainstream proactive DRM investment into plans and budgets. Given the magnitude of losses sustained by Pacific island countries as a result of disasters, and the need to minimise damage and losses in the future, a number of economic analyses have recently been undertaken in the Pacific to underpin advocacy for DRR and/or mitigation work. Presented in this paper are three analyses conducted to support DRM in flood management in Samoa and Fiji:

- Economic Analysis of a Flood Early Warning System in Navua, Fiji (Holland, 2008);
- Economic Assessment of Alternative Flood Mitigation Options in Samoa (Woodruff, 2008);
- Socioeconomic Assessment of Flood Losses in Nadi and Ba, Fiji (Holland, 2009; Ambroz, 2009).

RATIONALE FOR THE ANALYSES

All three economic analyses were conducted to advocate for appropriate investment in flood avoidance or mitigation in the future. In the case of Navua, Fiji (a rural centre about one hour west of Fiji's capital, Suva), an economic analysis of flood warning was conducted to support advocacy for increased investment by Government in disaster risk reduction. Navua is highly susceptible to flooding, with floods occurring an average of once every seven years. In the recent past, four of the major flooding episodes in the area have been initiated by intense and prolonged rainfall associated with tropical cyclones. Over the years, flooding has had considerable damage not only in the Navua township, but also in adjoining villages and settlements. Floods in 2003 and April 2004 caused extensive damage to crops, livestock, houses, roads and bridges. Thousands of people lost their homes and belongings. To minimise future damage from flooding, the EU had agreed to support the design and establishment of an early warning system. However, it was likely that ongoing financial support for the system would be needed by the government to ensure its long-term effectiveness. To demonstrate to governments the value of investing in the system in the long term, it was agreed that a benefit cost analysis of establishing the warning system would be useful. The benefit cost analysis was also used as an opportunity to consider other conditions needed to ensure the success of the system.

In the case of Samoa, a series of comparative economic analyses was conducted to determine which activity out of several should be funded. To mitigate the regular flooding experienced in Apia, Samoa's capital, numerous measures had been identified as potentially valuable, including the establishment of flood walls, a diversion channel, improving flood forecasting and/or the introduction of development controls. While each measure offered the potential to mitigate flood damage in the future, it was unlikely to be necessary or practical to implement all of them since the costs of doing so would be prohibitive and, in any event, only a selection of measures would probably be sufficient to substantially reduce flood damage. Consequently, an economic analysis of options was conducted to assist the Government of Samoa to compare options and select which measures to target.

In the case of Nadi and Ba, a socioeconomic assessment of flooding was conducted immediately following the devastating 2009 floods to determine the economic cost of flooding. The data was to be used to inform investment in flood mitigation and risk reduction in the future, such as (if appropriate) to advocate for flood mitigation and warning systems.

ANALYTICAL/ CONCEPTUAL FRAMEWORK AND METHODOLOGY

Navua

A benefit cost analysis of introducing and operating the Navua flood warning system was conducted using a 'with and without analysis' (Holland, 2008). Benefit cost analysis is a technique that evaluates the benefits and costs of a project from the perspective of society (as opposed to a single individual). It involves:

- Measuring the gains and losses to the community, using money as the measuring rod for those gains and losses; and
- Aggregating the monetary valuations of the gains and losses and expressing them as net community gains or losses (Pearce, 1983).

The economic benefits of a flood warning system are the value of reduced losses arising because of it. In practice, a warning system is likely to reduce the scale of losses that the Navua community would incur in the future. However, it would be unable to prevent them experiencing all losses. This is because a sufficiently timed warning would only enable families and businesses to prepare for the flood (protect some possessions, protect themselves, families and livestock), but would not prevent the flood from taking place. Some residual damage would therefore be inevitable, such as the loss of buildings or the destruction of crops which could not be moved (Holland, 2008).

The economic benefit of the flood warning system is therefore the difference over a certain time period between the value of economic losses that are likely to occur without the flood warning system, (e.g. the losses a repeat of the 2004 flood would impose today) and any reduced value of losses likely to occur with it. In economic terms, this involves a 'with and without' analysis of flooding in Navua.

For the 'without analysis', estimates were made of the losses that Navua would sustain if flooding occurred without an effective warning system. The costs of flooding without warnings were based on the last major floods impacting Navua in 2004. To determine these losses, two activities were conducted:

- a review of government records to identify government and international costs of the floods; and
- a household and business survey to estimate personal losses (information not collected by the government).

Government records of flood losses described costs associated with damage to infrastructure, government services (e.g. health, education), primary industries (agriculture and fisheries), as well as outlining assistance provided on humanitarian grounds by international and national agencies. Unfortunately, costs estimates were often not broken down to the Navua area itself. Since the 2004 floods had been spread across the country, many flood estimates for Fiji had only been calculated on a national or provincial scale only. Where this was the case, national or provincial losses had to be scaled down to the Navua area.

A sample survey of businesses and families around Navua was conducted to estimate losses by families. Sixteen (16) per cent of households and 31 per cent of businesses were interviewed. Once average figures were determined for groups of stakeholders (e.g. different types of businesses), values were extrapolated to the population.

A 'with analysis' of the warning system involved estimating the likely impact that warnings might have had on minimising losses. Benefits associated with each flood management option were measured as flood damage avoided. Flood damage sustained as a result of floods in Navua would not necessarily equate the benefits of a flood warning system to the area. This is because not all economic losses that occurred in the last floods would have been avoided had a successful flood warning system been in operation since:

(i) the flood would have happened anyway and (ii) some damage – such as destruction to “lean to’s”[2] and large-scale items that could not be rapidly moved (large-scale equipment, etc.) – would thus have occurred regardless. On the other hand, with sufficient warning, some smaller items might have been protected by moving them to higher ground (livestock, personal possessions) and some injuries might have been avoided by vacating the area earlier. This difference in losses sustained is the benefit that would arise from a warning system.

Estimates of the impact that a flood warning system might have had were based on stakeholder consultations (one-to-one and a focus group session) of what type of damage could have been avoided had a warning been provided one to three hours prior to inundation and how much. This information was used to estimate the benefits of the flood warning system using losses avoided as a proxy. For instance, senior hospital staff indicated that a quarter to half the losses sustained by the hospital could have been avoided had sufficient warning been provided since equipment could have been moved to higher grounds in time. Using such estimates, losses avoided were calculated by multiplying proportional savings by 2004 flood losses.

The costs of a warning system were provided by technical agencies contracted to establish infrastructure and from consultations with agencies supporting the work, including SOPAC and the Government of Fiji.

On the basis of this work, costs and benefits accruing over time from the operation of the system were estimated and discounted. A net present value and a benefit: cost ratio for investing in the system were then determined for each of three key stakeholder groups (community, Government of Fiji and all stakeholders together).

Samoa

A comparative benefit cost analysis (see above) of alterative flood mitigation measures was conducted for Apia (Woodruff, 2008). Over 2006 and 2007, the Government of Samoa, in collaboration with other agencies, developed a plan of action to reduce flood risks in the lower Vaisigano catchment area around Apia. The resulting Plan outlined a number of structural and non-structural management measures that could potentially reduce flood risk in the Vaisigano including:

- Structural flood management options:
  - Construction of floodwalls
  - Construction of a by-pass channel
  - Construction of a reservoir
  - Increasing channel conveyance
  - Pumping
  - River maintenance
- Non-structural flood management options
  - Development control-raised floor heights
  - Improved flood forecasting system

Before conducting a comparative economic assessment of measures, a stakeholder meeting was conducted for participants to prioritise and narrow down measures identified under the Action Plan for assessment. Four priority measures were selected as requiring consideration: the construction of floodwalls, the construction of a by-pass channel, improvement of the current flood forecasting system and strengthening of development control measures by requiring houses located in the floodplain to be built with elevated floor heights. A ‘with’ and ‘without’ benefit cost analysis was then used to determine the potential economic payoff of each measure.

For the ‘without analysis’, estimates were made of the flood losses that the Vaisigano area would sustain without mitigation measures. Information from published records was used to assess losses to government for issues such as infrastructure, education and churches. A dedicated household and business survey was used to estimate the value of household and businesses losses for items such as lost earnings and clean up costs. An associated stock-take of physical structures (height of floor, building material, size of building) was also carried out in the survey area.

[2] Rough shelter whose roof has only one slope.

While the data from the survey could be used to estimate business losses, data proved unreliable, specifically for the loss of personal possessions due to floods. Recall problems meant that most families were unable to remember either the types or values of losses sustained. Instead, loss of assets for families was estimated using a combination of selected data from the survey, together with GIS data and information from flood maps produced by SOPAC for various flood events and formulae from the US Corps of Army Engineers. In this case, US Corps of Army Engineers 'stage damage curves' display the relationship between flood height and the average proportion of a house flooded. Using this information – and referring to flood inundation maps for Vaisigano which identify the extent of building flooding under floods of different severity, the average degree of damage to buildings across the Vaisigano area was predicted. Additionally, the household and business survey determined typical household/business contents. US Corps of Army Engineers stage-damage curve display the relationship between floodwater depths and the percentage of damage to household/business contents. Using estimates of the average household/business contents from the survey, these curves were used to value flood damage to household/business contents without flood mitigation.

Benefits associated with flood mitigation were measured as flood damage avoided (damage suffered from flooding without the proposed measure in place less damage suffered from flooding with the measure in place). Data on the costs of measures was obtained from consultations with relevant stakeholder groups, including construction (floods walls) and technical agencies (e.g. flood monitoring). The impact of the mitigation measure on flood damage was determined using evidence from various flood studies (floodwalls/ embankments/ bypass/diversion channel), lead time damage function (prediction of damage prevented function, given warning times – improved flood warning/advisory system) and flood maps/US Core of Army Engineers stage damage curves (elevated flood heights).

On the basis of this work, costs and benefits accruing over time from the different mitigation measures were estimated and discounted and a net present value and benefit: cost ratio for investing in the system determined.

Nadi and Ba

An economic valuation of the losses sustained by families and businesses in Nadi and Ba greater town areas was conducted (Holland in press; Ambroz in press). Assessment was based on a sample survey in each town in which the following were interviewed: 18 and 6 per cent of households in Nadi and Ba respectively, and 17 per cent of businesses in both towns. The survey collected data relating to the full range of direct and indirect economic losses arising from flood damage, including: structural damage, lost assets or possessions, medical impacts (e.g. injuries), evacuation or relocation of people or goods, loss of wages and/or business, trauma and the loss of irreplaceable items (e.g. business and financial records, land titles, passports, school or work and/or items of sentimental value) (table 1).

Table 1: Direct and Indirect Losses Estimated for Nadi and Ba 2009 Floods

Direct	Indirect
Structural damage	Medical impacts
Lost assets or possessions	Evacuation costs
Loss of irreplaceable items	Relocation cos ts
	Loss of income/earnings
	Trauma

Data was cleaned to remove outliers or any inconsistent values. Gross monetary losses per respondent were then calculated for structural damage, assets or possessions damaged, medical impacts (e.g. injuries), evacuation or relocation costs and loss of wages and/or business. The term 'gross losses' refers to the total value of losses sustained for an item. In some cases, respondents may subsequently have experienced inputs that lessened the overall impact of the loss. For instance, a few respondents stated that they had some insurance which would mitigate their losses. In other cases, a few businesses stated that they experienced an increase in business following the floods because customers were diverted to them when they were unable to reach their preferred shop. Nevertheless, data to estimate mitigating effects of economic losses was not calculated due to the extremely small sample size of people who observed any mitigation or because people were unable or unprepared to put a value on the assistance or benefits they experienced. Consequently, only gross losses – not net ones – from the floods were calculated. This aside, most losses from the floods could reasonably be considered as net losses because the level of insurance and benefit from the flood was very low. Additionally, in calculating gross losses, no values were assigned to trauma or irreplaceable values.

The distribution of gross losses was determined for families and businesses and, within those categories, losses were grouped and average losses estimated. Average gross losses were then extrapolated within groups to the survey population.

In addition to the calculation of gross loss estimates, respondents were asked a variety of questions to reveal attitudes to flood warning (e.g. did they try to protect their possessions once they were aware that a flood was coming), how they received or passed on information within the community, or what their insurance coverage was. This information was used to identify policy issues related to future flood management initiatives.

RESULTS

Navua

The 2004 floods in Navua were estimated to have cost a minimum of FJ$13 million, including household, business and other losses. This value was likely to be conservative as it did not include the value of direct losses for the loss of critical records, nor indirect costs associated with trauma. Additionally, many respondents who stated that they had incurred losses as a result of the floods were unable to provide any estimate of losses or damage sustained. Nil values were retained for these cases, bringing down average values.

Successfully implemented, a warning system for Navua was estimated to most likely generate a minimum benefit: cost ratio of between 4:1 and 7:1. In other words, for every dollar invested in the system, it was estimated that savings of between FJ$3.70 – FJ$7.30 would be achieved. The investment return to the Government of Fiji specifically was estimated to be 1.1:1 to 2.2:1. The variation in values reflects uncertainty in the scientific community about the recurrence interval for the 2004 floods (estimated to be between once in 10 years to once in 20 years). Investment returns would likely be extremely conservative since numerous smaller (and potentially rare larger) floods would also occur during the life span of the warning system, generating greater benefits.

The results of this analysis were presented to the Government of Fiji National Disaster Management Council in March 2008 and resulted in a commitment at least at that time to fund the awareness raising and maintenance work needed to ensure effective operation of the system into the future. To the best of our knowledge however, this funding commitment did not materialise.

Additionally, the social data collected during the study is being used to develop a communication strategy to assist in the dissemination of flood warnings down to the community level. The strategy includes, among other things:

- how to reach people in an emergency, including at night (with results demonstrating that most of the community do not have access to a landline but prefer to use mobile phones. There thus might be potential to involve local phone companies (Digicel and Vodafone) to disseminate warnings via text messages);
- which community groups play an important role in undertaking education/awareness raising activities (with 30 per cent of respondents that were active in a community group stating that their group was the Methodist Church or local Mandirs).

Currently, the Navua warning system is physically in existence but operation has been temperamental due to institutional problems (e.g. lack of trained personnel to interpret data as well as adequate equipment to monitor data), or technical constraints such that some river and rain gauges are not operating as effectively as necessary.

Samoa

The cost of flooding without mitigation measures was estimated for floods of a variety of flood severity. Floods were estimated to cost an average of between WST$1.2 million for a 1 in 5-year flood through to WST$5.4 million for a 1 in 100-year flood. On average, damage from flooding for all sectors in the lower Vaisigano catchment area was estimated to be around WST$619 000 per year.

In the case of an improved forecasting system, the benefit cost ratio was estimated to be between 1.72:1 to 1.92:1 while the rate for constructing homes with raised floors was estimated to vary from 4:1 to 44:1 for wooden homes, and from 2:1 to 28:1 for cement block homes. Structural measures were found not to be economically viable with the benefit cost ratio for floodwalls estimated to be in the region of 0.1:1 to 0.64:1 (depending on the choice of floodwall design and discount rate) and the benefit cost ratio for diversion channels estimated to be in the region 0.01:1 to 0.09:1. These low expected payoffs result from the high costs of building and maintaining structures. Additionally, time-consuming and costly negotiations with landowners would further reduce the viability of the options. Although it is likely that many of the indirect or non-monetary benefits not captured in the analysis, such as avoided health costs or trauma suffered by residents during flooding, or reduced flood damages to households and businesses in nearby districts, would raise the benefit-cost ratios, it is unlikely that they would be significant enough to raise benefit-cost ratios above one.

The findings of this economic analysis are to be used to implement the Samoa Flood Management Action Plan and to lobby the government to invest in DRR measures, such as more training in flood forecasting and building controls to raise floor levels. At the launch of the report in 2008, some donors expressed interest in supporting some of the interventions that were assessed as most economically feasible. For example, the EU expressed early interest in using the information generated to determine whether to invest in further flood modelling work. However, to date, nothing appears to have materialised from these discussions.

The findings of the analyses have been promoted in meetings in the Pacific and, importantly, appear to have set the scene for selection of future water interventions, with SOPAC being requested to ensure comparative economic assessments of water management options for other projects that it is conducting.

Nadi and Ba

By the time of the survey, an estimated FJ$330 million was lost by families and businesses located in the greater Nadi and Ba town survey areas, with the single biggest cost arising from the destruction of possessions and assets. Lost earnings were substantial, accounting for a third (30 per cent) of total losses at FJ$100 million. This was mainly due to lost business as many businesses were unable to operate during the floods and often for several weeks afterwards. (The surveys were conducted 6 to 7 weeks after the floods and many businesses were still nonoperational at this time.)

Losses represent 7 per cent of GDP (2007 prices. This is the most recent set of figures available). The figures are large but are highly conservative. A key issue in assessing economic losses was insurance. On average, less than 7 per cent of families and only 24 per cent of businesses interviewed stated that they had any form of insurance. Given the scale of business earnings lost, the flood costs will have a significant impact on the tax base and are therefore a matter of national economic concern. A number of policy implications have been raised in the study, including the need for government to consider options to speed recovery such as improving access to insurance, introducing long-term watershed management, improving awareness raising and managing the expectations of the community.

The results of this analysis were presented to the Government of Fiji's Development Subcommittee in July 2009 and to the National Disaster Management Council in September 2009. Findings and recommendations are to be directly fed into flood management/integrated watershed management work currently scheduled for Nadi. More generally, the results are to be fed into rehabilitation/recovery plans for Nadi and Ba by the UNDP and ADB.

CHALLENGES AND CONCLUDING REMARKS

Reconciling Results with Other Work

As with most work, results from economic assessments must be credible to ensure that outcomes are realised. In some cases, this meant reconciling estimates from the economic work presented here with related work conducted by other stakeholders. In the case of Nadi and Ba, for example, estimates of the losses of businesses around Nadi were made provisionally by the Nadi Chamber of Commerce (see Government of Fiji 2009). The estimates generated by this work, while in the same magnitude, differed, presenting the sensitive issue of how to present results without appearing to question or undermine efforts made elsewhere in a time of emergency. In the case of this Nadi work, the Chamber of Commerce were unable to explain the methodology or physical area represented by their estimates (personal communication, July, 2009) which means that it is not possible to show how the two sets of figures relate.

Data and Surveys

Access to data was in all cases a challenge. It can be seen that for all case studies, a survey of households and businesses had to be undertaken to underpin analysis. Aside from the time and costs associated with this (see table 2), surveys conducted were not always ideal. For instance, the use of local counterparts to conduct interviews was sometimes a constraint as, even with training, interviewers did not always secure the information needed to guide respondents in the way that had been planned. For instance, where respondents had suffered from floods but could not advise the losses sustained, they were often not prompted to at least identify in what way they had suffered or what they had lost.

Table 2: Sample Sizes for Surveys.

Survey	Householders interviewed	Businesses interviewed	Total	Number of interviewers used
Navua, Fiji	225	68	293	26
Samoa	97	15	112	(not reported)
Nadi Fiji	717	230	947	64*
Ba, Fiji	328	91	419	20

* Personal communication

Additionally, survey data was also not always reliable, particularly when the time between the event and the survey were relatively large. For example, households and businesses in Samoa and Fiji were surveyed during 2007 and asked to recall the value of their losses from previous flood events. There were sometimes large time lags between the time the flood events occurred and when households were asked to report losses suffered which severely affected the quality of responses included in the survey. Where data appeared reliable (such as for businesses in Navua), the information underpinned estimates of the value of investing in flood management. Where data was questionable, proxy data was critical to achieve estimates:

- In Navua, data on household losses from an informal survey conducted in 2004 was used. The values were found to be comparable to losses sustained in other floods in Fiji and therefore, looked more reliable.
- In Samoa, the generic depth-damage curves developed by the US Corps of Army Engineers were used to estimate household flood damage. (See above for more information.)

Disseminating Results

The results of all analyses were presented to national (government) stakeholders in a variety of ways. While stakeholders were always interested to hear the results – indeed, they had asked for the information – this did not always ensure the key findings were addressed, as evidenced by the subsequent non-materialisation of funds for the Navua project. The reason for any lack of follow up is not clear although, it is possible that strong competition for government funds is a contributory issue. Sometimes, just getting stakeholders to hear the results of the work and their implications was difficult. In the case of Fiji, economic impact assessments of Nadi and Ba were designed to present feedback to the Government of Fiji, two months following assessment. However, due to government commitments, seven months after the surveys were conducted, results have still not been presented to Cabinet, despite this being expected in the early days of the work.

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CHAPTER 3

Vulnerability of the Fiji Sugar Industry to Disasters: An Economic Assessment

Padma Narsey Lal

INTRODUCTION

The impact of climate change and other natural disasters is determined not only by the nature and scale of hazard conditions, but also by the vulnerability of a household, community and the society at large. Vulnerability is defined as the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard (UNISDR, 2009). The purpose of this paper is to empirically assess the economic costs associated with the 2009 floods on the sugar belt in Fiji and to demonstrate that vulnerability is determined by not only the nature and intensity of hazard event, but also the health of the farm production system and the health of that industry, as well as the timing of the hazardous event. This study also demonstrates that Government's macroeconomic policy at the time also had a major influence on Fiji's vulnerability, including economic well being of households.

THE SUGAR INDUSTRY

The Fiji sugar industry has been the largest contributor to Fiji's economy, until recently when tourism industry took over in the early 21st century. The 2008 export value associated with the sugar industry was FJ$138 million, and accounted for about 3 per cent of GDP and generated about 30 per cent of exports in 2008 (www.statsfiji.gov.fj/Key%20Stats/Foreign%20 Trade/8.5_Major %20Domestic%20Exports.pdf). The industry also provides around 12 per cent of total employment in the country[3], and it is the single most important employer in the rural areas.

The sugar industry, at its peak, had over 23,000 registered growers with registered land area of almost 181,976 ha. In recent years, particularly since 1987, the sugar industry has been on the decline due to the effects of the 1987 and subsequent coups, and non-renewal of land leases in Fiji (Kumar and Prasad, 2004; Prasad, 2006; Lal, 2008; Lal and Rita, 2008). In the last five years alone, the number of active growers decreased from 17,363 in 2003 to 14,096 in 2008, and is still declining. With increasing input prices and substitution of the family-worked farms to farms reliant on hired labour, farm costs have increased with almost half the farms being close to being non-viable (Lal, 2008; Lal and Rita, 2008).

Management of the Fiji Sugar Corporation (FSC), the sole miller running four mills, too, have been on the decline, resulting in regular mill breakdowns (Lal, 2006). Milling and processing efficiency had decreased from 89 per cent sugar recovery in 1968 to 81 per cent in 2003, with some mills reporting a sugar recovery of as low as 79 per cent (Lal, 2006). The FSC's financial situation has gradually decreased from FJ$9.6 million in profit in 1974 to FJ$19.3 million in loss in 2007-2008 financial year. At the same time, the EU Protocol prices which have been 2-3 times the world market price that Fiji has enjoyed for the last four decades, has now been lost due to reforms in the European Common Agricultural policy (see Lal and Rita, 2006 and Levantis et al., 2003 for details).

[3] Estimated using data from several sources, including www.statsfiji.gov.fj and the Fiji Sugar Corporation Cane Accounting System data, and 2003 Farm Economic Survey.

Sugarcane Production

Fiji sugarcane farming is based on rain-fed agriculture, with cane harvesting restricted to generally June-July to November-December period; planting of cane usually occurs immediately after harvest and field preparation however, in recent years, less than 5 per cent of farmers planted cane (Lal and Rita, 2008).

Much of the initial expansion of the sugar industry was brought about by the clearing of land during the early colonial period, after climatic and suitable soil conditions for sugarcane farming was assessed, similar to the British colonial power's experiences in the Caribbean Islands and South Africa. The colonial government, and post-independence governments, also created 'new land' by establishing large drainage schemes on coastal, largely-mangrove lands, which were regarded as state land. These mangrove-reclaimed lands were developed by constructing seawalls to keep seawater out, clearing mangrove forests and reclaiming mangrove land for sugarcane plantations. Large drainage canals were constructed to encourage drainage of low-lying areas. These coastal flat plains today comprise approximately 1/3 of the area under sugarcane, areas that are often also susceptible to regular flooding (Hemraj Mangal, then Fiji Sugarcane Experimental Extension Officer, personal comm., 2004). Post independence, the Fiji sugar industry also expanded into hilly lands following the preferential access to the markets, first in the UK under the agreement with the UK Government, and subsequently in European Commission countries under the Lome Convention's EU Sugar Protocol (Kumar and Prasad, 2004 and Lal and Rita, 2005a). Much of the later expansion took place on lands with slopes in excess of 80, areas that are considered unsuitable for agriculture under the country's Soil Conservation Act.

FLOODING IN FIJI AND THE 2009 FLOODS

Flooding is almost an annual event in Fiji with floods accounting for almost a third of all disasters in the country, for example, since 1970 (Lal et al., 2009). Over the last four decades, flooding alone has affected a total of 220,000 people plus, causing 88 fatalities, according to statistics reported to the global databases, EMDAT and GLIDE and records maintained by the National Disaster Management Office, Suva (Lal et al., 2009). Flooding is generally associated with excessive rainfall beyond the regulatory capacity of landscape ecosystems, causing water logging of low-lying areas and overflowing of rivers and creeks. It may also be associated with coastal water intrusion through storm surges and high tides, and breaks in physical infrastructures. Much of the sugar belt is regularly affected by regular freshwater-flooding and seawater intrusion, with flooding being an almost annual event in Fiji.

The 2009 Floods

The 2009 floods, which were reported as the worst since the 1931 floods (Rajendra Prasad, Director, Fiji Meteorological Service, personal comm., April 2009), resulted from a confluence of factors interacting with the geographic characteristics of the various catchment areas. Several consecutive depression zones within a short duration and associated rainfall over a short period of time coincided with high tides. Many parts of the country were affected by floods that spread over several days – from the Western Viti Levu where the impact was greatest, to the Northern and Central Divisions of Fiji. Intense rainfall, over 60 cm of rain, over a 24-hour period led to flash floods beyond the coping capacity of the catchments. With continuous torrential rains over 2 weeks, most of the low-lying areas in the country had been under water for days and in places experienced flood levels of up to 3 – 5 metres (Fiji Meteorological Service, 2009b). The 2009 flood event was considered to be a 1 in 50 year event (Fiji Service, 2009b). Excessive flood waters also caused breaks in the coastal infrastructure causing the seawalls to breach and sea reclaiming parts of what used to be wetland areas. The direct and indirect effects of floods were felt throughout the low-lying areas, including the sugar belt and the sugar industry as a whole.

ECONOMIC COST ASSESSMENT: ANALYTICAL FRAMEWORK

The United Nation's Economic Commission for Latin America and the Caribbean (ECLAC) recommends disaster economic cost assessment framework that has 3 key elements: the cost of immovable assets and stock (damage), the income foregone, and the secondary or macroeconomic effects (ECLAC, 2003). In this study, only the first two cost components are assessed using cost and value measures defined by the ECLAC (2003). For the assessment of macroeconomic impacts, a time lag of at least 18 – 24 months is suggested to allow for economy-wide flow on effects to be realised (Benson and Cay, 2004).

Direct and Indirect Effects of the 2009 Floods

Using the Australian Bureau of Meteorological definition of what comprises a flood (www.ga.gov.au/hazards/flood), the direct effects of floods in Fiji are broadly defined to arise where the heavy rainfall caused:

- overflowing of river and creek waters and flooding of farms, houses, access roads and other infrastructure, etc., together with associated deposition of silt;
- water logging of low-lying farm lands, together with associated deposition of silt;
- influx of seawater onto farms and homes resulting from breaks in seawalls caused by high flow of large volumes of rainfall-runoff; and
- other effects of heavy rain on hilly cane fields may include landslides and deposition of soil/silt on low-lying flat lands, bila farms[4].

Direct effects are defined as damages caused directly to growers (farms and households), miller and infrastructure due to the flood inundation. At the same time, there are also many flow-on, 'indirect' effects arising from flood inundation of farms, houses and access roads, etc., such as loss in wages, decrease in national economy, humanitarian. The direct victims of the floods in the sugar belt area are the growers and the miller.

Sugarcane Growers

There are many categories of sugarcane farms and farmers that were affected by the floods – those producing sugar cane only, sugar cane plus non-cane crops and sugar cane and non-cane crops and/or livestock. Floods directly affect sugar cane yield as well as its sucrose content. The effects of floods depend on the extent as well as the duration of floods and whether flood waters were stagnant or flowing. Losses are suffered either because the sugarcane drowns completely or because of a decrease in sugar content (Weiss, 1976 and Humbert, 1968 respectively quoted in (Berning et al., 2000)). Cane may also get 'lodged' ('fall down'), which, particularly when the cane is large, relative to the flood level, tends to recover quickly once flood water recedes. On the other hand, total loss of cane crop occurs when cane is dislodged or uprooted due to the force of flood water. In the case of non-cane crops, particularly vegetables which are highly sensitive to water submersion, floods usually result in a total loss of the crop. Similarly, animals may be lost due to drowning and/or being washed away. Where land is scoured away, the farmer loses a proportion of their land value. Another direct effect of flooding on farmer's livelihood included the impact on family homes, and household possessions.

Some of the cane farmers also had family members who worked in urban areas or elsewhere, and who lost their wages because of the inability to either get to work or because the work places were closed. These indirect costs are also regarded as a component of the effects of floods on household livelihoods. Similarly included are the costs of treatments, including transportation costs to get to medical facilities, incurred by family members that suffered from water and insect borne diseases spread by flood waters and poor conditions. Direct and indirect effects of floods on the sugarcane farming households are summarized in Table 1.

Table 1: Direct and Indirect Effects of Floods on the Sugarcane Farming Households.

Direct Effects	Indirect Effects
• on-farm impacts - total loss of cane and non-cane crop, or reduced productivity of crops from water logging, salt water intrusion and/or siltation. - loss in productive farm land due to scouring/washing away of parts of farm and other land; - loss in livestock (such as chooks/ ducks, goats and sheep) due to drowning and/or being washed away. • loss of or damage to household possessions and housing infrastructure.	• loss in wages due to inability to get to work either because the roads were blocked or because the work place was closed; • costs incurred to clean-up farms, homes and commercial sites; • human health effects caused by water and vector-borne diseases induced by poor water and sanitation conditions following flood conditions; and • hardship caused by loss of household possessions and belongings leaving families unable to meet their basic food and nutrition needs, clothing, and/or schooling needs of the family (often difficult to quantify). Some of these would have been temporarily addressed through humanitarian assistance.

[4] Landslides were reported but were not assessed here due to limited data about the areas lost. Similarly, scouring or washing away farm land was also reported, but due to limited data, it was not included in this assessment.

The Miller

Floods also caused significant damage to mill operations, including damage to machinery and equipment, and damage to key infrastructure such as tramline infrastructure. The nation also lost out on the millers' share of the industry revenue due to a decline in cane processed by the miller.

The Miller, Growers and the State: Infrastructure Costs

Miller, growers and the state also have to bear the cost of the effects of floods on the infrastructure. Floods have a direct effect on the local infrastructure on which the sugar industry depends – cane access roads, tramlines and bridges to get the harvested cane from farm to the mills, and infield drains and drainage scheme infrastructure. The costs of these are borne by the miller, growers and the government, according to a complex arrangement in the industry (see Lal, 2008).

The extent of such damage on infrastructure depends on the size of floods, the volume of water that flows through the flood plains, the length of roads, tramlines and other structures within the floodplains (Berning et al., 2001) and the extent and value of current economic activities within the sugar belt. In several places, flooding and the force of the deluge of water broke the seawall. This caused the influx of seawater into cane land, causing the cane fields to become inundated with saltwater. Saltwater caused a total loss of the affected areas, in areas such as the Drasa and Lovu flats. These salt-inundated farms may not produce crops for 2 – 3 years, depending on the rainfall and flushing of salts (Mr Hemraj Mangal, Manager, Cane Development, FSC, personal comm., June, 2009).

DETERMINING 'WITH AND WITHOUT' COSTS

The economic cost of flood on each category of flood-effect is most appropriately estimated using a 'with and without' benefit cost analytical framework (Sinden and Thampapillai (1995)), which involves identifying the economic value of each of the activities in the system without the floods and comparing this with situation with floods. Thus, for example, the effect of floods on the farm level cane output is estimated as the difference between sugarcane output expected in the absence of the flood ('without'), and the cane output following the floods ('with'). These effects were then translated into economic value of damage by multiplying the reduction in cane output times the forecast price of cane for the 2009 crop. In addition, any related costs incurred by the farmers are also considered, such as the cost of removing the debris from the farms, and bringing the remaining field to its pre-flood state. Table 2 summarises the cost categories assessed using the 'with and without' analysis.

Table 2: Cost Categories Estimated using the 'With and Without' Methodology.

Value of Activities	With Floods Scenario	'With and Without' Flood Damage Analysis
Farm		
Sugarcane production (Plant and ratoon)	Cane output following flooding	$GVP_{\text{without floods}} - GVP_{\text{with floods}}$
Non-cane crops & livestock	Non-cane crop & livestock output following flooding, assuming farmers lost only 6-month equivalent of their annual non-cane crops revenue	$GVP_{\text{without floods}} - GVP_{\text{with floods}}$
Clean-up of farm land of debris	Total Clean-up following floods	$TC_{\text{cleanup due to floods}} - TC_{\text{cleanup without floods}}$
Farming Materials	Replacement (Lost) or Damaged	$TC_{\text{farming materials replacement/repair}}$
Cane access road (private maintenance)	Repair costs following flood	$TC_{\text{Cane access road repair}}$
House & Household		
House & household possessions	Replacement (Lost) or Damaged	$TC_{\text{house replacement/repair}} + TC_{\text{household possessions replacement/repair}}$
Normal Off-farm Income	Gross income earned following floods	$TC_{\text{Off-farm Income without floods}} - TC_{\text{Off-farm Income with floods}}$
Normal home clean-up	Total Clean-up following floods	$TC_{\text{cleanup due to floods}} - TC_{\text{cleanup without floods}}$

Value of Activities	With Floods Scenario	'With and Without' Flood Damage Analysis
Human health	Increased disease incidence and injury following floods	$TC_{Health\ Costs\ with\ floods} - TC_{Health\ Costs\ without\ floods}$
Mill		
Mill infrastructure maintenance	Regular maintenance costs plus additional cost of damage	$TC_{maintenance\ with\ floods} - TC_{maintenance\ without\ floods}$
Miller share of sugar revenue	Reduced level of cane throughput	Miller revenue $_{without\ floods}$ – Millerr revenue $_{with\ floods}$
Infrastructure		
Cane access road (Regular maintenance)	Regular maintenance costs plus additional cost of damage to the cane access road due to floods	$TC_{maintenance\ with\ floods} - TC_{maintenance\ without\ floods}$
Tramline (Normal maintenance)	Normal maintenance costs plus additional cost of damage to the tramlines due to floods	$TC_{maintenance\ with\ floods} - TC_{maintenance\ without\ floods}$
Drainage scheme canals and drains	Normal maintenance costs plus additional cost of damage to the drainage schemes due to floods	$TC_{maintenance\ with\ floods} - TC_{maintenance\ without\ floods}$
Humanitarian		
Humanitarian assistance	Humanitarian disaster response	Monetary equivalent of disaster packs, medical kits, food rations, education support

Cost estimates were estimated using several different valuation methods, as summarized in Table 3.

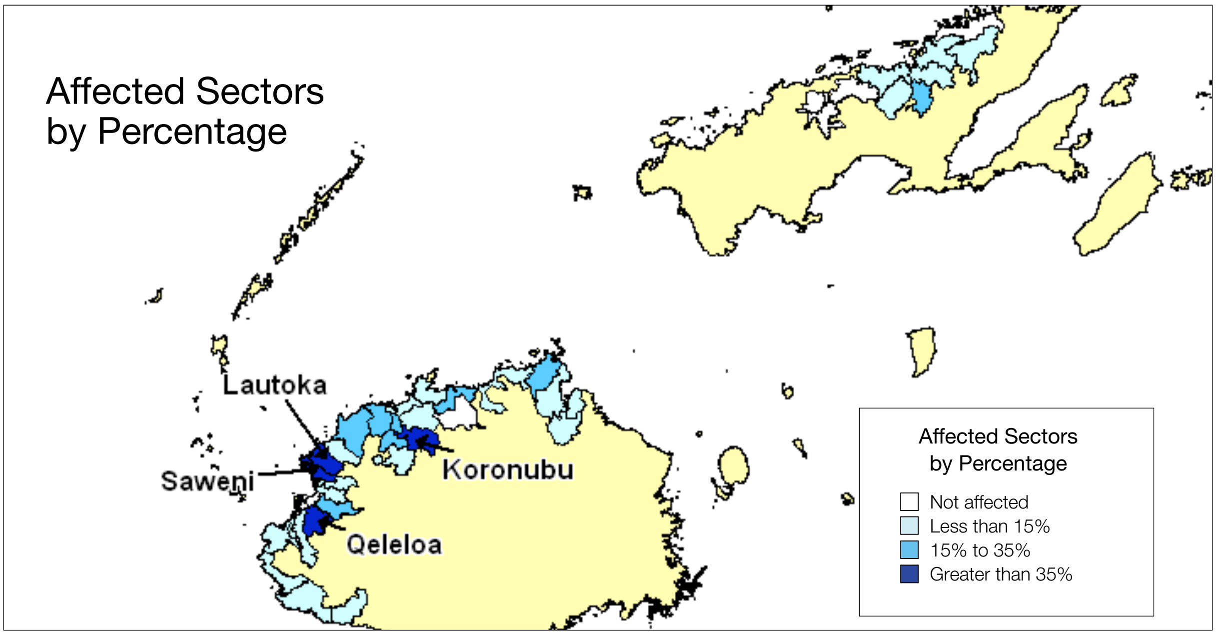
Table 3: Cost Valuation Methods used in this Study.

Production Method	Item
	Gross value of loss in sugar cane production
	Gross value of loss in non-cane crops and livestock
	Gross loss in wages due to lost work time
Replacement Method	Cost to replace household possessions; 'clean up' costs
Replacement Method (repair cost)	Costs to repair houses, household capita, etc
	Costs to repair infrastructure – cane access roads, tramlines, drainage, etc
Opportunity Cost	Costs for treatment of diseases (Human health)

RESULTS AND DISCUSSION

About 15 per cent, or a total of 2,181 sugarcane farms were affected across all the four mill areas by the 2009 floods. The impact though was not homogeneous throughout the industry. Affected farms were distributed across 34 of the 39 sugar sectors in the industry, excluding the FSC estate-sectors. Only four sectors, Lautoka, Koronubu, Saweni and Qeleloa, with significant large areas of low-lying and coastal plains accounted for over a third (35 per cent) of the farms affected by the floods. On the other hand, more than half sectors had less than 15 per cent of the farms had only small patches that were water logged/'flooded' (see map1).

Map 1: Sector Affected by the Floods – by Percentage.

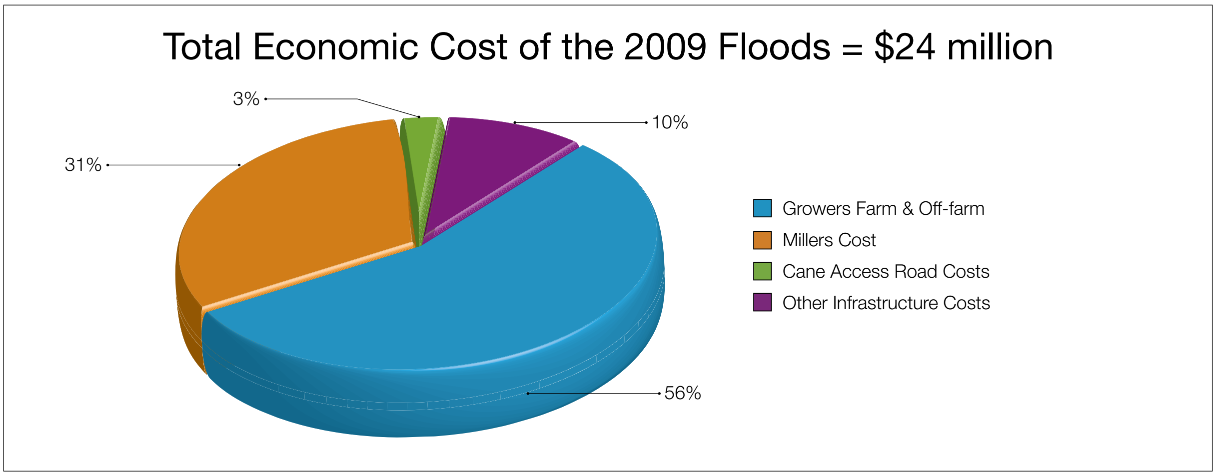


Source: 2009 Flood Economic Survey.

Total Industry Economic Costs

The total industry economic cost due to floods was $24 million[5], including millers' costs, damage to the cane access roads and other infrastructure (Figure 1). Of this, growers' cost was a little over a half, or about $13.4 million to the sugarcane farmers.

Figure 1: Total Economic Cost of the 2009 Floods on the Sugar Belt, Excluding the Humanitarian Assistance.



Source: 2009 Flood Economic Survey.

Sugarcane farmers in the two mill areas Rarawai and Lautoka, where low-lying areas are dominant, incurred almost 90 per cent of all flood related costs (Table 4).

[5] Does not include the value of the loss of land scoured out by the flood water.

Table 4: Direct and Indirect Economic Losses to Grower HH Income, Excluding Farm Costs.

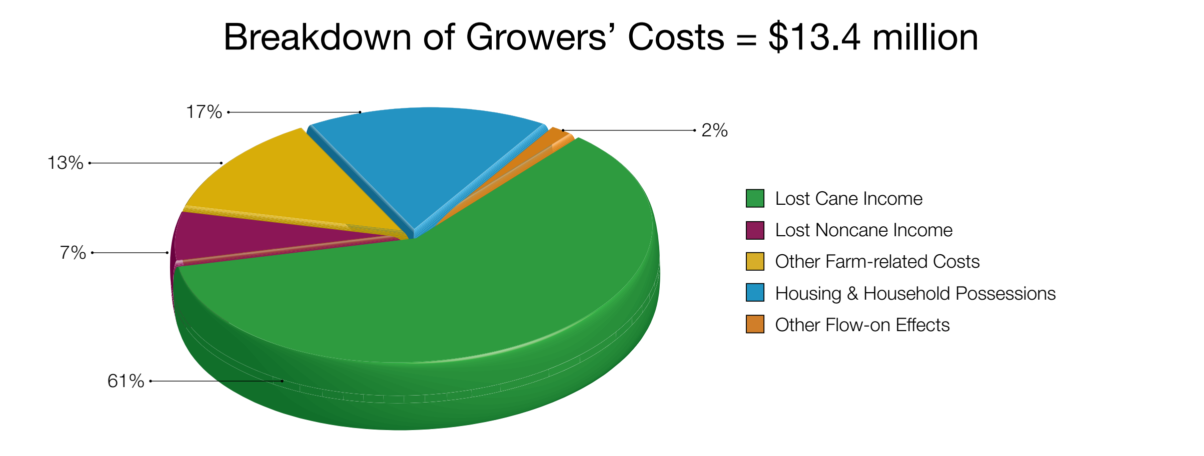
Cost Categories	Labasa	Lautoka	Penang	Rarawai	Industry
Cane Costs	$419 192	$2 976 878	$703 794	$3 938 443	$8 038 307
Non-Cane Farm Costs	$38 009	$231 989	$128 806	$333 359	$732 162
Direct & Indirect other costs	$126 864	$829 235	$13 337	$1 502 655	$2 472 091
Total Sugarcane Farmers Direct and Indirect Cost	$584 065	$4 038 102	$845 937	$5 774 457	$11 242 560

Source: 2009 Flood Economic Survey.

Within these mill areas, the low-lying sectors, Drasa, Koronubu, and Mota were the most affected, each losing over half a million dollars worth of cane.

Loss or damage to the cane crops accounted for the largest share (61 per cent) of costs borne by the farmers, or about $8 million, with other direct and indirect costs accounting for the balance (Figure 2).

Figure 2: Breakdown of Growers' Costs ($13.4 million).



Source: 2009 Flood Economic Survey.

Household Poverty

Flooding had significant impact on the household wellbeing. Almost fifty per cent of the affected sugarcane farming families, or a little less than 10 per cent of growers in the industry, is expected to fall below the poverty line, and almost 40 per cent will not be able to meet their basic nutritional needs[6]. Families in the Labasa and Rarawai mill areas are likely to be affected the worst (table 5).

Table 5: Percentage of Surveyed Farms that Fell Below the FPL and BNPL

Mill Area (farms surveyed)	Food Poverty Line (=$4 054) %	Basic Needs Poverty Line (=$8 361) %
Labasa (26)	46	92
Lautoka (148)	35	75
Penang (16)	19	56
Rarawai (190)	49	79
Industry (Average across flood affected farms)	42	54

Source: 2009 Flood Economic Survey.

[6] Household poverty in Fiji has been defined in terms of basic food poverty line (FPL), and basic needs poverty line (BNPL), which includes non-food basic needs, Using the 2002-2003 FPL and BNPL estimates of Narsey (2008), and time series consumer price index (CPI) reported by the International Monetary Fund (www.imfstatistics.org), the 2008 equivalent measures of FPL and BNPL were estimated to be $4,054, and $8,361 respectively. That is, any family earning less than the FPL, or $4,054, will not have sufficient income to meet their basic nutritional needs, and may even 'go hungry'. On the other hand, any household earning less than $8,361 a year will struggle to meet basic needs of their family.

Considering that the sugarcane farming families were already in poor financial state due to the effects of the loss in preferential market conditions (see Lal, 2008), 2009 floods increased the number of families below poverty line. About an additional 25 per cent of families are expected to fall below the BNPL as a result of floods (i.e. 'with' flood situation) than had the floods not occurred (i.e. under the 'without' scenario) (table 6).

It is important to note that, for the sake of consistency and ability to compare 'apples with apples' the analysis took into account loss in income due to the direct effect of the floods. It excluded flood-related farm costs, such as lost farming materials and cleanup, and household-related flood costs, such as, health costs, housing & possessions, cleanup, and evacuation. Nor does this analysis include considerations of any debt which almost all the farmers have[7]. Had such costs been included, almost all the farmers would have fallen below the BNPL.

Table 6: Share of 2009 Flood-Affected Sugarcane Families Expected to Fall Below the FPL and BNPL.

	% of farms below FPL (=$4 054)	% of farms below BPNL (=$8 361)
Post devaluation		
"Without" floods	19	54
"With" Floods	42	77
Pre-devaluation		
"Without" floods	55	98
"With" Floods	71	91

Source: 2009 Flood Economic Survey.

The analysis of the 2009 floods on the sugar cane growers confirmed that their ability to quickly respond to the effects of the floods is also very low, particularly since many of the farmers already have pre-flood debts, and little savings (based on the FSC Accounting System Data, see Lal 2008 for further details). The vulnerability of the sugarcane farmers is also heightened because of the latest (and final) decrease in the EU sugar prices when many sugarcane farmers are expected to struggle to make ends meet. Without floods and pre-devaluation, when the forecast price was $41.24 per tonne[8], almost 60 per cent of farms were expected to have had negative gross margin (estimated, using Lal and Rita (2008) survey data of 2003 and the 2008 FSC production data). This is not surprising, since the average production cash-cost of sugarcane farming in Fiji was $39 per tonne (Lal and Rita, 2008). With devaluation, the forecast sugar price is $61.17 per tonne, and the average farm household net income was $8 263 (table 7), which is below the basic needs poverty line, as discussed earlier.

Table 7: Net Revenue of Surveyed Farms (With and Without Flooding)[9].

	Without Floods Household Income	'With' Floods Household Income
Range	-$1 002 to $25 110	-$3 009 to $18 475
Average	$8 263	$5 345
rse	0.15	0.21

Source: 2009 Flood Economic Survey.

It was thus not surprising that many sugarcane farmers, and others in the flood affected areas, were forced to make some difficult choices immediately following the floods. Many families were reported by the local media having to choose between sending children to school or to meet their basic food requirements. Had it not been for the humanitarian assistance provided by many national and international organizations, it is likely that many children would have dropped out of school this year.

[8] Calculated using the EU contract price of Euro 301.68 per tonne CIF and standard industry deductions described in Lal and Rita 2005.

[9] Household net revenue = gross margin cane income + gross non-cane farm income+ off farm income.

Economic Costs of Floods and Stage of Sugarcane Crop

The effects of floods on the sugarcane industry could have been higher had the flooding occurred during later stages in the crop cycle, closer to the harvesting season when the cane crop is tall and can easily lodge. International research suggests cane becomes 'lodged' ('fall down'), when the cane is large, relative to the flood level and its duration (Bernign et al., 2000). Losses are suffered, either because sugarcane drowns completely, or because of a decrease in sugar content (Weiss 1976 and Humbert 1968 respectively quoted in (Berning et al., 2000)). Scientific research in other countries, such as South Africa, suggests that the minimum period of flood inundation before sugarcane is completely destroyed is approximately 3 days, particularly in the summer months (Plessis, 2001).

This is also supported by practical experience of the Fiji Sugar Experimental Station (Mr Hemraj Mangal, Manager, Cane Development, FSC, personal comm., April 2009). FSC notes that farmers can expect to see 'significant' damage if flood water remains stagnant for 2 days or more. If inundation remains for less duration and the flow of flood water remains, as was the case in 2009, cane losses of 2 – 10 per cent could be expected in Fiji, depending on the height of the cane crop. This is compared to a decrease of about 20 per cent reported in South Africa (Berning et al., 2000).

Flood Respite: Effect of Governmental Macroeconomic Policy

Some farmers would have been spared the full impacts of the 2009 floods because of a change in the government's macroeconomic policy. In response to the monetary crisis following the 2006 coup and the global financial crisis, the Government of Fiji devalued the Fiji dollar by almost 20 per cent, which meant a higher sugar revenue earned in Fiji dollar and thus farmers would expect to get higher cane price. This devaluation cushioned the effect of both the loss in preferential prices, as well as the flooding. Had the Government not devalued the Fiji dollar, the impact of the floods experienced by the sugarcane farmers would have been much more drastic. Without devaluation, less than three quarter (71 per cent) of the flood-affected farms would have fallen below the FPL, as compared to 42 per cent with devaluation. On the other hand, almost all (98 per cent) of the surveyed sugarcane families affected by the 2009 floods would have been considered to fall below the BNPL, as compared with about 77 per cent had the floods not occurred.

The State of the Industry and Vulnerability

For the industry, the January 2009 floods could not have come at a worse time than when it did. The industry has been struggling to reform its operations, despite several attempts in the last decade. The 2009 floods, without doubt, further aggravate their cash flow and the industry's financial situation. While Fiji has had similar, if not higher, disaster-related economic costs on the sugarcane farming sector, the 2009 effects are likely to be much more serious, particularly given the recent downturn in the economy, following the December 2006 political events. The flood outcomes will be further aggravated by the decline in the national economy, which has contracted by 6.4 per cent since 2006 (Reserve Bank, 2009), and the loss of the 120 million Euros allocated to Fiji under the National Adaptation Strategy. Secondly, in October 2009, Fiji lost its last set of price 'subsidies' from the European Union, and thus its cash flow will decrease considerably. Such economic woes will have flow on effects throughout the country, and many of the regional towns in the Western and Northern Divisions where cane is the lifeline, are likely to become ghost towns.

Economic Costs and Industry Management

While the severe rainfall pattern in January 2009 was considered to be a one-in-50 year event, and the volume of water in the rivers and creeks were beyond their normal discharge capacity, changes in the natural landscape for agricultural development over time would have caused a decline in regulatory ecosystem services.

In the sugar belt area, major changes in the landscape occurred during the expansion of sugarcane farming on steep slopes and mangrove reclaimed lands. To minimize the loss in regulatory services, an extensive drainage system was also established to ensure proper drainage and reduce risks of flooding, especially in flood plains and mangrove reclaimed lands. These systems were traditionally well maintained, especially during the CSR days. However, over time major drainage canals, in-field and main drains have become inadequately maintained (European Commission, 2008). Similarly, the good farm husbandry practices, which minimizes soil erosion, that were strictly enforced during the CSR days have progressively declined after the company's departure. For instance, following the signing of the Lome Convention which provided an incentive to increase production, sugarcane farms have expanded onto steep lands[10].

Generally speaking, farm management practices have deteriorated, particularly since at least the 1987 coups when contour planting was by and large not practiced, and farm husbandry was also found lacking. Soil erosion was exacerbated by the increased practice of pre-harvest burning of cane, which exposed bare cane fields to the elements following the 1987 coups (see Lal and Rita (2008) for details about cane burning and its causes). Consequently, with even short periods of intensive rain, excessive soil erosion and even landslides seem to have become common, silting up drains, water ways and rivers. Consequently, in the long term, if the 'business as usual' sugarcane farming practices continue, vulnerability of the sugar belt will continue and may even increase with climate change and climate variability.

The government, the sugar industry in partnership with the National Disaster Management Office (NDMO) and other catchment-based stakeholders must invest in enhancing regulating ecosystem services provided by the natural landscape, as well as in the maintenance of the drainage systems. As a minimum, unless the industry 'goes back to the future' and invests in maintaining the key drainage infrastructures – including the old CSR drains, main drains and infield drains in the sugarcane farms, as well as the drainage schemes in the reclaimed mangrove and other coastal areas – such floods will continue, and will get worse with extreme weather events associated with climate change. In the past, the Fiji Government, together with the sugar industry regularly invested in drainage and flood protection infrastructure, but the level of investment has decreased in recent years, particularly following the 1987 political coup. The industry must also revert to best practice farming and refocus on farm management practices that minimizes farm level soil erosion, including the banning of agricultural development on slopes greater than 80 under the Soil Conservation Act.

Disaster risk management in the sugar belt area however, must also go beyond focusing on flooding per se. Economic wellbeing of rural households must also be improved to make them less sensitive to disaster events, and better at coping with the residual risks they may face. In the sugar belt, this would mean increasing the profitability of the sugarcane farming by reducing the farming and harvest and transport cost, as well as increasing the efficiency in the milling and processing sector. Without such an approach, recurrent and more frequent disaster events that are expected with climate change would reverse past improvements in the human development seen in Fiji.

2009 Floods Compared to Other Disasters

Although 2009 floods were considered to be the worst in the recent history of Fiji (Fiji Meteorological Services, 2009), it is difficult to compare the effects with other flooding events in Fiji because of limited data and the use of different cost estimation methodology. For example, McKenzie et al. 2006 reported the economic cost estimates of about $13.6 million for Cyclone Ami and associated flooding damage. These estimates were based on gross estimates provided by the industry. Caution is advocated since such estimates, not only may be inflated, but also may be based on inappropriate methodology, as was discovered in the course of this study.

The economic cost estimates arrived at in this study were lower than the gross estimate of $27 million figure provided by the industry stakeholders. This is despite the industry stakeholders using the lower pre-devaluation cane prices, and not including many other costs, such as non-cane crop losses, costs of house and household losses and damages, drainage schemes, or humanitarian costs. It is also noted that many of the subcategories of costs estimated in this study are less than those earlier provided by the industry stakeholders, including cane access and tramlines damages, and loss in cane crop. This may be as a result of differences in the assessment methodology used, and more importantly perhaps the lack of capacity in the industry to undertake appropriate 'with and without' disaster impact assessment. In particular, the FSC impact assessments did not reflect additional cost of infrastructure maintenance due to the effects of the floods. The infrastructure costs estimates provided by the FSC staff reflected the annual cost of the maintenance of key infrastructure, such as cane access roads, or tramlines. In this study, the additional cost due to the floods is reported as the difference between 'with' and 'without' infrastructure cost.

10 Lome Convention provided preferential access to Fiji sugar at prices two-three times greater than world price.

These data challenges also apply to impact assessments of other disasters. Although government agencies are required to provide the NDMO with information on immediate losses and costs (damage to buildings, replacement costs for infrastructure, etc.), the historic NDMO data sets are incomplete and, in some cases, do not match the data reported by international agencies. Time series data may also not be reliable because there is no agreed damage assessment method in Fiji. Neither is there an agreed cost measure for determining a dollar value of losses.

In some cases, rehabilitation cost estimates are used; but for the agricultural sector, for example, the recorded cost of the standing crop lost or the costs of rehabilitation, is used. Similarly, a formal definition of 'number of people affected' is not available. That measure may, therefore, reflect variously the number of people whose livelihood was affected, the number dead, the number hurt and/or those affected indirectly. As a result, it is difficult to compare with the certainty the economic costs or the people affected by disasters.

The industry needs to develop a standardized definition of key terms, as well as methodology for estimating economic costs of disasters, such as floods, for ease of comparison as well as to support disaster risk reduction and disaster management decisions.

CONCLUSIONS

The 2009 Fiji floods caused almost $24 million economic costs in the sugar belt. Almost 50 per cent of the flood-affected farms are expected to fall below the basic needs poverty line and with at least 25 per cent of the affected farmers not able to meet their basic needs. Floods further exacerbated the industry profitability. Such outcomes are a product of the interaction across a complex web of factors between natural hazards – the timing, duration, and the intensity – and sensitivity of affected households, communities and industry to disasters. This study demonstrates that because of the state of the sugarcane farming, farm management, as well as the health of the milling and processing sector, the sugar industry suffered extensive economic costs, confirming global observations (UNISDR, 2009).

The results are consistent with experiences elsewhere in the world where households with poor socio-economic status, as well as weak and poor performing industries and economies, are highly sensitive to natural disasters and face significant difficulties in absorbing, and recovering from, disaster impacts (see e.g. Benson and Clay, 2004). In conclusion, this study emphasizes the importance of robust baseline information and consistent methodology in economic cost assessment of floods. The results also suggest that to reduce such economic costs, disaster risk management must go beyond the traditional post disaster management. It must also focus on adopting a multipronged approach to disaster risk reduction and disaster management at all levels – national, industry and household.

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CHAPTER 4

Economic Cost Assessments of Climate Change

Padma Narsey Lal

The purpose of this paper is to discuss challenges faced by analysts in the Pacific when estimating economic costs of climate change in the Pacific. It is based on the review of recently completed assessments of the economic costs of climate change impacts, as well as the literature on disaster economic cost assessments that have, and could be used to assess expected economic costs associated with changing climate in the Pacific.

INTRODUCTION

Disasters are common occurrences in the Pacific, causing significant damages. Of the 207 natural disaster events that occurred between 1950 – 2004 climatic hazards, hurricanes and cyclones, accounted for 76 per cent, costing almost 90 per cent of the US$6 billion total disaster related costs (World Bank, 2006) and 79 per cent of the associated fatalities. The majority of natural disasters were floods, droughts and storm surges, with floods reportedly causing additional fatalities and general devastation with concurrent effects of violent winds, high waves and storm surges (Terry, Kostaschuk et al., 2008). Climate change is expected to exacerbate the effects of disaster risks in the Pacific and countries must urgently improve their current risk management as well as proactively adapt to, and prepare for, the effects of climate change. With climate change expected to cause increased extreme weather events, such as prolonged droughts, heavy rains, and increased intensity of tropical cyclones, as well as increased climate variability and sea level rise (Christensen and Hewitson, 2007), the economic costs of Pacific disasters are expected to become more significant, particularly if countries continue 'business as usual' and do not take steps to reduce their current risks, let alone adapt to the adverse impacts of climate change.

Climate change adaptation is defined by Inter Governmental Panel on Climate Change (IPCC) as 'actual adjustments, or change in decision environments which might ultimately enhance resilience or reduce vulnerability to observed or expected changes in climate' (Adger, Agrawala et al., 2007). Vulnerability is defined as the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard (UNISDR, 2009). To reduce vulnerability, management responses may include, not only reducing exposure to hazards affected by climate change, but also targeting factors that reduce the sensitivity of communities to disasters such as for example, improving household wealth, improving human development conditions (through improved access to water and sanitation and education, etc.) and increasing the resilience of natural ecosystems (ISDR, 2009).

The standard impact assessment approach, based on the IPCC's seven step climate change impact adaptation and vulnerability (CCIAV) assessment (IPCC, 1994) includes: define problem; select method; test method/sensitivity; select scenarios, assess biophysical/socioeconomic impacts; assess autonomous adjustments and evaluate adaptation strategies. This is generally described as top down (Dessai, Adger et al., 2004). A top-down impact assessment usually combines scenarios downscaled from global climate models to local scales, with a sequence of analytical steps that begins with the climate system, through biophysical and towards socioeconomic assessment. On the other hand, bottom-up impact assessment starts at the local scale, addressing socio-economic effects and responses to climate change (Dessai and Hulme, 2004). More recently, sensitivity analysis to capture uncertainties and probabilistic representation of future climate change and socioeconomic conditions are also used (World Bank, 2000; Shorten, Goosby et al., 2003; Carter, Jones et al., 2007). Other approaches adopted include a stakeholder-based decision-making process, to assess local level vulnerability and potential responses (Conde and Lonsdale, 2005).

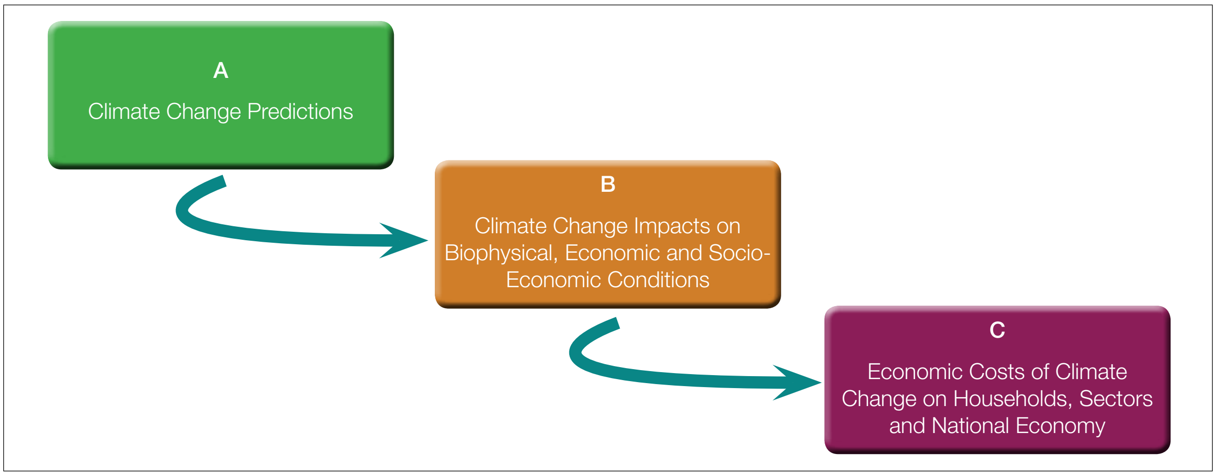
Economic cost assessment is an integral part of climate change impact assessment. Information on the economic costs of climate change-associated extreme events and the costs of inaction can be used for advocacy purposes and to provide a rationale for policy change and action as well as additional funding from international communities (World Bank, 2010). Economic analysis can also be used to help design better strategies and make choices between alternative response strategies and initiatives. Decision makers are increasingly calling for economic assessments to inform decision-making in an environment of climate change uncertainty (Carter, Jones et al., 2007). No doubt such assessments would need a combination of top-down and bottom-up approaches to adequately support decisions across all levels of society (Dessai, Lu et al., 2005).

To understand the economic costs of climate change, three sets of knowledge must be brought together (Figure 1):

- Climate Change Prediction: the meteorological understanding of effects of green house gas emissions and global warming, their effect on rainfall and temperature patterns, sea level rise, and oceanic patterns and associated uncertainties ('A');
- Climate Change Impact Assessment: hydro-meteorological impacts of climate change on physical and biological systems, and human systems, including infrastructure and human capital ('B'); and
- Economic Cost Assessment: economic costs and benefits associated with changes in the values of human livelihoods and economy, including government finances) ('C).

Figure 1 Relationship between Climate Change and Economic Values of as low as 79 per cent (Lal, 2006). The FSC's financial situation has gradually decreased from FJ$9.6 million in profit in 1974 to FJ$19.3 million in loss in 2007-2008 financial year. At the same time, the EU Protocol prices which have been 2 – 3 times the world market price that Fiji has enjoyed for the last four decades, has now been lost due to reforms in the European Common Agricultural policy (see Lal and Rita, 2006 and Levantis et al., 2003 for details).

Figure 1: Relationship between Climate Change and Economic Values.



As noted by Stern (2007), for economic cost assessments, it is important to take a programmatic approach, utilizing the best information available at the time, while realizing that there are uncertainties associated with each of the stages of economic assessment – A, B, and C. These uncertainties include those associated with:

- future GHG emissions levels;
- dynamics of climate changes at the global, regional and country levels;
- dynamics and geographic spread of the effects of climate changes and sea level rise and hydro-meteorological and ocean conditions;
- size and severity of the effects of changes in climatic and ocean conditions on different ecosystem systems and associated goods and services and infrastructure on which various economic activities dependent; and
- size and severity of changes in economic activities on household income and livelihoods as well as social wellbeing, including national finances.

ECONOMIC ASSESSMENTS OF CLIMATE CHANGE IN THE PACIFIC

From a pure economic assessment perspective, the costs of climate change adaptation are generally considered and expressed in monetary terms, while the benefits are most commonly considered as avoided climate impacts, and may be expressed in monetary or non-monetary terms, including changes in agricultural output and population at risk due to changes in welfare (Adger, Agrawala et al., 2007). United Nation's Economic Commission for Latin America and the Caribbean (ECLAC, 2003) recommends that assessment of the economic cost of disasters has three key elements:

- assessment of the cost of immovable assets and stock ('damage');
- assessment of income foregone; and
- assessment of the flow on or macroeconomic effects.

The economic costs of climate and other disasters is estimated using a 'with and without' analysis, estimating the costs of direct and indirect effects, as well as the flow-on effects of disasters through the economy (ECLAC, 2003; Benson and Twigg, 2004).

Costs assessments of climate change in the Pacific have been attempted using 'top-down' and bottom-up approaches. A variety of studies have been conducted reporting on the economic costs of extreme events, primarily as research projects (Nunn, Ravuvu et al., 1994a; Nunn, Ravuvu et al., 1994b; Koshy, 2007), but it seems also with the intention of providing empirical information for advocacy for disaster risk reduction or mitigation. Some studies have explicitly targeted government decisions makers and international financial institutions, such as the World Bank and the ADB, and provide specific policy recommendations for disaster risk management. For example, the World Bank report, 'If Not but When' (Betterncourt, Croad et al., 2006), was completed by a group of regional experts, primarily to advocate at the international level for disaster risk management and particularly to impress on development agencies the vulnerability of the Pacific islanders and the importance of increased assistance to mainstream disaster risk reduction to national development and decision-making. This 2006 World Bank study was subsequently instrumental in attracting international attention and funding to address disaster risk reduction and climate change efforts for the Pacific.

Other assessments of the economic costs of extreme events include benefit and cost assessments of climate-associated disasters. Although such studies (e.g. Woodruff, 2007; Ambroze, 2009; Holland, 2009; Lal, Rita et al., 2009), were not originally designed to make projections about potential effects of climate change, they can assist decision-makers to identify the most appropriate risk management response to adapt to climate change and reduce vulnerability. Holland's study on Navua floods (Holland, 2008), for example, was conducted to highlight the economic costs of flooding associated with the 'do nothing' option, and to provide an economic rationale for the need to establish a flood early warning system for the Navua River catchment. Lal and others undertook the study of the economic costs of 2009 floods in the sugar belt to provide disaster risk reduction-related policy guidelines for the industry (Lal, Rita et al., 2009). Results of such studies can be used to estimate the expected costs associated with predicted conditions under climate change (Hay, 2010).

Economic cost assessment of climate change, including climate-related disasters, can be broadly grouped in three categories: qualitative commentary; qualitative economic assessment; and quantitative assessment.

Qualitative Commentary

By far, the most common approach adopted in the Pacific to date to assess economic costs of climate change has been to apply IPCC global or regional projections of climate change, variability and sea level rise to Pacific island country conductions (environmental, social and/or economic characteristics) and describe the likely impacts (Hay and Mcgregor, 1994; Prasad and Manner, 1994; Sem and Underhill, 1994; Falkland, 1999; Hay, Mimura et al., 2003; SPREP, nd). Such assessments have conventionally formed research that used a normative approach to draw general conclusions about the nature of potential impacts from climate change. Other qualitative studies have included bottom-up community vulnerability assessments, (e.g. Carruthers and Bishop, 2003; SPREP, nd a; SPREP, nd b) that involve stakeholders adopting a participatory approach to self-assess their future hazard exposure, assess own adaptive capacity; and identify adaptive strategies. In these projects, analysis for the Pacific has been largely qualitative, where many locally observed changes in coastal areas were 'assumed' to be climate related.

Some qualitative commentaries have also been made based on on-the-ground observations following disasters. For example, following cyclones and other natural disasters such as drought, communities in some countries, such as the Solomon Islands and Papua New Guinea (PNG) have often been observed to face extreme hardship. At times, food shortages have been experienced, not only during the disaster, but also for extended periods of time following it. Such hardship has been so common that the locals even have coined specific terms for it, such as 'time blong hungry' where subsistence food shortages and income losses persisted following disasters. Being reliant on a few commodities, such as copra, some rural Pacific communities could be without income for several years following a disaster, such as when coconut trees fail to fruit following a cyclone. Additionally, some communities can become increasingly vulnerable to disaster events due to the weakening of traditional communal ties and social safety nets as the community modernizes (Warrick, 2007). Often the economic costs of such impacts are not included in the disaster cost estimates and, most certainly, they are generally not considered in the projected economic costs of climate change.

Qualitative Economic Assessment Based on Quantitative Scientific Assessment

Semi-empirical top-down impact approaches have also been used to make projections of 'socio-economic' impacts of climate change and climate-related disasters. Often, detailed global, regional or national climate change models are used, combined with general information about expected ecological and other effects of the climatic change.

Models such as SIMCLIM, and its predecessor VANCLIM, were used to generate context-specific predictions of key climate variables – temperature, rainfall, sea level rise, wind speed and storm heights, (e.g. Nunn, Ravuvu et al., 1994a; Nunn, Ravuvu et al., 1994b; Koshy, 2007). Nunn used the results of PACLIM, together with some basic inundation models and storm surge models to determine respective expected physical damage function in Fiji and Samoa under different climate change scenarios. At times, spatially referenced descriptive socio-economic characteristics have also been produced, using field surveys (for example for Navua river basin, Fiji (Koshy, 2007)), or combined field survey and expert opinion (for example, Natadola Bay, Fiji (Koshy, 2007), Yasawa Islands, Fiji (Nunn et. al., 1994a) and Savaii Island, Samoa (Nunn et al., 1994a; Nunn et al., 1994b)).

Such model simulations and other information have been used to draw conclusions about the scale and extent of damage that might be expected under different climate change scenarios on infrastructure, agriculture, and coastal land. Unfortunately, many of these studies fell short of undertaking a full 'with and without' analysis, including economic analysis, perhaps because such climate change research teams involved generally biophysical scientists and geographers, usually with little or no economic training. Nor did these studies include economic models or empirical economic cost assessments. Nonetheless, these studies produced valuable insights into the nature of climate change-related impacts in the Pacific and made general comments on the socioeconomic implications of climate change. For example, Koshy (2007) notes that 'impacts are deemed substantial, taking into consideration destruction of root crops, loss of income and properties, disease and, in some cases, death. Koshy (2007) also notes that coastal areas are unstable and the shoreline will continue to change over time for many years to come. It was agreed by the community members that it would be better to use their time, effort, and money to rebuild important buildings, on the high safe grounds and not to rebuild seawalls.

In some cases, fairly detailed scientific assessment has been undertaken to understand the possible causes of recent changes in the coastal landscape, which could be extended to include climate change modelling to predict future coastal scenarios under climate change. For example, studies in Kiribati (Webb, 2006a) and Tuvalu (Webb, 2006b) adopted scientifically robust GIS-based methodologies, aerial photographs and satellite imagery to determine recent changes in coastal landscape. Field visits and local knowledge were used to check (ground truth) the findings, before generalized policy recommendations were made. With such studies, when combined, 'with and without' analysis could form the basis for estimating potential economic impact of climate change.

Quantitative Assessment

Two general quantitative approaches have been used to provide empirical information about the economic costs of climate change:

- past disaster costs information to give an indication of the order of magnitude of expected climate change effects; or
- using climate models combined with physical models to predict the impacts of climate change.

The World Bank, for example, estimated that in the 1990s alone, reported natural disasters cost for the Pacific Islands region as US$2.8 billion in real 2004 value (Betterncourt, Croad et al., 2006). For the period 1950-2009, (Hay, 2010) estimated costs associated with climate change disasters was about $6.5 billion. Such cost estimates have usually been based on broad brush post-disaster impact assessments carried out by respective government departments for the purpose of humanitarian assistance and disaster rehabilitation, and reported in the Emergency Events Database (EMDAT), an international database established to assist in humanitarian actions at the national and international level (www.Emdat.be). Internationally, reported estimates are usually based on cost data collected by different departments, often adopting different and inconsistent methodologies and different costs measures (Chung, 2009; Lal, Singh and Holland, 2009). These disaster cost assessments also often excluded indirect, or flow on costs.

National economic costs of climate change in the Pacific are usually determined using sector-based 'business as usual' scenario and climate change predictions data from regional and global modelling available from IPCC. Habitat/ecosystem-based 'business as usual' calculations are made using baseline scientific information on 'goods and services' supported by specific ecosystems, such as coral or mangroves, and survey-based economic value data or average values obtained from the literature. The World Bank study (2000), which is one of the few studies that adopted a systematic approach to impact assessment, for example, examined the potential effects of climate change in a high island, Viti Levu in Fiji, and an atoll island, Tarawa, Kiribati, using an integrated Pacific Climate Change Impacts Model (PACCLIM)[11]. It used enhanced PACCLIM-generated scenarios of temperature, rainfall pattern, sea level rise and changes in cyclones and ENSO events.

This modelling was complemented with sector level impact models, population projections and base line historical climate records. Economic cost estimates of mainly direct effects were based on limited field surveys, expert judgments and 'cost transfer' from other parts of the regional or world. Empirical estimates of economic impact of climate change on four sectors: coastal areas, water resources, agriculture and tourism, are summarized in Table 1. The World Bank was though, also forced to also make many assumptions using qualitative information, or to rely on expert opinions where relevant scientific and economic information was absent. The characteristics of past disaster events combined with local information have also been used to make future predictions. For example, focusing on the estimated potential coastal inundation from climate change and insurance related damages in Vanuatu, Shorten and others used past cyclones, particularly Cyclone Uma, to predict precipitation and wind speed for future cyclonic events of various intensities (Shorten, Goosby et al., 2003). These predictions were combined with geo-referenced local surveys of villagers and households, urban building and infrastructure, and geographic information system (GIS) based analysis to develop potential average damage costs for the coastal zone, over different cyclone intensities.

Table 1: Summary of Estimated Annual Economic Impact of Climate) Change on the Coast of Viti Levu, Fiji, 2050 (millions of 1998 USD).

Category	Annual damages (USD Million)
Impact on coastal assets:	
• Costs due to Loss of land to erosion	2.9 – 5.8
• Inundation of land (including agriculture) and infrastructure	0.3 – 0.5
Impact on coral reefs - Cost of Economic Loss associated with:	
• Subsistence fisheries	0.1 – 2.0
• Commercial coastal fisheries	0.05 – 0.8
Tourism	4.8 – 10.8
Habitat	0.2 – 0.5
Biodiversity	*
Nonuse values	*
Impact on mangroves	*
Impact on sea grass	*
Total estimated damages	8.4 – 20.4

* Likely to have economic costs, but impact not quantified. An Accounted for in the erosion analysis.
Source: Background reports to the World Bank (2000).

[11] PACCLIM is a precursor to the SIMCLIM model developed by CLIMSYSTEM:www.climsystems.com/pluto/simclim.

KEY CHALLENGES OF UNDERTAKING ECONOMIC ASSESSMENT OF DISASTERS AND CLIMATE CHANGE IN THE PACIFIC

Past economic cost assessments in the Pacific faced many challenges for several reasons. These included: research being largely carried out within a single disciplinary framework; the presence of poor information about functional relationship between climate change, effects and sectoral and other impacts. The assessments were affected by the use of inappropriate analytical tools, consideration of only partial costs measures; and most seriously due to limited baseline data. These are discussed below.

Cost Assessment Team Composition

Most of the assessments made to date in the Pacific of the potential economic costs of climate change, adopting top-down or 'bottom up' approaches, were standalone activities and, with the exceptions of a few studies, generally focused on one of three steps, A, B, or C, of assessments (Figure 1). The other two aspects of that continuum were often commented on using general aggregate level information and/or making some very broad assumptions.

One of the reasons for this could be that, with the exception of a few cases (notably World Bank, 2000; Shorten, Goosby et al., 2003; World Bank, 2006), climate change impact assessments were generally carried our as academic research projects and were often undertaken by researchers coming from usually one of the disciplines – geography, physical sciences or economics. Most of these projects showed limited sign of expert knowledge located in other disciplines. Often knowledge about the other inputs were, as discussed above, either assumed or estimated using inappropriate methodologies.

Another reason could be that relevant scientific and technical baseline information to underpin economic cost assessment is generally very limited at best and almost non-existent, or difficult to access. As seen below, the robustness of economic cost assessments not only rely on economic information but also on the understanding of the dynamics of climate change, as well as the effect of climate change on respective sectors and human society.

Scientific Knowledge

As already implied, scientific understanding about the effects of climate change on sectors, ecosystems and societies is a key constraint to economic assessment of climate change anywhere in the world (World Bank, 2010). The effects of climate change are a result of complex interaction between climate and hydro-meteorological conditions and geographical, and socio-economic and human development conditions, and their direct and indirect impact on the environment, physical assets and human beings. An understanding of such interactions can help improve estimation of the costs associated with a disaster event.

For example, in the Fiji sugar industry, empirical information suggests that the impact of flooding condition depends, not only on the intensity of precipitation, the rainfall-runoff patterns and the resulting floods, but also on the ability of the excessive water to be flushed out of the system and the speed with which the flood waters can recede (Lal, Rita et al., 2009). Sugarcane, being a hardy crop, did not sustain much damage during the 2009 floods perhaps because the flooding occurred at the end of summer, flood water did not remain stagnant for long, and the peak flood level was relatively low compared to the height of the cane. Such detailed knowledge of the sectors is, however, not often known, making it difficult to assess expected costs of climate change.

In other cases, such as coastal fisheries, the incremental cost of climate change is difficult to predict, not only because coastal ecosystems comprise many different subsystems which are not well understood, but also because climate change will add to the already existing stresses on the coral ecosystems due to human activity on land and the sea. It is well known that coral reefs are valued for their goods and services which support subsistence, artisanal and commercial fisheries, besides providing building materials in some PICTs and supporting recreational (e.g. diving) and nature-based tourism. Coral reefs are also valued for their role in coastal protection.

With the projected increases in sea surface temperatures, coral reef ecosystems will be greatly affected (Buddemeier, Kleypas et al., 2004), including increased incidence in coral bleaching caused by the expulsion of colourful, symbiotic algae that corals need for survival, growth, and reproduction. Major bleaching events have been reported globally in the last decade or so, including Fiji and PNG (Davies, Dunne et al., 1997).

While coral species have some capacity to recover from bleaching events, this ability is diminished with greater frequency or severity of bleaching. As a result, climate change is likely to reduce local and regional coral biodiversity as sensitive species are eliminated, and with it the productivity. However, the functional relationship between climate changes, changes in productivity of the coral and associated ecosystems and the flow of effects on human activities is difficult to predict, as they vary from region to region, and even within a country (Buddemeier, Kleypas et al., 2004). This difficulty then flows into the assessment of economic costs, which needs information on the incremental effects of climate change on coastal ecosystem productivity, before expected cost assessment can be estimated.

Nonetheless, the total NPV of cost of severe coral bleaching in the Pacific (excluding Hawai'i) has been estimated at US$7.6 billion, assuming different functional relationships and outcomes, and calculated over a 50-year time horizon with a 3 per cent discount rate (Cesar, Burke et al., 2003). The loss and destruction of coral reefs is projected to lead to low productivity of associated fisheries, impact on adjacent ecosystems, and potentially lead to system collapse. However, the extent of the flow on effects is difficult to predict.

Other sector-level economic impact assessments also suffer from poor functional understanding as well as limited baseline data. For example, Lal and others attempted to estimate the economic costs of the effects of climate change on water-related health issues in Vanuatu (Lal, Wickham et al., 2009). They used historical national level health, disaster statistics and rainfall data to determine partial correlation of the increased incidence of water-borne diseases and increased rainfall in years when the country suffered a series of cyclonic events. Assuming Vanuatu experiences just one extra cyclone event, the associated increase in water and vector borne diseases, direct medicinal costs associated with treating such diseases could be about Vatu 6-14 million or about AU$542 000 to AU$600 000 a year. The authors note that such cost estimates are indicative only, and that a much more detailed 'with and without' economic analysis is required that includes, not only the economic cost of medicine but also other direct and indirect costs, such as the cost of foregone earnings and transportation costs. The economic cost of health effects of climate change must also estimate the incremental cost associated with climate change per se. However, this, too, is fraught with difficulties as functional relationships between climate change and diseases are context-specific and would depend, not only on the geophysical characteristics of the location, but also on the health status of people and the availability of health services in the region. Such an approach, however, is very resource intensive.

Similar difficulties are faced when determining the economic costs of climate change on the key ecosystems and associated economic values. A World Bank study in Fiji estimated an expected loss in commercial fisheries for Viti Levu to be in the vicinity of US$0.05 to $0.8 million with a further loss in subsistence fisheries at around US$0.1 to 2.0 million, whereas the loss in coastal habitats is valued between US$4.8 to 10.8 million. In the absence of detailed scientific information, these estimations were based on some broad assumptions (e.g. the functional relationship between climate change and changes in fish production). Similar broad assumptions were made when valuing the economic costs of climate change on the mangrove ecosystem (World Bank 2000; Lal, Wickham et al., 2009).

Lal and others, for example, used the economic values of mangroves reported for the Fiji (Lal, 1990), Kosrae (Naylor and Drew, 1998) and projected per cent loss of mangroves (Gilman., Lavieren et al., 2006) to estimate the expected economic cost of the loss of these mangroves by 2100 (World Bank, 2000; Lal, Wickham et al., 2009). This was estimated to be in the range of US$24 million to $470 million/year, with the latter estimate reflecting other considerations of ecosystem services, such as foreshore protection. Once again, these national cost estimates mask the local level vulnerabilities of communities, such as those at Crab Bay in Vanuatu who are largely reliant on mangrove resources for their food and income security (Hickey, 2006).

Methodological Issues: With and Without Analysis

Some economic cost assessments of climate change (and past disasters) have suffered from methodological issues. As noted earlier, the appropriate cost measure for a change in climatic conditions should be based on 'with and without' assessment (ECLAC, 2003). A 'with and without' analysis involves determining economic values of ecosystems, vulnerable sectors, and household livelihood under the scenario 'without climate change disaster' compared to 'with' climate change disaster. The difference then is attributable to the effect of climate change, allowing for the consideration of the changes in the economy due to other factors as well.

Only a few studies have directly tackled economic assessments of climate change based on probabilistic climate change scenarios and costs assessments of past natural disasters, such as cyclone and floods

(World Bank, 2000; Shorten, Goosby et al., 2003). However, there are several assessments of natural disasters based on deterministic models that give an indication of the future impacts of climate change (McKenzie, Prasad et al., 2005; Woodruff, 2007; Holland, 2008). Assessment of the impacts of natural disasters in the Pacific is also generally narrow in scope, even for major natural disasters. Often disaster costs are estimated immediately following disaster events with the primary purpose of prioritizing relief and rehabilitation needs. Thus, assessments of disaster impacts focus on the immediate and direct damage to mainly infrastructure. Where disaster impact assessments were based on data collected immediately after disasters (e.g. McKenzie, Prasad et al., 2005; World Bank, 2006), the cost estimates do not reflect the use of standard 'with and without' analysis.

Usually the direct costs of disasters in the Pacific are estimated to varying degrees. Valuation of direct damage typically reflects the monetary cost of rehabilitating damaged buildings, replacing subsistence and commercial crops, and replacing economic and social infrastructure. Such assessments have been conducted on an ad hoc basis, but without consistent methodologies and indirect and long-term impacts of disasters are considered in terms of the physical effects rather than valued in monetary terms (Chung, 2009). When direct and indirect (flow on) costs (such as those used in the Fiji study – Table 2) are included, the costs associated with single climatic events are significant (Lal, Singh and Holland, 2009).

Table 2: Some Examples of direct and Indirect Effects of Flooding, using Example from the Fiji Sugar Belt.

Direct Effects (on-farm impacts)	Indirect Effects
• Total loss of cane and non-cane crop, or reduced productivity of crops from water logging, salt water intrusion and/or siltation • Loss in productive farm land due to scouring/washing away of parts of farm and other land • Loss in livestock (such as chickens, ducks, goats and sheep) due to drowning and/or being washed away • Loss of/or damage to household possessions and housing infrastructure	• Loss in wages due to inability to get to work, either because the roads were blocked, or because the work place was closed • Costs incurred to clean-up farms, homes and commercial sites • Human health effects caused by water and vector borne diseases induced by poor water and sanitation conditions following flood conditions • Hardship caused by loss of household possessions and belongings leaving families unable to meet their basic food and nutrition needs, clothing, and/or schooling needs of the family (often difficult to quantify). Some of these would have been temporarily addressed through humanitarian assistances

More recently, several studies (for example, (Ambroz, 2009; Holland, 2009; Lal, Rita et al., 2009)) have adopted a more systematic assessment of the costs of disasters across key sectors of society, including the private sector and rural and urban households, and assessing direct and indirect costs effects as well. However, these studies only covered limited geographic areas or economic sectors.

Value Measures

Another major problem with disaster costs estimates in the Pacific is the use of different economic measures of costs. Woodruff, for example, adopted an infrastructure replacement cost approach to estimate the likely costs of different degrees of flooding events in Samoa (Woodruff, 2007). In Vanuatu, infrastructure and associated damage costs for Port Vila under a worst-case scenario is estimated to be about AU$640 million (Shorten, Goosby et al., 2003). On the other hand, the World Bank estimates the effect of a 1-in-50 year storm event in Fiji and associated inundation could damage about 0.6 to 5.9 per cent of coastline and produce an estimated annualized economic cost of rehabilitation in Fiji of about US$3 – 6 million (World Bank, 2000). The direct infrastructure damage costs associated with Cyclone Ami in Fiji were estimated to be FJ$5.8 million or US$3.5 million (McKenzie, Prasad et al., 2005). Such infrastructure costs are expected to increase as PICTs further urbanize, with an expected one in two persons residing in urban towns and cities by 2015.

A combination of valuation methods have been used to estimate economic cost of recent disasters. Holland (2008), for example, used socioeconomic data collected immediately after floods in 2006, and scenario estimates to arrive at the costs estimates for the Navua floods. Lal and others used several different valuation methods, including production and replacement cost methods to estimate economic costs borne by a stratified sample of households (Lal, Rita et al., 2009). Both direct and indirect costs to sugarcane farmers were estimated, together with 'with and without' costs to infrastructure and humanitarian costs, arriving at an economic cost estimate of US$13 million.

Table 3: Types of Economic Valuation Methods used to Estimate Economic Costs of the 2009 Floods in Fiji (Lal, Rita et al., 2009).

Method	Item
Production Method	Gross value of loss in sugar cane production Gross value of loss in non-cane crops and livestock Gross loss in wages due to lost work time
Replacement Method	Cost to replace household possessions; 'clean up' costs
Replacement Method (repair cost)	Costs to repair houses, household capita, etc. Costs to repair infrastructure – cane access roads, tramlines, drainage, etc. Costs for treatment of diseases (Human health)
Opportunity Cost	Value of humanitarian assistance

The economic cost of climate change, even those derived using 'with and without' assessment methodologies, are generally reported in terms of gross value estimates. Very few studies actually report in terms of standard net economic benefits, as suggested by (Berning et al., 2000).

Baseline Data

While globally, the focus has been on uncertainties associated with global and regional climatic change scenarios, for the Pacific, the real concern is the availability of limited baseline and time series information to base economic and other types of climate change assessments on.

Baseline information related to disaster is limited at best. In many cases, baseline socioeconomic costs, or for that matter, information and data that could be used to determine economic cost of climate change, are almost non-existent. National Disaster Management Offices (NDMOs) maintain some disaster-related information, although these are not complete and what is collected is not available in a form that can be readily accessed. National level disaster data is also poorly maintained, with many gaps being the norm. Some disaster data may be recorded with the EMDAT database. This international disaster data system however, reports only intensive disasters, where at least 10,000 people are affected.

This is not to say that some baseline data does not exist. Often broad aggregate level information is reported against national development goals, including MDGs. These are difficult to use when determining economic costs of climate change at the micro level. On the other hand, detailed information may be available but these are not geo-referenced. For example, primary data about population is available from census data; some household income and expenditure survey data is collected every 3 – 5 years (see, for example, Narsey, 2009). However, these were also not geo-referenced and so cannot be used to estimate context-specific economic costs. Similarly, detailed sector level information is often missing, or inaccessible. For example, even basic information about basic statistics, such as area of mangrove or coral reef systems is not known with any certainty, let alone functional relationships and incremental effects of climate change knowledge on these sectors.

Where geo-referenced data set is available, it is relatively easy to combine different layers of physical, social and economic information and use these to extrapolate to the affected population (see Box 1). Hays (2010) notes that such detailed analysis combined with probability estimates of climate change scenarios, would make it possible to determine the economic costs of climate change.

Box 1 Relevance of Multi-Layered Geo-Referenced Information Systems for Climate Change-Related Economic Assessment: An Experience with the SUGAR_GIS

To assess the economic costs of floods on different sugar-industry related stakeholders, a multilayered SUGAR GIS was used. This SUGAR-GIS contains geo-referenced census data on sugarcane growers, the river and stream locations, seawalls, etc. as well as the mill catchment areas (see Lal, 2008).

The flood-affected farms were identified by the FSC field officers and mapped using the SUGAR_GIS, and a sample selected to capture the geographical spread of the flooded areas (Lal, Rita et al., 2009) To design a stratified economic survey, several steps were followed.

Location of the selected farms in each sector and mill area was verified using the SUGAR_GIS and the base cadastral maps. A sample of affected farms was selected to ensure geographical representation of the farms within the sector. Sample farms were selected on the basis of the nature of flooding, such as waterlogged/inundated/silted and/or affected by salt water intrusion, ensuring at least 15–20 per cent of each category of farms was selected. Each selected farm was then visited by trained enumerators to elicit detailed information, using a specially designed questionnaire.

Sector level data collected from the Flood Economic Survey were scaled up to mill and industry level. Sample cost estimate for each cost category was derived for the sampled farms. These category costs estimates were aggregated within a sector. This sample total for each sector was then aggregated to the sector level using the 'sector sample factor'. A 'sector sample factor' is equal to 1 divided by the percentage of sampled farms as a percentage of the number of affected farms in the sector. The sector total was then aggregated across sectors to arrive at an estimate for each mill area. Mill area estimates were further aggregated to obtain the industry total.

Damage to the cane access roads and drainage system was estimated by the respective industry engineers in terms of the additional maintenance and/or replacement costs required to address the damage caused by the floods. Each category of cost information was estimated at the sector level. The sector total was then aggregated and extrapolated across sectors to arrive at an estimate for each mill area. Mill area estimates were further aggregated to obtain the industry total.

Source: Lal, Rita, et al. (2009).

Macro Level Impact Assessment

The ECLAC promoted methodology of disaster loss assessment, noted earlier, advocates not only damage assessment but also assessment of the flow on impacts of a disaster throughout the economy (macro level cost assessments).

To our knowledge, no economic cost assessments of climate change have addressed national flow-on effects in the Pacific. In fact, only a handful of studies have examined the macro level economic impacts of disasters at all (Benson, 2003; Lal, Singh and Holland, 2009). These assessments were based on regression analysis of past macro economic performance against key factors, including natural disaster event. These studies confirm that climate change effects will undoubtedly affect national macroeconomic and the national fiscal environment (Benson and Clay, 2004). These include:

- higher government expenditure and/or partial reallocation of already committed financial resources (usually from the capital budget), to meet both the costs of repair and rehabilitation of public property, and to provide support to victims;
- fall in government revenue as lower levels of economic activity, including possible net falls in imports and exports, imply reduced direct and indirect tax revenue; and
- increasing budgetary pressures, which may result in governments borrowing more, placing inflationary pressures on the economy.

CONCLUSIONS

There is no doubt that climate change imperatives for the Pacific islanders are highly significant relative to their national economies, and increased frequency and extreme events have the potential to undo any economic and human development gains the counties may have achieved in recent years. This review has demonstrated that, although economic cost assessment of natural disasters could inform expected costs of climate change, such assessments in the Pacific are limited in quantity at best and arguably in quality or scope. Only a few assessments have examined the economic costs of climate change, using a probabilistic climate change scenarios or sensitivity analysis. Generally, climate change cost assessments have only focused on rigorous assessment of one of the three steps – climate change prediction, climate change impacts, and economic cost assessment, while using broad aggregate level information about the other two stages.

Economic cost information in the Pacific generally suffers from several limitations, including poor methodology, partial analysis and poor baseline data. The Projection the economic costs of past disasters to predict future costs of climate change further suffers from poor scientific understanding about the functional relationship between climate changes and climate change effects of sector and society. The scope of disaster cost assessment has usually been restricted to only part of the geographical areas or to some sectors affected by the climatic extremes. In the assessment, different value concepts have been used to provide general gross cost estimates. Much of the analysis is based on significant generalizations and assumptions, not only about climate change scenarios, but also about socio-economic characteristics.

Most importantly, any economic cost assessment of climate change has suffered from poor context baseline information. While aggregate level costs estimates can serve the purpose of advocacy, to make informed decisions about climate change adaption, context specific costs information is critical together with the benefits of alternative climate change adaptation.

The economic assessment of the effects of climate change in the Pacific requires concerted attention on several fronts if the values generated can confidently be used in the policy environment, including comparisons over time, place and events. Without using a standardized methodology and consistent use of concepts of values and cost measures initially past disaster costs estimation, assessment of costs of climate change will always remain inadequate, and difficult to monitor trend, adaptation and/or resilience to changing climate.

A concerted effort is also needed to also develop robust and harmonized country-specific empirical national information systems to underpin policy changes and guide adaptation to climate change. While it is always desirable to have better information, in the case of informed climate change-related decisions, there is a critical need for a core set of robust information collected, using a methodology. Furthermore, a balanced set of multidimensional set of core information is needed to support economic cost estimation of climate change, including:

- climate change scenarios and their respective hazard assessments, together with the probability of the extreme events;
- pathways of climate change impacts on sectors and ecosystems and their ecological functionalities; geo-referenced household distribution and their vulnerability; and/or
- geo-referenced economic activity distribution and their vulnerability under different scenarios.

Such data can then be used to address many policy-related questions at the macro, sector and local levels with greater confidence and taking precautionary steps towards minimizing climate change-related risks.

Equally important is to the need to adopt an interdisciplinary approach when determining economic costs of climate change and economic analysis of adaptation options, or at least use a multidisciplinary team of analysts from the outset to inform a project design for assessing economic costs of climate change. Without such a programmatic approach, and strengthened baseline data systems for action, future economic cost assessment would continue to lack rigour and be difficult to use to inform climate change adaptation and disaster risk reduction decisions. In conclusion, it is also noted that ultimately, no amount of impact assessment will make a difference unless the national system of governance and action is also strengthened such that economic considerations become integral to climate change-related decisions at all levels.

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CHAPTER 5

Impact of Climate Change on Samoan Agriculture

Marita Manley and Hiroshi Sugano

INTRODUCTION

The agricultural sector is particularly sensitive to changes in climatic conditions. Changes in temperature and rainfall patterns will affect agricultural yields directly and the type of crops that can be grown. Managing water resources for agriculture may also become more difficult and costly as a result of changes in rainfall patterns and salt water intrusion to groundwater sources.

An increase in the frequency and severity of tropical cyclones is likely to lead to an increase in crop losses. To the extent that rainfall increases manifest as extreme events, flood risk is also likely to increase agricultural losses. Sea-level rises will increase coastal erosion, leading to the loss of productive land. Increasing inundation of sea water in coastal areas will also lead to the temporary loss of productive areas and a general deterioration in soil quality.

Changes in the types and incidence of plant and animal pests and diseases are likely to occur, threatening agricultural production and increasing the risk of transboundary diseases.

Adaptation responses include farm-level actions – such as the choice of crops and varieties to be grown, diversification of crops grown, increase in the use of food preservation techniques (modern and traditional), changes in planting dates and local irrigation – to national and regional adjustments – such as the availability of new cultivars, large-scale expansion of irrigation systems and changes to existing land use planning. Some studies suggest that relatively simple and low-cost adaptive measures, such as changes in planting dates and increased irrigation, could reduce yield losses by at least 30 – 60 per cent compared with no adaptation[12]. But avoiding these losses will only be possible for individuals or economies with the capacity to undertake such adjustments.

RATIONALE

There is a growing need to understand the magnitude of the climate change adaptation costs facing the Pacific. Such estimates can support calls for adaptation financing and can also inform decisions about adaptation measures and their cost-effectiveness. The absence of solid quantitative evidence, useful for persuading policy makers of the need to act, may postpone the timely development of adaptation strategies in the region.

Given the dependence of Pacific Island Countries (PICs) on agriculture for employment, income generation and subsistence livelihoods, more studies, scientific, social and economic, are needed that examine the vulnerability of Pacific agriculture to climate change and how it will be affected by predicted changes. Pacific communities have historically been fairly resilient in adapting to natural disasters and recommended adaptation strategies need to build on this resilience and traditional knowledge.

Early work to quantify the economic impacts of climate change on agriculture relied mainly on laboratory experiments which studied the effect of temperature change on crop yields. The results obtained from these experiments were then used to predict how yields might change under different climate change scenarios.

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[12] See Stern, N. 2007. Economics of climate change. Cambridge, Cambridge University Press.

These exercises implicitly assumed that farmers would continue growing the same crops, regardless of the climatic conditions. Cost estimates derived from this approach tended to overstate the impact of climate change because they failed to account for adaptation that would occur. Subsequent work adopted a more sophisticated linear programming approach whereby land is allocated to particular crops by profit-maximizing farmers, subject to agro-climatic suitability constraints. Such models enable researchers to predict the effect of movements in agro-climatic zones on world prices, patterns of trade and production, and consumer and producer surpluses. But despite their complexity, these models are nevertheless incapable of incorporating into the analysis all possible farmer adaptation strategies to changing climate[13]. For a critical overview of these methodologies and the bibliographic details of key studies, see Mendelssohn and Dinar (1999) and Kurukulasuriya and Rosenthal (2003).

ANALYTICAL FRAMEWORK AND METHODOLOGY

The Ricardian approach is based on the premise that productivity factors (including climatic variables) determine the value or perceived value of land.

By regressing measures of agricultural outcomes (as revealed by net revenues or perceived land values) on various climate and other variables, they provide an estimate of the importance of climate in determining agricultural productivity.

The following equation represents the basic version of the econometric model estimated:

$$V = \beta 1A + \beta 2\mathbf{S} + \beta 3A\mathbf{T} + \beta 4A\mathbf{R} + \beta 5A\mathbf{TR} + \beta 6A\mathbf{D} + \beta 7A\mathbf{C} + \beta 8A\mathbf{L} + \varepsilon$$

where V represents farm value, A is a scalar variable representing the number of hectares, **S** is a vector of structural attributes, **T** is a vector of climate variables and their squares, **R** is a vector of runoff variables and their squares, **D** is a vector of distances to relevant markets and their squares, **C** is a vector of country dummies, **L** is a vector of soil characteristics and ε is an error term.

These results are then used to determine the costs associated with expected changes in these climatic characteristics and are a result of climate change.

Theoretical Basis for the Approach

Economic theory predicts that in sectors with fixed factors of production the factor in question will command an equilibrium rental price reflecting its productivity. According to this theory, if we calculate the annual net revenue a farmer generates, this is the maximum amount he would be willing to pay to rent the land for a year. And when the net revenues from farming exceed the annual rental cost of land, the rental rate will be bid up until excess profits are eliminated. Where land is differentiated by quality, a farmer's willingness to pay for a particular parcel of land will depend on the productive advantages of that land. In equilibrium, more fertile land attracts a higher rental value equal to the increase in net revenues. The productive value of particular characteristics of land, such as soil quality may therefore, be derived from their observed importance in determining rental values or, equivalently, net revenues. The productive value of land characteristics may also be derived from the sale value of land, in which case the implicit prices of characteristics reflect their contribution to productivity in perpetuity – an observation credited to David Ricardo and developed by, among others, Palmquist (1989). Several authors have already used the Ricardian technique to estimate the implicit value of a variety of farmland characteristics, including topsoil depth and drainage. Others have used the technique to determine the implicit value of climate.

For a discussion of studies that have used this approach in the context of climate change, see Dinar et al. (2008). On the whole, the available studies confirm the existence of a nonlinear relationship between climate variables and agricultural performance and highlight the importance of using seasonal, rather than annual averages for climate variables. The availability of water supplies also appears to be a critical determinant of agricultural performance.

There are several conceptual limitations to this approach. Anyone with experience working in the Pacific will also be able to highlight several practical limitations to this methodology and its applicability in the region and other developing countries.

[13] Other forms of adaptation include, for example, changes in planting dates and changes in the method of cultivation.

The validity of the welfare measures requires unchanged prices (Cline, 1996). But climate change will change the global supply of agricultural produce, meaning that prices cannot help but be affected. The Ricardian approach does not account for the costs or time associated with adaptation. It assumes that a farmer will, when confronted with a change in climate, immediately behave in ways similar to a farmer long accustomed to farming in such conditions. But these transitional costs could be very significant. Thus the Ricardian approach can be considered to produce very conservative estimate of cost. Productivity losses that are predicted, accounting for full and immediate adaptation will be lower than the expected actual costs, but this approach gives us no insight into how far from reality these conservative estimates are.

The Ricardian technique assumes that trade in agricultural produce is sufficient to equalize the returns on differentiated factors of production in all locations. But impediments to the movement of goods might prevent prices for land of identical quality being equalized. Pooling information on land values from two or more countries (or areas within a single country) might result in attempting to fit a single regression to what are essentially separate markets. This is especially relevant in the context of island countries where markets can be separated by prohibitively high transportation costs and limited populations, constraining competitive pressures and the ability to generate economies of scale.

But the biggest weakness in the context of developing countries is that data on agricultural land prices are seldom available and studies tend to use net revenues instead. Using net revenues assumes that the year studied is representative of the long run profitability of agriculture. If the survey year is atypical, it might distort the results. Calculating net revenues also presents problems: valuing household labour inputs and the produce consumed by subsistence farms can be very difficult. In several studies, farmers' perceptions of the value of their land, based on other nearby farms, has been used. This also presents problems of eliciting true values from respondents in a region where the concept of selling or leasing land is unknown. Pacific Islanders also have strong cultural ties to their land and the concept of what a farm's worth can encompass much more than simply financial considerations, such that the assumption that net revenues from farm activities is related to land value may not hold.

Details of Field Research

Hiroshi Sugano (Yale University) conducted field research to quantify the economic impacts of climate change on agriculture in Samoa, using the Ricardian approach. The research was carried out in June and July 2009, including preparation of the questionnaire, literature review, collection of relevant data from different agencies (ministries, NGOs, academics, international organizations, etc.), and actual field interviews with farmers across Samoa. 51 sample questionnaires were conducted during 20 days spent in the two major islands in Samoa – Upolu and Savai'i Island. This research is the first of its kind in Samoa in the sense that it will attempt to quantify economic impacts of climate change on crop yield and thus farmers' revenues.

METHODOLOGY

Interviews

An existing questionnaire that was used in a World Bank project in Africa[14] was modified and revised to suit cultural conditions and agricultural practices in Samoa. A copy of the questionnaire may be secured from the authors.

Extension officers from the Ministry of Agriculture and Fisheries (MAF) and Women in Business Development Inc. (WIBD), a local NGO closely working with organic farmers in Samoa, generously supported this research and served voluntarily as numerators and translators. MAF extension officers were used mainly for conventional farmers and WIBD for organic farmers. Further detail is available at the annex to this paper. Table 1 provides an overview of interview activities by supporting agents.

[14] Kurukulasuriya, P; Mendelssohn R et al (2006). Will African agriculture survive climate change? World Bank Economic Review 20(3): 367-388

Table 1: Interview Activities.

Supporting agent	Days spent	Questionnaires collected
WIBD	10	10
MAF (Western region, Upolu)	4	17
MAF (Eastern region, Upolu)	4	20
Through FAO project	1	3
Other	1	1
Total	**20**	**51**

Source: 2009 Flood Economic Survey.

In addition to field-based interviews with farmers, further data was obtained from different sources as shown in Table 2.

Table 2: Additional Data Collected.

Data	Source	Period	Note
Market price of crops	Central Bank of Samoa	Since 1993	Monthly
Supply in the main market	Central Bank of Samoa	Since 1993	Monthly
Meteorological data (temperature, precipitation)	Ministry of Environment and Natural Resources	Since 1960 (4 weather stations)	Daily
Agricultural census	Ministry of Agriculture	2005	(every 5 yrs)
Socio-economic data (general)	Statistics department		
GIS vegetation map	FAO	1998	

CHALLENGES

A number of challenges arose in the context of the field research. These are described briefly below.

Interviewees

Various ENSO (El Nino South Oscillation) phenomena have been observed during 2009. Therefore, farmers were biased by unusual weather for the last couple of months. This was an issue when farmers were asked about their perception of changes in temperature and precipitation. Their perception of climate change impacts is critical to this research because one of the purposes it tries to elucidate is existing adaptation measures that farmers have already adopted in response to changes in climate conditions. However, most farmers assume recent fluctuation in temperature and precipitation are driven by climate change (rather than short-term ENSO phenomena) and yet they haven't taken any adaptation measures. This misperception might lead to a wrong conclusion that farmers implement no measures despite high-level awareness of climate change.

Close Relationships between numerators and farmers is generally preferred to ensure interviews run smoothly. This could however, lead to problems with personal questions, such as income level. For example, some farmers seem to overstate their income level, or at least they answer their highest ever earned income. Since income data is very critical to this research, such overstatements may distort results.

Issues with Interviewers/Numerators

Lengthy interviews made it difficult to keep farmers and even numerators engaged for the entire interview. Limiting the interviews to an hour and using multiple choice questions and simple examples helped farmers to grasp questions easily and answer quickly. For example, a question such as 'what is the adaptation strategy for the short-term climatic variations' seemed an unfamiliar concept to some farmers. In that case, answer options such as 'mulching (to keep moisture in the soil)' or 'screen net (to protect crops from heavy rain)' were used to illustrate some examples. However, examples provided might have offered farmers with some bias and led their answers in a certain direction whether it was intended or not.

Numerators did not always fully understand each question and the purpose and significance of the research. Data quality from the interviews was largely dependent on numerators qualifications. Detailed training for numerators is therefore essential and would have allowed them to conduct more interviews independently increasing the sample size.

Issues with the Questionnaire and Methodology

Farmers gave answers in their most convenient units for their crop harvests and sales, e.g. 'in banana leaf-woven basket' for root crops and 'in bunch' for bananas per week. These were then converted to conventional units, such as kilograms per year. However, variation in the quantities contained in convenient units and fluctuations in sales and consumption patterns may have undermined the accuracy of units.

Questionnaires were distributed to those who had a good command of English in an effort to increase the sample size. However, this often led to a delay in questionnaire resubmission and prolonged collection efforts. In addition, allowing farmers to fill out the questionnaire by themselves sometimes resulted in incomplete and/or insufficient answers, undermining data quality a great deal. Careful selection of farmers should have been made to get the kind of high quality answers that we received through actual interviews.

Methodological Challenges

Ricardian analysis assumes a wide range of climatic conditions. In the case of this research, although elevation may generate differences in temperatures due to the topography in Samoa, such variations can be too small to justify and carry out Ricardian analysis. This is likely to also be the case with most Pacific Island Countries apart from Papua New Guinea.

Ricardian analysis is better suited to countries with more developed and competitive agricultural markets. In Samoa, most farmers use the same prices that are used in the Fugalei market in Apia, the central market in the country. The limited variations in crop prices undermine the basic premise of Ricardian analysis.

Ricardian analysis presumes farm/land values change according to inputs and outputs into the farm. Land in Samoa is natively owned by customary land-owning groups and cannot be sold. Questions relating to land values are therefore hypothetical to Samoan people. Farmers were encouraged to use land lease prices of neighbouring farms, or the land proximity to towns and infrastructure as a proxy to estimate land values.

Root crops are widely grown in the Pacific and tend to be more resilient to weather and soil quality variations, limiting the need for adaptation measures in response to different climatic conditions. This limits the usefulness of this research, which is to reveal farmer's adaptation strategies that have been already adopted. In order to use this approach effectively in the Pacific Island context, crop varieties, in addition to the type of crop grown should be recorded as they possess traits that are better suited to different conditions.

Most farmers (the exceptions are usually vegetable growers) are not bound to seasonal differences between wet and dry seasons because Samoa has relatively stable temperatures throughout the year. Unless farmers grow rain-sensitive crops, they plant and harvest non-seasonal crops such as bananas, taros, yams or coconuts. Such little variations in crops may indicate vulnerability of farmers, (i.e. small selection of crops adaptive to changes) if the climate becomes unfavourable to those crops. Therefore, estimating the impacts on yields of existing crops due to climate change is crucial to understanding the associated costs and necessary adaptation strategies.

The study only takes into account the predicted impact of changes in temperature and precipitation on agriculture and therefore, fails to account for many of the predicted impacts of climate change beyond temperature and precipitation changes, such as an increase in pests and disease incidence. As water availability is also a key driver of the impact on crop yields, the fact that the approach fails to account for how other water sources (in addition to rainfall), such as groundwater sources will be impacted by climate change is problematic.

CONCLUSIONS

This study is a work in progress. Over the next few months, regression analysis will be conducted to identify significant variables (including climatic characteristics) that affect crop yield in Samoa and how these variables are interconnected. Economic analysis of the expected impacts of climate change will be conducted using IPCC projections of temperature and precipitation. The results of this study will be used to raise awareness of the potential costs of climate change on the agricultural sector in Samoa and potential farm level adaptation strategies that can be adopted to minimize these costs.

It is already evident though, that there are severe limitations to the application of the Ricardian approach in the Pacific for the reasons outlined above. In order to meet the demand for more quantitative analysis of the impacts of climate change on Pacific agriculture, economists will need to develop appropriate techniques that can be used, taking into account data limitations in the region. The dependency on root crops means that laboratory experiments that examine the crop yield impacts on different varieties is very much needed to inform country level research and adaptation strategies.

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SECTION II

ENCOURAGING RENEWABLE ENERGY: DECISIONS MADE ON TECHNICAL VERSUS ECONOMIC VIABILITY

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CHAPTER 6

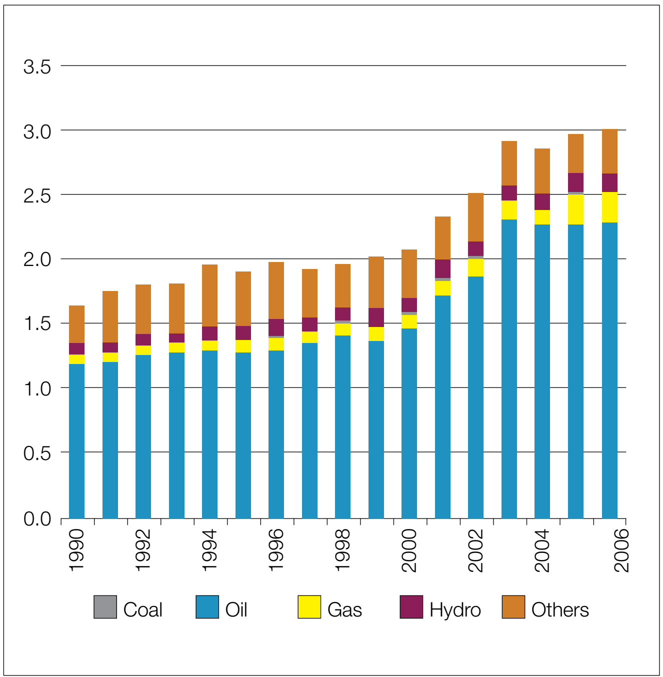
Economic Feasibility of Coconut Biofuel

Tim Martyn

INTRODUCTION

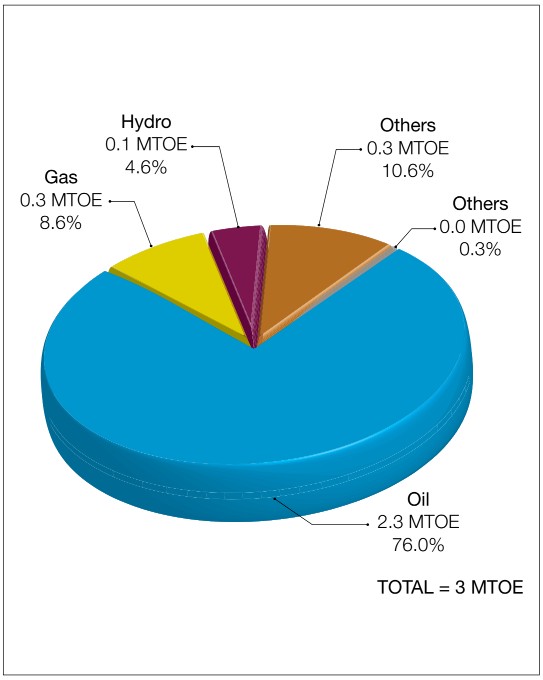
Pacific Island Countries (PICs), possessing few indigenous sources of oil and gas (with the exception of PNG), are extremely dependent on imported oil to power national development. (Figures 1 and 2) PICs can improve both energy security and their foreign exchange position by reducing their dependence on imported oil. This can be achieved by improving their efficiency in oil use; and by switching to renewable sources of energy (UNDP, 2007b).

Figure 1: Primary Energy Supply in the Pacific 1990-2006.



MTOE = million of oil equivalent
Source: APERC and UNSD.

Figure 2: Primary Energy Mix in the Pacific 2006.



MTOE = million of oil equivalent
Source: APERC and UNSD.

Why Coconut Biofuels?

Coconut has been an important export crop for the PICs since the 19th Century. Yet international demand and prices for traditional coconut products, such as copra have retreated in the face of competition from cheaper substitutes (McGregor, 2008: 36). As a result, PICs have sought to create a new demand for coconut biomass by converting it into coconut oil based fuels. However, creating a new source of demand for coconut has not been the sole focus of PICs.

Pacific Governments and donors have tended to pursue one or more policy objectives when it has come to the design and implementation coconut biofuels projects:

- Reduce dependence on imported fuel and improve national BOP: the local production of biofuels can contribute to a reduction of the dependence of the Pacific on imports of fuel, and therefore make a positive contribution to both the national balance of payments and greater energy security.
- Improve rural income generation: producing and consuming coconut oil as a fuel could provide Pacific farmers with new opportunities to earn an income.
- Increase rural electrification: coconut biofuels present rural and remote communities with a new local fuel source, and a new potential source of electricity.

This article explores, through each of these three policy lenses, why many coconut biofuels projects never move 'off the drawing board' because they fail to appreciate the changing socio-economic context in which many Pacific island communities live, leading them to under-price the value of local labour in their feasibility assessments. The low and falling returns to labour provided by copra have pushed producers out of the industry – many of who will never return, and certainly not at the marginal increases to labour offered by coconut biofuels projects.

IMPORT SUBSTITUTION

The Pacific Islands Applied Geoscience Commission (SOPAC) estimates that fossil fuel imports accounted for between 8 and 37 per cent of total imports in 2006 and are often many times the total level of exports (Woodruff, 2007:4). The Pacific's dependency on imported fossil fuels leaves them particularly vulnerable to price spikes for two main reasons. First, their economies are very energy intensive, meaning that they use a large amount of energy for every dollar of income that is generated – largely as a result of their dependence on long-distance transportation and the importance of energy intensive economic activities like fishing (Dornan, 2009:73). Secondly, electrical power generation in the islands is largely fuelled by diesel (UNDP, 2008:46).

Because of their distance from markets, fuel price increases not only impact on energy costs, but raise the cost of food, transport, fertilizers and farm inputs, and reduce the competitiveness of Pacific Island exports. Subsequently, large oil price rises can significantly increase inflation and weaken the balance of payments (BOP). (See Table 1.)

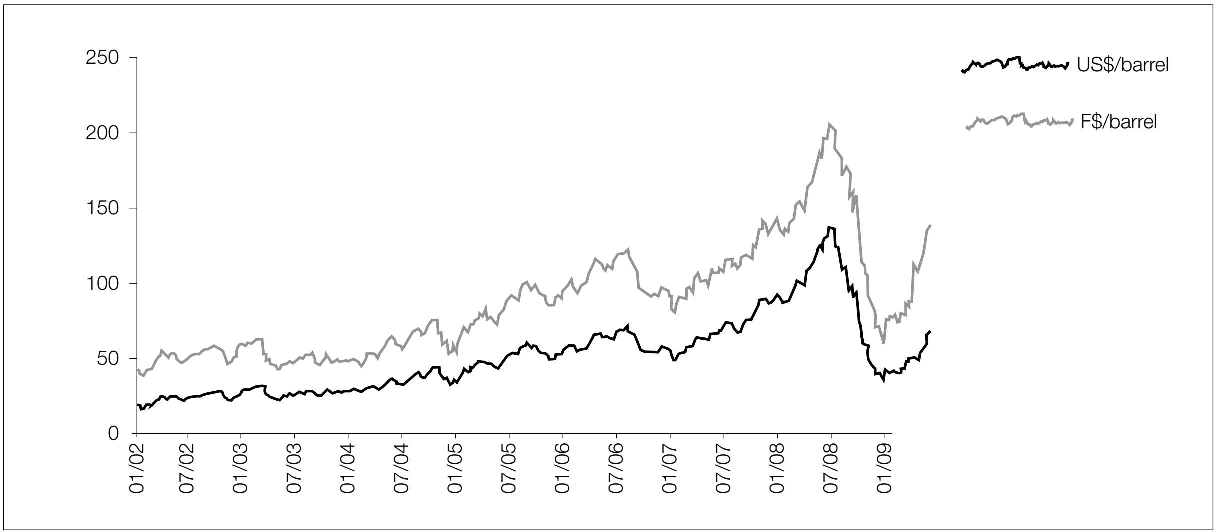
Table 1: Pacific Island Petroleum Imports 2006.

Country	Import Value (M US$)	% of Total Imports	% of Total Exports
Fiji	340.2	23.5	50.0
Solomon Islands	11.7	27.4	15.8
Samoa	22.6	15.1	160.3
Vanuatu	12.8	14.3	64.3
FSM	17.3	13.0	88.3
Tonga	17.6	25.5	293.3
Kiribati	5.7	10.0	172.7
Marshall Islands	20.4	37.3	224.2
Cook Islands	6.2	8.4	86.1
Palau	12.4	13.0	104.5

Source: Woodruff, 2007, p.4.

Between June 2007 and June 2008, the price per barrel of crude oil on the New York Mercantile Exchange (NYMEX) rose from US$65 a barrel to US$140 a barrel: an increase of almost 107 per cent (www.nymex.com, 2009). (See Figure 3.) The international Energy Agency (IEA) predicts that declining production, coupled with a growth in annual average demand, will contribute to the oil price reaching, in today's dollars, an average annual price of US$120 a barrel by 2030 (IEA, p.13).

Figure 3: World Oil Price, January 2002 – January 2009.



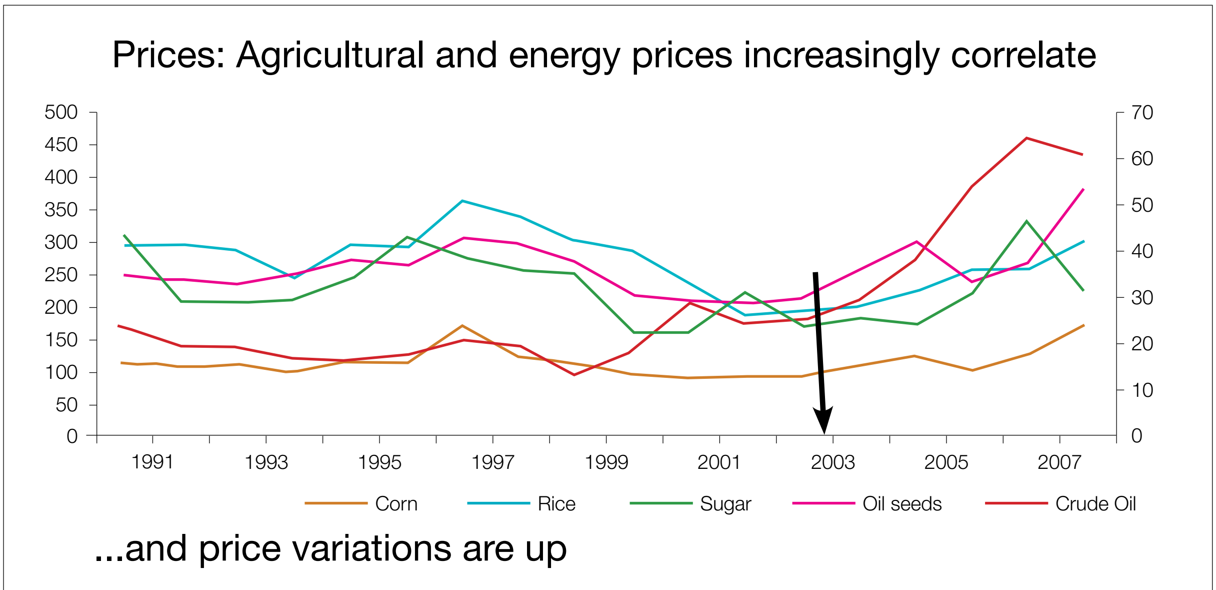
Source: Energy Information Administration, 2009, http://tonto.eia.doe.gov/

Given the Pacific region's dependence on imported oil and vulnerability to high oil prices, it makes sense for Pacific governments to prioritise the substitution of imported fuel with locally produced alternatives where they are available at a cheaper price (REM Communiqué, 2007). However, it is uncertain that coconut biofuels offer such an alternative. Significantly, part of the reason for this uncertainty is that as the price of imported petroleum products rose in 2007 and 2008, so too did the price of copra and coconut oil.

Correlation between the World Oil Price and Vegetable Oil Prices

The increasing use of vegetable oils as a fuel substitute has led to the growing correlation between the world oil price and world prices of vegetable oils, including coconut oil (Figure 4).

Figure 4: World Price of Oil and Vegetable Oils.



Source: IMF, 2007, OECD, 2005: World Bank, 2007.

Any diversion of soya bean oil or palm oil production to biofuel use impacts coconut oil prices, as less of these substitutes are available to compete with coconut oil in its traditional edible and industrial uses. With the predicted growth in the use of vegetable oils as biofuels and fuel additives, this trend is likely to increase (McGregor, 2008: 6). As a result, the presumption that high crude oil prices will make coconut oil more price competitive as a source of biofuel is decreasingly relevant, as the price of both become increasingly correlated.

Yet for many Pacific countries, another factor stands in the way of displacing a significant proportion of their fuel imports: the transport sector is the biggest consumer of imported oil in the Pacific and it is a sector not well adapted to the use of coconut oil fuel substitutes.

Utilities versus the Transport Sector

A majority of petroleum use in the Pacific is in transport, rather than in the electricity generation sector (Wade, 2004). For example, in Fiji, only 26 per cent of oil use was for electricity generation, while some 55 per cent of petroleum use was for the transport sector (Johnston, 2004} the Marshall Islands, 68 per cent of petroleum use was for transport and 30 per cent for electricity generation (Wade, 2004). In Vanuatu, 64 per cent of fuel use was for transport and 30 per cent for electricity generation (Johnston, 2004). Subsequently, if import substitution were the primary focus of government policy, then the transport sector should also be the primary focus of coconut biofuels development.

The problem is that coconut oil is a difficult transport fuel. The viscosity and propensity of coconut oil to solidify at temperatures below 22 degrees Celsius can contribute to increased engine failure and added maintenance costs, particularly when used in engines not adapted for the use of coconut oil. Furstenwerth, in a study carried out in the Marshall Islands, found that even in the best case scenario, using pure coconut oil as a transport fuel results in added maintenance costs of between US$0.25 – 0.50 a litre (SOPAC, 2007:22). Subsequently, coconut oil often works best as a transport fuel when blended with diesel; or converted into an esterified biodiesel. The transformation of coconut oil into a biodiesel involves the use of costly and volatile chemicals, and the production of glycerine as a waste product. The cost of small-scale esterification of vegetable oil is estimated by SOPAC to cost US$0.3-0.6 per litre, depending on the size of the operation (SOPAC, 2007:11). This adds a significant expense and technological complication to the production of coconut biofuels, and reduces its cost competitiveness relative to imported diesel. In addition, securing and safely storing the chemicals required to esterify coconut oil make it ill-suited to rural and remote island contexts. Engine manufacturers and insurers tend to recommend using coconut oil only in blends of 5 or 10 per cent to minimize potential engine damage or clogging of fuel lines, filters and injectors. While specialized services, such as marine transport and municipal bus services have been successful at using coconut oil in higher blends in the Pacific, some clear guidelines covering the limitations of coconut oil as a fuel and the quality controls that need to be in place to ensure the consistent fuel quality required to encourage wider use in the transport sector.

Yet the biggest obstacle to increasing the amount of coconut oil, thereby making import substitution not a demand is accessing a sufficient supply of copra. Indeed, the ‘production frontier’ places severe limitations on coconut oil’s potential contribution to energy import substitution and independence.

The Coconut Production Frontier

In 2005, SOPAC – with assistance from the University of London – considered the potential production limit to the use of coconut oil as fuel in the Pacific. It calculated this, not from current production levels of copra oil, but from an estimate of the total amount of coconuts available to be harvested in a given year (Table 2).

Table 2: Combined Consumption of Diesel and Gasoline versus Production potential of Coconut Oil.

Country	Current Fuel Consumption (Million litres) †	20% of Current Fuel Consumption (Million litres)	Potential Coconut Oil Production [Million litres] β
Fiji	159.4	31.88	17.47
Solomon Islands	15.9	3.18	3.06
Samoa	94.0	18.8	3.44
Vanuatu	73.0	14.6	10.92
FSM	78.0	15.6	7.10
Tonga	32.2	6.44	0.00
Kiribati	3.1	.62	0.29
Marshall Islands	47	9.4	30.51
Cook Islands	6.2	8.4	86.1
Palau	12.4	13.0	104.5

† Figures for Kiribati, Marshall Islands, Samoa, Solomon Islands. Figures for Tonga, Tuvalu and Vanuatu are taken from PIREP national Pacific Regional Energy Assessments 2004; Figures for Fiji are taken from Fiji Bureau of Statistics (June, 2008).

β Figures are taken from Pacific Regional Biofuels Workshop, Vanuatu, 2005.

World prices for copra have been declining, in constant 1990 dollars, from about US$1 400 a tonne in 1950 to under US$500 a tonne in 2008 (CIDA, 2008:2). This has significantly discouraged production of copra in the Pacific, as the returns for the difficult work of cutting copra have declined relative to other economic opportunities. This has resulted in widespread underinvestment in maintaining coconut plantations, ageing coconut trees and declining productivity per acre – making it even more difficult to generate sufficient income from copra farming.

In 2008, the World Bank concluded that, due to the declining production of coconuts in Fiji, there were only enough coconuts sufficient to substitute 5 per cent of Fiji's imported fuel with coconut oil blends. (LMC, 2008:6) This would be equivalent to producing approximately 4.6 million litres of coconut biodiesel a year – or 4,250 tonnes of coconut oil – a figure which is barely 25 per cent of the SOPAC figure.

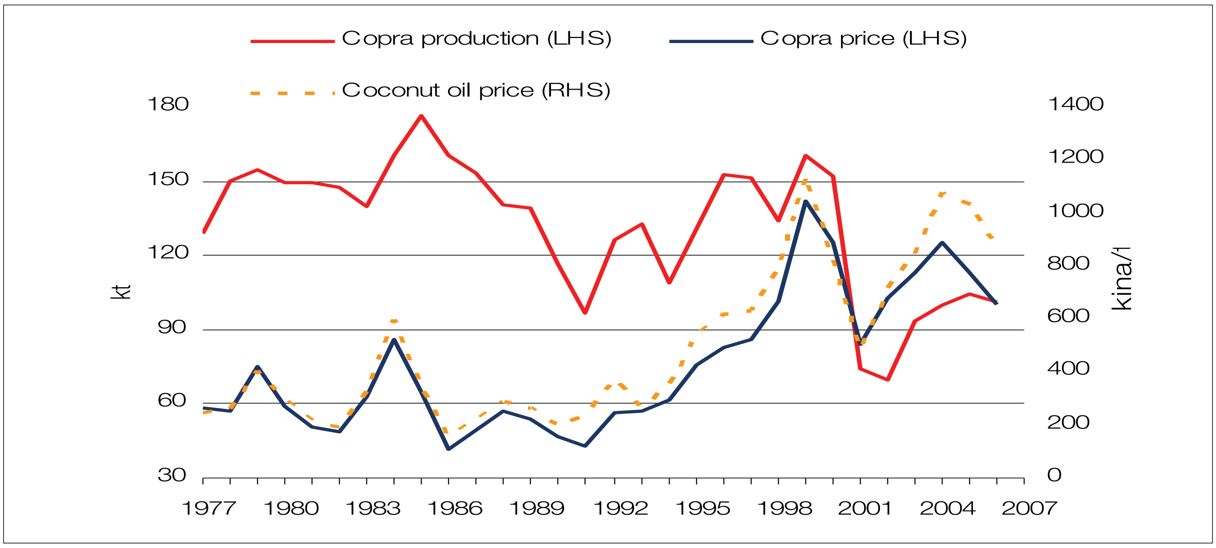
While the prospects for energy independence may be thwarted by relative high production cost of coconut oil and the low levels of copra and coconut production in the Pacific, there may be sufficient coconut biomass to produce much more. In particular, there may be sufficient coconuts in some rural and remote areas to meet local energy needs. However, the key obstacle is not the availability of biomass, but the availability of labour to turn that biomass into a cost-competitive biofuel; and as we will see in the next section, this availability is determined by the returns to labour on offer.

RURAL INCOME GENERATION

As a result of increasing standards of living in many Pacific communities, the returns to labour available from copra production have fallen below the 'reservation wage' at which many Pacific producers are willing to offer their labour. This has contributed to declining production of coconut products in the Pacific. Indeed, the reservation price at which household labour is offered is quite high in the Pacific, owing to the range of subsistence and cash activities each household manages, and their ability to reallocate labour between these activities as relative prices change (McGregor and Hopa, 2008: 46). Indeed, where communities are isolated from major markets for consumer goods, such as the rural and remote island communities where copra cutting remains a major activity, demand for cash is often quite limited and occasional; as a result, once enough copra or similar cash crop has been sold to meet household cash needs, labour is reallocated to subsistence activities (McGregor and Hopa, 2008: 46). This mode of production leads to intermittent periods of supply and may contribute to supply problems encountered by coconut biofuels projects.

Figure 5 illustrates this for the case of Papua New Guinea, where copra production has been closely linked to the domestic and world price (McGregor and Hopa, 2008: 48).

Figure 5: Responsiveness of coconut supply to price – PNG[a].



[a] Assuming 65 per cent oil yield from copra.

Source: MacGregor and Hopa, 2008, p.48.

McGregor argues that copra processing is declining rapidly in the Pacific where the opportunity cost of labour is higher (McGregor, Warner and Polemo, 2006:65). This is illustrated in Figure 8, which presents a comparison of the return to labour from copra at various prices, with the prevailing rural wage in different Pacific countries (Table 3). It suggests that it is only in the Solomon Islands, where alternative employment opportunities are scarce, that copra production is an attractive option. However, there are significant variations between rural wages within countries, depending on remoteness, which this table is unable to illustrate.

Table 3: Returns to Making Copra Compared with Rural Wage Rates in the Pacific.

	Return to labour as percentage of rural wage				
Copra price a	Solomon Islands	Fiji	Tonga	Samoa	Vanuatu
US$	%	%	%	%	%
90	173.3	46.8	22.8	60.8	68.5
105	200.0	54.6	26.6	70.9	80.0
120	226.7	62.4	30.5	81.1	91.5
135	253.3	70.2	34.2	91.2	102.9
150	286.7	78.0	38.1	101.3	114.4

Source: McGregor, Warner and Polemo, 2006, p. 65.

Returns to Labour: Alternative Cash Crops

Cutting copra is difficult, physical work that, on the whole delivers low returns to labour, which has made alternative cash crops, like kava and taro, increasingly attractive.

Taro and Kava farming require relatively few labour inputs per tonne of output when compared with copra production. According to the Ministry for Agriculture and Primary Industry (MAPI), the optimum marketable yield for a hectare of taro is 14 tonnes per year. (MAPI, 2008a:1) In contrast, the optimum yield for a hectare of kava is 2500 kg or 2.5 tonnes, in years four and five of a five-year farming cycle (MAPI, 2008b:1). However, kava is a significantly more valuable crop per unit weight.

At the optimum rate of output (averaged out over a five-year farming cycle to simplify the comparison between kava and taro), MAPI estimates that a farmer can earn FJ$11,403 per hectare of taro, per year, in return for 115 man days of labour (MAPI, 2008a:2). At the optimum rate of output (averaged out over a five-year farming cycle) MAPI estimates that a farmer can earn FJ$8 936 per hectare of kava, per year, in return for an average of 142 man days of labour (MAPI, 2008b:2).

To compare the return on labour for these two crops with copra, we will use the optimum return to labour calculated by SOPAC: FJ$3.60 per hour, in return for producing 30kg of wet copra per hour, and selling it at the prevailing roadside rate (PIEPSAP, 2007:42). If we consider one man day of copra cutting is equivalent to eight hours of producing copra at this rate, then the return on labour is FJ$28.80 per day. At the equivalent number of man days required to produce a hectare of taro – 115 – this will net a copra cutter FJ$3 312 per year. Thus, at this rate of return, even if the copra cutter was to produce 30kg of wet copra per hour – which involves gathering, cracking and scraping some 300 coconuts eight hours a day, 365 days at year – they would still be unable to reach the financial return gained from farming taro for less than a third of the effort. At 142 man days of labour a year – the equivalent effort required to produce a hectare of kava – the copra cutter would net less than half the reward: FJ$4 089.

At these comparative rates of return on labour, it remains true that where farmers have access to markets for alternate cash crops such as taro and kava, it will be very difficult for a coconut biofuels project to attract a sufficient supply of copra. However, where farmers have no other cash crops, such as on some of the outer islands of Fiji, Kiribati, Vanuatu and the Solomon Islands, then creating a local market for their copra by establishing a coconut biofuel project makes sense.

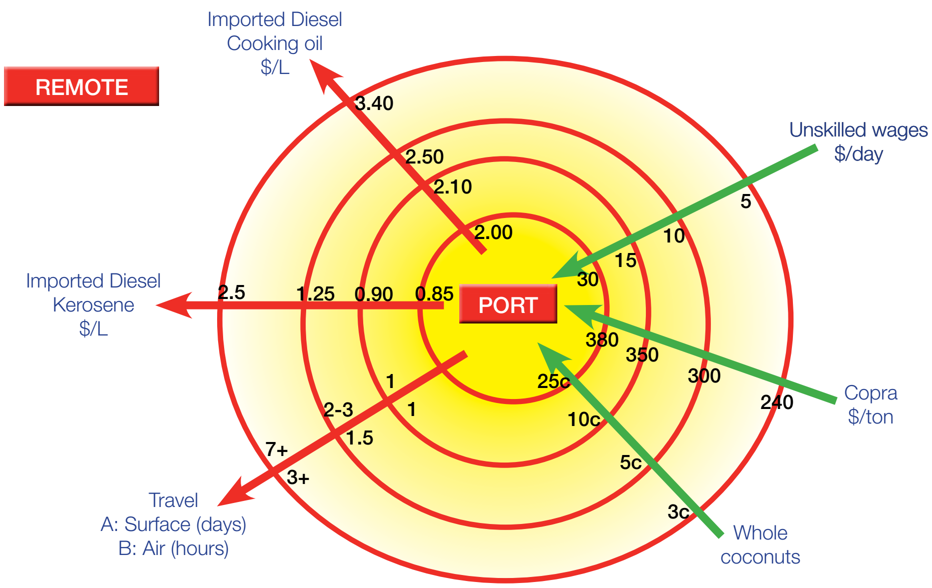
Project Location is the Key to Maximizing Rural Incomes

Pacific communities located in rural and remote areas face significant costs just getting their copra to the mill gate, in addition to paying higher prices for the goods they bring to their communities. As world oil prices spiked in 2007 and 2008 and settled higher in 2009, so too did transport costs, raising the cost of living in remote Pacific communities while reducing income received from goods sent to market.

This has important consequences for rural income generation. Woodruff notes that Pacific island countries often face a 'double freight penalty' since the high shipping costs they face mean they pay more for imported fuel, and receive lower earnings on coconut oil and copra exports (Woodruff, 2007:64). Before the product even reaches the Mill gate, farmers have to incur significant transport costs. Indeed, while the minimum mill gate price might be FJ$500 at the Savusavu copra mill, copra cutters in remote areas of Cakaudrove province in Eastern Vanua Levu report getting as little as 1/3 of this amount, once transport costs have been removed (Fiji Times, 2009:42).

Figure 6 illustrates how transport costs can raise the price of imported fuel and copra exports, whilst simultaneously lowering local labour costs.

Figure 6: Remoteness and the Cost of Freight in the Pacific.



Source: Etherington 2006:4.

Subsequently communities located some distance from urban centres, such as on outer islands and in rural and remote areas, have the opportunity to turn this 'double freight penalty' to their advantage by both producing and consuming coconut oil locally. However, the competitiveness of a coconut biofuels project is not only determined by local labour rates and fuel costs, but the efficiency of the expelling operation installed to produce coconut oil. And remoteness also creates a wide range of disadvantages: access to maintenance and spare parts; access to skills to manage and maintain the project; access to markets for any surplus oil.

This last point is crucial. Many rural and remote communities are small with relatively low demand for energy. In seeking to match the project to the community's needs, project designers may install a small oil expeller with relatively low levels of efficiency that require large labour inputs per litre of oil. This creates the danger of raising the cost of producing a litre of oil above a rate necessary to make it competitive with imported diesel. However, in contrast, project designers may seek to reduce the labour and coconut input cost of a litre of oil to an absolute minimum by installing a much larger expeller, which requires a much larger throughput of coconuts (stretching the capacity of local supply) and creating a huge surplus of oil that needs to be marketed outside of the community.

Finding the right balance between these two extremes is a difficult task. Yet, if maximizing rural incomes is the priority of government and donors, then there is a third option – and that is to tap into alternative sources of demand for coconut products.

Improving Incomes by Valuing the Whole Nut

Producing coconut oil for burning as a fuel is a relatively low value end-use for a coconut. Indeed, rural incomes could be maximized by transforming the national coconut industry into one that values the 'whole nut'. This would involve transforming their production system from one oriented towards oil production to one oriented towards utilizing the numerous by-products of oil production.

The 'whole nut' concept, pioneered by Divina Balwalan of the Philippine Coconut Authority, is an integrated system of coconut processing where all parts of the coconut fruit are converted into valuable products, rather than the current 'oil-oriented' approach. Indeed, the highest income gains to be generated by changing the orientation of Fiji's coconut industry, comes from properly de-husking nuts, so that the coconut husk can be sold and processed into value-added end products: coir for textiles industry; and coconut shell for charcoal filters; biochar to improve soil fertility; and provide fuel for bio-gassifiers to turn into electricity (Balwalan, 2008:65). From de-husked whole nuts, communities should be encouraged to produce and sell VCO, coconut vinegar from coconut water, and dried coconut milk for use in cooking (Balwalan, 2008:70).

Raising the value of de-husked whole nuts from a few cents to one dollar or more provides rural communities in the Pacific with a more valuable end-market for their products – sufficient to surpass the additional costs associated with transporting whole nuts from remote communities. However, such a transformation would require a significant commitment from national authorities and training and sensitization of communities to encourage them to change their harvesting techniques. At the same time it would require significant market research and development to link coconut producers to these emerging markets.

For those communities located in areas simply too remote to tap into markets for value-added coconut products, coconut oil can provide a locally produced fuel to power rural electrification. However, this opportunity is limited by a number of factors, which are explored in the next section.

RURAL ELECTRIFICATION

Poor access to electricity is common in the rural areas and outer islands of some Pacific Islands (UNDP, 2007:11). Many Pacific island countries have their rural populations dispersed over numerous small islands, making it difficult to provide access to energy for all via an island-wide grid. Typically, off-grid electricity supplies are met by diesel mini-grids connected to generators that are expensive on an energy-unit-cost basis, and which suffer unreliable, intermittent supply (UNDP, 2007:15).

Pacific governments and development partners have sought to justify investment in coconut biofuels production as a means to increase access to electricity for those rural and remote communities currently off the main power grids (and with little prospect of being joined up soon) by lowering fuel input costs. However, the implementation experience of small community electrification using coconut biofuel has been mixed.

There are a number of technical issues that must be properly addressed during the project design phase, including: the choice of the technology and control system; the method used for drying the copra needs to be capable of reducing moisture and acidity levels to a minimum; and the oil needs to be free of solids and other contaminants.

Outer islands and remote parts of the Pacific are difficult environments for maintaining machinery. When equipment breaks down, parts are difficult to acquire and local communities are often ill-trained on how to maintain or repair what has been installed. Relying on one or two local residents is ill-advised, as people often migrate or move away, leaving a skills deficit behind. In addition, poor quality copra drying techniques can lead to engine carbonisation and failure. In such an environment, it is important to ensure outside assistance is available to communities. By partnering with the private sector or government rural electrification departments, where available, to ensure that ongoing maintenance and repair is a shared responsibility, coconut biofuels projects will contribute to their own sustainability.

Sufficient training needs to be provided to the community to enable them to use and maintain the units that are installed, while access to external maintenance support is also an ongoing requirement. The additional maintenance complications and costs associated with the use of coconut oil biofuels in many engines is exacerbated by this lack of support, and can contribute to its unsuitability as a fuel for rural electrification. However, as was identified earlier, the major issue relates to matching the right expelling technology with local conditions.

The Most Appropriate Technology?

Whilst access to maintenance and good management of the local project is important, the key issue affecting rural electrification schemes using coconut oil is whether oil can be produced locally at a price competitive with imported diesel. This is determined both by the local cost of labour and coconuts, and the number of coconut and labour inputs required to produce a litre of oil.

Local production of coconut oil has been tried, with varying levels of success, with the distribution of Direct Micro-Expellers (DMEs) and other hand-operated oil presses and screw presses. However, many of these presses were designed from the production of a far more valuable end-product: Virgin Coconut Oil (VCO), which retails at three or four times the final price of coconut oil consumed as a fuel. For example, Kad and Weir estimate that the retail price for a litre of Virgin Coconut Oil in Suva is FJ$8.45 (Kad and Weir, 2007:49). Each DME unit employs four to six adults to expel oil to produce between 30 and 50 litres of oil a day (Kad and Weir, 2007: 52). Thus there is a high labour cost component in the production of each litre of oil. Increasing the scale of production is necessary to make coconut oil biofuels cost competitive with imported diesel, even in the most remote Pacific communities.

Another more efficient example is the Axis hydraulic press. Rather than requiring the strength of a number of employees to physically press the coconut oil from the copra, the hydraulic press does the same job more quickly and more effectively using hydraulics. This reduces the number of nuts required to provide one litre of oil. One Fijian group based on the island of Moala in the Lau Group, Origins Pacific Ltd, found that after moving from DMEs to an Axis expeller, they almost doubled their oil production: from 1067 to 2040 litres a month, despite only increasing the daily input of nuts by 28 per cent (Origins, 2009). As a result, they were able to almost halve their production costs per litre (Origins, 2009). However, at a cost of FJ$2.81 per litre before adding marketing and administration expenses, even an automatic hydraulic press is unable to produce coconut oil at a price capable of competing with imported fossil fuels.

A worthwhile innovation in the PIC coconut industries has been the introduction of Indian Tinytech cold press mills. Tinytech are well suited as a small scale bio-fuel operation as shown by the experience of Buka Metal Fabricators on Bougainville. The capital cost of Tinytech cold press mills is low and throughput is reasonably high: the mills are capable of handling around 600 kg of copra in a day. The oil extraction rate is lower than that of a conventional copra mill (around 52 per cent oil); therefore capable of producing some 300 litres of oil a day – six times the production of a DME or approximately three times the productivity of an Axis Press. Tinytech mills use far less labour than DMEs (three people are required to produce around 300 litres of oil compared with six people to produce 45 litres). This contributes to the much lower production costs per litre of oil. However, as for the DME and the Axis Press, it is still difficult to produce a litre of coconut oil at a price that is competitive with imported fuels, even in the most remote location. To reduce production costs of coconut oil to a price that is competitive with imported fuels requires a further increase the scale of production.

Subsequently in 2006, the Pacific Island Energy Policy and Strategic Action Planning Project (PIEPSAP) commissioned a study of the feasibility of establishing a medium-sized coconut oil biofuel facility on Fiji's most remote island, Rotuma.

Rotuma is an island of 525 households Located 640 km North West of Fiji's capital Suva. (Zieroth, 2007:3) As a result of its long distance from Suva – the arrival point for all fuel imported into Fiji – Rotuma has the highest fuel costs of any region in Fiji. (Zieroth, 2007:10) Indeed in August 2008, at the height of the oil price spike, diesel retailed on the island for FJ$2.59 per litre; however, by August 2009 this had declined to FJ$1.87 per litre (compared to FJ$1.67 in Suva) (Government of Fiji, 2009).

A detailed analysis of Rotuma's total harvestable nut production revealed that it was capable of producing 5 million nuts per year (Zieroth, 2007:40). With 1.5 million of those going towards local consumption, Rotuma is left with 3.5 million nuts per year – enough to produce 690,000 litres of coconut oil (or 635,000 litres of diesel oil equivalent): more than three times the estimated annual fuel consumption of the island (Zieroth, 2007:81). By scaling-up production to 100,000 litres of coconut oil per year, the PIEPSAP feasibility study concluded that the Rotuma project would be able to produce coconut oil biofuels at a price competitive with imported diesel (Zieroth, 2007:82). However, to reach this conclusion, PIEPSAP seriously underpriced the local reservation price for labour by judging that it would secure a supply of green copra at the current roadside price of FJ$0.12 per kilogram (Zieroth, 2007:4).

The PIEPSAP feasibility study identified that Rotuma's cash economy is driven by three sources of income: remittances, government salaries and the export of copra (Zieroth, 2007:22). Rotuma's copra cutters were estimated to have received a total of FJ$154 000 in 2005 – or FJ$293 per household, per year, on average (Zieroth, 2007:22). By way of comparison, remittances to Rotuma from just the island of Viti Levu on Fiji, totalled approximately FJ$1 million per month in 2007 (excluding informal transactions carried on outside of Western Union): some FJ$500 a month for every Rotuman living on the island (Hanan, 2008:234).

This comparison illustrates the superiority of remittances as a source of cash income on Rotuma, and its potential to satisfy the occasional cash needs traditionally provided for by copra production, identified by McGregor and Hopa (McGregor and Hopa, 2008). The prevailing socio-economic conditions on Rotuma dictate that a significantly higher return to labour would be required to attract a supply of surplus coconuts on Rotuma sufficient to justify the installation of a FJ$150 000 mini-mill; yet, to offer such a return to labour would be to render the production price of its oil output uncompetitive with imported diesel. Subsequently, this project was unable to proceed.

The Government of Fiji is currently embarking on a policy to install coconut expellers with approximately half of the oil production capacity of the one above, but with demand from significantly smaller local populations, in up to 42 locations around Fiji (Voravago, 2009). The success of this endeavour will rest on four factors: a) being able to motivate enough local labour at sufficiently low wages to supply sufficient throughput of coconut to keep to expeller operating on a cost-effective basis; b) finding markets for the large amounts of surplus oil that these projects will generate; c) being able to access maintenance assistance when things, inevitably go wrong; and d) maintaining good management, particularly financial management, of the project to ensure oil is supplied on a user pays system, and at above cost.

UNELCO in Vanuatu have proven that coconut oil biofuels-driven rural electrification can work, with their project at Port Lory on Santos, consistently producing and consuming coconut oil as a fuel at a price significantly cheaper than imported diesel (UNELCO, 2009). However, UNELCO have been able to take advantage of both low local wage rates and the very high cost of diesel fuel and electricity in Vanuatu. In addition, they have provided ongoing maintenance support and financial management assistance to the project. Where such private sector support isn't available or is divided by a number of consecutive projects; where energy prices are kept low through government subsidy or other intervention; where labour costs are high as a result of the provision or remittances or access to markets for higher value or value-added products, then coconut biofuels projects are unlikely to be sustainable.

LESSONS LEARNED

There have been a range of evaluations and feasibility assessments of the potential to use the Pacific's coconut resource for energy, particularly through the production and use of coconut oil as a liquid fuel.

Despite the best of intentions, many of these assessments have failed to appreciate the real cost of labour in the Pacific. Past assessments have repeatedly focused on arbitrary determinants, such as the world price of a barrel of oil: they have predicated the feasibility of coconut biofuels once the price of a barrel of oil becomes sufficiently expensive. Yet, what such efforts fail to appreciate is that the close and increasing correlation between world oil prices and the price of coconut oil means that when world oil prices rise, so does the price of coconut oil and copra.

Remoteness can be an advantage. By locating the local production and consumption of coconut oil in areas that suffer from high freight costs, a project can benefit from the correspondingly high price of imported diesel, as well as depressed producer incomes. Yet, this local labour cost limitation effectively eliminates the feasibility of implementing sustainable coconut biofuels projects in a majority of PICs, and in a majority of areas within them. Polynesian and Micronesian countries (apart from the outer islands of Kiribati) and much of Fiji, is unlikely to be enticed into copra production for biofuels at the rates of returns to labour that need to be on offer to make these projects price competitive with imported oil. Yet, much of Melanesia – PNG, Vanuatu and the Solomon Islands – possess the right local labour and imported fuel costs to make coconut biofuels production economically competitive, and so it is here that the greatest potential for rural income generation, rural electrification and import substitution lies (accompanied by the right management and maintenance support).

Subsequently, coconut biofuels are unlikely to revitalise the Pacific's copra industries. Transforming the national coconut industry into one that values the 'whole nut' rather than just the oil is critical to increasing the value of coconut and the returns that can be received for farming them. Until the coconut processing industries of the Pacific are transformed to value the 'whole nut,' the economics of copra production for Pacific communities will remain largely the same. Returns from alternative cash crops like kava and dalo will remain higher; and in many cases, remittances may maintain an artificially high reservation rate for labour. Subsequently, where improving rural incomes is the priority of government and development partners, communities should not be enticed back into copra production by the promise of cheaper electricity. Local coconut oil production for local consumption should be viewed as a 'last resort' for those communities whose distance from markets makes it difficult to shift into the production of alternative cash crops.

Those communities with access to alternate cash crops or markets offering superior returns to labour should continue to direct their labour towards these activities and use their additional income to purchase diesel fuel, or competitively priced coconut oil from other communities without the same income-generating opportunities.

The relatively small quantities of coconut oil that will be consumed and diesel imports displaced across the region might disappoint. However, following this approach will ensure that the limited funds for renewable energy projects are well spent. Indeed, the Governments of PICs and donors working in the region may find that the rewards from investing in energy efficiency measures and reducing current levels of consumption of imported oil, far outweigh the benefits of investing in the development of coconut biofuels.

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CHAPTER 7

Economic Feasibility of the Tailevu Biofuel Project, Fiji

Reshika Singh

INTRODUCTION

Biofuel is defined as solid, liquid or gaseous fuel obtained from relatively recently lifeless or living biological material. Various plants and plant-derived materials are used for biofuel manufacturing, (New World Encyclopaedia, 2009)[15]. Biofuel is an area of interest for Pacific Island Countries (PICs) to reduce reliance on expensive imported fuels. Over the past years, there have been ongoing trials of coconut biofuel as a substitute to diesel fuel within the region however, most trials were undertaken on an ad-hoc basis, with a lack of success due to a variety of issues that include poor management and lack of ownership by stakeholders. Identifying successful biofuel options for replication among rural communities in PICs is a challenge currently faced by many energy offices in the region. The type of biofuel best to use will depend principally on the type of available feedstock and factors, such as the quantity of the resource as well as whether the energy can be used locally (Wikipedia, 2009). Assuming that oil, gas and coal are being consumed at a constant rate, researchers suggest that we can consume fossil fuels produced from crude oil at the present rate for another 45 years, gas for about 72 years and coal for about 252 years before these finite resources are left (Ethridge, 2007). Biofuels, in this case coconut oil, can be re-grown, giving it a potential edge over fossil fuels as the latter are in danger of extinction and are non-renewable. The anticipated benefits of using biofuels include boosting rural economies, promoting energy independence and hence, security of supply and reducing GHG emissions (Marshall, 2009).

In exploring the opportunities to develop practical applications for the use of coconut oil as biofuel, SOPAC and the Fiji Department of Energy (FDoE) have, since 2005, undertaken a number of feasibility studies in rural communities within Fiji to assess the potential of using coconut oil derived from copra. By changing from the traditional production of dried copra to value-adding activities, such as biofuel for use in an adapted diesel engine, cooking oil and/or body lotions, coconut oil provides the village community with opportunities to increase and diversify their income base, and therefore their economic resilience.

BACKGROUND TO THE PROJECT

The Centre of Appropriate Technology and Development (CATD) provides training relevant to the development of Fiji nationals from rural communities where youth are taught a range of technical skills to contribute to building their economy and long-term sustainability. In 2008, CATD was offered the opportunity to establish a demonstration project on coconut oil processing through a project jointly funded by SOPAC and the ACP-EU Technical Centre for Agricultural and Rural Cooperation (CTA) via the project “Generating and Disseminating Knowledge on Community-Based Processing of Coconut Oil in the Pacific”. Under the project, SOPAC procured, installed and commissioned a coconut mini oil mill, a biofuel blending unit and a biofuel engine/generator as well as provided staff resources for the coordination and implementation of the project on Viti Levu in Nadave, Tailevu, Fiji Islands.

[15] On the other hand, fossil fuels, such as coal and petroleum, are derived from long-dead biological materials that have been transformed by geological processes.

CATD had been keen in pursuing a biofuel project in previous years as part of its 'Appropriate Technologies Programme'. The activities covered in the current CTA/SOPAC project include the following activities, some of which have contributed to meeting the objectives of the CATD as mentioned above:

- Milling and refining equipment:
  - adaptation of generator;
  - production of biofuel; and
  - production of cooking oil, body lotion and soap.
- Conduct training on processing and marketing oil-derived products.
- Prepare and disseminate information on small-scale processing of coconut oil.
- Implementation of one regional workshop on proposal writing for small-scale coconut oil processing projects.

The demonstration project was designed to ensure that the set up would be self-contained, meaning that the 18-kVA engine/generator included in the biofuel demonstration project package would be used to provide power for the coconut oil mill, the biofuel blending unit and, subsequently, the production of other value-adding activities, such as coconut soap and body lotions. In addition to this, the project would provide backup power to the CATD during FEA and supply blackouts.

Identifying and addressing the technical, economic and management challenges of the project was one of the objectives of setting up the project at CATD. This demonstration project, when replicated into rural communities, would provide a trialled and proven technology that is appropriate within the context of being user-friendly, reliable and sustainable.

SUPPLY, INSTALLATION AND COMMISSIONING

Calls for the supply of milling equipment were mainly undertaken in two lots – the first lot of the tender which was funded by CTA, covered the supply of 25 kg/hr coconut oil milling equipment, filtration and a biofuel blending unit. The second lot which was funded by SOPAC covered the supply of a generating set with an expected load in the order of 20 kVA. Tender specifications for the milling equipment and generator were sized based on the findings of the prefeasibility studies undertaken in Nacamaki, a rural community on Koro Island within the Fiji group. Schematics of the tender specification on the proposed equipment required are highlighted in Figures 1 and 2.

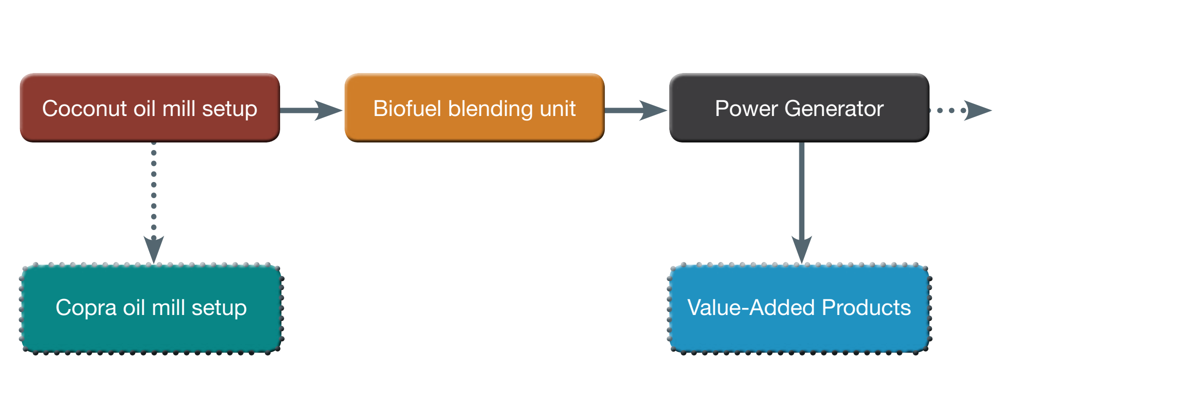
TECHSO (Pty) Ltd, an Australian company was awarded the tender to supply the milling equipment and biofuel generator. As part of the supply agreement, TECHSO (Pty) Ltd supplied 25 kg/hr coconut oil mill equipment, a biofuel blending unit, a 3-stage inline filtration system, a 18-kVA diesel generator and spare parts to last two years. In addition, TECHSO (Pty) Ltd were also responsible for the installation and commissioning of the equipment as well as train the local technicians during installation. A follow-up refresher course after 3 months was part of the agreement.

Installation and commissioning of the biofuel project equipment was undertaken in July 2009 at the CATD. As part of their contribution to the project, CATD provided the shed to house the equipment, store the copra and the electrical wiring in the shed. The coconut oil mill, during installation was firstly powered from the national grid to test the performance of the equipment. The generator was first operated with diesel for a couple of hours which then supplied power to the coconut oil milling equipment. Initially, 150 kg of copra was used during the commissioning, producing 70 litres of filtered coconut oil. Using a blending ratio of 80 per cent coconut oil to 20 per cent diesel, 48 litres of coconut oil was blended with 12 litres of diesel. This produced 60 litres of biofuel which was then used to fuel the 18-kVA generator. The generator was then put on load to supply power to the milling equipment. In producing the biofuel blend, care was taken to ensure that the required International Biofuel Standards relating to quality were met.

The Process

The coconut oil processing system comprises a copra cutter and coconut oil mill, biofuel blending unit and storage tanks, a power generator and the production of value-adding products (Figure 1).

Figure 1: Coconut Oil Processing System.



The paragraphs below explain the individual components in the biofuel generation setup at CATD.

Coconut Oil Mill (Figure 2)

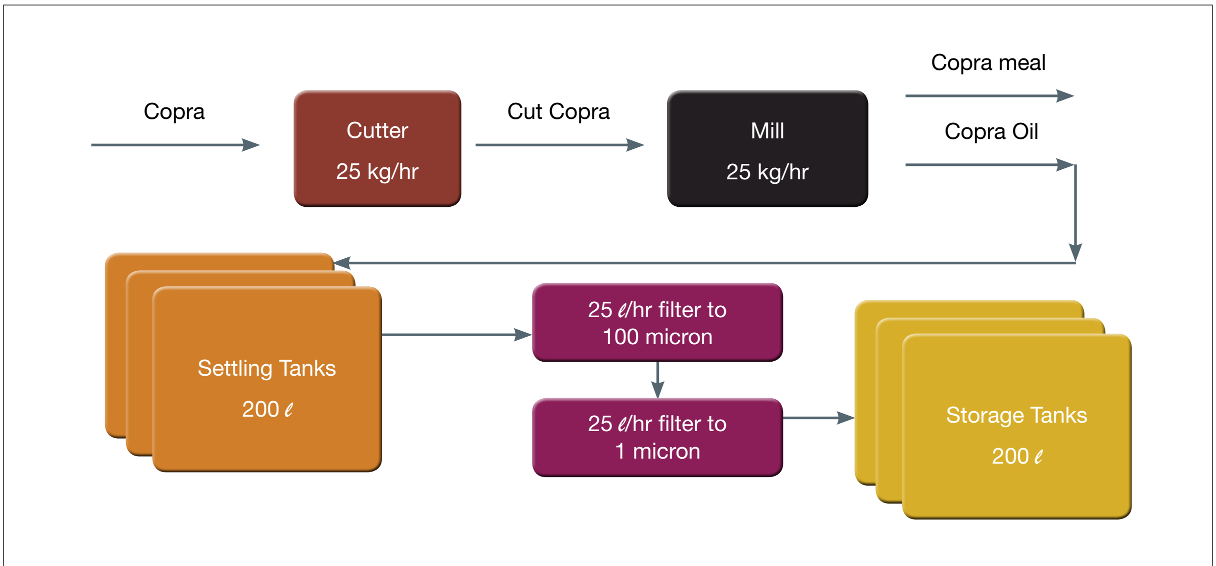
The coconut oil mill consists of a copra cutter to cut dried copra (preferably with a moisture content of less than six per cent) into small pieces that are then passed through a cold press which squeezes coconut oil from the copra, producing a by-product of copra meal which can be used as pig fodder or as manure. The expelled coconut oil is then stored in a settling tank for one to two days, allowing the big particles in the oil to settle and fall to the bottom of the settling tank.

Ideally after settling, the top layer should not contain any particles greater in size than 100 microns. The oil is then passed through a filter which removes any remaining particles larger than one micron in size. The filtered oil is then stored in 200 litre tanks for future use.

The coconut oil mill is designed to produce, on average, an output of around 15 to 18 litres of coconut oil per hour. Around 12 – 15 coconuts are required to produce one litre of oil. The moisture content of the copra is a determining factor in the output/production rate of the oil mill, such that the higher the moisture content – the lower the coconut oil yield. The expeller used in the coconut oil mill is a cold press expeller, meaning that virgin coconut oil can also be produced by the coconut oil mill if green copra is used.

The filtered coconut oil can be used later for a variety of purposes. For example, oil with a maximum particle size of less than five microns can be used for biofuel, while oil with a larger particle size might be used as a basis for value-added products such as body oil, body lotion or coconut soap.

Figure 2: Oil Mill with 3-Stage Inline Filtration.



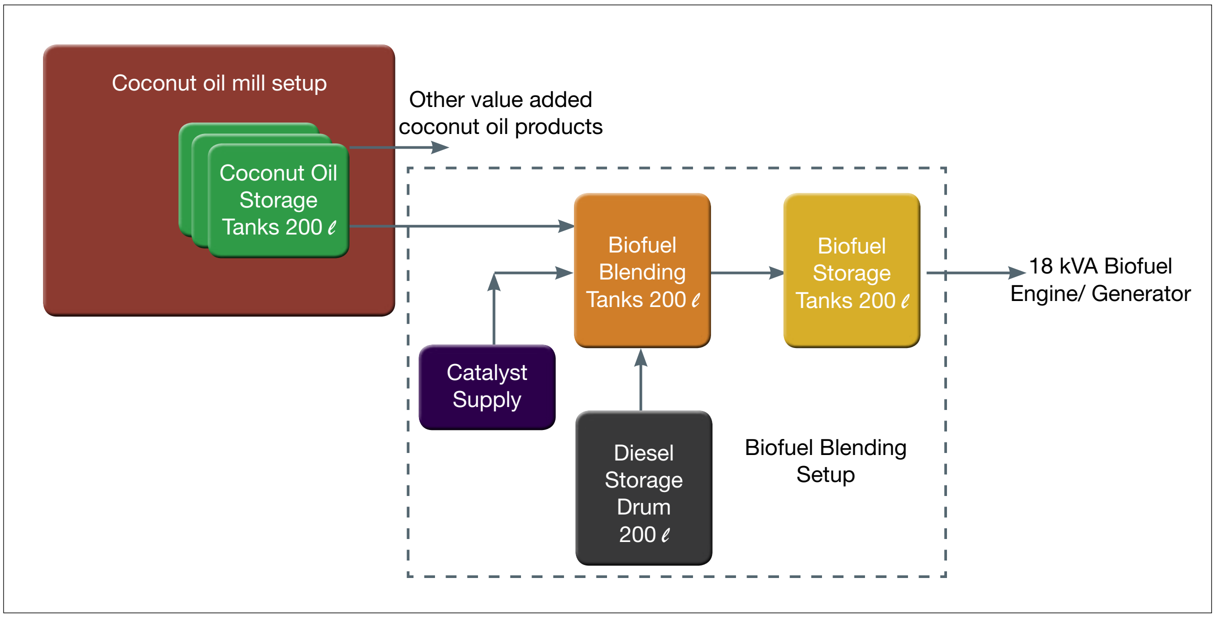
Biofuel Blending Unit (Figure 3)

A biofuel blending unit was included as part of the project to produce and store biofuel. The unit comprises a stirrer fitted into the 200 litre tank where coconut oil and diesel are blended in a ratio of 80 per cent coconut oil to 20 per cent diesel fuel[16]. The blended biofuel is then stored in a biofuel storage tank (200 litre tank). The biofuel as produced has a low freezing point, where pure coconut oil will solidify during the colder months when the temperature is 18 degrees Celsius or less. The 80:20 blend biofuel will remain in liquid state and at a fairly constant viscosity level at this optimal mix ratio.

Diesel Engine/Generator (Figure 3)

The diesel engine/generator comprises an indirect injection engine where the generator is rated at 18 kVA (14.4 kW) under standard (prime) operatio;n. In theory, "indirect injection" diesel engines are recommended for use with biofuels as they have the capability to burn practically any heavy fuel oil, including straight (100 per cent) vegetable oil; this is provided the oil has a low level of viscosity which can be achieved by including a heat exchanger in the system, or using a biofuel mixture such as that produced in the CATD biofuel blending process.

Figure 3: Coconut Oil Mill and Biofuel Blending Unit.



Value-Adding Activities (Box 1)

Theoretically, refined coconut oil can be processed to produce value-added products, such as body lotions and coconut soap, instead of being used solely for biofuel. This option is important where income generation is important to improve the quality of life in the community. Also, if the coconut mill is used at capacity, it is possible that more coconut oil is produced than needed at some point. Value-added products, such as soaps and lotions could theoretically be marketed locally in the local and peri-urban markets.

The production of value-added products requires additional/alternative processing activities and costs, such as:

- Coconut Oil Biofuel – consisting of a blended ratio of 80 per cent coconut oil and 20 per cent diesel fuel.
- Coconut Soap – involving coconut oil, mixed with caustic soda (sodium hydroxide), water, essential oils and incenses, consisting of native flowers. Soap produced is for washing, bathing and souvenirs.
- Body Oil – involving a traditional process of oil-making where the refined coconut oil is heated with incense, consisting of native flowers and adding essential oils.

[16] In mixing the 80% to 20% (CNO:ADO) biofuel blends, an additive (cetane additive) was also included in a number of cases to facilitate proper mixing and combustion. When introducing coconut oil and diesel biofuel blends for the first time in diesel engines, it is advisable that biofuel blends should contain around 20% coconut oil and slowly increase the coconut oil percentage in the blends over time.

- **Body Lotion** – involving a mixture process of blending emulsifying wax (bees wax), coconut oil, water, essential oil and fragrances, consisting of native flowers.

Presently, value-adding activities are not being applied in the CATD Nadave project at this stage, but it is anticipated that these will be targeted in the future. The processing costs and any revenue generated from the production or sale of value-adding products would be expected to have an impact on the financial feasibility of the CATD project.

Box 1 Value-Adding Products

If value-adding production is to occur in the future, soaps, lotions and body oils could be produced. The following is an indication of the types of products that could be targeted:

- Scented bathing soap from the coconut oil sold at $3.00 each. These include around four varieties of scents.
- 100 ml bottles of virgin coconut oil sold at $6.00 each.
- 100 ml bottles of body lotion sold at $5.00 each. The body lotions come in around four types of scents.

From experience, around four bars of soap can be produced from one litre of coconut oil. However, production solely for sale purposes has not yet begun as the above figures are based on the initial production for demonstration. It should be noted that the packaging costs would be minimal as most, if not all of the packaging materials are recycled products, such as using plastic bottles, coconut leaves, natural fasteners, empty containers obtained at minimal or free of costs. Therefore, initially, only marketing costs would be required to enable the products to gain market share. Likewise, the selling prices of the soap, oil and body lotions are based on similar products in the market (Pure Fiji, for example). These other product prices are higher than those ascertained for the above value-added products since they have an established market. Being conservative, it is anticipated that these products will gain its market share quite quickly since there are not many such products in the market. A second round of analysis on this would be helpful after the product is in the market so that the actual selling price and costing can be ascertained. Additionally, it is expected that net benefits would be achieved from the production of these value-adding products since costs are being minimized during the production and selling of the products.

Load Demand for the biofuel Demonstration Project

The total demand for all the equipment used for the coconut oil mill and crusher, the biofuel blending unit including, the pumps, heater and inline filtration system is around 7.1 kW. At present the 18-kVA (14.4 kW) biofuel engine in the project is running at less than 50 per cent load, meeting only the biofuel production needs. The inclusion of other value-adding activities (coconut soap, lotion and body oil making) and other equipment and appliances will see the biofuel engine operating at the recommended 75 per cent load or more which is optimal for better efficiency and performance. For backup power to CATD, the 18-kVA biofuel engine/generator will provide power to the important areas in CATD (refrigeration in the kitchen premises, the water pumps and around the main office premises).

Production Capacity and Operation of the Biofuel Demonstration Project

The actual production rate from the coconut mill was 10 to 15 litres of coconut oil per hour, capable of producing around 460 litres of coconut oil from 1 tonne of copra or 2.17 kg to produce 1 litre of coconut oil. Oil produced is filtered to 1 micron particle size and is stored in a 200 litre drum.

To begin initial production and operation, 51 litres of diesel fuel is needed to generate power (from the 18-kVA generator for 13 hours at 75 per cent load) to meet the coconut oil mill and biofuel blending unit load of 7.1 kW. The oil mill produced 128 litres of filtered coconut oil in 13 hours, fractionally under the lower specified production rate of 10 litres per hour. When the 128 litres of coconut oil is blended with 32 litres of diesel, 160 litres of coconut biofuel will be produced. This amount of coconut biofuel (80:20 blend) is capable of running the 18-kVA generator for 41 hours when operated at the recommended 75 per cent load. According to supplier specification, the fuel consumption is 3.9 litres/hour. The biofuel system as operating can provide fuel for the biofuel engine and production of value-adding products.

ECONOMIC ASSESSMENT METHODOLOGY

A benefit cost analysis (BCA) was used to assess the economic feasibility of the entire project. Assessment was based on a scenario where the project was installed in a village rather than at the CATD. The project was then considered using a standard "with" and "without" analysis. In the 'without biofuel project' scenario, the village would need to use a diesel generator for energy supply. No diversification of income generation would occur. By comparison, the 'with biofuel project' scenario, coconuts would be converted to fuel locally and pig fodder and manure/fertilizer are produced as 'free' by-products. Additionally, various value-adding by-products could potentially be produced for sale (although presently, these are not).

The benefits and costs achieved under the 'without biofuel project' and 'with biofuel project' scenarios were calculated over a twenty-year period from 2009 to 2029. Possible costs that would incur over the life of the biofuel generator relative to the diesel generator include:

- Initial capital costs: Includes initial and up-front costs associated with a project, including the costs of any project feasibility studies, system design costs and equipment purchase, transportation and installation. In other words, all costs incurred up to the point where the project starts running are considered capital costs.
- Operation and maintenance costs: Includes any costs associated with maintaining and operating the project, such as administrative costs, transport costs and other costs associated with operating the project.
- Fuel costs: Include the market value of the annual costs of any fuel used (diesel or biofuel) (Woodruff, 2007).

As the choice of assumptions varies under certain scenarios, a sensitivity analysis was undertaken to check the impact of changing these key assumptions. Sensitivity analysis involved adjusting various assumptions used within the analysis to determine the effect on key economic indicators of a range of likely future scenarios. The sensitivity analysis was necessary since assumptions made about the project in some cases had degrees of uncertainty in regard to values for future parameters, such as fossil fuel/oil prices. For the purpose of the analysis, a partial sensitivity analysis, in which only one assumption is adjusted at a time, with all other assumptions held constant, was used.

The stream of benefits and costs over time were discounted to estimate the present value of the project, using a discount rate of 10 per cent. Non-monetary or secondary benefits were not assessed in this analysis since the project was in its early stages and data was not available. It should be noted that the analysis is still preliminary as the value-adding activities generated from the project as mentioned earlier have not yet been fully assessed and are not included in the analysis. Although these activities have commenced, the products are yet to be launched in the market thus the unavailability of sales revenue data.

Assumptions

The following assumptions were made:

- Biofuel Generator:
  - The economic lifetime of the biofuel generator was estimated at 20 years.
  - The initial generator setup and installation cost was $FJ97 300. For the purpose of this analysis, only the cost of the generator is taken into consideration for consistency purposes. Therefore, the biofuel generator cost of $FJ26 000 was considered in the analysis. The analysis is thus based on the assumption that coconut oil will be purchased to run the biofuel generator.
  - The maintenance cost is estimated at three per cent of the capital cost and it is expected to increase at the rate of one per cent every year. This increase can be attributed to the other equipment involved in the process of producing coconut oil for use in the generator.
  - The generator operates for 10 hours per day.
  - Biofuel cost is estimated on a per unit basis with a price of $2.13/litre.
  - The generator has an operating capacity of 18 kVA (14.4 kW).
- Diesel Generator:
  - The economic lifetime of the diesel generator was estimated at 20 years.
  - The initial generator setup and installation cost was estimated to be FJ$17 500.

- The generator operates for 10 hours per day.
- Fuel cost was estimated on a per unit basis with a price of $1.73 per litre.
- The maintenance cost was estimated at 1.5 per cent of capital cost and is expected to increase at 1 per cent per annum.
- The generator has an operating capacity of 18-kVa (14.4 kW).

Note that the analysis is in Fiji dollars.

ECONOMIC ANALYSIS

A summary of the key issues in the “with” and “without” scenarios are presented in Table 1, together with key values used.

Table 1: Summary of Scenarios and Values.

Without Analysis (Diesel Generator)		With Analysis (Biofuel Generator)	
Inputs	Costs	Inputs	Costs
• 14 235 litres of diesel to run a generator for 10 hours per day for 365 days	• $1.73 per litre of diesel	• 4 015 litres diesel per day for 365 days to make biofuel • 34 tonnes of copra per annum • 15 litres of additive per annum • Labour/salaries required to access copra, produce oil and value-added products • Inputs[17] required to make soap, body lotion, virgin coconut oil and massage oils. These include the other ingredients, apart from coconut oil, to make the products and labelling, marketing and distribution	• $1.73 per litre of diesel • $622 per tonne of copra • $0.07 (additive) per litre of biofuel • $2 per hour paid for labourers • Costs of inputs to make body lotion • Costs of inputs to sell products
Inputs	Costs	Inputs	Costs
• Electricity generation	• Improved lighting system • No major modifications required to the main switch to start up the generator	• 16 060 litres of coconut oil solely for biofuel generation • Value-added products • Pig meal • Manure	• Sales revenue • Employment to locals

Source: SOPAC and Soqosoqo Vakamarama (2009).

Preliminary analysis indicates that assuming continual coconut processing to enable generator operation of 10 hours per day, the project would generate a social net loss over 20 years of over FJ$40 000 (Table 2). In other words, the value of social benefits of the project would not be expected to cover its costs. The benefit cost ratio at this point is 0.88, indicating that for every $1 invested in the project, only $0.88 would be recouped over the life of the project.

Table 2: Cost Benefit Analysis Indicators; Capital Cost Included.

Indicator	Value ($)
Net Present Benefit	295 000
Net Present Cost	336 000
Net Present Value	(41 000)
Discounted Benefit-Cost Ratio	0.878

[17] Since the project is just in its early stages, the actual quantity of value-added products that can be produced in a year is not yet known and the costs involved in making the products and marketing them is also known. Thus, this analysis is still in a preliminary form and after a year or two of operations is successfully completed and then another analysis incorporating each of these real costs would provide a much better picture of the biofuel system.

Key to the loss in the performance of the project is the costs of establishing the project, notably the expense of infrastructure (Table 2). In fact, the project was funded by CTA and SOPAC so the actual costs to the community are only its variable costs. If initial capital costs are excluded from the analysis and the feasibility of operations alone assessed, losses become much smaller, although the net value of the system over 20 years can be expected to remain negative (Table 3). In this case, the benefit cost ratio increases to 0.95, indicating that, for every one dollar invested in the project, $0.95 would be recouped over the lifetime of the project.

Table 3: Gross Margin Analysis (Economic Returns with Capital Cost Excluded).

Indicator	Value ($)
Net Present Benefit	295 000
Net Present Cost	310 000
Net Present Value	(15 000)
Discounted Benefit-Cost Ratio	0.952

Sensitivity Analysis

The biofuel project increases in economic feasibility if diesel costs increase over time. With capital costs excluded from the analysis, the project can be expected to achieve positive net benefits, provided diesel price increases by more than 4 per cent per year (Table 4). According to the US Energy Department's Energy Information Administration (EIA) forecast, high crude oil prices are expected for the next 20 years[18]. In addition to this, improving global economic prospects will increase the demand for crude oil leading to price increases. The net present value increases as the expected rate of diesel price increases; if the diesel price increases by two per cent, four per cent and five per cent, the net present value attained is $500, $49 000 and $72 000 respectively. This indicates that over time, the biofuel system has an advantage over the diesel system even if the biofuel generator is not funded; considering just the variable costs.

Table 4: Gross Margin Analysis with Diesel Prices Rising.

Diesel Price Increase	Net Present Benefit ($)	Net Present Cost ($)	Net Present Value ($)
2%	327 000	406 000	(79 000)
4%	725 000	415 000	310 000
5%	835 000	420 000	415 000

Economic analysis thus indicates that the biofuel project requires donor support and continued increases in the price of diesel to be socially feasible; however, given that a main input for the diesel engine is diesel itself, the volatility in diesel prices which is quite prevalent now could encourage the use of biofuel generators. By comparison, if the mill component is also included in the analysis and the total costs of the project would have to be covered by the village, then the net present value would be negative. High start up costs is an obstacle to the project despite low operational costs; however, it is possible that environmental benefits from the project – particularly in the form of reduced carbon emissions – might help render the project to break even from a social perspective.

In a village scenario where copra is freely available, producing a litre of biofuel would cost $0.71[19]. Additionally, the analysis shows that for every $1 invested in the project $1.43 will be returned after the first year of use and is presumed to continue for the life time of the project (Table 5). This outcome is possible even if the villagers are supposed to pay for the biofuel generator as well as the oil mill which gives a total capital cost of $97 300.

[18] www.highbeam.com/doc/1P2-16647301.html.

[19] This includes labour, additive, diesel and generator operation costs.

Table 5: Cost Benefit Analysis Indicators; Village Scenario where Copra is Free.

Indicator	Value ($)
Net Present Benefit	295 000
Net Present Cost	206 000
Net Present Value	89 000
Discounted Benefit-Cost Ratio	1.432

While these estimates discussed so far are conservative and presented using a 10 per cent discount rate, there may be arguments for lower discount rates, especially for development projects. If a lower discount rate is applied in the analysis, the absolute value of the expected net present value of the activity will be higher (Table 6).

Table 6: Gross Margin Analysis (at Various Discount Rates).

Discount Rate	Net Present Benefit ($)	Net Present Cost ($)	Net Present Value ($)
3%	484 000	520 000	(36 000)
7%	357 000	379 000	(22 000)
10%	295 500	310 000	(15 000)

Additionally, at this point, no value-added coconut oil products are being produced for sale (soap, lotions, etc.). In the future, if the community diverts coconut oil to these products and successfully markets them, it is possible that the commercial and social viability of the project may increase.

CHALLENGES AND LESSONS LEARNED

While potential benefits from the project exist, the project is currently challenged from several direct consequences. Firstly, getting low quality copra (which has high moisture content) would negatively affect the production of coconut oil. High moisture content can even affect the power output of the engine. Moreover, there is no fixed supplier of copra for the biofuel project. Currently, there exists no agreement between a copra supplier and CATD; this can affect oil production in future. In addition to this, some electrical modifications were required at the milling shed before the generator could be operated.

Table 7 lists challenges encountered from the biofuel demonstration project and some of the associated solutions undertaken.

Some broader lessons learnt from the project include the following:

- The appropriate technical specifications and design of equipment during procurement
- Integrated approach feasibility study, taking into account the social, economical, environmental risks and sustainability issues
- Maintaining a continuous supply of copra to CATD since the supply of this is imperative for the successful execution of the project
- Training of operators to ensure that equipment is operated at optimum level
- Marketing of oil-derived products from the project be given priority

More widely, it is not clear at this point the extent to which the commercial production of oils and lotions is financially viable. There is already an established set of suppliers in the beauty industry in Fiji (for instance Pure Fiji and Mokosoi) and competition would be strong against the established brands. There would need to be a financial assessment of the feasibility; for example, in marketing the value-added products.

Table 7: Challenges in the CATD Biofuel Demonstration Project.

Situation	Problem that will arise	Associated solution
High moisture content in copra (greater than 6%).	• Production rate of coconut oil drops • Moisture content in biofuel. This has a high chance of affecting the power output of engine	• Ensure moisture content in copra is decreased by re-drying copra
Large particles in settling tank entering the coconut oil filter.	• Coconut oil filter clogs and shuts down • Frequent shut downs and washing of filters occur delaying oil production time	• Ensure one or two days are allocated for settling to allow the large particles in the coconut oil to settle to the bottom • Avoid sudden movement of the settling tank or stirring of the settled coconut oil during decanting for filtering • Frequent cleaning of the settling tank
Coconut oil in settling tank has high viscosity (or solidifies) in the colder months.	• Coconut oil filter clogs and shuts down	• Use heater installed in the settling tank to heat coconut oil. (Care must be taken not to overheat coconut oil, which may result in a fire hazard)
Large particle sizes in biofuel.	• The large particles will quickly clog the generator fuel filters. Clogged fuel filters result in reducing the flow of fuel to the combustion chamber in the biofuel engine, resulting in a breakdown or 'choking'	• Ensure that the coconut oil filter is frequently cleaned • Biofuel blending tanks are covered at all times • Avoid any dust/particles entering exposed/open areas in storage and blending tanks

CONCLUDING REMARKS

The technical installation of the SOPAC–CATD biofuel project has been successfully completed and commissioned and is now operating. Training on the production of biofuel has been completed with additional training on the production of other value-added products to be undertaken towards the end of October 2009.

Preliminary economic analysis of the project found it to be a potentially viable option for replication in other similar locations and in other PICs, only if diesel price increases at more than four per cent per year. However, the environmental benefits achieved through the project have not been valued and may also increase social feasibility. In order for the replication to be successful in other locations in the future, the biofuel project needs to be established in an environment where there is an adequate supply of locally-produced copra, there is a willingness to cut the copra, appropriate training in the production of biofuel and other value-added products. There also needs to be an appropriate regular monitoring and servicing programme established. In consideration of these parameters, the CATD project has been monitored by SOPAC and CATD for its effectiveness for the first three months of operation where this led to identifying some of the current challenges. In addition, continual monitoring will be undertaken by CATD for the next five years to identify the exact performance, challenges, including identifying appropriate adjustments to the biofuel project (especially the performance of the biofuel generator during this period). The observations from the monitoring will be used to ensure that similar projects can be replicated among other rural communities in the PICs to an equal or better standard. In addition, the biofuel installation will serve as a demonstration project that will become an additional valuable training module for CATD. This will further provide opportunity for collaboration with the Fiji Department of Energy to use CATD's facilities for the training of rural technicians under the Department's Rural Electrification Programme. To further test the performance of the project, it is indeed necessary to carry out further BCA that will include the value-adding activities that are currently being carried out from the project, which might help achieve better rate of return.

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CHAPTER 8

Technical diversification in the Fiji sugar industry[20]

Peter Stauvermann and Sunil Kumar

INTRODUCTION

A recent published report, SOPAC (2009) considered the potential of biofuels in general. Regarding the production of bio-ethanol, they consider two resources into account – sugarcane and cassava. For some reason however, the production of ethanol from sugarcane does not seem to be of much importance in the report as it should be. This is especially surprising because the sugarcane industry is only second to the tourism industry as the foreign exchange earner for Fiji. Additionally, Stauvermann and Kumar (2009a) have shown that under realistic assumptions, the production of ethanol from sugarcane is economically beneficial and profitable from an investment perspective, which is not so clearly the case for cassava at the moment (Stauvermann and Kumar, 2009b). The use of Cassava as stock feed in ethanol production is less attractive for two reasons. First, it is a food commodity for the local populations and its use for ethanol production may induce price increase, causing hardship to poor families. This argument however, does not apply to sugarcane. Secondly, cassava production has not been done at this scale in Fiji and its prospect poses many questions about land use laws. From a worldwide view, 50 billion litres of ethanol is produced per year, using 15 million hectares of land, which is only one per cent of the worldwide agricultural land[21]. In this paper, it is shown that the ethanol production from sugarcane has net positive effect for the environment and also the Fijian economy.

With respect to the environment, it is shown that the local emissions can be reduced which would contribute towards the reduction of global emissions and global warming. The macroeconomic gain from ethanol production and use include the reduction of Fiji's trade balance deficit with a positive impact on employment and the national income.

The second part of the paper shows how the production and use of ethanol in Fiji would help improve the environment. The third part analyses the economic gains to Fiji with the help of a cost-benefit analysis. The framework for economic analysis in this paper is based on the Dutch Sustainable Development Group study in 2005 for the Dutch Government and the report of BNDES and CGEE from 2008.

ECOLOGICAL AND ENVIRONMENTAL ADVANTAGES OF BIO-ETHANOL

Ethanol is fermented alcohol which can be used as a direct substitute for fossil fuels like gasoline and also as an indirect substitute for kerosene and diesel. In the long-run, it will be possible to fully substitute the consumption of fossil fuels in Fiji if vehicular technologies change globally. This would be the case if all cars and airplanes would be able to use E100 (100 per cent ethanol), which is technically not a problem[22], but such change is not without complications and diseconomies that arise from the need for new technologies and investments. Strong negative short-run economic effects are that conventional engines would need

[20] All numbers, if not indicated, are taken from official agencies like the FIBOS, Reserve Bank of Fiji and Bayerische Landesumweltamt, Bundesumweltamt. A lot of calculations done by the authors have been explicitly shown since it is beyond the scope of this paper to explain all details. On request Peter J. Stauvermann will give or send interested persons all details of the calculations.

[21] See BNDES and CGEE (2008), p.14.

[22] In Brazil 12,000 aircrafts fly with ethanol (E 95), 600 busses in Stockholm run with ethanol (E100).

to be converted or replaced completely with new ones, which are suitable for ethanol fuel. Because of these diseconomies and technological restrictions, it is appropriate that these changes are considered on piecemeal basis. In a first step, the government should introduce E5 (five per cent ethanol, 95 per cent fossil fuels) or E10 (10 per cent ethanol, 90 per cent fossil fuels) as gasoline for cars, which poses no serious technical or economic problems[23]. Then, as the adaption process occurs and public awareness improves, the share of ethanol in the gasoline could be gradually increased to 100 per cent in the long-run.

Let us consider and analyze the reduction of emissions arising from the use of E85 like in Brazil and some other countries. The decrease of N_2O would be 15 per cent, of PM10, 20 per cent, of Carbon monoxide, 40 per cent and of SO_4, 80 per cent. The reduction of CO_2 depends on the ethanol production process. For example, if rain forests are cut down to produce feed stock for ethanol, then, the reduction of carbon dioxide in the whole life cycle of ethanol as fuel could be relatively low. The reduction could be as low as 10 per cent for CO_2 even when the fossil fuel is completely substituted with ethanol. The proposed concept of ethanol production in Fiji is most suitable since currently Fiji has a lot of unutilized or only partly utilized sugarcane fields (Lal, 2009). In this paper, we do not take into account a potential extension of sugarcane land, because this would lead to new environmental problems, such as soil erosion and damage to the biodiversity. However, the expansion of sugar production from the current level would not be hard without cutting any rain forests. So the net reduction in the life cycle emissions would easily reach higher than 70 per cent in terms of CO_2 emissions[24]. The introduction of E5 would reduce the CO_2 emission of gasoline cars by approximately five per cent. This estimation does not account for CO_2 emission from production process[25]. However, the use of E5 would mean reduction of five per cent and in absolute numbers a reduction of 2,982,359 litres of fossil gasoline, which means a reduction of 7 068 tons of CO_2 emissions per year.

Next, we show that Fiji would be able to produce a sufficient amount of ethanol without any additional production of sugarcane. One litre of ethanol uses 3.4 kg molasses, 2.7 kg of cane sugar B-syrup or 1.65 kg of cane sugar. Taking into account that one kg of sugarcane delivers 0.11 kg of cane sugar, 0.045 kg of molasses and 0.005 kg sugar cane B-syrup and considering that the Fijian sugar industry produced 120 000 000 kg of molasses, 208 000 000 kg of sugar and 13 333 000 kg of cane sugar syrup in 2008, it would be possible to produce 72 million litres of ethanol from cane sugar, 35 million litres from molasses and 5 million litres from of B-syrup. In sum, Fiji can easily produce 112 million litres of ethanol with 2008 levels of sugar production. That would mean only 2.6 per cent of the whole ethanol capacity would be necessary to introduce E5.

It should be noted that the sugarcane production in Fiji decreased by 12.5 per cent from 2003 to 2008 and the acreage of land used for sugarcane production declined by 19.6 per cent in the same period. The arable land available for sugarcane production was about 93 000 hectares in 2008 (Fiji Times, 2009; Lal 2008). Of this total available land, the actual acreage utilized for the production of sugar was only 51 000 hectares (FIBOS, 2009). The degree of utilization therefore, was only 54 per cent and thus ethanol production can be increased by about 100 per cent without cutting down any rain forest. In addition to this, the quantity of ethanol production can be increased substantially by improving sugarcane production per hectare of land (see Lal, 2008).

In Brazil the output per hectare is much higher (6 800 – 10 000 litres per hectare)[26] due to various reasons, but mainly due to better farm level practices and size of the plantations which often exceed 10 000 hectares. In Fiji, the sugarcane farms are very small, often in the order of five to seven hectares (Lal, 2008). However, the productivity of the farms could be enhanced if the farm level practices improve and the land laws are reformed[27]. Table 1 provides some data on sugarcane production per hectare in other sugar producing countries.

[23] It was not possible to find out how many engines can be damaged by the use of E10. However, the problem with old cars is that E10 could harm the plastic parts and seals of a car. To adjust old cars, the main work is handiwork, which is relatively cheap in Fiji.

[24] All technical information is from the Bundesverband der Deutschen Bioethanolwirtschaft (2009) if not noted otherwise.

[25] Macedo et al. (2008) found out that in the ethanol production process, one energy unit of fossil fuels is necessary to produce 9.3 energy units, taking the whole production process, including transportation into account. That means that the use of ethanol can reduce the use of fossil fuels by just around 90 per cent. If we would take into account that bagasse can be used to produce an electricity surplus, the reduction will be higher (BNDES and CGEE (2008).

[26] See BNDES and CGEE (2008).

[27] It is beyond of the scope of this paper to go into the details of the Fijian land laws and the conflicts which are combined with it; for details see for example Prassad (1998), Lal and Reddy (2003), Lal, Lim-Applegate and Reddy (2001). In the view of the authors, the best way to enhance the productivity of sugarcane farming would be to find production cooperatives, which would make it possible to exploit increasing returns of scale. At best, the farmers should manage the whole production process from planting to selling ethanol.

Table 1: Sugarcane Production per Hectare in Sugar Producing Countries.

Country	Yield of sugar cane in tons per hectare
Australia	100
Brazil	75
India	70
South Africa	70
Thailand	45
Average LDC country	40
Fiji	46-58

Source: Data from DSD (2005) and the Fijian Cane Growers Council (2009).

As a rule of thumb it can be estimated that Fiji should be able to produce just around 500 million litres of ethanol per year. In 2008, the aggregate consumption of fossil fuels calculated in energy equivalents amounted to about 170 million litres of ethanol. According to this, Fiji could meet its domestic demand and yet be able to export the surplus to the world market. The global demand for ethanol will most probably increase and is estimated to increase at a rate of about 2.3 per cent per annum at minimum (International Energy Agency, 2004). It is expected that the demand will increase from about 30 – 40 billion litres per year in 2003 to about 162 billion litres per year by 2015 (Global Biofuel Centre, 2008).

It is important to examine the trends followed by the countries that have introduced production and use of ethanol from sugarcane. The most prominent example is Brazil which introduced ethanol fuel in 1975 as a consequence of the oil crisis. With respect to Brazil, there exists a study by Gesellschaft fuer Technische Zusammenarbeit (GTZ) commissioned by the German government. GTZ (2006) stated the following:

> "From 1980 to 2002, the price reduction obtained was to the order of 71 per cent. As the efficiency and cost competitiveness of ethanol production evolved over time, this support was no longer needed and was not applied." And further, on GTZ stated that, "Today (Sept. 2005), alcohol is sold in gas stations at around 51 per cent of gasoline price. This economic competitiveness is already a reality for several years and will continue for years to come, especially with the current increase of the crude oil prices on the world market.", (GTZ, 2006, p.22).

Consequently, it must be concluded that there exists a learning curve and economics of scale in the production of ethanol. The changes of different indicators are represented in Table 2.

Table 2: Changes of Indicators.

Indicator	Change
Agricultural Productivity	+33%
Saccharose Average Content in Cane (1985/2000)	+8%
Efficiency in Saccharose Conversion to Ethanol	+14%
Productivity in fermentation (ethanol m^3 / reactor-day m^3	+130%
Agro-Industrial Conversion	+172%

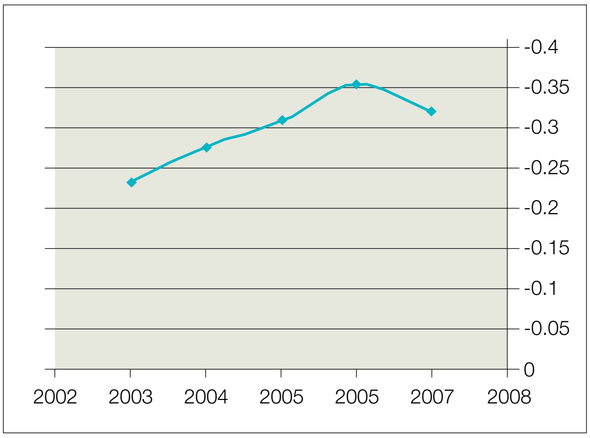
Source: Cadernos NAE (2005).

Of course, much has to be done in Fiji to reach such productivity growth rates seen in Table 2. The Fijian land laws, in particular, seem to make productivity growth much more difficult as farmers have lost incentive to produce sugarcane over the past decade due to expiry of leases and loss of private properties to unscrupulous landlords (see Lal and Reddy, 2003 and Stauvermann, 2010). If land reform can be achieved then Fiji would be able to substitute fossil fuels with ethanol production from sugar cane within a short time.

THE ECONOMIC ASPECTS OF THE ETHANOL PRODUCTION

Fiji's economic performance has remained poor for some time now. The main huddle for Fiji has been its inability to resolve its political problems. Of recent, the prospects for the sugar industry seemed quite bleak due to falling production and falling world market prices. Similarly, the tourism sector has also remained depressed, partly due to global economic crisis and partly due to political instability. The decline in tourist numbers was mostly due to global decline in tourism. Recent, the Fijian economy worsened and the Fijian currency was devaluated by 20 per cent in April 2009. Fiji has suffered from a relatively huge trade balance deficit for a long time. The ratio of trade deficit to GDP in 2007 was just around 32 per cent (Graph 1 shows the trends for the last few years[28].

Graph 1[29]: Ratio of Trade Deficit Trends in Fiji.



The relative trade deficit decreased between 2007 and 2008 but still remained high. Additionally, the sugar industry in Fiji continues to face the problems of declining cooperation with the European Union and thus a prospect of declining aid and price support. The fate of the sugar industry was sealed by the abrogation of the Constitution of Fiji by the Military Government in April 2009. This could be a significant loss for Fiji, which was a preferential sugar supplier for the EU. The price differential for Fiji sugar is presented in Table 3.

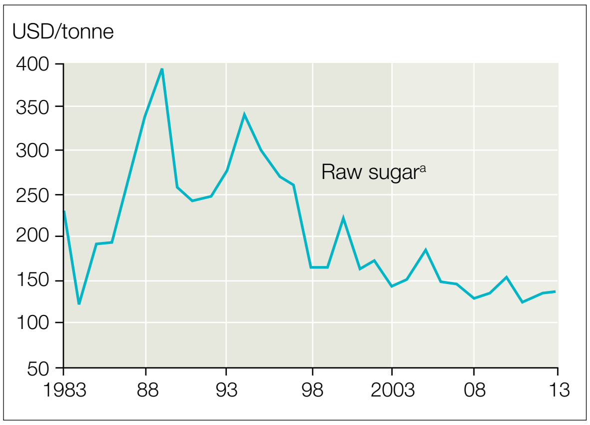
Table 3: Price Differential for Fiji Sugar.

Year	2003	2004	2005	2006	2007	2008
Value of sugar in FJ-$ per ton in Fiji	836.2	799.4	739.3	860.4	840.9	954.2
World market price sugar in FJD/Ton	188.24	247.06	436.73	590.51	414.46	481.06

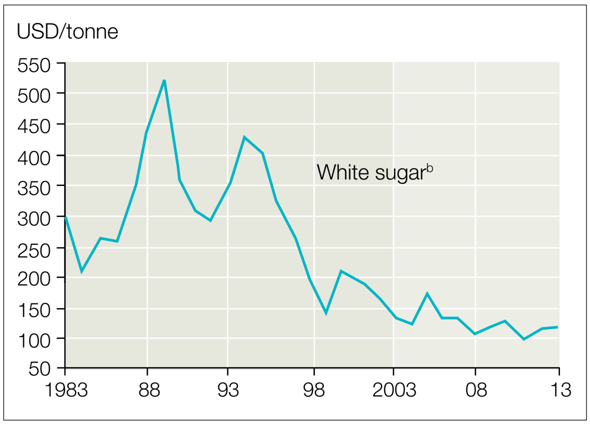
Source: FIBOS (2008, 2009).

The price differences are explained by the preferential prices that Fiji sugar receives from the European Union[30]. It is assumed here that the world market prices of sugar will continue to decrease as indicated by the OECD (2004) estimations given in US dollars (see Graphs 2 and 3 for the prices of white and raw sugar).

Graph 2: World Market Price for Raw Sugar.



Graph 3: World Market Price for White Sugar.



[a] Raw sugar world price, New York No. 11, f.o.b., bulk spot price, September/August.
[b] Refined sugar price, London No. 5, f.o.b. Europe, spot price, September/August.

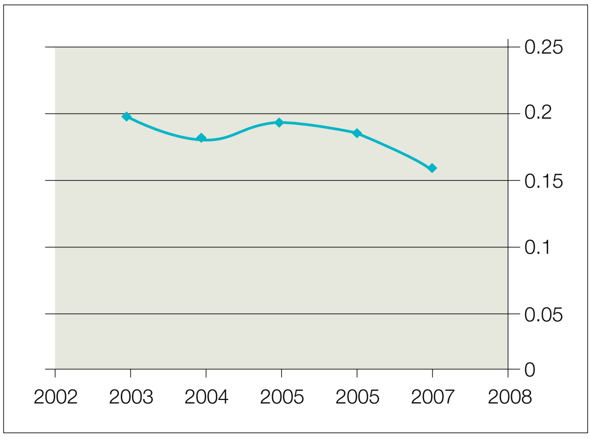
Source: OECD (2004)

[28] The figures are extracted from FIBOS (2009) and the ratios calculated using the GDP for respective years.

[29] The numbers are measured in actual prices in FJ-$ by Fiji's Island Bureau of Statistics (FIBOS) from March, 2009, own calculations.

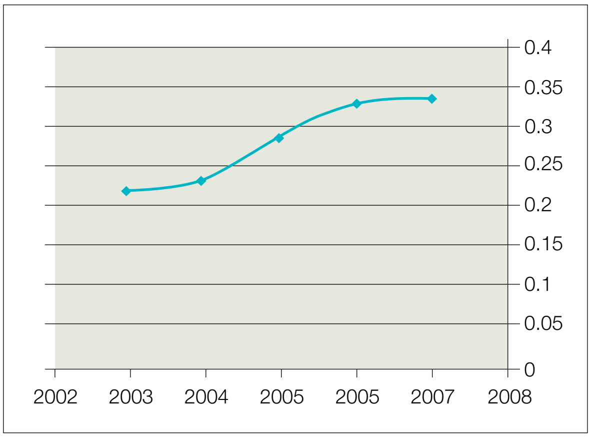
[30] The institutional prices of the European Union were reduced by 20% in 2006 and 2007 and by 33% in 2008. As compensation, the EU has offered a subsidy for Fijian sugarcane farmers of 135 million EUR, which is, at the moment, blocked because of the coups 2006 and 2009.

Graph 4: Export Share of the Sugar Industry.



Source: Data from FIBOS (2009) and own calculations.

Graph 5: Fuel Imports Share.



Source: Data from FIBOS (2009) and own calculations.

Despite this prospect for declining prices, sugar remains an important export commodity for Fiji. It is very important for the agriculture sector, particularly in relation to other commodities. Sugar production in Fiji has significant advantage over other crops although, the production value of sugar decreased between 2003 until 2008 from 34 per cent to 22 per cent of total agricultural GDP. As we can observe from Graph 4, the ratio of sugar exports to all exports is presented.

According to Graph 4, the export share of the sugar industry lied between 20 – 15 per cent, with a decreasing trend. On the other hand, one main import good of Fiji is fossil fuel, which has increased as a ratio of total imports and has contributed significantly towards Fiji's import bill. Graph 5 shows that fuel imports share has increased from a low of about 22 per cent to a high of over 33 per cent which seems to have an increasing tendency. Knowing these facts about the sugar industry and the fossil fuel imports, Fiji should decrease its dependence on fossil fuel imports and increase sugar exports. In this paper, we try to give a solution for this difficult problem by proposing production of ethanol from molasses and sugar.

In the following section, we explain how useful ethanol is as a fuel and how it can be used as a green product. The next section shows the cost-benefit analysis of ethanol production as a proof that the production of ethanol is profitable. This cost-benefit analysis is based on a study of the Dutch Sustainable Development Group (DSD, 2005), which was done for the Dutch Government. However, this study was not made to fit Fiji's situation so the model is adjusted to suit the study here.

GLOBAL TRENDS AND THE ADVANTAGES OF ETHANOL FUEL

In principle, ethanol is usable in all kind of combustion motors. However, it is also possible to use it as fuel in gasoline and diesel cars, with some restrictions in old model engines. However, it can be said that all cars can run with a mixture of ethanol and fossil gasoline, where the ethanol share is not higher than 10 per cent, this fuel is called E10. The number of cars that can run on the ethanol proportion of between 0 to 100 per cent has dramatically increased in the USA, Brazil and similarly in many other countries. These cars are called flexible-fuel vehicles and can switch from one fuel mixture to another. The fuel with pure ethanol is called E100 and is clearly an option with today's technology.

Typically, the energy content of one litre E85 fuel is lower than that of pure fossil gasoline. The consumption by volume increases by about 20 – 25 per cent with E85 fuel (85 per cent ethanol). These physical characteristics have to be taken into account when comparing ethanol with fossil gasoline. Different countries use different mixtures of ethanol and therefore, consumption by volume would differ. For example, in the USA, Australia and Thailand E10 is used, where as in Brazil E25 is used. Similarly, in Sweden E100 is used for busses and in the European Union E5 is used generally in all transport vehicles. However, in 2020, 20 per cent of all consumed fuel in the EU would be ethanol to comply with the environmental legislation. Similar developments are observed in other countries like Brazil, Thailand, China and India. This is caused by the fact that the ecological balance of ethanol is much better than fossil fuels. The net reduction in Green House Gases (GHG) depends a lot on the production processes and the nature of feedstock used (Table 4, provides some data on the reduction of GHG in per cent with respect to fossil fuel). Assuming that the ethanol production in Fiji would be similar to the production in Brazil, the GHG emissions from ethanol in comparison to fossil fuel would be 80-85 per cent. That means that even if Fijian cars are only able to use E10 (all cars produced since 1990), the reduction of GHG emissions from cars would immediately drop by just around 8-8.5 per cent, which would be a remarkable achievement. Because of the fact that the combustion of ethanol produces no environment-harming substances, it would contribute well towards improving the local environment, which is currently quite serious in certain areas of towns and cities in Fiji. This change would also contribute significantly towards global efforts on the protection of environment. If Fiji moves towards E85 in a few years time, then the higher fuel octane of ethanol will make it possible to reduce the consumption of fuel per km[31].

Table 4[32]: Reduction of Fossil Fuel Green House gases (GHG) (per cent).

Ethanol	Grain (EU, USA)	Sugar beet (EU)	Sugarcane (Brazil)	Cellulosic (USA)	Rapeseed (EU)
Minimum Reduction of GHG in %	-20	-35	-80	-60	-45
Maximum reduction of GHG in %	-43	-55	-85	-100	-60

Table 4 shows that ethanol could lead to a significant reduction of GHG emissions, which should be equally attractive and of interest to Pacific island countries[33]. Besides sugarcane, there is a number of other feedstock to produce ethanol, but none of them are as efficient as sugarcane and sugar beet. See Table 5, where ethanol production in litres per hectare is provided.

Table 5: Ethanol Production in Litres (per hectare).

Type	Litres of Ethanol per hectare	Estimated Costs in US dollars per 1000 litres
Sugar beet	2500-3000	300-400
Sugar cane	3500-5000	160-400
Corn	2500	250-420
Wheat	500-2000	380-480
Potatoes	1200-2700	800-900
Sweet Sorghum	3000-5000	200-300
Cassava	1500-6000	700
Synthetic	0	540

Source: Microdistillery – LAMNET project ICA4-CT-2001-10106 EU-project.

In Table 5, the cost of ethanol production from cassava is shown to be much more expensive than from sugarcane. Additionally, the experiences from Brazil could be taken as an indicator for the development options in Fiji. This is the case even when the economic structures of the Fijian and Brazilian agricultural industries are quite different. In Brazil, on average, sugarcane plantations are hundreds of times larger than those in Fiji. Nevertheless, it makes sense to look at the results realized by Brazil in the last 30 years.

It also should be noted that ethanol production created 60 000 jobs on sugarcane farms in Brazil, even though these small farms produce only 17 per cent of the Brazilian sugarcane. Additionally, GTZ (2005) found the following:

> "Salaries and benefits for the employees are 3.5 times more than the national minimum salary (now equivalent to US$ 83.62 per Month) in the crops – where the workers have a low level of skill and school education – and 5.3 times higher in the industrial businesses. Most of the agricultural producers, small and medium owners, are remunerated according to a parametric formula that takes into consideration the total sugar content of the raw material, the sugar and alcohol prices in the internal and external markets. The value paid for the sugar cane in Brazil means 60 per cent of the industry profits. In the State of São Paulo, during the harvest of 2003/2004, the producer earned an average of US$ 10.35 per ton of sugarcane provided to the industrial facilities."

[31] See US Department of Energy (2008). This is possible because of the high octane number of 130 RON octane of ethanol instead of only 98 RON octane of gasoline.

[32] See Greenpeace (2007).

[33] Please note contrary to Brazil, in Fiji it is not necessary to cut down the rain forests. The sugarcane fields are there. Only the production process of ethanol is responsible for the GHG emissions.

From this example, it can be concluded that it was a very good idea of the Brazilian Government to promote the production of ethanol. Additionally, UNCTAD (2006) noted that ethanol production has created 700 000 direct jobs and 3 500 000 indirect jobs caused by the ethanol industry to produce an additional 350 million tons of sugarcane. It was also estimated that in 2006, the production of one million additional tons of cane created 2 200 direct jobs, where 73 per cent of the employees were working in the agriculture sector.

Moares (2005) stated that 982 000 employees are working in sugar-ethanol production and Guilhoto (2001) estimated with an Input-Output analysis that one job in the sugar-ethanol industry creates 1.43 indirect fulltime jobs and 2.75 induced fulltime jobs. Insofar as this, it can be assumed that just around 4.1 million people are working directly or indirectly for ethanol production.

Most of the jobs were created in the rural areas and the infrastructure was improved significantly. Because of the fact that Brazil has a comparable climate as Fiji, similar productivity in sugar output per unit area of land can be achieved and a number of other economic gains of ethanol production from sugarcane can also be replicated. The following economic gains may be realized from ethanol production:

- Reduction of the trade balance deficit
- Increased GDP growth from value-adding
- Improvement of the energy security
- Employment generation

In the next section, the question of profitability from ethanol production out of sugarcane is investigated.

COST-BENEFIT ANALYSIS

Before we start with the calculations, we should investigate into the question of the choice of feedstock, the state of technology (techniques of production) and also the methods of measurement of benefits (economic and environmental). Here, we begin with the measurement of benefits since this entails specifying a pricing mechanism (Table 6 for price details).

Table 6: Price Details Chicago/Sau Paulo.

Year	2009	2008	2008	2007	2007	2006	2006
Centre	Chicago	Chicago	Sao Paulo	Chicago	Sao Paulo	Chicago	Sao Paulo
Average Price /1000 litre	399.63	621.67	501.27	561.32	405.33	648.86	466.944
Price USD/litre	0.3996	0.6217	0.5013	0.5613	0.4053	0.6489	0.46694
EX. Rate EUR/USD (Jan)	1.3	1.47	1.47	1.32	1.32	1.18	1.18
price EUR/litre	0.3074	0.4229	0.341	0.4252	0.3071	0.5499	0.39572

Source: Original weekly data are from the Bundesverband der Deutschen Bioethanolwirtschaft (2009) and own calculations.

Ethanol is traded in Sao Paulo (Brazil) and Chicago (USA) since 2006, so it is clear that the costs of production in Fiji should, at minimum, be equal to these prices. However, the prices in Chicago are not representative of the global market since these prices only reflect the domestic market where the production of ethanol is significantly subsidized and imported ethanol is taxed. So we take the prices in Sao Paulo as reference prices.

Criteria for Benefits

Measured in EUROS[34], our calculated costs per litre should be no higher than 0.34 EUROS. Even when it is assumed that the prices in the long run may increase, the indifference price for Brazil between sugar and gasoline per litre is just around 1.67 EUROS per litre (see BNDES and CGEE, 2008). This means if the price of gasoline is higher than 1.67 EUROS per litre, all sugarcane would be used for ethanol production.

[34] We are using EUR as reference currency, because it is relatively stable.

However, it is obvious that price of ethanol in the world market is strongly correlated to the fossil fuel price, which follows economic logic because ethanol and gasoline are perfect substitutes up to some degree. However, keeping in mind that 20 per cent of all consumed fuel in Europe would be ethanol, demand side pressure on prices on ethanol is anticipated. Table 7 gives cost prices of ethanol (less investment costs) calculated by the GTZ (2006) in China.

Table 7: Cost Prices of Ethanol (less investment costs).

Feedstock	Cost (Euros/ litre)
Corn	0.380
Manihot Esculenta	0.245
Manihot Esculenta	0.304
Sugar cane	0.288
Sorghum Biocolor	0.227

Source: GTZ (2006).

Proposed Technology

In principle, there exist three different technologies to produce ethanol from sugar cane. They are as follows:

- bio-ethanol directly produced on a stand-alone basis;
- bio-ethanol produced instead of cane sugar, applying the same process; and
- bio-ethanol produced next to cane sugar.

The first technology is very costly in regards to investment costs. At minimum, such an ethanol plant would cost 150-200 million Euros, following Gazprom and Sweftneft engineers. This option for Fiji, therefore, may be excluded immediately. The second type of technology looks better at first glance since it is possible to produce sugar and/or ethanol at the same site. However, the problem of investment costs, which is relatively high between 80-120 million Euros, is too prohibitive. This option therefore, may also be excluded on the same basis as the first. The preferred option for Fiji would then be the third type of technology, which only requires an addition of a distillery to the existing sugar manufacturing site. A significant advantage of this option is that ethanol can be produced the whole year around. During the period of harvesting, raw cane juice and sugarcane can be used for the production of ethanol and molasses can be used during the off-season period. This process, however, requires that molasses be produced and stored during the season. Additionally, the remaining bagasse, and other bi-products from sugar cane can be used to produce electricity and heat to supplement the ethanol-making process. The surplus electricity from this may be supplied to the electricity grid.

The cost of setting up such a plant costs approximately 10-15 million Euros and is able to produce on average 80 000 litres of ethanol per day. To produce 80 000 litres of ethanol, we have to take into account that one ton of sugarcane is necessary to produce 78 litres and one ton of molasses is necessary to produce approximately 278 litres. That means that everyday either 1 025 tons of sugarcane or 288 tons of molasses are necessary to produce 80 000 litres of ethanol. Fijian sugarcane farmers must therefore, be able to produce 374 125 tons of sugarcane or 105 120 tons molasses.

Fiji is producing 10 times more than necessary for the 80 000 litres of ethanol on a daily basis. Table 8 shows the potential production of ethanol in Fiji.

Table 8: Fiji's Potential Production of Ethanol.

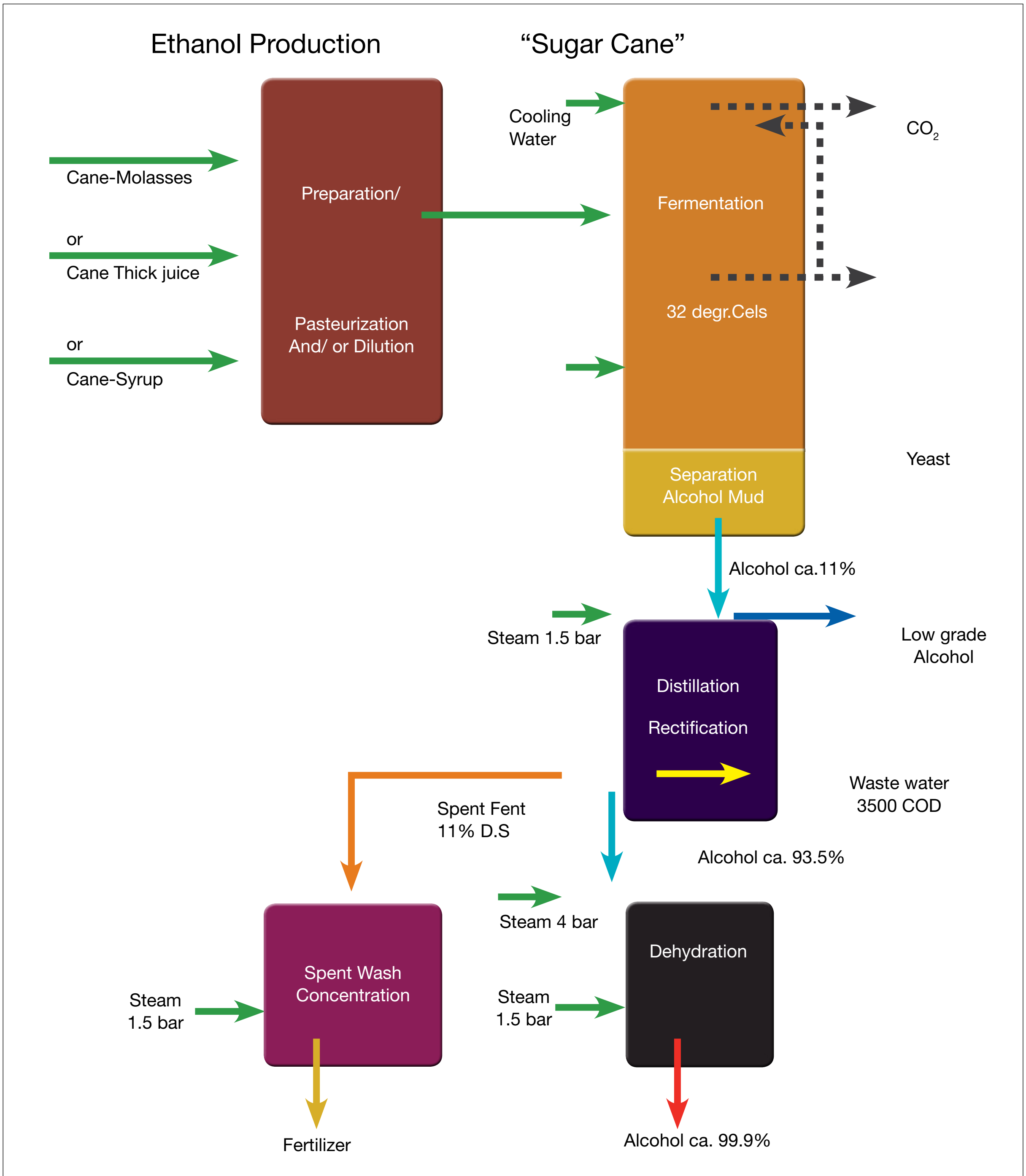
Potential Ethanol Production	2002	2003	2004	2005	2006	2007
Tons of Sugar Cane	3 422 896	2 610 011	3 001 235	2 788 720	3 225 551	2 479 000
Tons of Molasses	148 597	107 476	113 147	117 770	157 121	115 000
Litres of Ethanol from Cane Sugar	266 985 888	203 580 858	234 096 330	217 520 160	251 592 978	193 362 000

Potential Ethanol Production	2002	2003	2004	2005	2006	2007
Litres of Ethanol from Molasses	41 161 369	29 770 852	31 341 719	32 622 290	43 522 517	31 855 000
Aggregate Ethanol Production	308 147 257	233 351 710	265 438 049	250 142 450	295 115 495	225 217 000

Source: The numbers are from the Fiji Sugar Corp. Ltd. and Sugar Cane Growers Council in 2009, the calculations are ours. The numbers of the FSC and Cane Growers Council are different from FIBOS (2009).

Graph 6 gives the picture of the production process of ethanol. At first, ethanol will be produced from cane sugar in the conventional way, and then alcohol of 11 per cent concentration goes to the distillery after fermentation, where steam heating of the low-degraded alcohol converts the alcohol to high graded level with 93.5 per cent concentration. This alcohol is then dehydrated, to arrive at ethanol of 99.9 per cent concentration. The residue from this process is converted to fertilizer for sugarcane.

Graph 6: Ethanol Production Process.



Source: DSD (2005).

As pointed out earlier, the main advantage of this technology is that it can utilize the existing sugar plants and the conversion of cane sugar into ethanol can be determined by the manager, depending upon the prevailing world market prices. The choice of whether to produce sugar or ethanol is always there and the realization of this facility can just be part of the current diversification strategy.

Some Details of the Costs Calculations

The costs of ethanol production depend on a lot of factors; here we give an overview about the cost structure in detail. The total costs are the sum of; 1) the interest payments for the capital investment of about 10-15 million Euros; 2) the maintenance costs estimated to be about two per cent of the total investment on the plant; and 3) the labour costs of production. In addition to this, other variable costs constitute the raw material input costs, such as molasses, cane sugar B-syrup, cane sugar and other minor inputs, costs of steam, heavy oil, electricity and process water. Adding up all these costs and dividing by the quantity of ethanol measured in litres gives us the total production cost per litre.

A number of scenarios are calculated but only three of them are presented here. These four cases include the description of a good case, a worse case and the actual situation under different conditions. The assumptions are described for the benefit of the reader. The prices are calculated in Euros, except the wages for the year 2008 that are given in Fiji dollars. Even though the prices for all natural resources were very high in 2008, the same calculation can be done for 2007, 2006, 2005 and 2004, without changing the general results.

The costs are defined in the following way:

$$C(Q) = \underbrace{I(m+i) + wL}_{\text{fixed costs}}$$
$$+ \underbrace{\left(p_{steam} + p_{electricity} + p_{water} + p_{oil} + p_{chemicals}\right)Q}_{\text{costs of materials}}$$
$$+ \underbrace{p_x Q}_{\text{costs of raw materials}}$$

C(Q): production costs of ethanol

Q: quantity of ethanol in litres

I: fixed investment costs

i: interest rate

m: maintenance rate

w: daily wage rate

L: quantity of labour (aggregate labour days)

P_{steam}: price of steam per litre ethanol

$P_{electricity}$: price of electricity per litre ethanol

P_{water}: price of water per litre ethanol

P_{oil}: price of oil per litre ethanol

$P_{chemicals}$: price of chemicals per litre ethanol

P_x: price of raw materials per litre ethanol

x є (molasses, Syrup-B, cane sugar}

The economic calculations alone, without quantifying the positive environmental externalities, shift in labour productivity and trade gains, the net outcomes are positive, and thus it is concluded that the profitability of ethanol production in Fiji is more than probable. Only under very adverse conditions would the production not be profitable. It can be concluded quite assertively that production and use of ethanol produced from cane sugar (molasses and sugar syrup) would be largely profitable. What becomes clear is that beside the prices of raw materials, the interest rate has a large influence on the cost of production and thus profitability. Given the increasing trend in the demand of ethanol in Europe and improving production and vehicular technologies, it can be assumed that production of ethanol will continue to be profitable in the future.

This diversification strategy for the sugar industry would then permit production of cane sugar and ethanol at the same site as a choice. The calculations of course, do not impute any government taxes, either in the production or use of ethanol. Any form of government tax will reduce profitability of investment in ethanol production. However, taking into consideration the advantages of ethanol production and use as fuel, the government should subsidize and provide infrastructure support for ethanol industry.

What we did not take into account is the possibility of the sugarcane industry to find a partner in the developed countries and to bargain a start-up of a CDM (clean development mechanism) project. The clean development mechanism is one of the four mechanisms of the Kyoto-protocol. It allows firms from developed countries to invest in GHG, reducing projects in less developed countries to enhance their quantity of emission rights in their home country. Because of the fact that combustion of ethanol is almost completely environmental-friendly, unlike fossil fuel that has numerous problems, the main conditions of CDM cooperation are fulfilled. In the past years, the price of emission rights was very unstable. It lied in the range of 14 and 25 Euros per ton of CO_2. The minimum reduction per litre of ethanol is 1.65 grams of CO_2. Given a production of 28 million tons as in our case study, the CO_2 emissions would be reduced by approximately 46 000 tons in a year. Then, the additional income from the CDM would range between 695 000 Euro and 1 158 500 Euros per year. It means that the cost prices would decrease by about 0.024 Euros to 0.04 Euros per litre of ethanol. In this case, the use of molasses and syrup would be in all cases profitable to the investor and socially desirable as well.

Table 9: Production Costs per Case.

Production Costs		Case I	Case II	Case III	Case IV
Investment costs		10 000 000	15 000 000	15 000 000	15 000 000
Interest rate		5%	5%	8%	10%
Wage per day		50 FJ-$	50 FJ-$	60 FJ-$	60 FJ-$
Steam (EUR/litre)		0.07	0.07	0.07	0.07
Heavy oil (EUR/litre)		0.02	0.02	0.02	0.02
Electricity (EUR/litre)		0.02	0.02	0.02	0.02
Process water (EUR/litre)		0.05	0.05	0.05	0.05
Molasses (EUR/ton)		33	37.62	37.62	37.62
Cane sugar B-syrup (EUR/ton)		42	47.16	47.16	47.16
Cane sugar (EUR/ton)		290	324.40	324.40	324.40
Cost price in EUR per litre ethanol	Molasses	0.30	0.33	0.34	0.35
	Cane Sugar B-Syrup	0.30	0.33	0.34	0.35
	Cane Sugar	0.67	0.73	0.75	0.76
Price in Sao Paulo (2008) in EUR per litre		0.341001	0.341001	0.341001	0.341001

Source: Authors' calculations.

Trade Balance Deficit

The figures in Table 10 clearly show Fiji's increasing commodity trade deficit, which has been one of the reasons for the Reserve Bank of Fiji to devalue the Fijian currency in April 2009. It has been argued earlier in this paper that substituting fossil fuel with ethanol would reduce Fiji's trade deficit considerably. This seems to be a valid point from the data in this table. Fuel import is the largest component of all imports in Fiji, which constitutes about 34 per cent and food constitutes about 14.5 per cent. Another obvious reason why fuel import substitution is an ideal option for Fiji is because fuel imports form more than 57 per cent of the total trade deficit.

Table 10: Commodity Trade Deficit for Fiji.

Year	Sugar Exports	Molasses Exports	Fuel Imports	Bal. of Trade (BOT) Deficit	GDP (in Current FJD)	BOT as % of GDP
2001	225.2	12.3	443.5	-614.9	3296.0	18.7
2002	234.4	12.4	435.4	-690.5	3484.0	19.8
2003	225.7	6.9	463.0	-729.6	3696.9	19.7
2004	209.2	9.7	587.0	-1096.6	3989.5	27.5
2005	223.7	9.9	784.0	-1291.8	4237.9	30.5
2006	215.1	19.2	1021.5	-1607.9	4647.7	34.6
2007	185.0	10.1	958.2	-1680.3	4555.4	36.9
2008	248.2	13.6	1222.1	-2130.4	4940.9	43.1

Source: RBF (2009c) and FIBOS (2009).

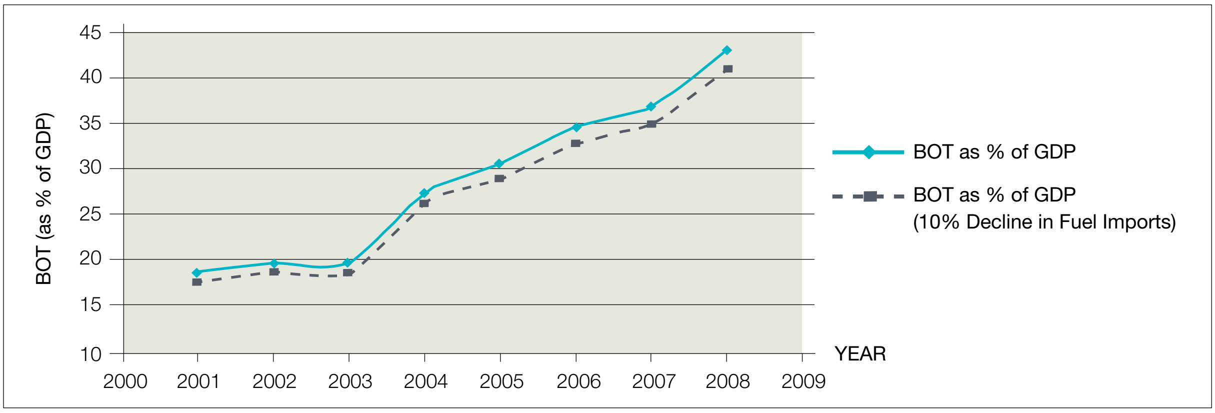
Table 11: Commodity Trade Deficit in Fiji with Ethanol Changes.

Year	BOT as % of GDP	BOT as % of GDP (with 10% Reduction in Fuel Imports)	% Point Reduction in Deficit	% Reduction in Deficit
2001	18.7%	17.7%	1.0%	5.2%
2002	19.8%	18.9%	0.9%	4.5%
2003	19.7%	18.7%	1.1%	5.4%
2004	27.5%	26.3%	1.2%	4.5%
2005	30.5%	28.9%	1.6%	5.3%
2006	34.6%	32.8%	1.8%	5.2%
2007	36.9%	35.0%	1.9%	5.1%
2008	43.1%	40.9%	2.2%	5.1%

Source: RBF (2009c) and FIBOS (2009).

Taking this argument further, if we consider a 10 per cent reduction in fuel imports by producing ethanol, then the following changes shown in Table 11 can be achieved. For instance, in the years 2001-2008 the total trade deficit would be lower by more than five per cent. This is a significant reduction in deficit since this kind of substitution would be easily achieved from a single ethanol plant of 80,000 litres per day, which requires approximately 375,000 tons of additional sugarcane production or 105 000 tons of molasses. It is assumed in these calculations that the ethanol production does not impinge upon the exports of sugar; it only affects molasses export. It is assumed that all molasses produced as bi-product of sugar is converted to ethanol. Therefore, the reduction in exports of molasses is factored in these calculations. The assumptions taken here are quite realistic since there is ample excess capacity for sugar production in Fiji and the current level of molasses and sugar syrup-B in the sugar mills is enough to produce 80 000 litres of ethanol per day. Furthermore, this option would be possible to establish for an approximate investment cost of $45 000 000 Fijian dollars.

Graph 7: Reduction of Import Deficit with Ethanol Production.



Source: RBF (2009c) and FIBOS (2009).

Graph 7 shows that the imports deficit will reduce by more than two per cent with only a 10 per cent reduction in fuel imports, which can be easily achieved by ethanol production. According to the calculation, taking into account the energy content factor of ethanol and fossil fuel, it would be possible to substitute all land transport vehicle fuels with E10 fuel from an ethanol plant of 80 000 litres/day capacity. Such a plant would, in fact be left with some surplus for export or some other use.

CONCLUSIONS

In this paper we have shown that the production of ethanol in Fiji is profitable and will improve the Fijian environment. The further advantages for Fiji would be that the use of ethanol in cars would reduce the merchandise trade deficit. Assuming the use of E10, the use of ethanol would have reduced the imports of fuel by about eight to nine per cent, or 122 million Fiji dollars (see Stauvermann and Kumar, 2009). Additionally, Fiji would export the surplus ethanol produced in the plants or possibly expand the proportion to 15 or 20 per cent, whichever is applicable. The export effect is absolutely desirable from an economic perspective and the surplus ethanol provides a solution for future development and better environment-friendly options. It also seems to be probable that the number of jobs on the country-side for low skilled workers would increase if the demand for sugarcane production increases. The job opportunities would arise directly in the primary sugar sector and also indirectly in the transport industry. The realisation of an ethanol sector would make the Fijian economy less dependent on the global oil market for energy. Fiji's global commitment on GHG emissions would also be met easily through this new economic sector. Additionally, the uses of ethanol would also spin-off changes in the transport sector technologies, and possibly introduce new types of engines for buses and trucks, such as Scania engines that use E100[37].

So far it is clear that ethanol fuel production would lead to a win-win situation in Fiji as it has done in all other countries. To take this further, the government needs to introduce and support initiatives for ethanol production. Appropriate legislations need to be implemented for fuel use and environmental protection. Discussions need to start at the national level and budgetary provisions made to support investment proposals in this sector. There are a number of international firms that have experience in international cooperation for setting up ethanol production plants and conversion of vehicular engines. The government should first establish a national committee to initiate discussions with domestic and international firms that have interest in this sector, or alternatively invest public funds in production units. In the view of the authors, a lot of the institutional settings in the agricultural sector need to be changed to enhance primary productivity of the sugarcane sector. The problem begins with the Fijian agricultural land market or better, with the National Land Trust Board, and goes further with the Fiji Sugar Cooperation. Both institutions are largely inefficient, because of monopolists on the one hand and a monopsony on the other hand. However, Fiji has some opportunities to experiment and realize a win-win situation, which it is in a position to consider decisively.

[37] See for example Egebäck (2004) and Haupt, Nord, Egebäck and Ahlvik (2004).

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SECTION III

ASKING THE RIGHT QUESTIONS: CONCEPTUAL ECONOMIC CONSIDERATIONS AND EMPIRICAL EVIDENCE FOR MAKING INFORMED CHOICES

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CHAPTER 9

Economics of Pacific Tuna Management

Vina Ram-Bidesi

INTRODUCTION

This paper reflects on the management of tuna in the Western and Central Pacific Ocean (WCPO) through a review of some recent economic studies to address important resource policy questions. It points out that the common pool problem remains because of the transboundary and shared nature of the resources with multiple interests which can lead to unsustainable outcomes. Strategies for optimal solutions can only be achieved through a greater cooperation and coordination of various competing interests. The challenge for Pacific Island Countries (PICs) is to strategically re-consider their tuna policy-making and to identify solutions that can allow for voluntary cooperation in joint management arrangements. In formulating their respective positions, Resource and Environmental Economics study can provide helpful policy tools for PICs given their peculiar dependence on tuna, much of which lie outside the conventional market economy. Firstly, the paper briefly describes the tuna fisheries and the issues arising in relation to management of the resources which have direct economic implications. It then examines the current policy options that are implemented or under consideration to show that these solutions are unlikely to lead to sustainable fisheries that can meet the development needs of PICs in the long term. The paper suggests that resource accounting and valuation techniques could provide useful insights into framing the PICs positions for negotiations in reaching agreements amongst the various interest groups.

TUNA FISHERIES IN THE WESTERN AND CENTRAL PACIFIC OCEAN

The tuna fishery in the Western and Central Pacific Ocean (WCPO) is the largest and most productive fishery in the world. In 2007, production from the region was around 2.4 million tonnes, worth about US$3.8 billion and accounted for 55 per cent of the global tuna catch (SPC, 2008). Catches from the EEZ of coastal states contribute to about 80 per cent of this catch. On the other hand, the Distant Water Fishing Nations (DWFNs) fleet account for 70 per cent of the total catch. The EEZs of the PICs make up about 50 per cent of the area covered under the Western and Central Pacific Fisheries Convention Area. The tuna resources of the Pacific PICs are therefore, not only of regional importance, but also of global significance. Its management and conservation is important for both coastal states and the distant water fishing nations (DWFNs). For example, canneries in Asia rely on raw materials from the WCPO and the region supplies almost 30 per cent of Japan's sashimi tuna (Gillett et al., 2001). The four main species that are commonly targeted are skipjack, yellowfin, big eye and albacore by using purse seine, longline, pole and line and troll gear.

Under the UNCLOS, the establishment of EEZs was seen as an important step to prevent the open access nature of the global fisheries when coastal states were given the responsibility to manage and optimally utilize the resources with the understanding that mutual development arrangements could be fostered between developing coastal states and developed countries with fishing capabilities.

The establishment of Forum Fisheries Agency by the Pacific Islands Forum therefore, has played a crucial role in coordinating the activities of the PICs, or else tuna could have been long over-exploited because of the inability to reconcile the development interests of PICs themselves as well as the Distant Water Fishing

Nations (DWFNs). The major management measure used has been through limiting access by licensing of fishing vessels within the EEZs. This in turn has been seen to generate the much needed government revenue[38].

Many PICs saw the extended jurisdiction as providing the opportunity for economic development through establishment of domestic tuna industries. On the other hand, over time, there was also the realization that harvesting of tuna in the high seas had increased due to its open access nature that was accompanied by improvement in technology since tuna is a highly migratory resource. Since the late 1970s until early 1990s, there was no upper limit on vessel numbers. PICs continued to issue licenses to domestic and foreign vessels to fish in their EEZs to maximize economic returns from the tuna fishery.

Concerns were first raised in the mid 1980s on the increase in purse seine vessels which contributed to increase in tuna catches. PICs realized the need to regulate the highly efficient purse seine fishery by placing a limit on the number of vessels. They established the Palau Arrangement under the Parties to the Nauru Agreement to address this concern. There was no direct economic or scientific rationale to limit vessel number to 205[39]. PICs were facing increasing concerns with decline in fish prices and there was limited progress of their domestic development programmes. Access fees paid were also considered low, averaging about three to five per cent of the value of catch. Around the same time, the DWFNs were also getting concerned about the declining profitability and increasing high seas fisheries.

Western and Central Pacific Fisheries Convention

While the negotiations on the Fish Stocks Agreement was underway at the United Nations to strengthen fisheries management in the high seas, the distant water fishing nations fishing in the region together with Forum Fisheries Agency member countries began a consultation process to bring about a more effective fisheries management regime to ensure the long-term sustainability of the tuna stocks in the Western and Central Pacific Ocean. Through almost seven years of consultations and negotiations, the Western and Central Pacific Fisheries Convention was established in 2000. The Convention led to the establishment of a Commission as a regional fisheries management organization in 2005 to implement the Convention. The Convention area covers the entire migratory range of the tuna stocks to ensure its conservation and long-term sustainable use. Since the start of the High-Level Multi-lateral Consultation and Preparatory Conference process, a number of studies have been done that look at various issues of concern, relating to the management and conservation of tuna and their economic implications, thus guiding the policy decisions of various interest groups and countries. Before reviewing some of the economic implications highlighted in these studies, it is important to understand the economic underpinning of fisheries management and how and what constitutes an optimal fisheries policy. This in turn helps to identify the challenges faced by the WCPFC Commission and PICs.

THEORETICAL UNDERPINNINGS OF FISHERIES MANAGEMENT

The conceptual Gordon-Schaefer open-access model itself provides the basic rationale for why fisheries should be managed if long-term economic benefits are to be optimized from the use of resources. It is desirable to operate a commercial fishery at a level that can optimize the resource rent as illustrated in figure 1 at the effort level denoted by e*. The purpose of a fishery is to maximize the net value of production that can effectively contribute to GDP and increase welfare.

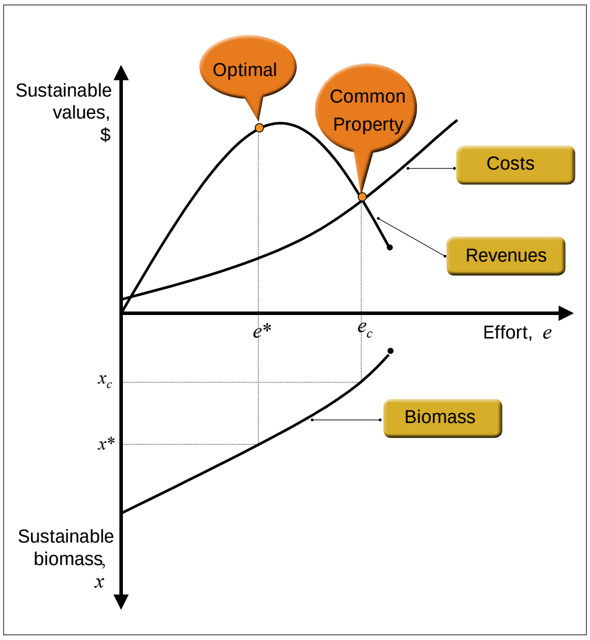
However, in reality, efficient and effective operation of a fishery requires both scientific data on stocks, environmental conditions, fishing effort, costs and market data. A number of uncertainties exist in relation to availability of such data and information. In the context of tuna fisheries, obtaining such relevant data has been a problem and in most cases non-existent. In addition, there has been limited coordinated effort to gather relevant data on the regional tuna stocks and the other fishery data until the mid 1990s, except for some biological data gathered by SPC.

However, it is clear that amidst uncertainty about the fishery, some adaptive management is needed that could be improved as time series data and other scientific information become available.

[38] While the conditions of licensing have been strengthened over time through the Harmonized Minimum Terms and Conditions of Access, the use of VMS and banning of transshipment at sea, these nevertheless do not put any limits on the amount of catch that could be taken.

[39] Placing a cap on the number of vessels to the existing level in 1994 which was 205.

Figure 1: Sustainable Fishery Model.



Source: Arnason, 2008.

The second basic principle in establishing a fishery is to ensure that in achieving its long-term goals, such as optimizing economic benefits and resource sustainability, it has to have an effective fisheries management regime, or an institutional framework that guides the management process. A fisheries management regime consists of a fisheries management system, a monitoring, control and surveillance system and enforcement and judicial system. Each of these components should be designed with respect to each other and should be fully functional and well coordinated. If any one of components fails, the other components, however well designed and implemented, will generate little, if any benefits (Arnason, 2008).

Tuna fisheries management system can be grouped into biological or economic. Economic fisheries management can be further grouped into direct or indirect restrictions. Direct restrictions impose explicit constraints on the activity of fishers, while indirect management changes the incentives faced by fishers, such as through taxes and property rights.

Biological management aims to increase the biological productivity of the fish stocks, such as area closures, TAC, mesh size limitations and so on. These measures help conserve fish stocks and enhance the sustainable yield. On their own, they fail to generate net economic benefit because they do not remove the common property nature of the fisheries. Direct economic restraints attempts to remove the symptom of fisheries problems, such as excessive fishing effort or harvest levels by imposing constraints on the industry, such as through time restrictions, number of vessels, vessel capacity and so on. These methods fail to generate economic rent because they do not remove the common property problem; as a result fishers are forced to compete with each other for a share of catch until net benefits are dissipated through expansion of fishing inputs that are not controlled.

Property rights have been used as a means to eliminate common property problem by establishing rights over fish stocks. Several types of property rights could be employed to deal with the fisheries problem, such as territorial use rights, fishing licenses and individual fish quotas. Property right is the issuing of entitlements to limit the number of individuals that may harvest the fisheries resource and to provide a means to restrain how much and where to harvest fish. The more clearly defined the user rights or 'the property right', the lower the likelihood of perverse incentives to increase fishing effort and catches.

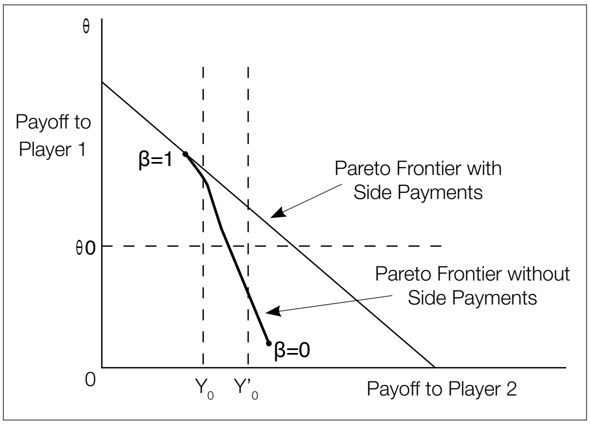
Monitoring, control and surveillance (MCS) can also be a costly component of fisheries management. An MCS study of fisheries in Iceland, Newfoundland and Norway were found to be ranging from 3 to 28 per cent of the value of catch (Arnason, Schrank and Hannesson, 2000). It was also found that in 26 of the OECD countries, management costs accounted for six per cent of the landed value of the catch (Wallis and Flaaten, 2003). It is also well understood that MCS costs associated with tuna management in the Pacific are high and beyond the scope of many PICs budgets given the vast distances and ocean area covered. As a result, fisheries management costs are not negligible but can be a substantial part of economic rent. Therefore in rent maximizing fisheries policies, it is necessary to take full account of the costs necessary to implement fisheries policies. An effective enforcement and judicial system is also an essential component of a fisheries management regime where there are appropriate sanctions to offenders. Fishers will break rules if expected benefits of doing so exceed expected costs.

In addition to having an efficient and effective fisheries management regime, the economics of tuna which is a transboundary and highly migratory resource is more complex because of multiple jurisdiction and interests of various groups and countries with different management goals and objectives.

Munro (1987) combined the standard biomass model used for fisheries of a single state with the theory of games to explain the economics of management of transboundary fish stocks which in turn is used as a foundation to explain the economics of management of straddling and highly migratory fish stocks (Kaitala and Munro, 1993). Munro uses the analogy under the theory of games to analyse the strategic interactions between and among individuals be they persons, fishing nations and others (Munro, 2004).

In the case of WCPO, various interest groups exist at the different levels. The two dominant groups are the Pacific Island States and Territories (PICTs) and the Distant Water Fishing Nations. Within these two groups are several sub-groups such as within the PICTs, there are Parties to the Nauru Agreement Group (PNA Group) and the non-PNA group and the dependent territories. Within the DWFNs, there are new states and those that have been fishing in the region historically. Even at the regional level, WCPF Commission also needs to harmonize management measures with other RFMOs such as the IATTC, ICCAT and so on to effectively achieve a global tuna management regime that can control fleet migration. In developing a cooperative resource management programme, it is not sufficient to be only concerned with allocation of benefits from the fishery, but there is also a need to consider the different interests of the players (countries or parties), such as their different management goals. This means that a compromise management programme will have to be negotiated as illustrated in figure 2. Suppose if player 1 (say country A's) management options are dominant, then Player 2 (country B) would agree only to follow A's management strategy if B is compensated by 'side payments' which then increases the payoff for B as well. Without this, B will not agree as the situation will be below the threat point of B, which will make B worse off than without cooperation[40].

Figure 2: Cooperative Game With and Without Side Payments.



Source: Munro, 2004.

Binding cooperation arrangements are favoured over non-binding and the need for side-payment is important when management goals differ to compensate the fellow player (Munro, 2004). Munro further goes to state that when side payments are possible, then the optimal policy is one in which the management preferences of the player placing the highest value on the resource should be given dominance (Munro, 2004; Thebaud, 1997). Allocation of fishing opportunities however reflects the relative bargaining strength of the players and also the player's perception of equity. These are important considerations in reaching cooperative arrangements on any management measures.

Review of Studies on Tuna

Given what economics can inform about fisheries management, the next section will review some economic literature to identify the key issues arising in relation the management of tuna. What is apparent is that fisheries management strategies, whether they are input controls or output controls, require an understanding of how fishers respond to economic incentives. Many of the studies have been done with specific questions and consequently have specific purposes and constraints in interpretation and extrapolation. For example, Campbell and Nicholl (1995) looked at the issue of optimal fleet composition by examining the marginal allocation of yellowfin stock from purse seine to longline fishery by taking into account the production process and economic costs of both type of fisheries. The study illustrated that the benefits gained by reallocation of yellowfin tuna stock to the longline fleet will outweigh the cost to the purse seine fishery because the yellowfin caught by longline fetches a higher price, compared to purse seine-caught tuna.

Hampton et al. (1997) presented a bioeconomic model of the purse seine and pole and line fishery in the Solomon Islands fishing zone. The study showed that rent generated by the two fleets in the Solomon Islands could be increased by an increase in purse seine effort. The backdrop of this study was on the need to increase supply of tuna to the Solomon Taiyo cannery at that time. This study however, did not consider the effect of increased purse seine catch on the longline fishery. Bertignac et al. (2000) conducted a bioeconomic analysis of the WCPFC to estimate the changes in effort levels and composition of effort on the production in FFA members' EEZs. The aim of the model was to determine the optimal exploitation of tuna resources in the region. By taking into account the various interactions between longline and purse seine, the model concluded that purse seine vessels catch juvenile surface swimming yellowfin, thereby reducing the number of mature yellowfin exploited by the longline fleet. A number of scientific studies and stock assessment surveys on tuna by the Secretariat of the Pacific Community have improved the overall understanding on the biology, ecology and ecosystem dynamics of tuna, although there are still gaps on some of the environmental uncertainties.

40 For a more detailed explanation – refer to Munro 2004: 95-112.

The early concerns about the status of fish stocks raised by the SPC studies had led to the resolution by MHLC participants to exercise reasonable restraint in the expansion of fishing effort and capacity[41]. A study by Hampton et al. (2005) further provided the basis for discussion at the Science Commission Meeting (SC1) on catch and effort levels and their impact on target species. The scientific studies have given economists a better understanding on how the changes in stocks may affect the overall fishery profitability. For example, using the SPC scientific studies, Reid (2006) provided an economic analysis of possible trade offs of the various management measures to reduce fishing mortality on big eye and yellowfin tuna stocks[42].

The study concluded that the major beneficiary of an across the board 25 per cent reduction in fishing effort would be the frozen longline fishery that targets sashimi tuna while the economic costs would be borne by the purse seine fleet in the Pacific Island waters. The option that would best move the fishing mortality for big eye towards MSY would be 25 per cent reduction in the longline catch. However, the impact of this reduction would be on the southern albacore fishery of the Pacific Islands. The study further indicated that outcomes where all stocks are maintained at or above the levels associated with MSY will be difficult to achieve because the value of PICs fisheries is dependent on skipjack and albacore which are predominantly targeted by their vessels. In December 2008, the WCPF Commission adopted management measures which seek to reduce fishing mortality on big eye by 30 per cent from 2001-2004 average levels and limit yellowfin tuna fishing mortality to 2001-2004 levels in order to maintain stocks at levels capable of producing MSY[43]. These objectives are pursued through a combination of measures involving longline catch limits, purse seine effort limits, closure, relating to purse seine fishery, using FADs and a closure of two high seas pockets to purse seine fishery. Most of these measures have various exemptions and are phased in over the 2009-2011 period. An evaluation of these management measures to see if they are able to meet the objectives of the WCPF Commission has been done by Hampton and Harly (2009). The study indicates that with the exemptions, it will not be possible to achieve 30 per cent reduction in big eye mortality and the maintenance of yellowfin. The focus of the above scientific and bioeconomic studies has been on reducing fishing capacity by various technical measures and input controls.

On the other hand, studies by Chand et al. (2003), Grafton et al. (2006), Parris and Grafton (2005) see the tuna management problem as one that requires the strengthening of its institutional arrangement, such as through a property rights system by way of allocation of participatory rights which can place limits on the catch and vessel numbers. For example, the above studies recommend that the WCPF Commission as a RFMO to establish a TAC by species and area and then allocate non–transferable and permanent country shares (as a proportion of the total harvest to member countries). A two tier allocation to countries of permanent shares of a TAC and then annual harvest allocations to vessels of member countries would help mitigate and overcome problems of overcapacity and over exploitation. The argument in the above studies is that over exploitation is caused by a lack of well-defined property rights. Overcapacity is seen as a symptom of a problem. Effective fisheries management that addresses the underlying problem should therefore, remove the need to consider capacity as a separate issue (Pascoe, 2007). The problem at the WCPF Commission with allocation is firstly, reconciling the jurisdictional issues between EEZs and high seas areas. Pacific island states argue that the Commission should only allocate fishing opportunities in the high seas since they have sovereign rights over resources within the EEZs while DWFNs argue that the Commission is responsible for the entire Convention area which also covers the EEZs. The outcome of their decisions will have major economic implications for both DWFNs and for PICs.

A study by MRAG (2006) on allocation scenario heavily relies on the use of historical catch as a basis for allocation as has been experienced in a number of countries where quota systems have been instituted. However, allocation – at least the initial allocation is usually a bargaining game and there is no standard formula (Kaufmann, 1999). Under article 10 (3) of the WCPC Convention, a set of possible criteria for allocation has already been suggested. The given options should be explored to determine the attributes that would be most appropriate in the context of WCPO given the unique fishing experience and data recording that existed in the region. The MRAG study also points out that non-inclusion of new members can also lead to increase in IUU fishing. This issue has also been extensively debated within the Commission and membership has been increasing accordingly. Hannesson (2008) views PICs role in fisheries as renters where revenue could better be derived by allowing access to fishing states whose cost of operations are lower. He further adds that access fees should flow to the nation as a whole instead of ending up in private accounts of individuals who are responsible for fisheries. He recommends the establishment of a trust fund that can provide long-term flow of returns from the fishery.

[41] (4th MHLC in 1999 and 3rd Prep Con in 2002).

[42] Options and combination of options – include 25% across the board reduction in effort; three-month closure of purse seine; 10 weeks WCPO FAD closure and 25% reduction in long line effort.

[43] WCPFC –SC5-2009-GN-WP-17.

In a similar study, Munro (2004) considers the relative cost efficiency of coastal states and DWFNs by arguing that DWFNs have a lower harvesting cost and so they could generate greater economic surplus and their ability to pay rent is higher indicating that PICs should allow DWFNs to harvest tuna in return for access fees. The costs and benefits of these options for PICs need to be thoroughly investigated.

Different studies look at different aspects of fisheries. The scientific studies point to the declining status of some of the important target species while economic studies allude to the need to create more stable fisheries with clearly defined use rights. From a natural resource policy perspective, it is apparent that there is a lack of coordinated effort to achieve the appropriate management design and to see the fruition of an effective tuna management regime with all the three components, i.e. management system, MCS, and enforcement and judicial system that could optimize the net benefits. The studies nevertheless, draw attention to some of the key issues in relation to the management of tuna resources that would have major economic implications.

Issues Arising in Relation to Tuna Management

Key institutional issues that have economic implications include:

- Need to reduce fishing effort and to place catch limits to achieve optimal benefits from the fishery as a whole
- Identifying measures to deal with new entrants and at the same time to reduce IUU fishing so as to avoid free rider problems
- Resolving jurisdictional issues in relation to decisions regarding EEZs when dealing with allocation
- Need to meet Pacific island development aspirations in light of limited opportunities
- Ensuring that cooperative arrangements among the different groups are not undermined, but strengthened to achieve mutually beneficial outcomes, considering the highly migratory nature of tuna resources

POSSIBLE SUGGESTIONS

There is a need to resume discussion on determining the TAC for the Convention Area and to design a mechanism for possible sharing arrangements amongst coastal states and fishing states. This can be seen as the “bitter pill” of good fisheries management despite the problems it may pose in practical terms because of the various divergent interests of parties. From the experiences of other RFMOs, this is often a long process therefore, it is essential that discussions on this issue remain on the top agenda of the Commission to reach agreements sooner than later.

Given that strategic behaviour of partners play an important role in creating the right incentives for cooperation, these need to be identified and perused. In the case of PICs, the opportunity cost of having rights to tuna resources needs to be carefully assessed, not only in financial terms, but also in the broader social context, such as by identifying the replacement and substitution costs. The cost of loss in incomes against the benefits of access or domestic development options also need to be carefully assessed. The use of Resource and Environmental Economics can provide useful tools to inform policy decisions in this area. Many of the smaller PICs are highly dependent on tuna resources, i.e. they are fishing economies and therefore, this needs to be articulated well. This will help such countries to be more transparent to support their positions when negotiating with DWFNs on issues in relation to the allocation criteria.

There should be careful consideration given to the need to have an effective and efficient fisheries management regime with its three components designed to achieve optimal resource rents from the fishery. MCS systems, enforcement and judicial systems must be considered with respect to each other and not in a compartmentalized manner as the current practice may suggest. In any cooperative decision making, the long-term solutions should be considered, especially when imposing limits on fisheries. Every country should be better off with cooperation than without, keeping in mind that there may be short-term losses in order to achieve long-term gains. Resource economic tools such as cost and benefit analysis can be useful in determining the long-term discounted outcomes of such policy decisions.

It is important to take note that when the Commission was established, it was envisaged that new entrants would be excluded and only vessels flagged to the Commission members and Cooperating Non-Members would be licensed. While the rationale for new entrants is clear, it seems the longer the allocation decisions are prolonged, the harder it will be to achieve consensus given the increase in membership size.

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CHAPTER 10

Socio-Economic Assessment of Pacific Coastal Management

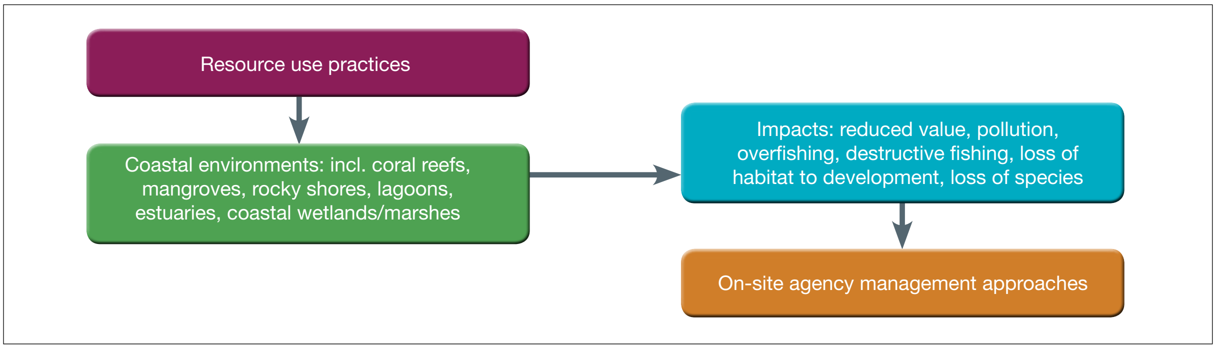
Nicholas Conner

INTRODUCTION

Coastal zone environments, such as mangroves, reefs, rocky foreshores, sandy beaches, lagoons, coastal wetlands, and sea grass beds in many Pacific countries are facing a significant range of socio-economic and biophysical impacts which are leading to declining ecological health and loss of economic and cultural value for local communities dependent on these environments[44]. Impacts include pollution, overfishing, destructive fishing, land-based activities causing siltation of reefs, and mangrove clearing for agriculture or tourism development (World Bank, 2000).

Marine and coastal resource managers have typically responded to these impacts by site-specific management approaches relating to the issue at hand. For example, marine managers have responded to coastal overfishing by introducing regulations to limit the size, age and type of species caught in an attempt to allow stocks of depleted species to recover to levels appropriate for sustainable harvesting (see Figure 1 for a simplified picture of this type of approach).

Figure 1: Simplified Approach to Managing Coastal Zone Environments.



However, impacts on coastal zone environments can be the result of influences outside the coastal area (see Box 1 for an example). Site-specific management approaches may be unsuitable to address the effect of these influences, and alternative approaches to identifying impacts and developing management responses may be valuable here.

Box 1: Impacts of Upstream Influences on the Great Barrier Reef World Heritage Area & Marine Park.

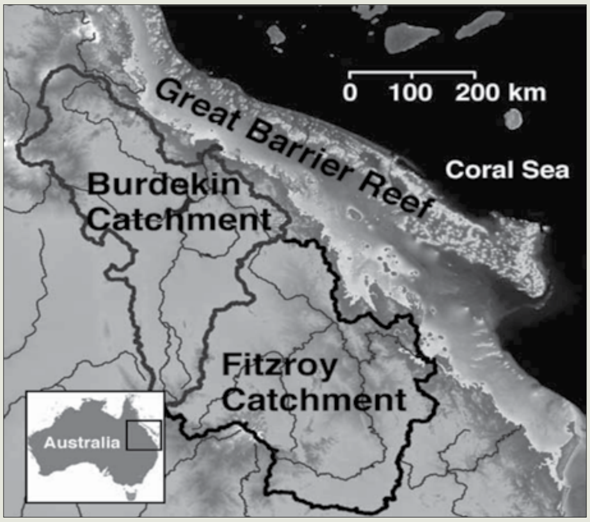
About one quarter of the Queensland land surface drains to the Great Barrier Reef World Heritage Area, as shown below. Agricultural industries, including grazing and cropping are the largest users of land in the Great Barrier Reef catchments, with some 80 per cent of land adjacent to the Great Barrier Reef Marine Park supporting agricultural production, mainly beef cattle grazing & intensive cropping. There are approx. 4.5 million beef cattle in the Barrier Reef catchments.

[44] For the purposes of this paper, 'environments' are defined as natural or modified terrestrial and aquatic ecosystems and habitats such as mangroves, coral reefs, rocky shores, sea grass beds, and other ecological bionetworks. 'Resources' are defined as the goods and services derived from use of these environments. 'Coastal management' is broadly defined as coastal and marine environment management such as marine park management, and coastal and marine natural resource management such as fisheries management.

Agricultural industries have a significant impact on the ecological health of the reef and have resulted in a considerable increase in runoff of sediments, nutrients, and other pollutants since pre-European times. Agriculture has been responsible for extensive clearing of vegetation for cattle grazing. Overstocking on farms has led to widespread soil degradation, especially during droughts, and transport of eroded material to the reef during heavy rainfall. Soil erosion has been estimated at 0.9 tonnes per ha p.a. on catchments with minor gully erosion; 1.6 tonnes with one active eroding gully; and 27–30 tonnes with severe gully erosion.

Sugarcane cropping covers the largest area of agricultural activity in the reef's catchments, which also support production of grain, cotton, bananas, and other fruit and vegetables. Sugar cane and other cropping use fertilisers such as nitrogen and phosphorus, and pesticides, a significant proportion of which reaches coastal waters (cane production is estimated to add some 20,000 tonnes of nitrates p.a. to the Great Barrier Reef).

Inland Catchments of the Great Barrier Reef.



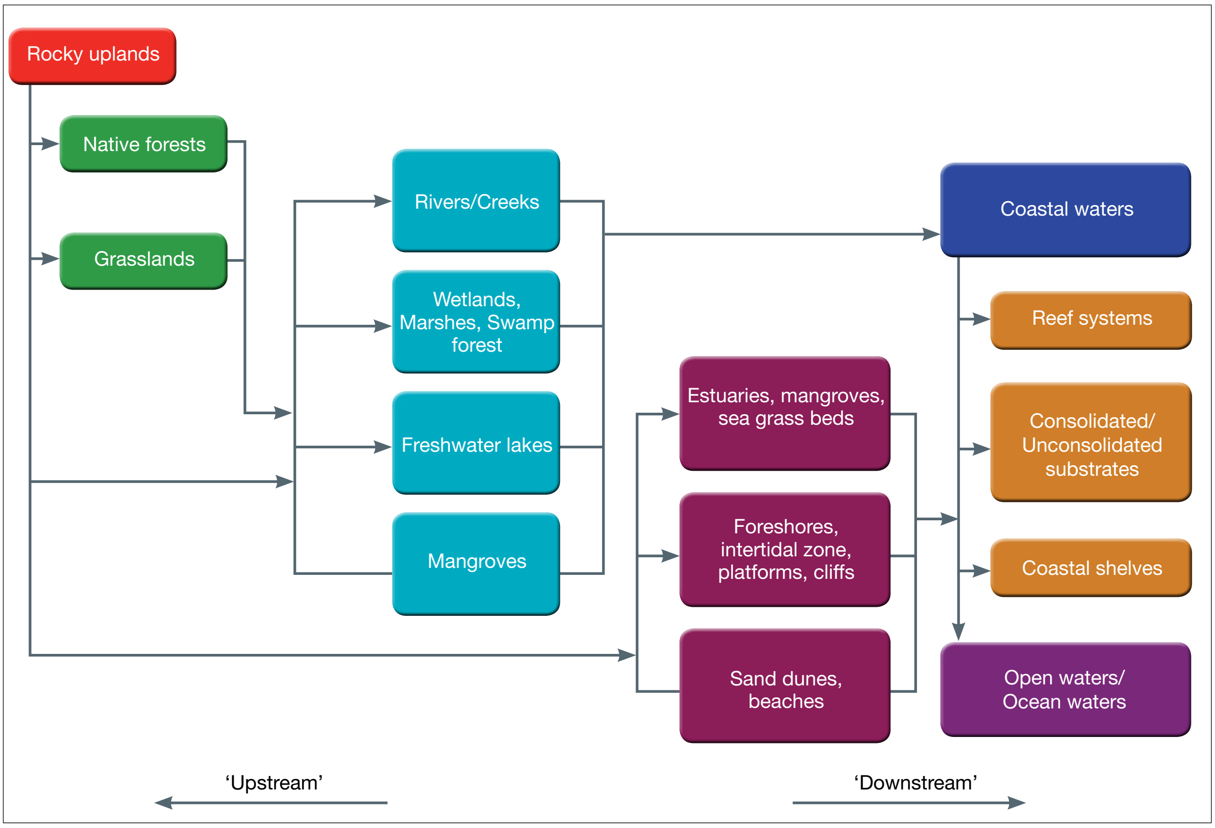
NASA (2006)

Source: Great Barrier Reef Marine Park (2009).

A RIDGE TO REEF PERSPECTIVE ON IMPACTS ON COASTAL ZONE ENVIRONMENTS

An alternative approach to site-specific actions for managing coastal zone impacts is to use a 'ridge-to-reef' perspective to identify key external influences on the condition of coastal zone environments and to indicate appropriate areas for management intervention. Under a ridge-to-reef perspective, coastal zone environments comprise part of a continuum of environments from 'ridge' (upland environments) to 'reef' (coastal and marine environments) in a catchment or river basin. (Some component environments which may be found in a catchment from 'ridge-to-reef' are shown in Figure 2).

Figure 2: Generic Environments in a Ridge-to-Reef Continuum.



A range of biophysical processes occur in environments in the ridge-to-reef continuum which affect inter alia, plant reproduction and resilience, surface water and groundwater flow, soil fertility and absorption and storage of atmospheric carbon. These processes contribute to the quality and volume of goods and services communities obtain from these natural environments, such as fresh water, fish stocks, and forest resources. Some examples of relationships between biophysical processes and economic activities associated with resources derived from natural environments are shown in Table 1.

Table 1: Relationship Between Biophysical Processes and Economic Activities

Environments	Biophysical processes	Benefits for economic activities
Headwaters	• Smoothing of peak flows and reduction of downstream flooding • Provision of flows during dry seasons; climate and moisture regulation through evapo-transpiration • Prevention of soil erosion through reduction in velocity of precipitation and increased percolation, and maintenance of soil moisture • Water filtration	• Avoided costs of flood damage • Additional water and moisture available for crop production • Avoided costs of applying artificial fertilisers due to more fertile soils • Avoided costs of alternative methods of water filtration, and economic benefits to industries dependent on high quality water for processing and production
In stream	• Provision of habitats for aquatic flora and fauna	• Suitable habitats and free source of food supply for commercially valuable species
Wetlands	• Nursery grounds • Habitats for animals and plants • Source of fibres and plant products • Absorption of nitrogen and phosphorus to reduce downstream eutrophication	• Maintenance of suitable water quality and other conditions for growth and reproduction of commercially valuable species • Source of commercial aquatic species, e.g. crab, shrimp • Source of commercially valuable raw materials, e.g. plants • Provision of biological wastewater treatment functions as alternative/supplement to structural engineering treatment methods
Estuaries	• Provision of habitats for different species in food chain, removal of sediments and nutrients through flushing	• Maintenance or suitable conditions and habitats for farmed/wild commercial fisheries and non-timber forest products

However, these processes and the environments they occur in are subject to a range of social, technological, economic, environmental and political/institutional factors which can affect their continued functioning and ecological health, as shown in Table 2 below.

Table 2: Factors Influencing Biophysical Processes and Catchment Environments

Type	Examples
Social/cultural	• Demographic trends in surroundings areas • Changes in social capital, i.e. changes in networks and community values
Technological	• Changes in recreational and commercial fishing technology, leading to greater efficiency and catchability • Changes to recreational technology, e.g. jet-skis • Improved access, by either improved access roads or greater numbers of off-terrain vehicles
Economic	• Changing use-values such as an expanding recreational sector, increasing tourism (domestic and international) • Decline in commercial harvesting due to, for example, competition from imports • Changes in input prices • Changes in non-use values, i.e. existence and option values • Resource constraints, including available expertise

Type	Examples
Environmental	• Climate change • Extreme climatic events (e.g. storms and floods) • Anthropogenic environmental factors such as point source and non-point source pollution in upstream catchments
Political/ institutional	• Changes to federal/state fisheries management and marine biodiversity policies • Changing social and economic objectives of agencies and government (e.g. ecologically sustainable development) • Unexpected legal developments • Restructuring of managerial institutions

Factors influencing an environment in one part of a catchment can have impacts on environments in other parts of the catchment. For example, demographic pressure may lead to increased clearing of forests for cattle grazing in upland environments, which can increase surface run-off and reduce groundwater infiltration. Increased surface water flow will transport sediments into rivers and estuaries and accelerate nutrient runoff from lowland cropping areas. Increased water-borne nutrient and sediment loads will damage the ecological values of coastal and near-shore environments such as sea grass beds and coral reefs. Damage to these environments will reduce the economic value of the resources communities obtain from them, for example, increased sediment and nutrient loads discharged to coastal waters will damage habitats for artisanal and commercial fisheries[45].

ECONOMIC CONCEPTS AND ANALYSIS OF IMPACTS IN COASTAL ZONE ENVIRONMENTS

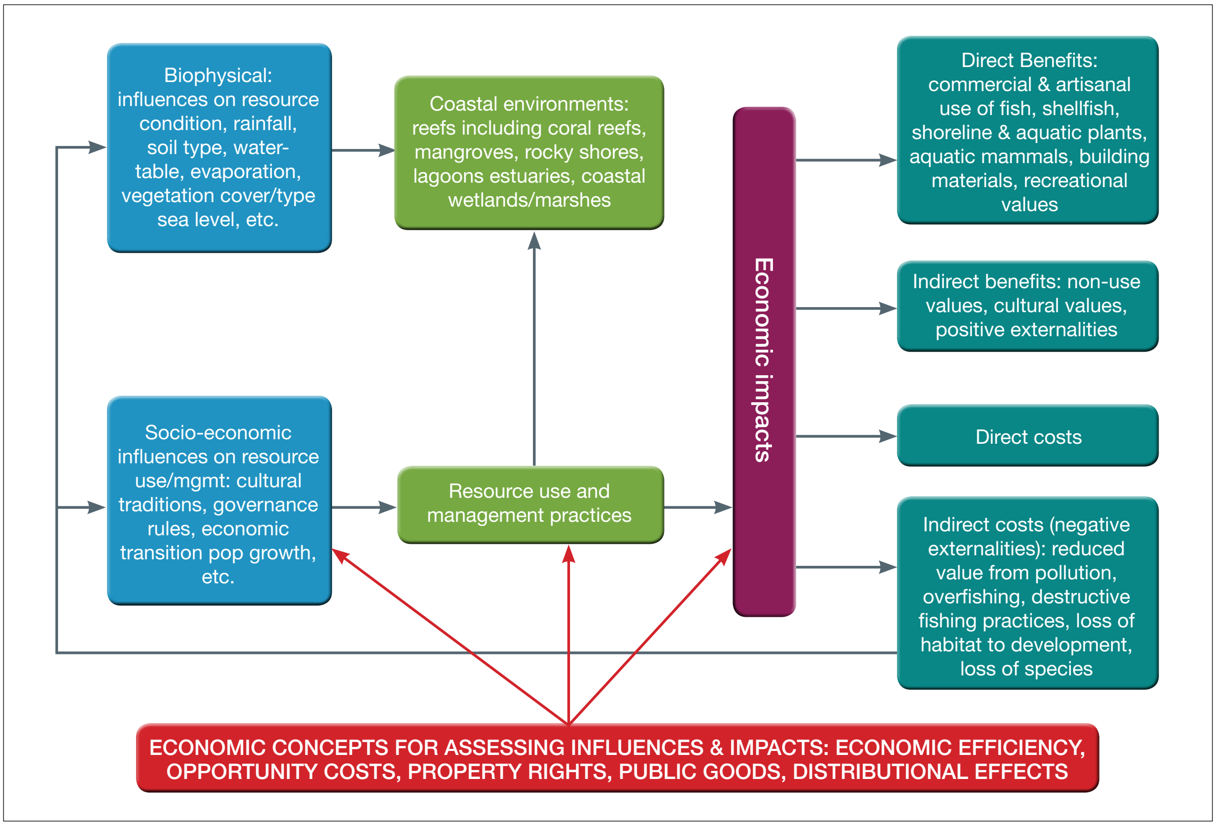
Economic concepts can be useful in analysing the impact of these social, technological, economic, environmental and political/institutional influences and in suggesting possible economic approaches to reduce negative impacts. For example, factors leading to impacts on coastal resource use can be seen in terms of market failure or institutional failure associated with:

- a lack of information for resource users on the economic and opportunity costs of particular resource use practices, alternative sources of supplies, and alternative markets;
- a lack of individual property rights, and the potential for free riders under cooperative resource management arrangements;
- a lack of effective regulatory frameworks for managing open access resources;
- the public good nature of many coastal resources (being non-excludable and non-rival) and the ambiguous role of government in managing access to the resource; and
- negative externalities associated with resource use and asymmetrical distribution of intra-& intergenerational costs & benefits.

A potential role for economic analysis, relating to the upstream/downstream perspective of a ridge-to-reef concept is shown in Figure 3. (For a more detailed explanation of the economic concepts referred to in the diagram see Appendix 1.)

[45] See Prasad and Jupiter (2007): "…when forests are cleared or logged, exposed topsoil enters waterways during heavy rain. The sediment is then carried downstream and distributed within the marine environment via river plumes. Excessive sediment can bury corals and associated reef organisms, thus destroying precious habitat for reef fish and commercially valuable invertebrates, such as sea cucumber".

Figure 3: Influences on Coastal Environments and Resource Use from an Economic Perspective.



Economists would be interested (amongst other things) in examining circumstances where particular policies, including the use of economic incentives, could alter activities which directly and indirectly lead to environmental degradation.

The ideas discussed above have been used to develop a project to examine social, technological, economic, environmental and political/institutional prerequisites for effective management of coastal environments and resource use in different contexts in the Pacific. The background, methodology, and outcomes of this project are discussed below.

A SOCIO-ECONOMIC ASSESSMENT OF COASTAL ZONE MANAGEMENT APPROACHES IN THE PACIFIC

The IUCN Regional Office for Oceania is currently managing a research project, examining the economic dimensions of influences on coastal zone environments in the Pacific, using a ridge-to-reef framework as described earlier in this paper. This project will analyse the effectiveness of management approaches used in different PICTs[46], identify prerequisites for effective management, and develop guidelines to help coastal management and donor agencies identify social, technological, economic, environmental and political/institutional prerequisites for successful coastal management approaches for different situations in the Pacific.

This project was developed as a result of a 2008 workshop organised by IUCN and CRISP[47] to examine suitable economic approaches for assessing coastal and marine management issues in the Pacific and to identify research projects that could be carried out under funding from the CRISP programme (see CRISP 2008).

[46] Pacific Island Countries and Territories.

[47] The Coral Reef Initiative for the South Pacific.

Key parts of the project are:

- a literature review of coastal issues in PICTs to identify the status of, and major impacts on, coastal zone environments and resources;
- a review of coastal management approaches used in PICTs, and their effectiveness, categorised according to their generic strengths, weaknesses, and factors influencing the success or failure of these management approaches;
- the development of an analytical framework based on economic concepts for assessing impacts on coastal environments and their causes based on factors affecting market and institutional failure;
- an analysis of the effectiveness of coastal management approaches applying the above analytical framework; and
- identification of prerequisites for sustainable coastal zone management and development of guidelines for coastal resource management agencies and donors in PICTs, based on the above analysis.

The outcomes expected from the project will be:

- production of guidelines for resource management and donor agencies to help identify social, technological, economic, environmental and political/institutional factors likely to influence the effectiveness of coastal zone management approaches; and
- identification of appropriate economic, ecosystem-based, regulatory or customary approaches for coastal management under different conditions in the Pacific.

It is hoped that the adoption of these guidelines will lead to an improved awareness and understanding among coastal management agency planners, policy makers and managers about the impact of social, economic, institutional, and other influences on resource use. Also, it is hoped that adoption of the guidelines can provide opportunities for more effective coastal management through the use of non-structural management approaches, such as awareness-raising initiatives and market-based incentives (where markets exist).

CONCLUSIONS

This paper has discussed how coastal zone environments can be seen in the context of a catchment containing a continuum of environments from ridge (upland environments) to reef (coastal and marine environments). A range of factors can cause impacts on environments in one part of the catchment which can subsequently affect environments elsewhere in the catchment. For example, impacts on upland environments in a catchment can lead to environmental degradation and loss of ecological and economic values in downstream coastal zone environments. Frameworks for identifying the influence and impact of these factors can help coastal management agencies to develop appropriate strategies for managing impacts on coastal zone environments.

The paper also describes a project being managed by the IUCN Regional Office for Oceania to produce guidelines that coastal management and other agencies can use to identify social, technological, economic, environmental and political/institutional factors, directly and indirectly affecting coastal zone environments. These guidelines will help to identify prerequisites for effective coastal management under different conditions in the Pacific. In addition, where such prerequisites are absent, these guidelines can indicate what broad measures coastal management agencies may, or may not be able to implement to help put such prerequisites in place.

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APPENDIX 1: SOME ECONOMIC CONCEPTS

Economic Efficiency

Scarce resources such as land, capital and labour will provide the greatest overall benefit to the welfare of individuals and to society when allocated to their most productive uses. This allocation will involve resource owners deciding how to allocate their resources to uses which will yield the best return, once all costs and benefits are taken into account. Resources would be considered to be allocated efficiently where any other allocation would result in no-one being made better off and someone made worse off. For example, production processes leading to illegal discharges of carcinogenic pollutants are an inefficient use of resources because the full costs of this production (i.e. the costs of properly dealing with the waste produced) have not been taken into account by the resource owners when deciding to allocate their resources to this use, instead of some alternative activity.

Opportunity Costs

This concept concerns the value of alternative activities that have to be foregone when resources are allocated to one particular use rather than another. If allocated efficiently, resources will be used for those activities that return a greater stream of net benefits than could be achieved by allocating the same resources to any other activity. In theory, scarce resources can always be allocated among a range of alternative uses (e.g. allocating resources to a trip to a national park compared to watching television at home). In extreme cases, some resources may have no alternative uses to their present allocation, and thus would have zero opportunity cost.

Public and Private Goods

In contrast to private goods, public goods are ‘non-rival’ in that one person’s consumption of the product does not reduce the amount available to any other consumer (Pass et al., 2000). Public goods are also ‘non-excludable’ since it is difficult or impossible to exclude any person or group from obtaining the benefits they provide. As there is generally no direct relationship between the cost of supply and the consumption of public goods, market prices cannot easily be used in determining their allocation. Many such non-rival and non-excludable goods are supplied by governments, and in these cases, governments decide on the amounts of such products to provide, and require individuals to pay for them through taxation (Pass et al., 2000).

Distributional Effects

This concept concerns the nature of the distribution of costs and benefits, arising from particular resource allocations among different individuals and groups. As long as beneficiaries can theoretically compensate losers for the additional costs imposed on them, it will still be in society’s interests for resources to be so allocated. However, in many cases, groups are forced to bear the direct and indirect costs of decisions which benefit others, without any prospect of recompense. For example, the creation of protected areas (which may benefit ecotourists) may result in the dispossession of traditional subsistence hunting areas for indigenous communities. Natural resource managers need to be aware of the potential unintended impacts of conservation measures on other parties.

CHAPTER 11

REDD-Based Carbon Financing for Fijian Forests

Marita Manley[48]

BACKGROUND

Forests play a crucial role in the climate system, absorbing carbon dioxide as they grow and locking it away for as long as they stay standing. The forests of the world are therefore, an important reservoir of carbon. Unfortunately, that reservoir is being depleted rapidly and tropical deforestation and forest degradation accounts for a significant proportion of human-induced annual greenhouse gas emissions.

The fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC) estimates that the forest sector accounts for 17.4 per cent of total carbon dioxide emissions, directly and up to 20 per cent if land use change is also taken into account. Finding a mechanism to incentivise the reduction of deforestation and forest degradation is therefore, a crucial element in reducing greenhouse gas emissions overall.

The motivation for this paper arises out of a growing interest in the Pacific region in attracting carbon financing as a means of supporting efforts to sustainably manage forest resources. Significant differences exist between Pacific Island Countries (PICs) in terms of the size of their forestry resources, the effectives of their governance structures and their rates of forest resource exploitation. The focus of the paper is Fiji, which is currently in the process of developing a policy to cover carbon finance in the forestry sector.

What is REDD+?

REDD+, or 'Reduced Emissions from Deforestation and Degradation Plus' is a proposed global climate policy response[49] to the challenge of tropical deforestation and degradation. For many developing countries without large industrial sectors, the principal source of carbon emissions is from deforestation and forest degradation. Originally proposed as a mechanism to reduce emissions from deforestation, it has now been expanded, hence the 'plus', to cover sustainable forest management, forest conservation and enhancement of carbon stocks through afforestation and reforestation. These activities may not reduce emissions, but act to protect and enhance the reservoir of carbon contained within forests and reward those countries with a history of protecting their forest resources.

REDD+ involves the development of incentive mechanisms and associated quality assurance criteria to reduce the rate of forest-based carbon emissions in developing countries. In simple terms, it will enable developing countries and/or their forest resource owners to gain financial support (carbon financing) for activities that result in a reduction in forest-based carbon emissions or enhancements in carbon stocks.

The proposed REDD+ incentive mechanism provides a means of assigning a monetary value to the climate-related ecosystem services that are provided by in-tact forest ecosystems. This is designed to counter the current situation whereby existing financial incentives tend to motivate countries and/or resource owners to harvest timber and convert land to agriculture at unsustainable rates leading to increasing emissions of carbon dioxide from the sector.

[48] Views presented are the authors own and do not necessarily represent those of SPC.

[49] Currently being negotiated as part of the United Nations Framework Convention on Climate Change (UNFCCC) process.

For REDD+ to work effectively, it needs to effectively address the social and economic drivers of deforestation and forest degradation. This includes providing resource owners with alternative livelihood and economic development options capable of meeting development goals.

This paper looks at the issue from the perspective of a resource owner, examining whether carbon financing to preserve and enhance forestry resources would be attractive. As such, it ignores some of the macro-economic effects and government incentives.

RATIONALE

Discussions on REDD+ are advancing at the international level and several PICs are preparing themselves to actively participate in such a mechanism (getting REDD-ready) once it is agreed. Papua New Guinea was one of the original proponents of REDD when they put it back on the UNFCCC agenda in 2005 and are currently receiving assistance from a number of donors. Vanuatu, with assistance from the World Bank's Forest Carbon Partnership Facility, and Fiji, with assistance from the German Technical Cooperation (GTZ) are undertaking a variety of activities necessary to enable participation in any future mechanism. This includes upgrading forestry inventory information to create a forest carbon inventory, identifying deforestation drivers and trends and putting in place the necessary regulatory and institutional structures to address these drivers and regulate carbon projects.

Using scenarios, this paper attempts to examine the level of carbon financing required to provide sufficient incentives to resource owners to protect and enhance forested land rather than using it for other potential uses. There remains a lot of uncertainty about how REDD+ could operate which has knock-on implications for the level of resources required to participate in a REDD+ programme. This paper mainly focuses on the level of carbon finance required to overcome private opportunity costs of alternative land uses and whilst participation (or transaction costs) are important, they are left for a future, more comprehensive analysis[50].

How Will REDD+ Work?

The basic premise underlying the proposed REDD+ mechanism is that resource owners[51] or governments would receive finance based on the amount of avoided carbon dioxide released into the atmosphere or the amount sequestered from the atmosphere. This would be framed in terms of a price per tonne of CO_2 (avoided or sequestered).

It has yet to be decided whether REDD+ finance will come from the private sector, by allowing companies to use forest-based carbon credits to meet domestic carbon reduction obligations, or from international funds. Currently, most carbon credits arising from forestry projects are those in the voluntary market, purchased by consumers and businesses wanting to offset their emissions. It is arguable that once a REDD+ mechanism is finalised, forestry credits will attract higher prices, but the voluntary market may remain attractive as a result of lower transaction costs. Table 1 gives an indication of the prices that voluntary market projects and forestry projects in particular, have attracted over the last few years.

Table 1: Recent Trends in Prices for Forestry-Based Credits (USD).

	2006	2007	2008
Over the counter voluntary projects (all types)	$4.10/tCO2e	$6.10/tCO2e	$7.34/tCO2e
Afforestation/reforestation plantation		$8.2/tCO2e	$6.4/tCO2e
Afforestation/reforestation conservation		$6.8/tCO2e	$7.5/tCO2e
Forest Management			$7.7/tCO2e
Avoided deforestation		$4.8/tCO2e	$6.3/tCO2e

[50] In the case of small projects, which are to be expected in small island states, transaction costs can form a large proportion of the overall budget.

[51] Depending on the precise mechanism agreed.

How can Countries Benefit from REDD+?

Many countries, including several PICs (PNG, Vanuatu, Fiji) are currently positioning themselves to be able to participate in a REDD+ mechanism when it is agreed. There are a number of technical and governance-related pre-requisites for participation, including the development of a forest carbon inventory, methodological issues relating to baseline setting and crediting, monitoring requirements and governance issues, such as overarching regulatory and policy frameworks, benefit distribution, the participation of indigenous resource owners. Addressing these necessary pre-conditions is broadly termed getting REDD-ready. These have been extensively covered elsewhere so will not be discussed in detail in this paper[52].

What Determines whether Resource Owners Convert their Forests or Not?

When resource owners consider how to utilise their land, decisions are often driven by a comparison of the financial returns associated with using the land in different alternative uses. This tends to ignore the value of all the ecosystem services provided to resource owners by forest ecosystems, resulting in a sub-optimal allocation of resources.

By monetising the economic value of the carbon storage and sequestration services provided by forests, REDD+ attempts to address these market failures and the existing financial incentives that tend to motivate resource owners to harvest timber and convert land to agriculture at unsustainable rates, leading to increasing emissions.

In principle, in order to alter the decision-making framework of resource owners, carbon financing must provide the private opportunity costs of not converting forested land to agriculture. However, as highlighted above, sustainably-managed forests provide a number of goods and services to communities. These include goods such as timber and non-timber forest products that can be marketed (or valued according to market prices when consumed for subsistence purposes). They also provide ecosystem services, such as watershed protection, soil fertility enhancement and soil erosion prevention. The economic value of these services are rarely realised in practice but these values may mean that resource owners are willing to accept less than the full opportunity cost associated with converting forested land to agriculture which includes returns from timber sales and subsequent agricultural activities.

Table 2 depicts a framework for comparing the values associated with the conversion of forested land to agriculture with those of sustainably-managed forest land based on the ecosystem services provided by forest as depicted in the Millennium Ecosystem Assessment.

Table 2: Comparison of Forested Land and Conversion to Agriculture and Ecosystem Services.

	Source of economic values from forested land	Source of economic values from conversion to agriculture
Provisioning services	Timber (at sustainably-managed harvest rates)	Timber (for initial years)
		Agricultural goods
	Non-timber forest products (e.g. nuts, medicinal plants)	
Regulating services	Watershed protection	Risk of lower water quality and quantity
	Carbon storage	Reduced carbon storage
Cultural services	Source of cultural goods, such as indigenous wood for artefacts	Loss of cultural heritage
	Preservation of traditional sacred sites	Loss of cultural heritage
	Recreational value of forests (e.g. eco-tourism opportunities, such as hiking, bird watching)	Loss of option value for conversion into eco-tourism opportunities
Supporting services	Prevention of soil erosion	Reduced soil fertility from soil erosion

[51] See for example CIFOR (2008), Moving ahead with REDD

In the context of the above framework, payments for carbon storage together with the other values provided by forested land must compensate for the loss in earnings from timber and agricultural goods, taking into account reduced values from the loss or deterioration of ecosystem services.

In reality, it is unlikely that studies will be able to compare the values as completely as depicted in the table above. Environmental economics and economic valuation studies of ecosystem services, such as watershed protection and avoided losses associated with soil erosion have only emerged in recent years in the Pacific and are still relatively few and far between.

What can be done in a relatively quick and dirty way is to look at the dominant financial flows of timber and agriculture goods sales in comparison to carbon finance and examine what level of carbon finance would be necessary to alter the decision-making framework of resource owners.

This does not take into account the changes in the values of other goods and services, but one can assume that forested lands provide higher levels of ecosystem services that non-forested lands.

As described below, this is done for illustrative purposes only and a more detailed assessment would be necessary to validate the robustness of the data available.

ANALYTICAL FRAMEWORK AND METHODOLOGY

Various studies have been conducted to examine the costs of reducing emissions from deforestation. The Stern Review on the Economics of Climate Change (Stern 2007) estimated that reducing annual deforestation by 50 per cent would cost between US$3 billion to $15 billion with US$5 billion as a central estimate. Translated into price per tonne of CO_2, this equates to a range of US$1 to US$5, suggesting that reducing deforestation would be a very cost-effective abatement option. Other studies have indicated that costs are likely to be higher. The Eliasch Review (2008) estimated that it would cost $17-33 billion per year or a global carbon price of US$15 to halve the emissions from the forestry sector.

There is a variation in the estimates for a number of reasons. Different studies measure different components of the costs associated with REDD. These include[53]:

Opportunity Costs – At the very least, financing from REDD will have to cover the net revenues or rents received by resource owners if they were using the land differently. Opportunity costs refer to the forgone rents associated with other land uses for a forested area – this includes net revenues from timber and agriculture.

Transaction Costs – A number of prerequisites will be required for governments and landowners to participate in any future REDD+ programme. These include costs that government will have to bear, such as upgrading existing forestry inventories to include carbon information, and costs resource owners will have to bear, such as the costs associated with consultation processes and monitoring.

Rents – Economic rent occurs when prices are set by marginal costs – in this case the marginal cost of the last unit of avoided deforestation/degradation. This means that the price received for previous units of avoided deforestation will be above its marginal price and will therefore, attract economic rent on all previous units purchased. Including these rents into estimates of the costs, vastly increases the overall costs.

Many studies, including this one, focus only on opportunity costs – i.e. how much would a landowner have to earn to be persuaded to protect rather than log or convert their forests. This approach has its limitations in that transaction costs can comprise a significant amount of the costs of participating in a carbon trading mechanism, especially for small projects. It can however, provide some indication of the price of carbon necessary to change behaviour.

FRAMEWORK FOR EVALUATION IN FIJI

This paper focuses on the incentives of smallholders in Fiji to convert their forest for agriculture purposes. The forestry department actively monitors commercial logging of plantation and natural forests. The encroachment of smallholders into forested areas is a gradual process by many individuals but, when aggregated, could be a significant source of deforestation and forest degradation and therefore carbon emissions.

53 This typology is based on Bond et al (2008)

Different alternative land uses result in different opportunity costs. The estimates below compare four different scenarios:

- Clearing of low-density forest for taro planting;
- Clearing of low-density forest for kava planting;
- Conversion (logging) of virgin forest to secondary forest; and
- Conversion (logging) of high density forest to low-density forest.

The estimates of average economic returns from agriculture are based on Fiji Department of Agriculture estimates (derived from McGregor, 2003). The estimates of economic returns from forestry activities are based on an FAO study of the Fiji forest industry[54].

Presenting the economic returns from land use change per tonne of CO_2 equivalent emitted as a result of the change, gives an indication of the carbon price necessary to change the incentive structure (see Swallow, et al.).

In order to do this, economic returns are combined with data on time-averaged carbon stock changes[55] for the different scenarios to derive a price per tonne of CO_2 necessary to incentivise the maintenance of the land use in its original use. The results are presented in Table 3.

Table 3: Carbon Stock Changes in Different Scenarios for Price per Tonne of CO_2.

Original land use	Conversion to:	Annual average returns from conversion/ha (FJD)	Change in carbon/ ha (tonnes)	Implied US$t CO_2 (FJD$t CO_2)
Low-density forest	Taro	11403[56]	138.1	40.53 (82.57)
Low-density forest	Kava	8936[57]	138.1	31.76 (64.71)
Virgin forest	High density forest	1624	50	15.95 (32.48)
High density forest	Low density forest	541	100	2.66 (5.41)

Source: Fiji Department of Agriculture, Whiteman (2005), Bond et al. (2008)

The results provide some indication of the likely carbon prices required to discourage land conversion in each of the scenarios. Carbon prices would need to be highest to discourage the conversion of low-density forest to agriculture, as has occurred for example, on Taveuni over recent decades. This is to be expected as returns from growing taro and kava are relatively high per hectare. Discouraging the conversion of virgin forest to high density forest would require higher carbon prices than those required to discourage the conversion of high density forest to low density forest. There is relatively little virgin forest remaining in Fiji.

The indicative figures presented above suggest that current voluntary market carbon prices would be sufficient to discourage resource owners from converting high density forests to low density forests, but are currently not high enough to discourage clear felling for agricultural purposes.

CHALLENGES

The rough and ready calculations presented above are based on relatively crude estimates given available data. Further detailed calculations that take into account Fiji-specific information could refine these estimates further. A thorough analysis would involve the construction of marginal abatement cost curves for Fiji, based on alternative land use change scenarios and current land use information.

A number of limitations of the estimates in Table 3 are given below:

- The carbon per hectare figures given above are based on values for Indonesia (Swallow et al., 2008). More detailed estimates would be required to obtain Fiji-specific data. For example, no differentiation is made between taro and kava carbon stocks even though it is likely that they differ in reality.
- Additional benefits of maintaining forest cover (watershed protection, the supply of non-timber forest products, soil erosion protection, etc.) have not been taken into account. Assuming these are valued by resource owners', carbon prices could be lower and still discourage deforestation.

54 Whiteman (2005)

55 Based on estimates from Indonesia

56,57 In reality, these are likely to be higher as returns from timber sales are not included though costs of land clearing are.

- The estimates for conversion to agriculture do not take into account any income that may be obtained from the forest products (timber, fuel wood, etc.) resulting from land clearance. Taking these into account would increase the returns from conversion and mean that higher carbon prices are required to discourage deforestation.
- The estimates presented are static. If a future REDD+ mechanism were to succeed in discouraging land conversion in Fiji, this could raise the price of timber, timber products and agricultural produce, increasing returns to deforestation and necessitating a higher carbon price to discourage it.
- The estimates of economic returns from logging activities are an average per m^3 of round logs based on the whole country. In reality, these will differ significantly, depending on the class of species and the accessibility of the forest. Higher value species would tend to increase the returns from logging and necessitate higher carbon prices whilst more inaccessible forests are likely to have higher transport costs associated with them and deforestation could therefore, be discouraged at lower carbon prices. Carbon storage will also differ depending on the species.
- As mentioned above, the transaction costs of resource owners are not taken into account in these estimates and they may be significant. Given the likely complexity of any future REDD+ mechanism, they are likely to be higher than the transaction costs associated with a logging concession.

CONCLUSIONS

These estimates are broadly consistent with other studies and confirm that avoiding deforestation is a relatively cost-effective mitigation opportunity in Fiji as it is elsewhere. Currently, realised forest carbon prices in the voluntary market are probably not high enough to change behaviour. The formalising of any REDD+ regime is likely to lead to higher carbon prices for forestry projects and in Fiji it appears that such higher prices would be necessary to discourage clearing of low-density forest for agricultural purposes.

The estimates indicate that discouraging the first cycle of harvesting in a virgin forest is likely to require higher carbon prices than discouraging secondary logging as the carbon stock changes are lower. However, the conversion of virgin and primary forests probably account for the greatest loss of biodiversity from these ecosystems. There are not many significant stands of virgin rainforest remaining in Fiji.

The promotion of high-biodiversity REDD that delivers the greatest co-benefits should be accounted for in the design of the mechanism, but additional mechanisms are likely to still be necessary to protect biodiversity hotspots.

It is possible that the market will pay a premium for higher-quality REDD credits as currently happens in the voluntary sector, but if the majority of the demand comes from companies sourcing carbon credits for compliance purposes, this is less likely.

The scope of this paper has been limited to examining the opportunity costs of alternative land uses and carbon prices necessary to discourage conversion of forests to other land uses. There are many other factors that will influence Fiji's ability to participate in a future REDD+ mechanism. These include having the necessary legal, institutional and governance framework in place, the technical capacity necessary to implement and monitor programmes, education and awareness programmes for resource owners and transparent benefit sharing systems.

There are also important lessons that can be learnt from other payment for ecosystem services schemes, including the importance of targeting interventions which will be crucial in a REDD+ programme for the purposes of proving additionality. For a discussion of these issues see IIED (2008).

It was expected that the Conference of the Parties in 2009 in Copenhagen would agree on the broad parameters of the REDD+ mechanism. This did not happen so 2010 will provide an opportunity to further refine these figures and provide a more robust assessment of the carbon prices necessary to change behaviour.

Whether small island states, such as Fiji can participate in any future mechanism will depend largely on the design of the mechanism and the significance of the transaction costs. Although relatively small in absolute volumes of avoided CO_2, this study provides some indication that forest mitigation options are as cost-effective in Fiji as they are elsewhere. It is therefore sensible that Fiji is positioning itself to get REDD-ready and should as much as possible, try and influence the mechanism design to ensure that it is appropriate for the context of small island states.

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CHAPTER 12

Economic Feasibility of Aggregate Mining

Paula Holland, Angela Ambroz and Allison Woodruff

INTRODUCTION

For many atoll nations in the Pacific, a combination of growing populations, inward migration from rural areas/islands and development investment has resulted in the rapid growth of capital cities, typified by an ongoing increase in small-scale domestic developments (e.g. houses) as well as sporadic large-scale investments (e.g. public facilities such as hospitals, schools and/or government buildings). The small land area of these atoll nations, combined with increasing frequency in severe climatic events, also means that there has been an increasing activity in construction for land reclamation purposes and/or sea walls.

The expansion in construction to underpin these developments demands access to 'aggregates' – sand, gravel, rip rap or rocks used for construction. Conventionally, demand for aggregates for construction on Pacific island atolls has been met by excavating locally available aggregate from the beaches and coastal flats. In the case of Kiribati, for example, government diggers mechanically excavate aggregates from the beach flats around South Tarawa while families excavate by hand (figure 1), although no less extensively. Such 'coastal' mining is common around Pacific atoll cities, including South Tarawa (Kiribati), Funafuti (Tuvalu) and Majuro (Marshall Islands).

Figure 1: Hand Mining off Majuro.

Source: Image courtesy of Arthur Webb, SOPAC.

While coastal mining provides a cheap and effective source of aggregates, there is usually only a limited amount of material available on atolls. Atoll countries in the Pacific currently seeking increased access to aggregates for construction include Kiribati, Tuvalu, Tonga and the Marshall Islands.

A key issue in coastal mining around Pacific atolls is that the removal of too much aggregate has been demonstrated to increase coastal erosion. (See Webb, 2005a, 2005b, 2006.) For low-lying atolls, especially those with increasing population sizes that demand housing and critical government facilities, land erosion has negative impacts on the quality of life to the local community. In the case of Tarawa, for instance, vulnerability of the hospital facility to flooding has been linked to the "significant disturbance to the longshore sediment budget by the widespread removal of sand (beach mining) and "upstream" (east) reclamation (Webb, 2005a). Flooding is becoming an increasing concern in the face of rising sea levels from climate change. At a time when atoll residents most need aggregates to build seawalls to protect them from the sea, removing aggregates from their coastlines to build the walls can ironically, actually put them at greater risk of flooding.

An alternative to coastal mining for some atoll nations is to import aggregate from overseas (with Fiji being a common source for the Pacific). However, importation of aggregate is usually extremely expensive, out of the reach of most commercial or domestic users and only practical for donor led developments. Further, importation has quarantine risks with the potential introduction of plants, insects or other pests. Previous aggregates imports to Kiribati and Tuvalu had seen the discovery of a (dead) frog in cargo to Kiribati (see Greer, 2007) and the introduction of some 19 invasive weed species to Funafuti (see Ambroz, 2008).

Given the risks to the environment of importing aggregate and the threats to wellbeing from coastal mining, there needs to be a rigorous analysis of aggregates sourcing for Pacific atoll nations. Presented in this paper are three analyses conducted to investigate policy issues related to coastal mining:

- Economic assessment of the true costs of aggregate mining in Majuro Atoll, Republic of the Marshall Islands (RMI) (McKenzie et al., 2006);
- Economic Analysis of Aggregate Mining on Tarawa, Kiribati (Greer, 2007); and
- An economic feasibility assessment of lagoon dredging in Funafuti, Tuvalu (Ambroz, 2009a; 2009b).

WHY WERE THE ECONOMIC ANALYSES UNDERTAKEN?

The assessment for aggregating mining on Majuro Atoll, RMI was conducted in response to a request by the Government of RMI. RMI has witnessed severe coastal erosion around the main atoll of Majuro over the past three decades and questioned if aggregate mining was a causal factor. In Majuro, aggregate is most commonly obtained onshore, from beach mining, and nearshore from dredging and reef blasting. Aggregate mining has been reported as contributing significantly to coastal erosion around Majuro (Xue, 1997) and in recognition of this, the Government of RMI requested an economic assessment of current aggregate extraction activities to consider the feasibility of shifting supply towards more environmentally sustainable sources of aggregate such as offshore sites (see for example, Smith, 1995a; Smith et al., 1994; Smith and Collen, 2004) and/or imports from overseas.

In the case of both Kiribati and Tuvalu, the dire shortage of aggregate on the atolls had raised questions about how to secure sustainable aggregates supplies from somewhere other than the coastlines. Around Tarawa, a large amount of work had been conducted over the previous 10 years to identify alternative sources of aggregate including, for example:

- work conducted under previous development projects had revealed the existence of large reserves of aggregate in the lagoon and assessed their suitability for low scale construction or infilling (Smith and Biribo, 1995; Smith and Collen, 2004); and
- preliminary flow modelling of the lagoon had been conducted which supports environment monitoring of any lagoon extraction operation (Damlamian, 2008).

The Government of Kiribati was thus interested to establish lagoon dredging to replace coastal sourced aggregate. However, it was keen that any project would be self sustaining. It therefore, sought advice to determine whether a self-sustaining government managed commercial enterprise could harvest aggregates from the lagoon in the long term. To answer this question, a feasibility assessment of lagoon dredging was required.

In the case of Tuvalu, limited access to local aggregates resulted in renewed interest in lagoon dredging in much the same vein as Kiribati. Aggregates were required for local construction but also to infill ‘borrow pits’ – pits from which aggregates had been sourced during the 1940s by the US Army in the process of land reclamation and airport construction. Lagoon dredging had been piloted in Funafuti lagoon, Tuvalu in the 1990s and whilst successful from a technical perspective, was not sustained as the Funafuti community became concerned that the dredging was causing environmental damage and coastal erosion. However, growing demand for aggregates in Funafuti and the recent development of a lagoon aggregate dredging company in Kiribati has renewed the Government of Tuvalu’s interested in whether it should revisit the question of lagoon basin aggregates as a solution to construction and other needs. Scientific work recently conducted (Webb, 2006) has shown that the pilot aggregate dredging project in the early 1990’s was not linked to erosion in Funafuti and that renewed dredging in the designated resource area was also unlikely to lead to any significant environmental damage and that an adequate quantity and quality of aggregates was available in the lagoon (Smith, 1995b). The Government of Tuvalu therefore, sought technical advice on commercially sustainable dredging in Funafuti lagoon. This advice would assist in determining whether a detailed examination of issues should be made later.

ANALYTICAL/CONCEPTUAL FRAMEWORK AND METHODOLOGY

Majuro, RMI

The economic analysis of coastal mining which was conducted on RMI took the form of a least cost analysis of three alternative aggregate supply options: (i) aggregate mining from beaches (ii) dredging from nearshore and offshore areas and (iii) aggregate importation.

To determine demand for aggregates and also the scale of aggregate mining in Majuro:

- commercial use estimates were obtained from stakeholder interviews; and
- domestic use estimates were based on a dedicated household survey. The survey addressed issues such as the type and average quantity of aggregates collected by householders, as well the purpose, location and frequency of beach mining. The survey also included the collection of information on the extent and types of coastal protection structures along Majuro's coastline and land use patterns.

The costs of aggregate supply include monetary and non-monetary costs. Monetary estimates of production costs were based on published estimates (for aggregates dredged from the lagoon) and government records (imports). The non-monetary costs of alternative aggregate sources include:

- quarantine risks from imported aggregate; and
- the loss of ecosystem services arising from mining coastal aggregate. In the latter case, removal of aggregates was recognised to contribute to erosion of coastlines resulting in damage (e.g. flooding) to local infrastructure, as well as saltwater intrusion of local water supplies. Currently, the proportion of coastal erosion arising from coastal mining (as opposed to other causes) is not known so a hypothetical proportion of 10 per cent was used for illustrative purposes.

On this basis, the cost of coastal erosion arising from coastal mining was estimated, using preventative expenditure as a proxy. Two economic valuation methods were used to measure the different non-market costs of coastal erosion:

- the preventative expenditure approach, which estimates the cost of investments in coastal protection structures to prevent coastal erosion. The costs of building hard coastal protection structures as a way to protect the coast and prevent erosion in the absence of aggregate were estimated. The amount of seawalls needed to protect the coastline was identified in a shoreline survey by the Environmental Protection Authority (conducted in 2005). Cost data for seawall construction per metre was sourced from published estimates of high quality seawall construction; and
- the damage cost approach, which estimates the value of potential damage to land and infrastructure due to coastal erosion. The costs of land on Majuro were sourced from the government annual land lease rate (value of public land), annual land lease rate for businesses (value of commercial land) and annual residential lease rates (value of residential land). As part of this study, the RMIEPA carried out a land use survey which classified coastal properties in Majuro, according to whether they were: residential, commercial, education, government, tourism, church and open-space. Published estimates of the rate of erosion around Majuro were used and assumed to remain static over time.

The use of the two non-market valuations was undertaken to compare the practicality of applying each option in a Pacific context. On the basis of the calculations described above, the average costs of supplying 1 m^3 of aggregate for each option was estimated and compared.

Tarawa, Kiribati

Both a commercial feasibility assessment and an economic feasibility assessment (using an economic 'with' and 'without' analysis) of lagoon dredging were conducted for Tarawa. To underpin both of these assessments, current demand for aggregate around Tarawa was first estimated on the basis of: government maintenance needs and extraction records, imports (based on recent imports), commercial demand (based on consultations) and household needs (recently reported in a survey of household aggregate mining – see Pelesikoti 2007). Assumptions about increases in demand over time were also made.

The financial costs of sourcing aggregate per m^3 were estimated for:

- Hand mining (e.g. by local families);
- Mechanical mining (based on government records);
- Imports (based on import costs per m^3 of aggregate); and
- Dredging. The costs of production using dredging was based around (i) a technical proposal to the EU that sought funding to establish lagoon dredging. The proposal specified the type and scale of dredge under consideration, and input needs; (ii) costs estimated under an earlier feasibility study of dredging Tarawa lagoon, updated with more current costs (e.g. for fuel).

Economic costs of mining under each option was estimated by including:

- the resource costs for fuel (tax removed);
- a shadow labour for family labour in the case of hand mining; and
- an assessment of the impact of different types of mining on the environment. For the most part, this was included qualitatively although, in the case of infrastructure, environmental damage was quantified, using the costs of replacing seawalls as a proxy.

Potential revenue from dredging was based on:

- expected capacity of the dredge. (This included estimations of 'down' time, such as weekends when government officers do not work and time needed for general maintenance etc.);
- expected proportion of sand collected compared to gravel. (More sand would be dredged from the lagoon than gravel but gravel would require more processing and sell for a higher price.)

Commercial feasibility assessment involved comparing revenues with financial costs. Economic feasibility assessment involved a 'with' and 'without' analysis. Under the 'without' analysis, the net flow of benefits from coastal aggregate extraction over time was estimated. This involved continual coastal mining (with a small degree of expensive imports), accompanied by coastal erosion. Under the 'with' analysis, the net flow of benefits over time was estimated, using dredging where coastal mining, importation and coastal erosion were all reduced. Values under both cases were discounted over time to determine the net present value and internal rates of return for alternative options.

Tuvalu

Adopting the methodological framework used for the Kiribati assessments, a commercial feasibility and economic feasibility assessment of lagoon dredging were conducted for Funafuti lagoon. In this case, the major difference was that the Government of Tuvalu was undecided as to whether to further investigate lagoon dredging. Consequently, no discussions had taken place on the possible scale, form and nature of production. To help the Government of Tuvalu decide whether lagoon dredging should be examined and, if so, what issues it might consider, a preliminary economic analysis of lagoon dredging off Funafuti was based on a hypothetical dredge project. The hypothetical project was informed by the proposed Kiribati lagoon dredge project (above – Greer Consulting Services, 2007) and an assessment of a dredging and borrow pit filling project in Funafuti (Shimata and Brady, 2003). Using these two studies as a base, costs were estimated for a dredge appropriate in scale to Funafuti.

In addition to this, a dedicated household survey was conducted on Funafuti, specifically to ascertain the demand for aggregates and the degree of coastal mining as existing data was patchy or unavailable (in the case of Kiribati, a survey had recently been conducted). Otherwise the process to assess the feasibility of hypothetical lagoon dredging was conducted in much the same way as for Kiribati, with the following estimated:

- current and future demand for aggregates by government, households and business;
- supply of aggregates by government coastal mining, household mining and imports;
- financial and economic costs of aggregate production and processing per m^3 including, environmental damage; and
- Likely revenues from the sale of aggregates.

As with the Kiribati assessment, commercial feasibility assessment involved comparing revenues with financial costs. Economic feasibility assessment involved a 'with' and 'without' analysis, estimating the discounted net flow of benefits from aggregate extraction over time: (i) without dredging and therefore including coastal mining, environmental damage and costly imports and (ii) with dredging, involving fewer imports, less coastal mining and less coastal erosion, but potentially greater pressure on the roads to transport aggregate from the dredge. Net benefits (profits and net present value) and internal rates of return for alternative options were estimated.

RESULTS

Majuro, RMI

The present value of erosion damage around Majuro arising from coastal mining was estimated to be between US$87.5 to $373.2 million over 25 years. Including this cost with estimated costs per m^3 of aggregate supplied, it was estimated that the true cost of coastal mining was almost 50 per cent more expensive than offshore dredging and only marginally cheaper than importing aggregates from overseas.

The findings are particularly significant when considering (i) that the mining and quarrying industry on average only accounted for about US$300 000 per year (around 0.3 per cent of the country's GDP) at the time of study (compared with estimated total erosion damage costs of US$87.5 to US$373.2 million over 25 years); and (ii) the threats from rising sea levels.

Tarawa, Kiribati

Lagoon dredging was estimated to be commercially feasible in a 'quiet' year when no major infrastructure developments were underway. In these cases, a small profit in the order of A$60 000 might be expected. In years when large scale infrastructure developments were underway, it was estimated that profitability might be expected to improve significantly. From an economic perspective, lagoon dredging was estimated to be economically feasible, offering potential economic returns of 16 per cent. However, both financial and economic feasibility were extremely sensitive to assumptions about prices that could be commanded and to costs of production. Small changes in these assumptions would dramatically affect the feasibility of commercial dredging.

Realisation of potential commercial and economic benefits was found to be highly reliant upon a number of enabling environment issues. These included the need to reach some form of understanding with local families who rely on coastal mining as a source of income. Currently 1200 families are estimated to conduct coastal mining and at least 150 rely on the sale of those aggregates as their primary source of income. Realistically, they would be unlikely therefore, to observe any cull on coastal mining (many already knowingly mine illegally) and would threaten the sustainability of the dredge profitability by competing and perhaps undercutting prices. Other critical issues affecting the feasibility were the need to consider dual pricing policies (to encourage purchases from the company rather than from local coastal miners), the need for strategic communications to allay public fears about lagoon dredging and the need for further assessment of costs and prices.

Tuvalu

Bearing in mind the highly preliminary nature of this analysis, only broad conclusions on the feasibility of dredging could be made. The analysis indicated that current use rates of aggregate on Funafuti are low such that it is unlikely to ever be cost-effective to dredge only to meet current use. Instead, independent dredging by Funafuti could only ever practically be considered in the context of using all surplus dredge materials to infill low-lying land or borrow pits. This would mean that the government would need to commit to spend money to 'purchase' the spare aggregate. On this assumption, dredging could be financially sustainable, but only at a cost to government of a minimum of A$330 000 per year (company breaking even) or more (if dredging was to operate at a higher capacity or generate profits) to purchase spare aggregate. Under the same conditions, the economic rate of return was estimated at 13 per cent.

The analysis emphasised that feasibility estimates were highly preliminary and that any future investigation of lagoon dredging would require more accurate cost data. It also noted the possibility of seeking development funding for the initial investment in dredge capital and equipment which would reduce pressure on the government to cover costs in the early years of the project. The analysis indicates that government would need to contemplate a number of critical issues before considering dredging any closer, including:

- Government commitment to underwriting aggregate sale;
- the final scale of dredging;
- the future price of lagoon-dredged aggregate;
- how quickly borrow pits and low-lying areas should be filled; and
- the need to better control coastal mining (which appeared to contain a large dredge of unreported mining, based on household survey results).

Additionally, Woodruff (2009) indicates the recommencement of secondary phosphate mining on Nauru, removing existing limestone pinnacles to access remaining phosphate resources. In so doing, crushed limestone pinnacles present Nauru with the opportunity to sell high quality aggregate around the region, if financially feasible. Given that domestic demand for construction on Funafuti is low – and certainly if the government was not able to commit to purchasing sufficient aggregate to make extraction sustainable – continued importation from either existing sources (Fiji) or from Nauru might be more practical than dredging. However, this would depend on whether Nauru was able to provide a reliable source of aggregate when needed (compared to producing it locally at will around Tuvalu) and at a competitive cost (compared to established suppliers).

OUTPUTS AND OUTCOMES

Majuro, RMI

Following the study, the figures estimated were used by the Government of the Marshall Islands to lend weight to the then proposed coastal management framework which included the phasing out of lagoon reef blasting/foreshore mining over a three year period. Like many other draft pieces of legislation in RMI, this is still waiting to be approved.

Tarawa, Kiribati

The feasibility assessment was incorporated to a proposal to the EU to fund the establishment of a dredge company to divert aggregates sourcing from the coastal flats of Tarawa to the lagoon. The proposal was successful and €2.2 million was assigned for two years to support establishment of the company and ultimately its transfer to the Government of Kiribati. Recruitment for the project manager to oversee the work is now underway.

Tuvalu

The report was submitted to the Government of Tuvalu in 2009. As this has only recently been submitted, no outcomes or decisions have yet been fed back.

CHALLENGES AND CONCLUDING REMARKS

Data and Surveys

Access to data regarding aggregate demand and source was, in all cases, a challenge. Government records of aggregate exploitation in all countries were low. For example, the Government of Kiribati was unable to inform how much its own departments collected and used of aggregate from the coastal flats around Kiribati. In the case of both Kiribati and Tuvalu, no records are kept of household exploitation of aggregates, despite this appearing to be significant. In the case of Kiribati, the economic assessment of lagoon dredging was conducted as part of a programme of work under which a household survey of dredging was accompanied for social assessment purposes. Consequently, the economic analysis was able to directly use this data for feasibility assessment purposes. However, the absence of any data on Majuro or Funafuti necessitated dedicated surveys. The survey was significant in revealing the extent of domestic mining – particularly in highlighting the scale of unreported mining and the need to more effectively manage the activity.

Social Issues

A key issue in the management of aggregate exploitation in the Pacific islands, particularly resource-poor atoll nations, is likely to be community attitudes. The success of lagoon dredging in reducing erosion in Kiribati and Tuvalu, for example, will hinge on the ability of the government to convince households to use (and possibly purchase) aggregates taken from somewhere other than the coastline. This is likely to be especially challenging in the case of Kiribati where commercially, mining families might compete hard to sell their dredged aggregate for income.

Reluctance to cease coastal mining is ultimately an economic trade off. The community requires aggregates to underpin economic development but, with limited access to imports, most families and businesses use the cheapest most available resource – which can then lead to environmental degradation and risk. The problem is compounded by the fact that the demand for local aggregates is now fuelling a small mining industry in which some aggregates are being illegally mined. The combined effect is that externalities generated from coastal mining (risk of erosion and flooding). Education about the impact of coastal mining is likely to help to some degree where families do not realise the impact on erosion that mining has. However, many families do realise the impact but mine regardless. Therefore, community policing is important. Nevertheless, the Tuvalu case study indicates that illegal mining may be extremely extensive, maybe as much as 25 times that permitted. (See Ambroz, 2009b for details.) Improved government policing, together with harsher penalties may need to be considered together with some form of rewards scheme (e.g. community championing) to encourage more sustainable behaviour.

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CHAPTER 13

Mainstreaming economics to waste management in the Pacific

Padma Narsey Lal

INTRODUCTION

International and regional communities have regularly called for the mainstreaming of economic considerations in environmental management, particularly since the World Commission on Sustainable Development in 1987. The Secretariat to the Pacific Environment Program (SPREP, 2000) noted the need to promote the use of economics 'to assist environmental officials, national and fiscal planners in taking stock of economic implications of environmental impacts of development'. At the 2007 Pacific Islands Forum Leaders Meeting, the Leaders called for "… identifying and accessing alternative financial resources for waste management, including the use of economic instruments, (e.g. user charges)". The participants at the Nature Conservation Conference in the Pacific recently held in Rarotonga in the Cook Islands in July 2002, too, identified economic valuation of natural resources as one of the key strategies needed in the region to encourage environmental conservation (Lal, 2003). While some effort has been made to operationalise these commitments with some positive results, countries still face significant challenges in 'mainstreaming of economics in waste management'.

The purpose of this paper is, using two recent waste management projects in the Pacific, to highlight the types of challenges faced in mainstreaming economic considerations in environmental management projects in small island states. It also discusses how such challenges could be overcome, with minimal additional effort.

Waste Management as an Economic Concern

Waste management is a major concern in the Pacific islands (SPREP, 2006). Key concerns associated with solid and liquid waste include:

- negative aesthetic effects of litter and indiscriminate dumping of solid waste in drains and waterways, and on public and unoccupied private land;
- increases in mosquito-borne diseases, such as dengue and filariasis (and malaria in some countries) due to poor solid waste disposal, increasing breeding ground for mosquitoes;
- increase in water-borne diseases such as diarrhoea, dysentery and other gastrointestinal illnesses and skin diseases, due to the contamination of drinking and bathing water by human and animal waste; and
- eutrophication of coastal and riverine water, and associated negative effects on aquatic life, due to increased organic material from animal and human liquid wastes.

Such concerns can be analysed from an economic perspective (Choe and Fraser, 1998; Lal and Holland, 2010) and thus also address waste management problems, using market based instruments. Inappropriate disposal of waste, for example, in coastal areas causes less than desirable social welfare. Indiscriminate waste disposal in public spaces often does not involve direct costs on the person committing the act, although it does incur externality costs on others. Thus, for example, when waste is dumped in a mangrove habitat, pollution may reduce the quality and quantity of fisheries products harvested by subsistence or commercial fishermen, while the person dumping the garbage may not directly bear the costs of pollution. S/he also continues dumping the rubbish, as they are only interested in having a clean surrounding for their family.

In a market context, such pollution effects are caused by what is commonly known in economics discipline as market failure (Choe and Fraser, 1998; Lal and Holland, 2010). Market failure occurs where a market for wastes does not exist, nor is there a market for clean environment which results in a 'price' paid by a person disposing the rubbish - almost zero - that does not fully reflect the externality costs imposed on others. On the other hand, when a person is forced to pay for the negative impacts of his/her disposal of wastes, applying 'polluter pays' or 'impactor pays' principles (e.g. Panayotou, 1998), s/he has the incentive to avoid waste disposal or at least minimize the costs by reducing the volume of their waste. Conversely, when a person is forced to pay, for example, collection and disposal, thus creating a 'clean environment', this can be seen as beneficiaries paying for the benefit, s/he enjoys. To adequately mainstream economics in waste management, such economic issues need to be considered at key stages of a waste management project cycle (see e.g. Lal and Keen, 2002).

By understanding economic dimensions of waste management, policy makers in the Pacific can also make more informed policy decisions as well as design better management instruments that directly target human behaviour, addressing motivations and underlying incentives behind their action. Use of incentive based instruments, or economic instruments, is generally considered to be more effective in changing human behaviour than command and control-based regulatory instruments, such as prohibition (Panayotou, 1998; Thampapillai, 2002). It is for such reasons that some of the GEF-funded IWP included economic subcomponents in the country projects.

International Waters Programme (IWP)

The Pacific IWP was designed to address root causes of degradation in the waters of 14 Pacific island countries. These root causes were primarily seen to be in the form of 'deficiencies in management'. Deficiencies in management included (United Nations Development Program (UNDP), 1999; Holland, 2006 (draft)):

- weak governance – characterized by the need for mechanisms to integrate environmental concerns into development planning and sector-level decision-making; and
- poor understanding – such as about the effects of wastes on, for example, human health and the environment, and the importance of proper waste management.

Several waste management projects were included in the Pacific IWP, including those related to solid wastes in Tonga and liquid waste management in Tuvalu. These projects were designed to:

- engage stakeholders (national and community) in collaborative and consultative processes to analyse local environmental problems; and
- identify and implement possible options to address them (SPREP, 2001).

Each of the Pacific IWP projects followed a stakeholder-based adaptive management-based project cycle processes, recognizing the importance of incorporating local views, knowledge and needs in decision-making processes, akin to those issues highlighted by (Thrupp, 1994; Chambers, 1997). Communities were involved in developing their pilot project after undertaking a strategic planning exercise, during which they identified the issues, root causes and solutions. This was followed by detailed project design, implementation and monitoring.

CASE STUDY 1: TONGAN WASTE MANAGEMENT PROJECT[58]

In response to poor waste management being regarded as a major concern in Tonga (Prescott, 2003), the Tongan IWP project focused on community-based solid waste management on Tongatapu island. Adopting a participatory learning approach (PLA) and participatory problem analysis (PPA), Nukuhetulu villagers identified, with the assistance of Department of Environment staff and the IWP Project Coordination staff from SPREP, key 'root causes' of, and solutions to poor waste management in Tonga (Sione Faka'osi, February, 2005, personal comm.) to primarily include:

- a lack of awareness of the waste problem; and
- a lack of knowledge of basic waste management issues, including recycling, composting, reuse and safe disposal of solid and human waste.

[58] The material presented here is based on Lal et al 2006, unless otherwise noted.

The Tongan project team, under the Department of Environment, decided to develop and implement a village-based ‘action project’ to demonstrate how waste problems could be addressed in an integrated manner at the local level, while working with the government to establish an enabling unit at the national level. Amongst the community-based undertaken were: awareness-raising, waste stream analysis and community-based activities that promoted the three Rs: reduce, reuse and recycle, including composting of human, organic garden and kitchen waste, and recycling. Lessons learnt from the Nukuhetulu village site were then to be used as a basis to scale up improved waste management in other communities. At the national level, the Tongan IWP project included public education programs through radio and television programmes and community-based training workshops on topics such as composting and recycling.

Economic Content of the IWP Project

The Tonga IWP design initially did not include an economic component, even though the original regional International Waters Project was intended to be multidisciplinary, including a resource economics subcomponent. During the design and implementation phases of the IWP-Tonga project, neither the PMU, nor the in-country team obtained such inputs from elsewhere. It was not until about two years into this five year-project that the PMU recruited a Resource Economist. Subsequently, with a concerted effort on the part of the Resource Economist, interest in economics gradually grew. It was later noted in the context of the Tongan project that although “the suggestion [of undertaking economic valuation of solid wastes in Tonga] was enthusiastically received, [even though] IWP Tonga [team] admit[ed] that they were still somewhat ‘puzzled’ by the idea as little has been done on the cost of waste in our region” (Holland 2006, p 10).

The economic valuation was commissioned under the IWP to encourage the Tongan government to develop and implement an appropriate household and island-wide national waste management system. This decision had also followed the exposure of the Tongan IWP Coordinator to resource an environmental economics concept during a regional economic training course organized under the IWP Project. (Holland, 2006). However, the original design of the economics subcomponent had to be subsequently changed.

The Policy Context

The policy context for the economic valuation had to be rethought because the government no longer needed convincing about the benefits and costs of poor waste management, as it had already made a decision to establish a centralized waste collection and disposal system in Tongatapu. The Department of Public Works had, without the knowledge of the Department of Environment, obtained AusAID funding for The Tonga Solid Waste Management Project (TSWMP) for Tongatapu. The Department of Public Works is mandated to deal with infrastructure aspect of waste disposal, whereas the Department of Environment addresses environmental dimension of waste.

The TSWMP project was designed to target reduction, collection and disposal of residual solid wastes, covering urban and rural households and businesses. However, the project had not included a financing strategy, post AusAID funding for continued funding of the collection and running of the landfill site.

Realizing that a sustainable financing strategy had not been identified for the collection and disposal of solid wastes and the operation of the Tongatapu landfill after AusAID’s project was completed, the focus of the economic subcomponent of the IWP Tonga project was changed to address the issue of cost recovery, and the application of ‘beneficiary pays’ principle.

The proposed objectives of the economic analysis of waste in Tonga were thus, amended to:

- estimate Tongan household willingness to pay (WTP) for an improved solid waste management system proposed by the AusAID project; and
- compare the economic cost of solid waste pollution with the proposed average user fees under the Tonga-AusAID Solid Waste Management Project (SWMP) that was expected to have opened in October 2005.

Information generated was expected to help:

- develop advocacy material, highlighting the economic costs of current poor waste management practices on Tongatapu and thus, the benefits of proper collection and disposal of solid wastes and a cleaner environment to households;

- the government to justify a user-pays system for the collection and disposal of solid wastes, by comparing household's willingness to pay (WTP) for clean environment and user charges based on full cost recovery under the TWSMP, including any subsidy the government may need to provide in the first instance.

Economic Valuation Methodology

The economic valuation associated with solid waste management was estimated using a 'with and without' cost analysis of direct and indirect impacts of solid wastes. To determine direct and indirect costs associated with the current solid waste situation, each of the effects of poor waste management ('without management') and respective adaptation response to these effects ('with management') were identified. In the absence of robust local empirical information, changes in each of the impacts directly attributable to poor solid waste management were determined, based on literature and information and opinions supplied by experts working in the respective fields of human health, sanitation and coastal fisheries.

Economic costs estimated included: willingness to pay for the aesthetic value of a clean environment; loss in tourism earning, due to reduced number of tourists due to poor waste management; loss in foregone recycling earning; foregone earnings from organic matter not composted.

A mixed methodology was used to collect relevant primary and secondary data, including a stratified sample-based household survey of the residents of Tongatapu. A household survey was used to do waste audit, and to obtain baseline socio-economic information about, for example, basic health effects and associated costs attributable to poor wastes disposal. The survey was also used to identify adaptive responses already adopted by the households to reduce waste-related health risks. Various prices, technology costs, labour and other cost data were collected from government departments, local retail market outlets, and local suppliers of raw material.

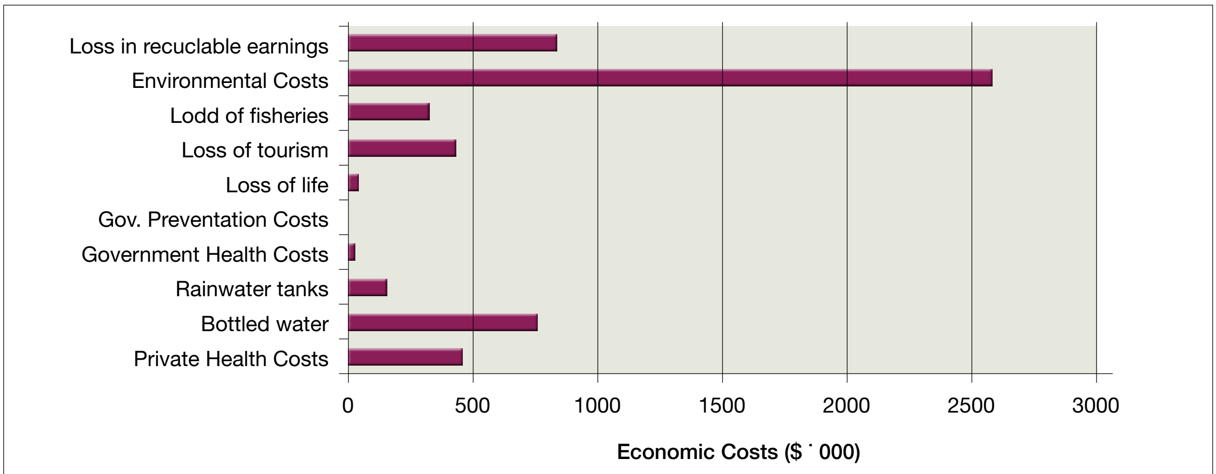
Market-based production and market pricing methods were used to estimate the foregone earnings of not recycling and not composting. Contingency valuation method (CVM) was used to estimate non-market value associated with clean environment. Total economic value for Tongatapu was first estimated and these were extrapolated to apply to the country as a whole. All estimates were given in Tongan Dollar (or Pa'anga).

Results

The direct and indirect economic costs associated with solid wastes alone in Tongatapu were estimated to be $4 million per year, with a range $2.3 million to $5.5 million. That is, the annual cost per household could range from $140 to $340, or $2.80 to $6.50 per week. The loss in aesthetic value was the most important economic loss. This is followed by the potential foregone earnings from recyclable products, and then the cost of bottled water (see figure 1).

The average WTP for improved waste management is $3.10 with most households (95 per cent) willing to pay between $2.80 and $3.30 per week for improved solid waste management. The average WTP is however, lower than the average total economic costs associated with solid waste — $2.80–$6.80 per week.

Figure 1: Distribution of Economic Cost by Category.



Source: Lal et al. 2006.

Costs of Tongan Solid Waste Collection and Disposal Project

The Tongan-AusAID Solid Waste Management Project (SWMP) designed the solid waste collection and disposal system for Tongatapu with an expected operating cost of Tongan $1.8 million – $2.2 million (SWMP Team, pers. comm., June, 2005). This translated into a weekly average operating cost of TOP$3.20–$3.60 per household. If a full cost recovery policy were adopted, the waste collection, and disposal charge would have been within the range of estimated average household's WTP for improved waste management.

With the introduction of a full cost recovery fee, and if households practiced recycling, which would have earned an average annual income of $120, each household could still expect to have a net financial earning of $30 per year. If the economic value associated with a litter-free environment was to be taken into account and with the introduction of user fees for regular waste collection at approximately $3 per week, Tongan households could expect to have a net economic gain of about $100 per year, or close to $2 per week.

Policy Impact?

The results of the project were used by the IWP Tongan Coordinator, in collaboration with the Department of Environment and the AusAID project team, to prepare a Cabinet paper, advocating the introduction of a waste collection fee. The Government ultimately introduced a flat fee of $10 a week per household[59] (Sione Faka'osi, IWP National Coordinator for Tonga, personal comm. May and September, 2009).

The results of the economic component of the IWP Tonga project also informed the national waste policy development and community education programmes. The results helped to emphasize the extent to which the Tongans could not only enjoy benefits derived from a clean and aesthetically pleasing environment, but more importantly, the economic cost savings they could have from reduced health effects as well as savings in the value of land that otherwise would have been required for landfill. The IWP Coordinator noted close to the end of the IWP project that "understanding of basic costs of certain behaviour [has made] people think twice about their actions and its impact" (Holland, 2006, p. 28) and increased the profile of the waste issue in Tonga.

CASE STUDY 2: TUVALU LIQUID WASTE MANAGEMENT

Funafuti residents suffer from serious effects of pollution from leaking septic tank systems used for poor human waste disposal and conditions exacerbated by high groundwater table and regular flooding. Adopting a participatory planning framework, the IWP Tuvalu team under the Department of Environment worked with local communities from two villages, Alapi and Senala, to identify root causes of groundwater and surface water pollution from human wastes and indentify suitable management responses.

Root causes of ground and surface water pollution from human wastes identified included a:

- lack of institutional mechanism for waste water management;
- poor understanding of the impacts of waste water on the environment and human health; and
- poor understanding of the island's geology and water resources before introducing septic tank-based human waste management systems.

Solutions implemented included:

- a short-term communication campaign, including community workshops, to raise awareness of the urgency of sanitation-related issues, focusing on technical aspects of the alternative management options, such as upgrading existing septic tank systems, installing composting toilets and using composted animal and human wastes to improve the quality of local soils; and
- a community-run groundwater monitoring, by taking regular water samples and conducting basic tests, using water testing kits.

[59] The collection system involved local women's groups, and the system worked well initially, but more recently it appears to have stalled because the charging system was introduced without relevant legislative backing and thus there was no way of enforcing the payment of fees (Sione Faka'osi, personal comm., September 2009).

Economic Content of the IWP Project

An economic component was only considered relevant after the National Coordinator (NC) for the Tuvalu IWP became aware of the value of economics, following recruitment of the Natural Resource Economist (NRE) and delivery of the short course training in resource and environmental economics concepts.

The objectives of the economic subcomponent of the Tuvalu IWP were to:

- determine economic costs of direct and indirect impacts associated with the current human waste management;
- compare these costs with the economic costs of alternative human waste management options, including considerations of the economic cost of water use; and
- identify practical feasibility factors that may influence the adoption and sustainability of alternative waste management options.

Information generated from the economic subproject was expected to help:

- develop advocacy material, highlighting the economic costs of current poor waste management practices on Funafuti;
- provide advice on the most appropriate waste management technology based on economic benefits and costs considerations; and
- identify what other social issues may need to be addressed to increase the adoption of the most suitable human waste management system.

Methodology

A benefit cost analytical framework was adopted in this study to determine the economic costs of poor waste management as well as the choice between alternative technological solutions for improved human waste management.

Economic Cost Assessment

A "with and without" benefit-cost analytical framework, similar to the one used in Tonga, was used to determine economic costs associated with the current poor liquid waste management and alternative waste management options. A stratified sample of households in Funafuti was used to collect baseline information, such as health effects, and their respective costs associated with current waste management practices, and the costs of adaptive responses adopted by the households to reduce their health risks. Base price, technology cost, labour and other cost data were collected from government departments, local retail market outlets, local suppliers of raw material, and fisheries cooperatives. Where value information was only available for years prior to 2005, annual consumer price index statistics published by the government were used to adjust the economic values to 2005 Australian dollars.

Choice between Human Waste Management Options

Alternative waste management technologies considered in the economic assessment included: replacing leaking septic tanks, adopting a centralized reticulated system for waste management, and adopting composting toilets, either retrofitting to existing homes, or when building with new houses.

The choice of suitable technology was based on not only the economic benefits and costs of options, but also feasibility factors, such as availability of financial resources. Another key consideration in the choice of suitable technology was the availability of water, particularly given climate change. Tuvalu experiences dry weather for 3–4 months of the year when access to fresh water is limited. Availability of water is likely to become more extreme and drought conditions much longer in duration with climate change. In addition, when the rainy season and king tides coincide, much of the land area is subjected to regular flooding, and this also had important bearing on the choice of technology.

Results

Poor liquid waste management in Funafuti was estimated to cost Tuvalu almost half a million dollars a year (Table 1). Of this, human health costs of key water-borne diseases, directly attributable to liquid waste management, accounted for about 80 per cent of this cost, or about AUD 400,000.[60]

Table 1: Economic Cost Associated with Current Human Waste Management (AUD).

Component	High	Best	Low
Human health	452,630	395,807	284,749
Desalination water	49,961	37,470	12,490
Rain water	44,584	27,020	-
Bottled water	14,676	9,784	4,892
Fisheries	14,190	5,676	2,838
Total economic cost	576,040	475,758	304,969

Choice between Technological Solutions

An ecological sanitation system based on composting toilet, either as a retrofitting option, or when new houses are being constructed was assessed to be economically viable and it did not rely on the availability of water (Table 2).

If Funafuti residents were to convert to compost toilets, individual residents would have better health and minimize their health costs and sufferings. Tuvalu, as a nation, could expect to generate annual net benefits of approximately AUD $2 million, which is about four times the annualized cost of half a million dollars, or $3.2 million for retrofitting the house. None of the other technologies were found economically not to be viable.

However, despite technological feasibility, and economic net gain, composting toilets are likely to be not acceptable to the Tuvaluans due to social issues. Some residents have argued the use of compost toilets is a step backwards, particularly after converting to the flush toilet system, which was seen as a prestige symbol, offering comfort and privacy. Another reason for limited social acceptability was the concerns, albeit wrong (Crennan et al., 2002), about human health effects, particularly from handling composted material. While no local trials have been carried out regarding survival of pathogens in composted material, studies from Kiribati atoll in Kiribati suggest that within six months of composting, there is no evidence of common pathogens and the risk of diseases from handling composting material is believed to be very low, and certainly lower than the risk of diseases from the current situation.

CHALLENGES IN MAINSTREAMING ECONOMICS IN WASTE MANAGEMENT DECISIONS

These two projects provide some very useful lessons that can help reduce many challenges in integrating economic considerations in not only other waste management projects, but also other resource and environmental projects in the region.

Relationship between Scientific Knowledge and Economic Impact Analysis

One of the prerequisites for successfully undertaking economic impact analysis of poor waste management is the availability of robust and reliable scientific information. As observed in both these case studies discussed above, to determine the economic costs associated with poor waste management, one needs to have a good understanding about the relationship between poor waste management and its effects on human health, health of coastal ecosystems as well as the aesthetic value people place on clear environment.

Accuracy of the economic valuation is very much dependent on the quality of the empirical evidence available about, for example, the causal relationship between waste and its direct and indirect effects on

60 Note that this figure excludes costs associated with worm infestation. Empirical information on worm infestation was unavailable, although worm infestation is very common, particularly among children under five years of age.

Table 2: Funafuti's Aggregate Economic Net Benefit Associated with each Liquid Waste Management Option (AU$).

Sanitation options	Initial capital establishment investment	Annualised cost	Water savings	Compost soil benefits	Annualised option's net benefit (loss)	Health, preventative and environmental benefits (costs)	Total net economic benefit (loss)
Do nothing option						(475,758)	(475,758)
New septic tank	2,683,800	590,136			(590,136)	475,758	(114,378)
Fix septic tank	2,556,000	569,337			(569,337)	475,758	(93,579)
Plastic septic tanks	2,300,400	527,740			(527,740)	475,758	(51,982)
Hybrid + septic	5,239,800	1,038,063	27,215		(1,010,848)	475,758	(535,090)
Mini-treatment	23,962,500	11,514,105			(11,514,105)	475,758	(11,038,347)
Compost (add-on)	3,322,800	556,745	1,814,363	52,467	1,310,084	475,758	1,785,842
Compost (new)	2,556,000	431,952	1,814,363	52,467	1,434,878	475,758	1,910,635

fisheries, coastal ecosystems and human health. In the absence of robust functionality understanding, costs estimates could only be derived by, either making some key assumptions about functional relationships between wastes and its effects and/or using expert judgment or Delphi system. Similar issues were also identified in other economic projects in the Pacific (Lal, 2003; Lal, 2004; Hajkowicz and Okotai, 2005; Hajkowicz et al., 2005; Lal and Cerelala, 2005; Woodruff and Holland, 2008).

Root Cause and Solution Analysis, Economics and Project Cycle

These two case studies demonstrate that adopting participatory problem-solution analysis would ensure that the problems are analyzed from the perspective of the people whose livelihoods are at stake, and not purely from a theoretical perspective or from the perspective of what the governments can do. Ideally, 'root cause analysis' assessment can ensure that underlying causes of a problem from the perspective of the communities are addressed. Such root causes and their solutions may be technological. In some cases, root causes may relate to individual incentives, such as economic and financial, determining behaviour and actions, and which may require different types of management responses. Or alternatively, they be related to the underlying institutional and governance issues.

In both these case studies, as in other IWP projects dealing with economics of waste management in the Pacific, (e.g. Hajkowicz and Okotai, 2005; Hajkowicz et al., 2005), situation analysis (including root cause analysis) primarily addressed scientific/technical aspect of waste. In both these two projects, the poor human waste management situation was, it seems, 'assumed to be due to 'lack of awareness; and the lack of knowledge'. During the 'root cause' and solution analysis, it seems that the stakeholders did not consider other issues, such as economic or governance issues. Nor it seems that the stakeholders considered policy option-based on management instruments that targeted human incentives.

There could be several reasons for this. Firstly, the approved IWP design did not fully reflect the importance of economic considerations in the entire project cycle. The IWP Project document, although recognizing the relevance of economics input, seemed to have been restricted to the solution analysis stage of the project cycle, and that too, from the narrow perspective of choices between technical solutions. For example, the mention of economics dimension is restricted to a single clause in the original project document (UNDP, 1999: 24): to determine the economic viability of demonstrations. There was loose reference to institutional issues in the situation analysis, and the economic aspects of the project were rather vague and open to interpretation (Holland, 2006). Subsequent country projects, too, did not include explicit considerations of economic incentive issues during the project design and initial implementation stage.

This is despite an earlier report, commissioned by the IWP Project Coordination Unit, that highlighted key economic considerations of particular relevance to the success of past community-based environment and development projects in the Pacific (Lal and Keen, 2002). Lal and Keen had also recommended the adoption of a more holistic approach that treated environmental management and development as a continuum and integrated economic considerations in each of the main stages of a project cycle from identification/pre-feasibility, feasibility assessment; project design; implementation and monitoring/evaluation and then feedback and adaptation.

Appreciation of different dimensions of economic considerations and the relevance of economics in particular, advocacy and choice between options was heightened, once the Resource Economist was recruited by the IWP PMU, and specialized short course training was conducted involving the IWP National Coordinators. The IWP Natural Resource Economist, once on board, developed an Economic Strategy to 'outline economic considerations' in IWP pilot projects. But her efforts were constrained by a lack of understanding of economics in participating countries, which led to initial limited interest in conducting economic analysis of environmental problems.

It is also important to note that there is also often a lack of resource and environmental economics experience in many government departments, universities/NGOs/partners, and even in the regional university. This meant that although a stakeholder approach was adopted, involving key government and NGO representatives with various tools was used to undertake the situation analysis, a key economic aspect of the root cause analysis could not be systematically addressed. Consequently, the project design could not benefit from relevant analysis about, for example, individual incentives and externality costs.

Secondly, there was limited institutional capacity in the country to identify appropriate policy context, and thus to ask relevant economic questions. This then, made it difficult for NCs to fully appreciate economic dimensions of the resource problem they were dealing with, and/or to produce realistic terms of reference for external consultancy. Although this can easily be addressed through both hands-on training as well as short targeted courses, such as the one developed by SPREP and ANU under financial support from the United Nations Division of Ocean Affairs and the Law of Sea, and offered at the University of the South Pacific.

KEY LESSONS LEARNT

From these, and other waste management IWP projects, it is evident that, as a minimum for integrating economic considerations in resource and environmental management efforts, an experienced resource economist must be available from the outset to guide country teams in asking the relevant economic-related questions throughout a project cycle. Such questions could be found in Lal and Keen (2002).

'Hands on training' as well as targeted professional short courses, can help increase project managers' basic knowledge of key economic concepts. Towards the end of the Tongan IWP, the National Coordinator reported to the SPREP IWP PMU that:

> … economic assessment is an important tool that can be applied at almost all stages of the project cycle. But it is important to understand where it can be fitted in properly and help decision making at different stages of the project (Personal communication between PMU Natural Resource Economist and the National Coordinator, reported in Holland (2006), p 28).

Tuvalu Country Coordinator also realized the power of economic information, and thus economic analysis, for advocacy purposes, when he noted that:

> We will use [the analysis] to prove to stakeholders that we are definitely wasting money on things that we can prevent if we have to manage our wastewater. We can prove to government that [they are] spending money to cure sicknesses [that] can be prevent[ed] [if] we were to [have an] improved wastewater management mechanism. (Personal communication between the PMU Natural Resource Economist and the National Coordinator, reported in Holland (2006), p 31).

Similar sentiments were echoed during the final assessment of the IWP project, when the national coordinators noted that where economic analysis was undertaken, it helped "in bringing the environmental issue to the attention of national leaders... and [the] national level decision makers were often surprised by the effects of polluted water on health' (Aitaro et al., 2007, p.24).

In conclusion, the experiences in the two case studies reaffirm that even if regional policies on mainstreaming economics in the environmental management process have been agreed to at the Forum Leaders level, for projects to be successful, economic considerations must be explicitly included and systematically integrated during the entire project development process, and not at the tail end of a project. It is also important that resource and environmental economics expertise is sought for the initial 'problem-root cause-solution analyses' stages as well as project and policy design stages. Although national capacity in resource and environmental economics may be limited, broader appreciation of the importance of economic analysis to underpin resource and environmental management decisions can be enhanced through well designed and implemented economics analysis used to inform government policies, such as those in Tonga and Tuvalu. Basic understanding can also be acquired relatively easily through 'hands on' and targeted short training courses. Once the power of economics can be demonstrated, governments can be more willing to embrace economics mainstreaming, as illustrated by the following quote from the Secretary of the Ministry of Finance, observed during the Development Coordinating Committee meeting where the results of the study on the economic costs of poor human waste management in Tuvalu, was presented:

> ….projects in Tuvalu should follow the same path, encouraging the introduction of BCA [in other resource management projects]. (IWP Tuvalu, personal communication between PMU Natural Resource Economist and the National Coordinator, reported in Holland (2006), p 31).

Annex IWP Projects

The GEF-funded International Water Program, jointly executed by the Secretariat for the Regional Environment Programme and the United Nations Development Programme (UNDP), called economic subprojects within some of the individual pilot projects. The IWP program, with a budget of $US8.5 million[61], included a suite of pilot projects, covering community-based coastal fisheries, freshwater or waste management issues. The projects were implemented across 14 countries, of which over half addressed waste management concerns at the local level.

The goal of the IWP activities was to "address the root causes of environmental degradation and the project, placing special emphasis on understanding the social, cultural, and economic factors that govern resource use at the community level". At the community level, particular emphasis was placed on promoting increased involvement and responsibility for local resource management initiatives. It recognized that "people are an integral part of most ecosystems and that the participation of key stakeholders in decision-making is essential at all stages of project activities if sustainable resource management is to be achieved." The key objectives of the IWP project in each country were to:

- understand the social, cultural, and economic factors that govern resource use;
- encourage greater community participation in decision-making;
- develop low-cost solutions at the community level; and
- strengthen resource management capacity at the national level.

The IWP also recognized the need to use a range of tools to engage stakeholders and support behaviour change at the national and regional levels. The IWP program had identified the relevance of the following tools: Community Participation; Resource Economics; Strategic Communications; Monitoring & Evaluation; and Institutional Strengthening. Each case study emphasized particularly, community participation and strategic communication. Not all projects addressed or used all the other tools. Nor did all the projects address the issues at both the community and the national levels.

[61] There is a discrepancy in the report on the size of the GEF funded IWP project. On the SPREP website, two separate figures are given - $12 million and $8.5 million.

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ANNEXES

Picture reproduced with the kind permission of SOPAC Survey Team, Fiji Floods.

ANNEX 1

REEN Workshop Programme

28th – 29th September 2009

Venue: Veitiri Conference Room, IUCN Regional Office for Oceania

5 Ma'afu Street, Suva

Opening Session – 28th September

8.30 – 9.00	Registration of participants	MC: Paula Holland Rapporteur: Marita Manley
9.00 – 9.15	Welcome Address (Ms Cristelle Pratt)	
9.15 – 9.25	Participants' self introduction and expectation	
9.25 – 9.35	Objectives of the REEN Workshop and expected outcomes (Padma Narsey Lal)	
9.35 – 9.55	TEEB (Haripriya Gundimeda)	
10.00 – 10.30	Morning Tea	

Presentation Timetable

Day 1 - 28th September 2009			
Theme	Time	Author(s)	Subject
1. Energy Chair: Mahendra Reddy Rapporteur: Nic Conner	10.30 – 10.50	Peter Stauvermann Sunil Kumar	Sugar Industry Technical Diversification: A Solution to Fiji's Economy and Environment of Ethanol a way out for Fiji?
	10.50 – 11.10	Tim Martyn (Marita Manley)	The Economic Feasibility of Making Coconut Oil Biofuels Work for the Pacific
	11.10 – 11.30	Reshika Singh	SOPAC-CATD Biofuel Project
	11.30 – 12.00		DISCUSSION
	12.00 – 13.00		LUNCH
2. Climate Change and Extreme Events Chair: Sunil Kumar Rapporteur: Paula Holland	13.00 – 13.20	Emily Gaskin	Socioeconomic Costs of Climate Change Events in American Samoa
	13.20 – 13.40	Marita Manley Hiroshi Sugano	The impact of climate change on Samoan agriculture: a Ricardian approach
	13.40 – 14.00	Padma Narsey Lal	Assessing economics of climate change in the Pacific : key issues and challenges
	14.00 – 14.30		DISCUSSION
	14.30 – 14.50		TEA BREAK

3. Offshore and Coastal Chair: Sunil Kumar Rapporteur: Padma Narsey Lal	14.50 – 15.10	Vina Ram-Bidesi	Economics of Tuna Management: reflecting on experiences and identifying the challenges for Pacific Islands
	15.10 – 15.30	Nicholas Conner	A socio-economic assessment of coastal natural resource management approaches in the Pacific
	15:30 – 16.00		DISCUSSION
4. Protected Area and Conservation Chair: Nicholas Conner Rapporteur: Marita Manley	16.00 – 16.30	Andrew Seidl (via Skype)	Economic valuation, protected areas and biodiversity outcomes – lessons from other developing countries
	16.30	DRINKS AND SNACKS	

Day 1 - 29th September 2009			
Theme	Time	Author(s)	Subject
5. Disasters Chair: Steve Pratt/ Rapporteur: Nicholas Conner	9.00 – 9.20	Marita Manley	Can carbon financing provide incentives for avoided or reduced deforestation and forest degradation in Fiji?
	9.20 – 9.40	Paula Holland	Economics to promote disaster risk management in the Pacific
	9.40 – 10.00	Padma Narsey Lal	Determinants of disaster vulnerability: Economic costs of the 2009 floods on the sugar belt
	10.00 – 10.30		DISCUSSION
	10.30 – 11.00		MORNING TEA
6. Protected Area and Conservation (Cont.) Chair: Nicholas Conner Rapporteur: Marita Manley	11.00 – 11.20	Mahendra Reddy	Trust and Social Capital Framework: Implication for Resource Extraction in Small Economies
	11.20 – 11.40	Paula Holland	Alternative options for coastal projection: feasibility of aggregate mining in Pacific atoll nations
	11.40 – 12.00	Padma Narsey Lal	Mainstreaming economic considerations in waste management decisions: Experiences from Fiji and Tonga
	12.00 – 12.30		DISCUSSION
	12.30 – 13.30		LUNCH
	13.30 – 14.30		DISCUSSION: Key Lessons for submission to TEEB
	14.30 – 15.30		DISCUSSION: REEN and Way Forward
	15.30 – 16.00		AFTERNOON TEA AND CLOSE

ANNEX 2

REEN Workshop Participants

Surname	Given Name	Organization	Title
Conner	Nicholas	WCPA (IUCN)	Principal Conservation Economist, Government of New South Wales, Australia
Gaskin	Emily	NOAA	Fagatele Bay National Marine Sanctuary Officer
Holland	Paula	SOPAC	Manager, Natural Resources Governance
Jiwanji	Moortaza	UNDP PC	Natural Resource and Environmental Economist
Khatri	Neehal	IUCN	Research Assistant, Resource and Environmental Economics
Kumar	Sunil	USP	Senior Lecturer, School of Economics
Lal	Padma	IUCN	Chief Technical Adviser
Manley	Marita	SPC	Agriculture And Forestry Policy Adviser
Martyn	Tim	SPC	ODI Research Fellow
Pratt	Stephen	USP	Lecturer, Tourism
Ram-Bidesi	Vina	USP	Lecturer, Fisheries Economics
Reddy	Mahendra	FIT	Dean, Faculty of Commerce, Hospitality and Tourism Studies, FIT
Singh	Reshika	SOPAC	Energy Economist
Stauvermann	Peter	USP	Lecturer, Resource and Environmental Economics

ANNEX 3

Opening Comments

Ms Cristelle Pratt,
Director of the Pacific Islands Applied Geoscience Commission (SOPAC)

Good morning and welcome to you all, to this the 1st Pacific Resource and Environmental Economics Network Workshop. I am pleased to be with you today and to on behalf of IUCN's Oceania Director Taholo Kami and SPC's Director General Jimmie Rogers, who are co-initiators of this meeting, make just a few short opening remarks before you commence with a full and a rather interesting agenda over the next two days.

As many of you will be aware the Pacific Resource and Environmental Economics Network was established a few short months ago by the IUCN. Its primary purpose being to provide a forum for Resource and Environmental Economics practitioners to share between them ideas and lessons in how each conducts the very necessary resources economics work in our region.

I wish to commend the IUCN for this initiative, as it is both timely and essential with the growing demand for economic analysis for resources in the Pacific, ever present. For example, in SOPAC we have realized the benefits as well as the necessity for such work as we progress our applied scientific and technical outputs toward national outcomes in our member states. This is demonstrated by the number of technical economic reports that we have and that we are producing and also in our commitment to grow our small team by recruiting an additional two appropriately qualified professionals in the very near future.

In this respect we are not alone and I understand that there are other regional organizations who are also making similar commitments to bolstering the capacity in this increasingly important area of work.

AND why we ask is it becoming so terribly important.

Clearly there is no argument that economics is critical in the Pacific to supporting our sustainable development endeavours and that as a key pillar in this pursuit it is being used increasingly for advocacy purposes to influence shifts in policy. For example it can be most useful to demonstrate the damage from environmental degradation and the potential benefits of sustainable practices.

However, in saying this I am sure that you will agree that economics for resource use is still a relatively small area in the Pacific. There are still only few practitioners that we know about; as demonstrated by this rather small but precious turnout to this workshop. Yet as I have already mentioned the demand for such work is increasing and the type of demands are likely to change over time, which brings us to the raison d'être of this workshop and its objectives which I understand are simple and straight forward.

You will over the next days discuss and consider the role, the relevance and the usefulness of economics in resource and environmental management in the Pacific; you will seek to identify people to do analysis in the future that will strengthen and grow this network; you will between you share your lessons and experiences to ensure continual improvement and; you will I hope gain the trust and confidence between yourselves to create through this network a supportive environment that will enable and engender peer review.

If you achieve these, and there is no reason why you should not then I am confident that a strong network for Resource and Environmental Economics will have been established and as a consequence of this, the support to Pacific islands to critically assess and plan for resource uses in the future will be that much stronger.

I understand that some participants to this meeting were unable to attend in person and so I hope that technology allows for them to contribute as they would have if they had been able to travel to Suva. I hope that this will not be the only time that the Resource and Environmental Economics Network meets and that it will become an important coordination and collaborative mechanism in this important field of work and action toward sustainable development of our natural resources and that it will find its place as a crucial and important meeting on what is a rather crowded regional agenda.

I would like to thank the IUCN for providing this comfortable venue for the meeting and the steering committee that has worked tirelessly to plan and organize this meeting. I finally would like to thank all of your organizations for agreeing that this is a meeting worthy of your attendance and to thank you all in advance for executing a meeting that will deliver outcomes that ultimately result in improved Resource and Environmental Economics approaches and outputs for Pacific Island countries.

I wish you all the very best for the next few days and I would also like to wish the Pacific Resource and Environmental Economics Network good health and good growth.

Thank you.

ANNEX 4

Pacific Resource and Environmental Economics Network (PREEN): Terms of Reference

BACKGROUND

The use of resource and environmental economic analytical information to support and/or underpin economic development and environmental conservation decisions is relatively new in the Pacific. Resource management has conventionally either not involved consideration of economic factors at all or has involved it only inadequately. Similarly environmental conservation decisions often did not include livelihood or opportunity cost considerations The failure of some environmental or natural resource management initiatives has consequently been attributed to the poor policy or project design arising from that economics gap (see Lal et al., 2002a; 2002b).

Part of the reason for inadequate consideration of economic issues in natural resource management is the lack of capacity in natural resource economics in the Pacific. Many Pacific island country governments do not have the resources to employ dedicated natural resource economists in their administration. In any event, there are few trained resource and environmental economist around to employ; most economics graduates find employment in the financial, macroeconomic or general planning sector while others may move overseas or not use their economics training at all. For those few natural resource economists that do operate in the Pacific, progress in conducting economic analysis can be hampered by isolation; there are few resource economists around with whom to share ideas, develop initiatives or share work.

In response to these issues, IUCN-Oceania organized a small gathering of practicing resource economists and other interested people in 2007 to form a Resource and Environmental Economics Network (REEN). The purpose of the Network was to provide peer support and share ideas to progress economic analysis for sustainable resource management in the Pacific.

In September 2009, IUCN hosted Experiences in the Use of Economics in Resource and Environmental Management, a Pacific Resource and Environmental Economics Practitioners' Workshop. The workshop brought together known resource economists operating in the Pacific who were able to make themselves available to discuss current issues and share experiences.

ESTABLISHMENT OF THE PACIFIC RESOURCE AND ENVIRONMENTAL ECONOMICS NETWORK (PREEN)

At the September meeting, participants confirmed the ongoing need for a network of resource and environmental economists to build support among practitioners and increase the capacity of stakeholders to conduct and/or benefit from the economic analysis of natural resources and the environment.

In light of this, participants agreed to formally establish the Pacific Resource and Environmental Economics Network or PREEN for short. Membership of the PREEN as at 29 September 2009 us provided in attachment A.

FUNCTIONS OF THE PREEN

- Provide a forum for practitioners in Pacific resource and environmental economics to exchange information, ideas and experiences for mutual learning and professional development
- Provide peer review support and advice
- Establish and maintain a database of key resource and environmental economics practitioners in the Pacific, outlining their contacts, areas of expertise and interest
- Develop, as appropriate, joint proposals or work to meet the needs of the Pacific
- Establish a web site to support the economic analysis of natural resources and the environment in the Pacific. Potential functions of the web site are to provide:
  - Background information on the PREEN and tabs to apply to join
  - Highlights of any PREEN activities (e.g. workshops)
  - Details of members (brief bio-notes, contact details, etc.)
  - Links to relevant economic analysis document for the Pacific
  - Links to relevant documents generally (e.g. resource economics)
  - Links to the Pacific Environmental and Natural Resource Economics News (e.g. PENREN)
  - Links to other relevant sites and/or organizations
  - Information on upcoming events.

COORDINATION OF THE NETWORK

IUCN-Oceania will coordinate the Network with the support of SOPAC and the SPC. Key contact points for 2009 – 2010 are:

Organization	Representative	Incumbent
IUCN-Oceania	Chief Technical Adviser, International Union for Conservation of Nature	Dr Padma Narsey Lal
SOPAC	Manager, Natural Resources Governance	Ms Paula Holland
SPC	Agriculture And Forestry Policy Adviser	Ms Marita Manley

Notes on authors

Hiroshi Sugano is an intern with the Food and Agriculture Organization of the UN (FAO) office based in Apia. As part of his work with FAO, he conducted independent research on economic impacts of climate change on crop productions and farm values in Samoa with the use of Ricardian analysis. Prior to this position, he was a Climate Change intern for Micronesia Permanent Mission to the UN (New York City), Japan International Cooperation Agency, JICA (Suva) and Institute for Global Environmental Strategies, IGES (Hayama, Japan). Hiroshi is a candidate for Master of Environmental Management, Yale University.

Marita Manley is currently an Agriculture and Forestry Policy Adviser at the Secretariat of the Pacific Community (SPC). She is also working on improving the sharing of information and experiences in relation to agriculture and forestry policies between Pacific Island Countries and other developing countries through strengthening the Pacific Agriculture and Forestry Policy Network. Previously, she was involved with SPC as a resource economist under the Overseas Development International programme of UK and as an economist with UK Department of the Environment, Food and Rural Affairs. She completed an MSc in Environmental and Resource Economics in 2005. Her areas of interest include climate change impacts on agriculture, forestry and carbon markets.

Mahendra Reddy is the Dean of Faculty of Commerce, Hospitality & Tourism Studies. Prior to this, he was the Head of School of Economics and Associate Professor of Economics at the University of the South Pacific. He has authored/co-authored a wide array of papers and articles in the areas of Economic Development, Public Finance and Agricultural Economics. He also holds the position of Chair, the Fiji Commerce Commission.

Nicholas Conner has over twenty-eight years experience in natural resource management and rural development, focusing on conservation economics, socio-economic impact assessment, and natural resource policy development and analysis, particularly in Australia. As well as coordinating the IUCN World Commission on Protected Areas Economics and Protected Areas Specialist Group, Nicholas is Principal Conservation Economist with the New South Wales Department of Environment, Climate Change and Water. His work involves developing and managing projects on economic aspects of biodiversity conservation in relation to natural resource management, regional economic development, tourism, and ecosystem services. Nicholas has also worked as an environmental economics consultant in Europe, South-East Asia and Australia.

Padma Narsey Lal is the Chief Technical Adviser to the IUCN-Oceania office in Suva. She is an Ecological Economist with an academic background in ecology, economics and integrated environment management, and economics. She has over 30 years experience working on natural resource and environment management issues. She has worked in many parts of Oceania, including Australia and the Pacific Islands in various capacities, including civil servant, researcher and research manager, consultant and as an academic and Director of Graduate Studies Program in Environment Management and Development at the Australian National University, and regional civil servant. Padma has published widely on a variety of subjects, including agricultural and resource economics, environmental economics and adaptive natural resource management, economics of forest certification, recycling and coastal zone management and economic instruments; adaptive management in the Fiji sugar industry; and economics of waste management in the Pacific.

Paula Holland manages the Natural Resources Governance programme at the Pacific Islands Applied Geoscience Commission (SOPAC). She has been a natural resource economist for 19 years and has experience in applying economic analysis to a variety of sectors, including fisheries, waste management, disaster and conservation. She has experience in researching and developing natural resource policy in the Pacific, Australia and northern Europe in governments as well as academic institutions.

Peter Stauvermann is a senior lecturer at the University of the South Pacific (USP). He is involved in teaching Resource & Environmental Economics and Economics of Growth and Development. His research areas include Ecological economics, Environmental & Resource economics, National Accounting, Institutional Economics, Economics of Conflict, Growth Theory, Public Economics and Regional Economics.

Reshika Singh is a Project Officer-Resource Economist at the Pacific Islands Applied Geoscience Commission (SOPAC). Her areas of interest include Poverty and Energy Economics. She was recently involved in a study on the relationship between natural disasters and poverty, using Fiji as a Pacific case study. She is currently working with the Reserve Bank of Fiji.

Sunil Kumar is a lecturer at the University of the South Pacific (USP). He specialises in teaching Economic Statistics and Policy Analysis. His areas of research interest include Poverty, Computable General Equilibrium model, Developing theory and Policy research.

Tim Martyn is a Resource Economist at the Secretariat for the Pacific Community (SPC). His areas of interest in research include valuing sustainable land use management, measuring impacts of poor land use management, assessing the contribution of integrated pest management and sustainable agricultural practices on farm productivity, and valuing the contribution of land management techniques to reducing the costs of land preparation.

Vina Ram-Bidesi is a Senior Lecturer at the Division of Marine Studies in the University of the South Pacific. She teaches courses in areas relating to fisheries economics and management, fisheries policy and planning and integrated coastal management. Her research interests include social and economic aspects of tuna industry development, economics of community based resource management systems and gender issues in the marine sector.

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