THE ROLE OF RENEWABLE ENERGY IN THE ACHIEVEMENT OF SUSTAINABLE LIVELIHOODS IN RURAL SOUTH-EAST ASIA AND THE SOUTH PACIFIC

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ABSTRACT

Access to an affordable and reliable supply of energy is an accepted part of our day to day lives. While the increasing price of oil and environmental issues are of concern, the great majority of people in developed countries are not yet faced with the prospect of energy becoming unaffordable or unavailable. The situation in developing countries is far less comfortable where the purchase of energy can account for 25% of total household income and price increases can mean that an energy source becomes no longer affordable. Given that energy supplies underpin economic and social development, such situations can not only hold up development and the consequential move out of poverty but actually move people further away from this goal.

This thesis examines the role of energy in people's livelihoods in two locations, one in South East Asia and the other in the South Pacific. The first of these comprises six farming villages in the Kerinci Valley in Sumatra while the second is Niue Island. Both these communities rely heavily on energy supplies but in very different ways, this being a function of the different economic situation that applies in each location. Both communities have renewable energy resources which are yet to be used or yet to be used effectively or sustainably.

The sustainable livelihoods approach is used to analyse existing livelihoods with particular reference to the role of energy. The available renewable energy resources are identified and the impact that increased use of these could have in terms of livelihood outcomes is determined. The conclusion is that renewable energy has the potential to contribute to the achievement of sustainable livelihoods. However, while the outcomes are positive, renewable energy will not by itself achieve the transformation necessary for sustainable livelihoods. There are also barriers to the implementation of renewable energy programmes, not the least being access to funding.

PREFACE

I am pleased to acknowledge the assistance and support of my thesis supervisor, Dr Manuhuia Barcham. His guidance and constructive criticism was invaluable together with his willingness to meet and discuss any matter I wanted to raise at short notice.

I acknowledge with gratitude the permission received from the New Zealand Agency for International Development (NZAID) to use material collected while undertaking development projects funded by NZAID in Sumatra and Niue.

Also, my colleagues at Empower Consultants Limited without whose support and encouragement this thesis could not have been written and especially Ann McLean who read through the final draft and made many helpful comments. The assistance of Gillian Dias as both colleague and interpreter when in Sumatra was invaluable.

My thanks to those in Niue and Sumatra who willingly answered my questions on life and livelihoods in those locations.

Last but certainly not least, Barbara, my wife, for her support, encouragement and tolerance.

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CHAPTER 1: INTRODUCTION

THE RESEARCH QUESTION

In 1992, the United Nations Earth Summit stated that "energy is essential to economic and social development and improved quality of life" (UNDP, 1992). The reality is that energy is far more than this: it is a prerequisite for human life (Najam and Cleveland, 2003:119). Even in the simplest lifestyles, a source of energy is essential for cooking food, in some cases for warmth and often to provide light for security. For people to continue even a basic, traditional rural lifestyle, reliable and plentiful sources of energy are critical (DFID, 2001).

In the developed world, plentiful and cheap energy based on fossil fuels has been taken for granted, the main concerns being with the local environmental impacts associated with combustion of these fuels and the security of the supplies, these being at times vulnerable to political instability in the regions in which many of the world's reserves of oil and gas exist. However, in recent years concerns that these easily accessible reserves of oil may be declining have pushed the price of oil up to record levels and this, coupled with the belief that use of fossil fuels generally is contributing to global warming, has resulted in increased investment in renewable energy technology throughout the developed world.

While the increase in the price of oil is of concern in developed countries, to date the impact on the day to day lives of most people has been minimal. On the other hand, in developing countries the impact has been much greater as the purchase of energy can account for 25% of total household income (World Bank, 2006)[1]. Governments have often attempted to shield domestic consumers from the impact of energy price increases by the application of subsidies but this can result in severe fiscal stress, forcing governments to reduce or eliminate fuel subsidies (ADB, 2006b). As I will discuss in Chapters 3 and 5, the impacts of such actions can be severe on the people who are affected - particularly if they are poor.

Increased use of renewable energy is frequently promoted by leading international development agencies such as the World Bank, Asian Development Bank and the United Nations as a solution to poor peoples' energy supply problems. Instinctively, this

[1] According to BRANZ (2002: 3), in 2002, the average household expenditure on energy in New Zealand was 3.4% of household income.

appears almost to be a truism - renewable energy = sustainable = good. But is this answer to poor peoples' livelihood needs and if so how much of an answer? While some communities may be blessed with abundant and readily usable renewable energy resources, many are not so fortunate. And if a community has abundant renewable energy resources, are they able to benefit from the use of these resources?

The "Research Question" I intend addressing and answering in this thesis is:
"In the context of rural South-East Asia and the South Pacific, can community- based renewable energy supply systems contribute to the development of sustainable livelihoods?"

In order to answer this question, it is necessary to first answer two other questions:
"What is the role of energy in rural livelihoods?"
and
"What are the impacts of changes in energy availability on livelihoods?"

The objective of this thesis is therefore to study the relationship between sustainable livelihoods and energy with particular emphasis on renewable energy. The study is based on the results from field work in communities in two locations, Sumatra and Niue, and secondary data from a range of sources.

DEFINITIONS

In this thesis, there are two terms which are frequently used and are defined below:

Renewable Energy

The term "renewable energy" is, according to Elliot (1999: 129), *"so called because it relies on natural energy flows in the environment, which, since they are continuously replenished will never be exhausted".* It is a term that like the word "sustainable" has assumed the status of being unquestionably "good". But like so many things that have this status, can it produce the results that people expect? As a professional engineer specialising in the supply and use of energy in both developed and developing countries, this is a question that I have yet to answer to my own satisfaction and was one of the reasons for selecting the subject of this thesis.

I will also use the term "renewable energy resource" which, in the context of this thesis, shall mean the combination of the source of renewable energy and the technology required to convert the source into useful energy. As an example, the sun is a source and with a water heating panel, the combination becomes the resource known as solar water heating.

Sustainable Livelihoods

DFID (1999: 1) provides a useful definition of the term "sustainable livelihood": *"A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base".*

APPROACH AND METHODOLOGY

I have adopted a sustainable livelihoods approach based largely on the DFID Sustainable Livelihoods Framework and the associated Guidance Sheets (DFIDb, 1999).

My rationale for adopting the sustainable livelihoods approach (SLA) is that it provides a means to examine and analyse the complex relationships that make up people's livelihoods. It is intended to be "people centred" (DFID, 1999: 3) by "putting people first" rather than the environment and development which, according to Chambers (1986: 7) were the priorities of sustainable development professional thinking in the late 1980s.

The DFID framework was developed as a tool to help development practitioners to understand and identify livelihood relationships (DFID, 1999b:2). I will use the framework as the guideline for the analysis carried out in Chapter 5 of this thesis as I believe it to be a useful tool in that it helps maintain the focus on people and to better understand the impacts of actions or events on their livelihoods.

Field research included two visits to the Kerinci Valley and two visits to Niue. However, in the case of the Kerinci Valley, I will also use some material collected during a visit that took place in late 2004 not long before I commenced preparation of this thesis.

The approach to field research was quite different for the two sites. In the Kerinci Valley, information was collected through a number of semi-structured interviews with key informants and from village meetings. In the case of the village meetings, my method was to ask a series of open questions relating to specific aspects of energy supply and use. In all cases, an interpreter[2] was used as most people did not speak English.

In the case of Niue, the main source of information was a series of semi-structured interviews with key informants, typically people I knew from a number of previous visits to Niue. Also of value was information gleaned during casual conversations in shops, cafés, the hotel and government departments with people ranging from government ministers to hotel staff. These conversations were not interviews as such and tended to relate to social and cultural issues rather than energy and as such I found these conversations to provide useful background material and assisted as a cross-check for official information.

A list of key informants will be found in Appendix C.

Secondary sources of information included a wide range of published material sourced from libraries and the Internet. A list of references is provided following the appendices.

SELECTION OF STUDY SITES

The two study sites were selected because both possess characteristics that I believe to be common to other parts of South-East Asia and the South Pacific. They also each provide a contrast to the other in terms of location, economic and social conditions and culture. I had also visited both sites prior to commencement of this thesis which provides a significant advantage in that contacts and networks were already in place.

The Kerinci Villages

The Kerinci Valley site comprises collectively six villages, which I will refer to as the "Kerinci Villages" in this thesis. Agriculture dominates as the main livelihood with rice growing being the main activity supplemented by cash cropping or livestock raising. There is little immediate prospect of significant alternative economic development and employment prospects for school leavers are limited. In fact, in economic terms, over

[2] The interpreter was usually Gillian Dias, a social scientist and a colleague.

the past five years, changes have been mainly negative with large reductions in prices for cash crops and big increases in energy prices.

Renewable energy resources exist and some are already used including woodfuel and solar crop drying. However, the woodfuel is mainly burnt in inefficient woodstoves and there are indications of some stress on the woodfuel resource. Solar crop drying is inefficient and losses are reported as being around 25%. On the other hand, there are good supplies of biomass waste including rice straw which is mainly burnt. There are also geothermal hot springs and streams with micro hydro power generation potential.

Niue

People in Niue enjoy a relatively high standard of living and this includes a reliable and affordable supply of energy. However, virtually all energy needs are met from imported oil products as Niue has no resources of fossil fuels. Furthermore, the purchase of this energy source is helped substantially by financial assistance from New Zealand which amounted to over $8 million in 2004 or about $4,700 per head of resident population (NZAID, 2005). However, unlike the Kerinci Villages which are located inland with a cloudy climate characterised by light winds, Niue enjoys a windy and sunny climate which appears to be ideally suited for wind and solar power generation.

Relevance to other parts of South-East Asia and the South Pacific

Given that the title of this thesis includes South-East Asia and the South Pacific, this raises the question as to how relevant the analysis and conclusions will be to other parts of these two regions.

Based on my visits to other parts of the two regions and a review of economic and energy data, I consider that there are sufficient shared characteristics to justify this assumption. However, in the Conclusions of this thesis (Chapter 6), I will test and review this assumption.

THESIS OUTLINE

The thesis comprises six chapters followed by a series of appendices including two that set out the technical data used to estimate energy requirements, potential capacities and costs.

Following this introductory chapter, Chapter 2 will review the history and development of the sustainable livelihoods approach and implementation in practice including application of the DFID Sustainable Livelihoods Framework (DFID, 1999b). The linkages with energy will be identified and the criteria for assessing the sustainable livelihoods potential of an energy source will be established.

Chapter 3 will provide a profile of the six Kerinci Villages that comprise the first case study. This profile will be based on information obtained during three field visits supplemented with secondary data from various publications. While the profile will include such matters as the geographic and political context, the economy and the culture, the main emphases will be on livelihoods and the role of energy.

In Chapter 4 I will provide a profile of Niue and again this will be based on information gained during two field visits and secondary data. Again, the emphasis will be on livelihoods and energy.

In Chapter 5, I will carry out a sustainable livelihoods analysis of both study sites using the DFID framework (1999b) and the DFID Sustainable Livelihoods Guidance Sheets (1999b), using data from Chapters 3 and 4 for the Kerinci Villages and Niue respectively. This will be followed by an assessment of renewable energy resources in both sites in terms of potential capacities and benefits. A second sustainable livelihoods analysis will then carried out assuming that the identified renewable energy resources are used and a series of livelihood outcomes will be developed.

Chapter 6 will comprise my conclusions. This is divided into three parts addressing the main "Research Question" discussed above, preceded by the two "Supplementary Questions". As noted above, the relevance of the results and conclusions to other parts of South-East Asia and the South Pacific will be examined.

In summary, the answer to the Research Question is positive in that I conclude that community-based renewable energy can contribute to the development of sustainable livelihoods. The answer is conditional however in that while renewable energy can contribute, it cannot by itself achieve a condition of sustainable livelihoods in isolation as other factors that contribute to sustainable livelihoods must exist.

CHAPTER 2: SUSTAINABLE LIVELIHOODS AND ENERGY

INTRODUCTION

The sustainable livelihoods approach has been developed with the objective of enabling development practitioners to gain a better understanding of people's livelihoods and in particular their strengths or assets and thereby be better placed to help them use and build on these strengths. The sustainable livelihoods approach and its use as a tool by development practitioners in poverty elimination activities is well established and has been used by a number of agencies since the early 1990's. These agencies include DFID, UNDP and FAO together with international NGOs such as OXFAM and CARE (Solesbury, 2003: 3).

In principle, the concept is rational and easy to understand: if people are able to achieve a satisfactory standard of living in respect to housing, food, health and education and are able through a political system to participate in the making of the decisions that impact on their day to day life and this achievement can be maintained on a continuing basis, then poverty becomes a thing of the past. Yet the reality is complex with livelihood systems being made up of innumerable elements which include not just the obvious economic factors, but also social, cultural and spiritual components (Högger, 2004: 36).

As I stated in Chapter 1, energy is a critical component of people's livelihoods. However, the role energy plays in achieving development that will improve people's livelihoods is less clear. The objective of this chapter is to investigate this role to identify the relationships between energy and sustainable livelihoods.

In the first part of this chapter, the history and development of the sustainable livelihoods approach will be reviewed followed by discussion on its application in practice and in particular the frameworks developed by DFID and others. The linkages between energy and the principal sustainable livelihood assets as defined in the DFID framework (DFID, 1999b) will be identified. These linkages will be developed further to produce a series of sustainable livelihoods potential criteria intended for use when evaluating the various energy technologies available.

SUSTAINABLE LIVELIHOODS- THE HISTORY AND DEVELOPMENT

The concept of sustainable livelihoods can be traced back to the 1980s, evolving from the debates that took place during that period on the environment and the risks to the environment from pollution created by industrialisation, population increase and modern agricultural techniques, including if not directly, by implication, pollution from the consequential increased consumption of energy (ITDG, 2002: 9) Initially, the concerns regarding environmental pollution and degradation were all-embracing and the needs of people, and particularly poor people, were ignored (Chambers, 1986:4). This was probably not a deliberate action but rather a consequence of the overwhelming nature of the environmental problems as perceived at that time. But perhaps also there was an underlying view that people have created these environmental problems and therefore need to bear the consequences, forgetting that the impact of this approach was likely to be greatest on poor people who were largely not to blame.

However, as the debates progressed, the view developed that somehow there needed to be a "middle way" where both the needs of people in carrying out their day to day lives and the needs of the environment were taken into account. One outcome was the birth of sustainable development, which was endorsed in 1985 by the World Commission on Environment and Development (WCED) as a marriage between the objectives of development on one hand and protection of the environment on the other (Chambers, 1986: 3).

In 1986, Robert Chambers questioned the priorities that had been set in these debates which typically still focussed on the physical impacts of environmental pollution and resource depletion. Chambers (1986: 7) argued that people must be put first, as the "environment and development are for people, not people for the environment and development". He supported this argument with the moral justification that "deprivation of hundreds of millions of people on this planet is an intolerable outrage, an affront to humanity and a cause for personal shame for all of us who are well off (Chambers 1986: 7)". He followed this with two practical justifications, the first being that deprivation was best approached from the perspective of the poor people themselves rather than that of outsiders. The second justification was that poor people are often forced to adopt survival measures that damage the environment such as overgrazing, over-cropping and excessive woodcutting. It was by "putting poor people first" (Chambers, 1986: 3) and helping them to replace these measures with techniques that were sustainable that not only stopped the environmental degradation but provided people with an adequate quality of life.

Chambers (1986: 10) went on to propose "sustainable livelihood thinking" as an alternative to the then existing methodologies and analytical approaches to development. This new approach took sustainable development, the marriage between "environmental thinking" and "development thinking" a stage further by adding "livelihood thinking", the primary focus being livelihoods with the emphasis on poor people. (Chambers, 1986: 11).

"Official" recognition of the linkages between the environment, development and poverty elimination was part of the 1987 report of the World Commission on Environment and Development (WCED), generally referred to as the Brundtland report. While arguably the Brundtland report is best know for its oft-quoted definition of sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987: 51), the report was a landmark document in that it gave priority to poverty elimination on the grounds that "poverty is a major cause and effect of global environmental problems" (WCED, 1987: 19). The report addressed not just environmental issues and economic development but also the related social and institutional issues such as, for example, the need for political systems that provide for all citizens including the poor to receive their fair share of resources and to participate in decision making (WCED, 1987:25).

Although expressed in very different terms, there are similarities between the views of Chambers (1986) and those expressed in the Brundtland report, notably the strong relationship between poverty elimination and the prevention of increased environmental degradation coupled with the need for accompanying institutional changes that provide for all people, including the poor, to have a greater say.

SUSTAINABLE LIVELIHOODS- THE MOVE FROM A CONCEPT TO AN APPROACH

While the concept of sustainable livelihoods may have emerged, some years were to pass after the publication of the Brundtland report before there was any attempt at serious adoption of sustainable livelihoods as an approach to poverty elimination. For example, while the theme of sustainable livelihoods was taken up by the International Institute for Environment and Development (IIED) in a conference held in 1987, with the (unsurprising) exception of the contribution of Robert Chambers (Chambers, 1988a), no real attempt was made in the various papers as published in the conference proceedings (Conroy and Litvinoff, 1988) to define sustainable livelihoods or to demonstrate how the case study projects being discussed helped to achieve sustainable livelihoods. Instead, the authors tended to focus on the sustainable development outcomes, which suggest that while the idea of a sustainable livelihood had considerable appeal, development professionals still had to develop the methodology to apply this concept in practice.

Solesbury (2003: 5) attributed the breakthrough which led to the adoption of sustainable livelihoods as a practical concept to Robert Chambers, and particularly as expressed in the paper co-authored with Robert Conway in 1991 (Chambers and Conway, 1991). In this paper, they described sustainable livelihoods as an "integrating concept" where "capabilities, equity and sustainability combine in the concept of sustainable livelihoods" Chambers and Conway (1991: 5). These three terms are defined below in the context of sustainable livelihoods:

Capabilities

Capability was defined by Amartya Sen as being that which "people can do or be with their entitlements" (Scoones ,1998: 6). It was more than simply being adequately nourished and clothed or having improved health and increased lifespan. Rather, it included being able to achieve a quality of life beyond subsistence with the ability to have and make choices (Chambers and Conway, 1991: 4). Simplistically, it could be summed up as the achievement of wellbeing in one's day to day life (Chambers, 1995: 33). The elimination of poverty was implicit if we assume that wellbeing and poverty cannot readily co-exist.

Equity

According to Chambers and Conway (1991: 4), the achievement of *equity* was not simply a matter of relative income distribution but included "less unequal distribution of assets, capabilities and opportunities" and the removal of discrimination against the more vulnerable members of a society.

Sustainability

Sustainability often is taken as referring to environmental or resource isses, but Chambers and Conway (1991: 5) split sustainability into two categories: environmental and social. Environmental sustainability meant using natural resources carefully to avoid over exploitation or over-use that can lead to degradation. It included adopting methods and systems that can withstand disturbances be these stress (a regular and predicable disturbance) or shock (a major infrequent and unpredictable disturbance) (Scoones, 1998: 7). Social sustainability on the other hand meant maintaining the capabilities on which livelihoods are based while improving those livelihoods (Chambers and Conway, 1991: 5) including the ability to better withstand outside pressures, ie reduce vulnerability (Chambers and Conway, 1991: 9).

Sustainable livelihoods to be "people-centred".

However, the underlying principle of sustainable livelihoods as expressed by DFID (1999a) was that it was "people-centred", with the focus on peoples' needs (DFID, 1999a). This principle was not just based on moral grounds but was pragmatic in recognising that development, in the context of the achievement of a sustainable livelihood would not be sustainable if it did not meet the concerns of people and if they did not participate (Mahat, 2004: 14).

Arguably, this central principle of sustainable livelihoods is also the key weakness of this approach, not because it is inappropriate but because it presents some difficulties in practical application. As noted earlier, livelihood systems are made up of innumerable elements (Högger, 2004: 36) and to fully understand these issues, particularly cultural issues, is not an easy task for an outsider. Even the tenet of "sustainability" can be interpreted differently by the different parties involved - Baumgartner (2004: 23) used the example of a farmer in a semi-arid area, where the overseas expert may see the sustainability issue as one of soil erosion while the farmer will see it as the sustainability of his family's livelihood. Baumgartner (2004: 25) went on to discuss the concept of "multiple rationalities" where in a development project, people (eg farmers in an agricultural project) will make decisions based on a wide range of factors, sometimes with only partial information, including market options, family needs, social status and spiritual beliefs; the rationality of the decision making process is described as being "bound to a context as perceived and experienced".

An example is the growing of *qat* in Yemen, *qat* being a mildly narcotic leaf that is chewed by a large proportion of the population for relaxation purposes (Ward, 2000: 14). Its cultivation and use have been frequently reviewed and questioned in terms of sustainability on both *micro* and *macro* level. At a micro level, the cultivation involves high water use and heavy use of pesticides to the extent that land degradation is occurring and there are serious concerns at the depletion of aquifers (Milich and Al-

Sabbry, 1995: 5). But from the *qat* farmers' point of view, *qat* is an ideal crop: it is very profitable - on a land area basis, the returns are nearly 25 times that from grain crops (Ward, 2000: 18), risks of crop failure are small and it is less labour intensive than other crops (Milich and Al-Sabbry, 1995: 5). It is hardly irrational therefore for the farmers to have abandoned their traditional agricultural practices, described by Milich and Al-Sabbry (1995: 5) as "an environmentally sensitive, largely subsistence-based, agro-ecological system" considering the concept of "multiple rationalities" discussed above.

On a macro basis, *qat* has brought wealth to rural areas, and according to Ward (2000: 18) has saved many rural communities. However, the consensus is that there are negative health impacts from *qat* consumption, although the level of impact was uncertain. Possibly a greater concern is the long-term exposure to the pesticides used in cultivation (Milich and Al-Sabbry, 1995: 7). Arguable, in terms of sustainability, is the impact of *qat* on Yemen's economy given that the purchase of *qat* can take as much as 40% of income (Milich and Al-Sabbry, 1995: 7) and use of *qat* can occupy time that could be used productively and is a "brake on development"(Ward, 2000: 23)[3].

The issue of how people see sustainability is crucial in the context of a development project. Development practitioners often rely on local counterparts to provide not just translation services but insights to the way people in a village live and think yet, in my experience, the counterparts are typically middle-class, urban dweller and university graduates, sometimes have antithetical agenda, and are perhaps at times closer culturally to the overseas development practitioners than to the villagers. As will be discussed later in this chapter, methodologies have been developed with the objective of assisting practitioners to obtaining what Högger describes as "holistic understanding of livelihood systems" (2004: 37).

CRITICISMS OF THE SUSTAINABLE LIVELIHOODS APPROACH

A review of the literature suggested that the most common criticism regarding the sustainable livelihoods approach (SLA) was that it was over-complex. FAO (2002: 3) referred to comments that included "SLA is time and money consuming" and "... requires multi-disciplinary teams and specialist SL training" while Norton and Foster (2001: 14) commented that the "agenda is 'too big'". In a review carried out for DFID (Ashley and Carney, 1999: 12), issues related to the complexity of SLA were cited by

[3] As an illustration of the role that *qat* plays in Yemeni life, during one visit I made to Sana'a during 1998, riots broke out in the morning over the removal of subsidies on flour, kerosene and LPG and I was confined to my hotel. However, I was assured that the riots would finish by 2 pm as this was the time for *qat* chewing- and this proved to be accurate almost to the minute.

users as the most common weakness. But as Cahn (2002: 5) pointed out, complexity was inevitable given that peoples' livelihoods are complex.

Toner (2002) agreed with Cahn and stated that the complexity of SLA was in fact a strength. However, Toner (2002) expressed the concern that in practice, the use of SLA was rather simplistic with its use of tools and checklists. A response to this criticism could be that given the complexity of the SLA, many practitioners (including this writer) may find the use of tools and checklists essential.

While SLA was designed to work across sectors, this can be difficult in practice given that typically sectors are managed by different government ministries and departments (Cahn, 2002: 5).

As will be seen from my comments in Chapters 5 and 6, my conclusion is that SLA is a useful tool. It is not intended to replace traditional development practice and methodologies but rather to facilitate while maintaining the focus on people by putting them "at the centre of development" (DFID, 1999a: 1). The way a tool is used and the desired objectives are a matter for the user.

SUSTAINABLE LIVELIHOODS -APPLICATION IN PRACTICE.

The achievement of this people-centred objective may appear simple, only requiring a sincere and well motivated approach by an experienced development practitioner using well established procedures, such as participatory rural appraisal. Yet as noted above, livelihoods are extremely complex and are made up a number of elements - not just economic but also social, cultural and spiritual, factors that are very hard for outsiders, such as development practitioners, to understand (Högger, 2004: 36).

With this in mind, considerable efforts have been put into methods of analysis that will enable development professionals to apply the concept in practice and to provide the tools that are needed.

A pioneer in this field of research was Ian Scoones (1998: 3) who, in an attempt to develop a methodology for application, identified three key questions that should be addressed in respect to operational implications of a sustainable livelihoods approach:

- *How can you assess who achieves a sustainable livelihood and who doesn't? In other words: what are the relevant outcome indicators?*

- *What are the livelihood resources, institutional processes and livelihood strategies which are important in enabling or constraining the achievement of sustainable livelihoods for different groups of people?*
- *What are the practical, operational and policy implications of adopting a sustainable livelihoods approach?*

Scoones (1998: 4) proposed a framework for analysis developed by the IDS, which is reproduced here as Figure 1. This framework had five basic elements, all of which combine to influence the sustainable livelihood outcomes:

- Context - the pre-existing conditions that apply.
- Livelihood resources - the "natural" and other forms of capital available.
- Livelihood strategies - the ways and means by which livelihoods can be maintained or improved.
- Outcomes - the result of implementing the strategies using the capital available.
- Institutional processes - the institutions and organisations that influence access to capital and the livelihood strategies available.

This framework recognised the linkages between these elements and thereby suggested an approach to analysis.

In 1999, DFID published a series of guidance sheets (DFID, 1999a). These build on the work carried out by Scoones (1988) and the IDS team and others such as Chambers and Conway *(*1991).

As an aid to analysis, DFID developed the well known Sustainable Livelihoods Framework (DFID,1999b: 1) which is reproduced below as Figure 2.

The DFID framework is similar to the IDS framework (Scoones, 1998: 4) but emphasised more strongly the relationship between the structures and institutions involved in transformation and the necessary processes involved. Vulnerability, the reduction of which is a major factor in achievement of a sustainable livelihood, was also given greater emphasis by DFID. The framework introduced the "asset pentagon" in which five asset categories are identified DFID (1999b: 3). As will be seen, this is of particular relevance when considering the role of energy.

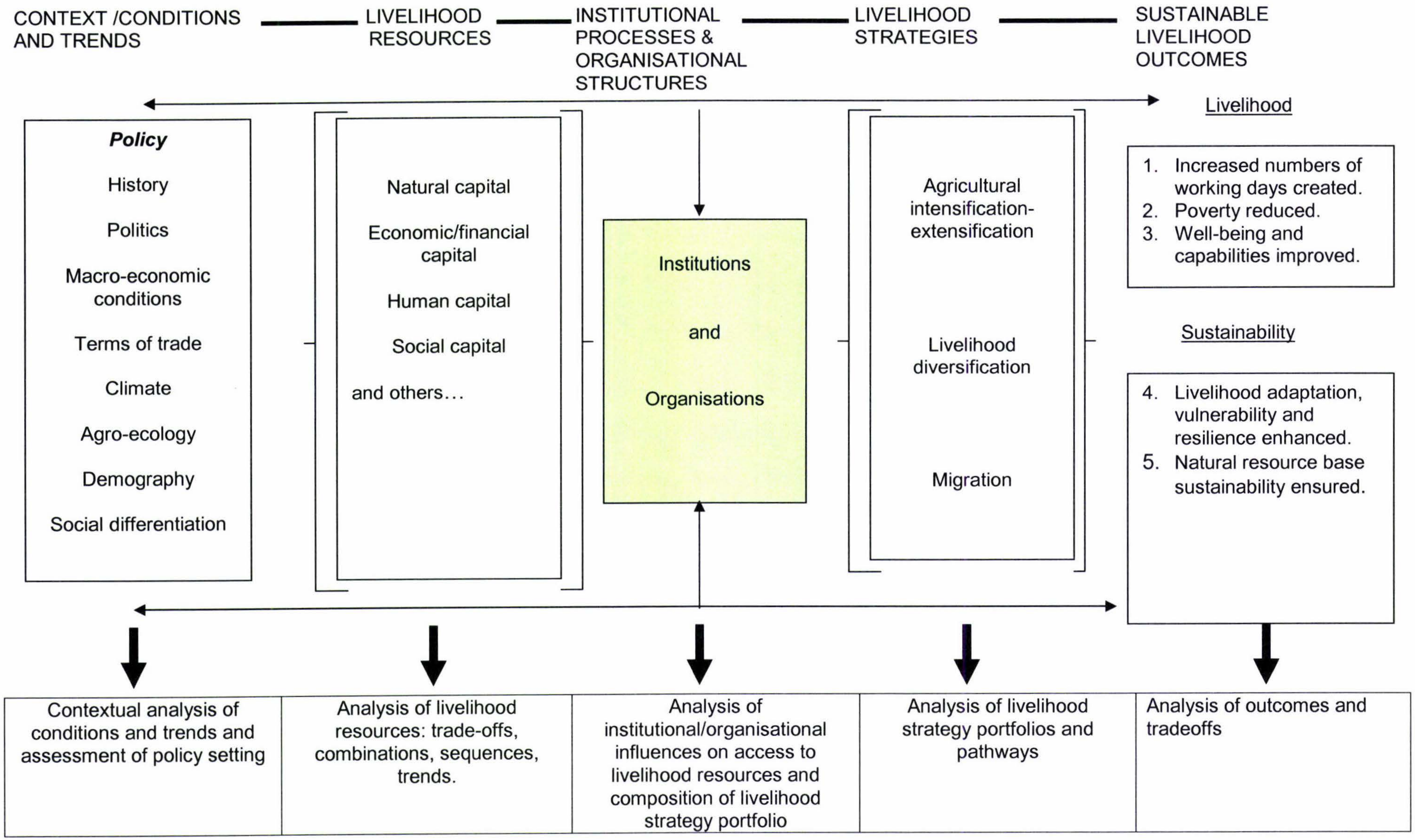

Figure 1: Sustainable rural livelihoods: IDS framework for analysis
(source: Scoones, 1998)

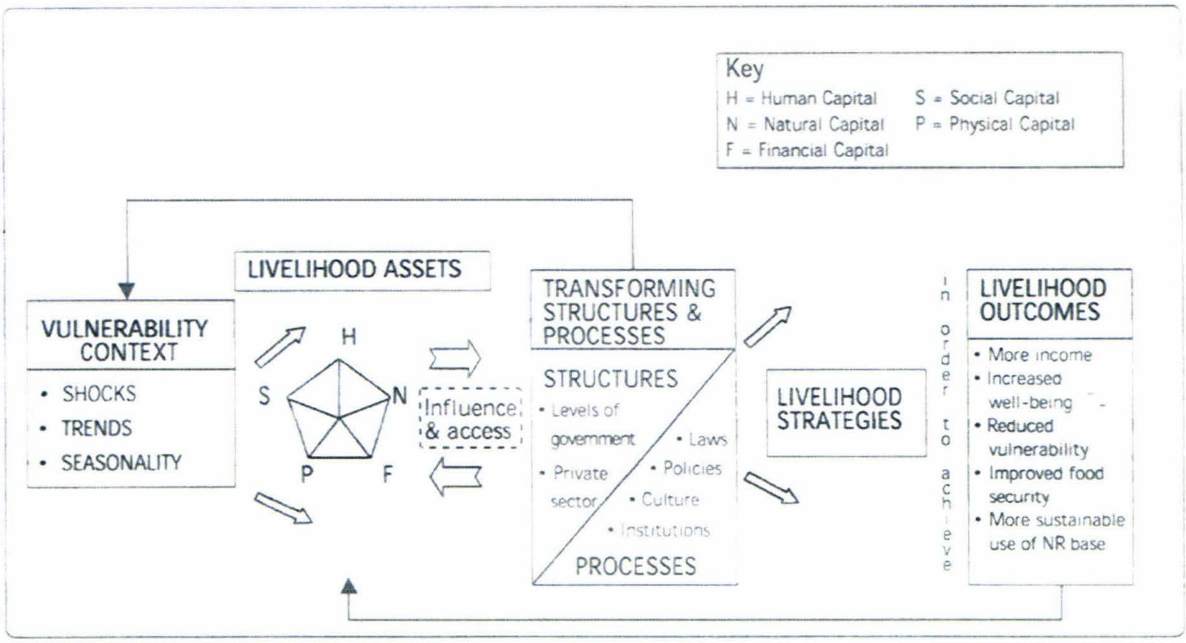

Figure 2: DFID Sustainable rural livelihoods framework

(source: DFID, 1999b)

Both frameworks are planning tools aimed at showing clearly relationships between factors that affect livelihoods. DIFD (1999b: 2) stressed that the framework is not intended to indicate a specific process; rather, it is intended to help understand livelihood relationships and to identify the critical factors. Other tools such as poverty, stakeholder and institutional analysis are still required as part of the sustainable livelihood implementation process (Ashley and Carney, 1999: 2).

Both these frameworks are notable in that cultural considerations are not given great emphasis. Yet, if we are to agree with Högger (2004), cultural considerations, including social structures and status and spiritual beliefs can dominate the way a community responds to a situation. This view was shared by Miranda Cahn (2002), who concluded that while the sustainable livelihoods approach had a number of commendable features and the DFID frameworks were useful tools, there was a lack of guidance on how culture and tradition can be incorporated into the livelihood system.

While agreeing with Cahn that the DFID framework did not give enough prominence to cultural and related issues, IFAD[4] has made the more fundamental criticism that the framework was not sufficiently "people-centred" with greater attention being directed towards assets than the poor themselves (Hamilton-Peach and Townsley, 2003). During a series of workshops, IFAD developed an alternative framework which is reproduced below (Hamilton-Peach and Townsley, 2003: 3):

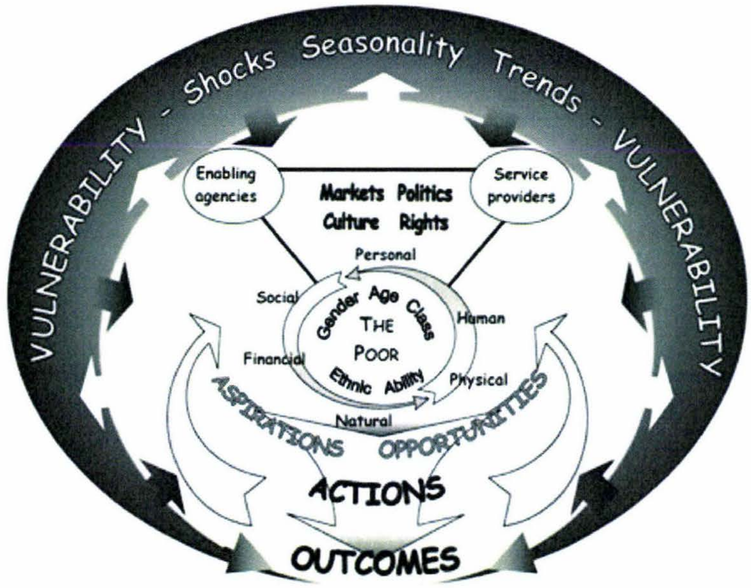

Figure 3: The IFAD Alternative Sustainable Livelihoods Framework

(source Hamilton-Peach et al, 2003)

The IFAD sustainable livelihoods framework included a number of changes to the DFID framework (Hamilton-Peach and Townsley, 2003):

- Linkages between the different elements were given more prominence and made more obvious.
- The poor were placed at the centre to emphasise the poverty-elimination objective of the sustainable livelihood approach.
- Certain key "processes" ie gender, age, class (or caste), ability and ethnic group, were shown around "the poor" in the centre of the framework to emphasise the influence these have on the linkages between the poor and other factors in the framework.
- "Personal' assets were added, these being factors that may affect the way people respond to change.

[4] IFAD: International Fund for Agricultural Development

These included beliefs - spiritual, cultural, political - and rights, this factor assuming more significance as poor people become increasingly aware of their ability to make demands on the institutional environment.

- Markets were included in the personal asset category on the grounds that markets influence the ability for people to sell produce or products, something not acknowledged in the DFID framework. I consider this to be a very important point: a lack of understanding of the importance of markets and marketing, competition issues and the private sector can result in the poor producing goods into an already flooded market and only able to obtain low prices or producing goods where there is no market, this situation being perpetuated by a lack of access to the financial and human capital that is required if the necessary livelihood changes are to be made (Dorward, 2001).

The criticisms that the DFID framework failed to provide sufficient emphasis on the importance of culture made by Cahn (2002) and Hamilton-Peach and Townsley (2003) may have some foundation. Yet, the DFID framework is easy to follow and the linkages between the factors that affect people's livelihoods are clearly shown. A useful compromise is along the lines proposed in the IFID framework (Hamilton-Peach and Townsley, 2003) but without the remodelling of the framework and this is to add the sixth asset category of "personal" assets to the five assets categories in the DFID framework. This will ensure that cultural issues are appropriately highlighted and analysed.

SUSTAINABLE LIVELIHOOD ASSETS

Referring to the DFID definition at the beginning of this chapter (DFID, 1999a: 1), assets (both tangible and intangible) are a critical component in a livelihood approach (Chambers and Conway, 1991: 7). Tangible assets are in effect available capital such as cash in the bank, natural resources such as land, water and trees, livestock and crops and personal or household possessions. Intangible assets include knowledge, social capital and access to assets and services owned by others, ranging from means of transport to the ability to grow crops or graze livestock on common land. The ability to make claims on other family members, governments and other agencies during adverse periods can be a critical intangible asset (Chambers and Conway, 1991: 7).

The sustainable livelihood approach assumes that a range of assets is needed if people are achieve sustainable livelihoods. Poor people often rely on a number of different assets, as access to a single asset category will be too limited to meet livelihood needs (DFID, 1999b: 3) and typically, income or livelihood diversity is an important if not critical factor (Elliot, 1999: 104). In Indonesia, for example, even people who by local standards are clearly "middle-class" and have a regular income, in my experience often find it necessary to seek other sources of income over and above their core employment if they are to enjoy a standard of living that is still modest by developed country standards. The DFID framework identifies five core livelihood assets:

- Human capital.
- Social capital.
- Natural capital.
- Physical capital.
- Financial capital.

To which I add a further asset:

- Personal capital.

Table 1 below provides a brief description of each core asset category:

Natural capital: The natural resource stocks from which resource flows useful for livelihoods are derived (eg land, water, wildlife, biodiversity, environmental resources) **Social capital:** The social resources (networks, membership of groups, relationships of trust, power and influence, access to wider institutions of society) upon which people draw in pursuit of livelihoods. **Human capital:** The skills, knowledge, ability to labour and good health important to the ability to pursue different livelihood strategies. **Physical capital:** The basic infrastructure (transport, shelter, water, energy and communication) and the production equipment and means which enable people to pursue their livelihoods. **Financial capital:** The financial resources which are available to people (whether savings, supplies of credit or regular remittances or pensions) and provide them with different livelihood options. **Personal capital:** The spiritual, cultural, political beliefs that influence a person's approach to life, a person's rights and access to markets (Hamilton-Peach and Townsley (2003).

Table 1: Sustainable livelihoods capital assets

(Adapted from Cahn, 2002: 3 and Carney, 1998)

No single asset category by itself can achieve a satisfactory livelihood and a range of assets (or access to them) is required (DFID, 1999b: 2.3). Furthermore, the assets are linked and any change in circumstances in one asset may impact on others. For example, a drought may result in reduced farm production which necessitates family members who normally work on the farm having to leave the household to find work elsewhere. A reduction in natural capital- ie the rain that provides the water to grow the crops - therefore leads to a reduction in human capital which the departure of one or more family members. Political change of a repressive nature could have far reaching effects not only in terms of personal capital but also of impact on financial and human capital. On the other hand, an increase in financial assets could lead to positive outcomes in terms of physical, social and personal capital.

Changes in energy supplies can impact on all six core assets and Table 2 below shows the linkages between energy and the six core assets.

ENERGY - A LIVELIHOOD ASSET

As discussed in Chapter 3, a source of energy is essential for human life at even a bare subsistence level. But if a livelihood is to be achieved that provides a quality of life that is beyond the mere subsistence level, then a reliable and affordable source of energy is an important asset in the form of an enabling input. Energy does not create a livelihood; rather, it contributes to the achievement of a livelihood in a similar way that energy facilitates development without actually causing it.

Using the DFID definitions, energy can be part of *natural capital* or *physical capital.* Natural capital is defined as "the natural resource stocks from which resource flows and services useful for livelihoods are derived" (DFID, 1999a: 3.3). The range of natural capital assets that can provide energy sources is wide and includes:

- Biomass - the main "natural capital" energy source including woods, twigs, leaves, crop residues, human and animal waste.
- Falling water - to generate electricity or to drive machinery.
- Solar and wind - to generate electricity.
- Geothermal energy - to generate electricity, to dry crops or to incubate eggs.
- Fossil fuels - "micro" natural gas fields, coal or peat (that can be hand-dug).

Some of these assets require financial capital to convert the resource to a form in which it can be used. For example, to generate electricity from falling water, solar radiation or wind requires investment in generator plant (Barnett, 2001: 2).

On the other hand, others may only require the simplest form of apparatus that can be homemade – for example, the *tannur* or open oven, used in the Middle East, which can be made out of mud.

ENERGY ASSETS	**HUMAN CAPITAL** INPUT TO ENERGY: • Human resource to provide and maintain energy supply OUTPUT FROM ENERGY: A reliable energy supply can: • Lead to new employment opportunities. • Facilitate education through better lighting, introduction of computers. • Improve healthcare through better lighting, refrigeration, use of diagnostic and treatment equipment. • Improve access to communications and information. • Improve physical security. • Save labour. • Extend mobility.
	NATURAL CAPITAL INPUT TO ENERGY: Energy resources from: • Biomass. • Winds, falling water, sun. • Local fossil fuel supplies
	FINANCIAL CAPITAL INPUT TO ENERGY: • Access to financial investment to develop/utilise energy resources OUTPUT FROM ENERGY: A reliable energy supply can result in: • New or improved household incomes from new employment opportunities. • Improved incomes through development of new skills from improved education.
	SOCIAL CAPITAL INPUT TO ENERGY: • Access to energy resources and associated technologies. OUTPUT FROM ENERGY: A reliable energy supply can: • Facilitate development of new skills from improved education. • Facilitate access to technology. • Increase social interaction.
	PHYSICAL CAPITAL INPUT TO ENERGY: Supplies of energy from external sources: • Electricity • Fuels- household, transport and industry
	PERSONAL CAPITAL OUTPUT FROM ENERGY: An energy supply can: • Improve communications from and to the household (radio, TV, telephone). • Facilitate education and communication skills. • Facilitate obtaining of market information. • Facilitate sociality.

Table 2: Linkages between energy and other livelihood assets

(adapted from Barnet,2001: 2)

In sustainable livelihood terms, access to these sources of natural capital is critical if the resource is to have any value. While lack of financial capital is an obvious (and common) factor, other factors include who has control of the resource. A landowner who controls a river may divert the water to irrigate land, depriving a community of the water for a micro-hydro generating plant. Similarly, a forest owner may mill the trees, thereby depriving a community of a fuelwood source, or a change in government policy may make a forest off-limits to a local community, such as the arbitrary designation of an area as a national park.

Biomass from forests and fossil fuels are susceptible to over-exploitation which may occur for a variety of reasons within or without the control of a community. While the exploitation of forest resources can be carried out in a sustainable manner - at least up to a point - a fossil fuel resource will ultimately be exhausted.

In addition to these human-driven factors, natural capital assets are especially vulnerable to natural disaster. A drought will result in reduced or zero water flows to micro-hydro plant while other adverse weather conditions may reduce the power generated from wind or solar generators. In the case of geothermal activity, earthquakes have been known to result in hot springs ceasing to produce water and steam fields producing steam. These adverse factors all form part of the vulnerability context as shown in the DFID framework. This is defined as framing "the external environment in which people exist" and over which they have limited control (DFID, 1999b: 2.2).

DFID (1999b: 2.3.4) defines physical capital as comprising "the basic infrastructure and producer goods needed to support livelihoods" and as including "clean, affordable energy". In practical terms, this includes the supply of electricity and other fuels for household, food production, income generation, transport and communication purposes. While in some cases, these needs will be partly met from natural capital assets, it is rare in my experience for natural capital assets to meet all these needs if other than a very basic standard of living is to be achieved and certainly not to the level that could meet the definition of a sustainable livelihood.

Typically, the energy assets classified as physical capital are provided by others, either government or local government or (increasingly) by private enterprise. As such, in the majority of cases people have to pay for this asset and while in the past, government subsidies have to a degree shielded people from paying the "true" cost of supply, increasingly subsidies are being reduced or removed.

For example, and as will be discussed in Chapter 3 in more detail, in late 2005, the price of kerosene in Indonesia increased from Rp 1,500 (US 15 cents) to Rp 4,000 (US 40 cents) while petrol increased from Rp 2,450 (US 24 cents) to Rp 4,500 (US 44 cents), increases of nearly 300% and 100% respectively (BBC, 2005).

Given that kerosene is a major source of energy for cooking and lighting in non-electrified households, the impact of the kerosene cost increase in particular will obviously be significant and coupled with the potential for substantial increases in the price of electricity resulting from similar increases in the price of diesel, this is an example of a "shock" within the "Vulnerability Context" as shown in the DFID framework in Figure 2 above, a shock being defined as an impact on people's livelihoods over which they have no control (DFID, 1999a: 2.2).

One way of dealing with an economic shock of this type is to stop using the asset and substitute another source of energy that is available and affordable, eg to revert to fuelwood for cooking purposes. While clearly a health and often an environmental negative in terms of maintaining a sustainable livelihood, there may be no other immediate solution.

If an energy supply is to have a positive impact on achievement of sustainable livelihoods, it must have a number of characteristics that minimise vulnerability and maximise people's control. Table 3 over sets out *sustainable livelihood potential* criteria for evaluating energy supplies, based on four key issues:

- Access to energy supplies, including physical and financial accessibility.
- Ownership and/or control of the energy assets.
- Sustainability of the energy source and supply – environmentally and economically.
- Relevance - the energy supply must meet people's needs and be acceptable in terms of culture.

These criteria will be used initially in Chapters 3 and 4 to carry out a preliminary evaluation of the various forms of renewable energy and in Chapter 5 when analysing the results of the field work.

ISSUES	SUBSETS	COMMENTS	INFLUENCES/ VULNERABILTIES
ACCESS	Physical access	Includes access to a resource, ie natural capital (eg biomass), or an external supply, ie physical capital (eg grid connected power supply).	• Government policy or regulation- can be negative or positive. • Where natural capital resource is on private land, owner can terminate customary or long-standing access. • Natural capital can be subject to seasonality or natural disaster.
	Financial	Includes both the ability to pay for externally supplied energy and the initial capital cost of equipment to permit use of local resources.	• Cost of externally supplied energy. • Where using local resources: - Availability of capital funding. - Cost of energy conversion plant and servicing debt. - Cost of operating plant.
OWNERSHIP/ CONTROL	Institutional arrangements	Householder or Community management versus external management.	With external control (government or private sector): • energy supply can be terminated or cost increased without justification; • no guarantee of equitable distribution of benefits. With local control, appropriate community based organisations should be in place to ensure efficient and equitable operation.
	Human resources	Availability of skills to manage and operate the energy supply system.	This can be a challenge with locally controlled supply: • Level of technology must match typical rural skill-base. • Capacity building must be part of any energy project.
SUSTAINABILITY	Environmental	Impact of energy supply system on environment.	Includes: • Local ecosystem- eg deforestation. • Harmful air or water emissions. • Nuisance- such as excessive noise, visually offensive, smells. • Global impacts- eg use of fossil fuels
	Economic	Ability of energy supply system to pay its way.	• External supplies using fossil fuels are subject to market pricing. • In the case of locally supplied energy, effective management must be in place to ensure appropriate pricing, bills are paid and effective energy metering. • Subsidies from government or other agencies are rarely sustainable in the long term.
RELEVANCE	Social	Ability of energy supply system to meet social needs such as health, education, employment and income generation as well as basic needs.	Energy supplied may be limited in respect to: • Application. • Capacity. • Reliability.
	Cultural	Traditional cooking methods will have been developed to suit local food sources.	
	Safety and Health	Energy supply system must not present a safety or health risk to operators, users or the community at large	Safety and health risks associated with energy systems include: • Fire and explosion. • Toxic emissions (gaseous and liquid). • Physical injury due to lifting, burns, electric shock.

Table 3: Energy supplies- sustainable livelihoods potential criteria

CONCLUSIONS

While being derived from the concept of sustainable development, the sustainable livelihoods approach is aimed at putting people at the centre of development; it is way of thinking and understanding people's - and particularly poor people's- livelihoods (DFID, 1999a: 1.1). It recognises the importance of looking at issues from a poor person's perspective rather than that of the development practitioner, thereby providing an opportunity for an improved understanding of the issues and a better chance of resolving them (Hiremath *et al*, 2004: 101).

However, there are difficulties with application, not the least being the sheer complexity of people's livelihoods. Another difficulty is the meaning of "sustainability": as this chapter has argued this has different of meanings in different contexts - environmental, social and economic. In the environmental context, simplistically this means only using resources at a rate at which the resource is naturally replaced. But for example, if a community has a small gas field or coal mine, the resource is clearly not sustainable. On one hand, it could be argued that the resource must be used very sparingly so that some is left for future generations or alternatively, it could be argued that the resource should be used as necessary to improve livelihoods immediately on the grounds that this is the first priority and what chance will future generations have anyway, if this current generation remains in poverty? The answer no doubt comes back to the need to see the issue from the community's point of view. Social sustainability is another complex issue which can be difficult for a development practitioner to reconcile - for example, when working with communities that impose strict exclusion on women thereby significantly reducing the human capital of the community.

The DFID and IFAD frameworks are aimed at helping development practitioners to understand livelihoods. While the criticism that the DFID framework does not give culture and markets sufficient prominence, it is clear and well structured and well backed up with the series of guidance sheets (DFIDa, 1999). The framework is readily modifiable as shown by the work of Cahn (2002) and Dorward (2001). The livelihood asset arrangement lends itself well to identifying the role of energy. For these reasons, I propose to use the DFID framework as a tool for livelihoods analysis, modified by the addition of the "personal" capital asset to enable better recognition of cultural issues. In Chapters 5 and 6 I will comment on the application of the framework and any identified strengths and weakenesses.

The linkages between sustainable livelihoods and energy are clear. Furthermore, the sustainable livelihoods approach is a useful means of evaluating an energy supply and its relevance for, or to, a community. This is because it facilitates a genuinely thorough understanding of a situation, not just, for example, the environmental and economic sustainability factors that in my experience are often used to assess an energy supply.

CHAPTER 3: CASE STUDY- THE KERINCI VILLAGES

INTRODUCTION

The Kerinci Valley is located in the *Kabupaten* or Regency[5] of Kerinci in the far west of Jambi Province in central Sumatra (refer Figure 4 over). Much of the Regency's population lives in the Kerinci Valley, which has an economy almost entirely based on agriculture, notably rice growing supplemented by cash cropping. The study site comprises six villages in the Kerinci Valley which rely mainly on rice growing and livestock raising for livelihood purposes. Of these six villages, three form part of a development project[6] funded by NZAID where geothermal energy will be used for agricultural processing.

In terms of average per capita income, reported to be around $US550 per annum (Kerinci Regency, 2004: 37) or $840 in New Zealand dollar terms[7], most people in the regency can be classified as poor, but with the high soil fertility and the good rainfall that prevails, lack of food is not a primary concern. Rather, it is the very basic lifestyle that most people experience and not surprisingly, it was clear from discussions during my field visits that most people want a better quality of life, if not for themselves, at least for their children. Of particular concern at both official (ie local government) and household levels are the limited opportunities for young people to obtain employment that will help in the achievement of this desired better quality of life.

This chapter is in two sections: the first section will be an overview of the Kerinci Valley in terms of geography, politics, economics, energy resources, social conditions and culture, these forming the overall context in which the people in the six villages live. The second section will be a profile of the six villages with particular reference to people's livelihoods and the part that energy plays. In the general context of this thesis, the renewable energy resources available in the locality will be identified.

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[5] A regency is an administrative subdivision of a Province (*Propinsi)* of Indonesia

[6] "Using Geothermal Heat For Small Scale Agricultural Use In Indonesia" funded by the New Zealand Agency for International Development (NZAID) as part of the Asian Development Assistance Facility (ADAF). This is referred to throughout this thesis as the "ADAF geothermal project".

[7] Throughout this thesis, the symbol "$" shall mean the New Zealand dollar except where the US dollar is used, this being indicated by "$US". The rate of exchange used is $NZ1 = $US0.6547, this being the average rate of exchange from 1/10/05 to 30/09/06 (RBNZ (2006).

I conclude that while the people who live in the six villages are fortunate in that they live in a location that enjoys a benign climate and fertile soil which means that most if not all have enough to eat, a number of negative factors apply and as a consequence, there is little opportunity for many people to improve their livelihoods to much above subsistence.

The lack of adequate and affordable energy supplies is identified as one of the barriers to improved livelihoods in that this lack limits people's opportunity to increase incomes either from traditional farming activities or from new employment opportunities. In fact, recent price increases for kerosene, the main source of household energy together with electricity, have had a major negative impact on livelihoods by forcing the majority of households to revert to woodfuel for cooking purposes.

THE KERINCI VALLEY- A PROFILE

GEOGRAPHICAL AND POLITICAL CONTEXT

The Kerinci Regency has a land area of 420,000 hectares with much of the land available for agriculture being located within the Kerinci Valley, which was formed by a subsidence in the Bukit Barisan mountain range. The average height of the valley is around 700 metres above sea level, resulting in a moderate temperature range of 18 to 26°C even though the valley is only about 2 degrees south of the equator. With an annual rainfall of up to 2,000 mm and a fertile soil, the Kerinci Valley is ideally suited for agriculture (Watson, 1992: 1).

Kerinci[8] is best known internationally for the Kerinci-Seblat National Park (KSNP), which is classified by both UNESCO and ASEAN as a Heritage site. The Valley is an enclave in the KSNP, this having a direct impact on the local population in that it limits the amount of land available for agriculture. On the other hand, as is discussed below, the presence of the KSNP and the tourism it attracts is a source of employment, possibly with considerable future potential.

The Kerinci Regency is one of six in the province of Jambi and has a population of approximately 300,000 of which 280,000 live in the Valley (Lushli, 2000). According to

[8] I will use the term "Kerinci" as meaning the general area in which the six villages are located. The study site lies within the "Kerinci Valley" which is the geographic area, and is part of the "Kerinci Regency", the political area.

the Kerinci Regency Investment Profile (2004:36), the average population growth in the immediate period to 2003 was 0.54%.

The administrative head of the Kerinci Regency local government is the *Bupati* or Regent. There is an elected local assembly forming the political arm and both the Regent and the assembly sit in the main town of Kerinci, Sungai Penuh.

Figure 4: Map of Kerinci
(from Burgers, 2004)

In terms of infrastructure, Kerinci is reasonably well served. There is a tar-sealed road network linking most villages with Sungai Penuh and other towns. Electrification is widespread, but as will be discussed later, the system is inadequate in capacity and can no longer meet existing demand for power, let alone any future increase. The telephone system is good with public telephone facilities located in many villages and a cellular network serving Sungai Penuh and the larger towns. However, with the exception of Sungai Penuh, most households do not have a piped water supply or even a basic sewage disposal system.

THE ECONOMY

The importance of agriculture in Kerinci becomes obvious during the six hour drive from Padang to Sungai Penuh. As one enters the regency passing through the hill country to the north of the Kerinci Valley, there are tea plantations and fields of cabbages, potatoes, tomatoes and similar crops while in wooded areas, the distinctive red leaf of the cinnamon tree is a common site. Once in the valley, rice fields stretch on each side to the foot hills of the Barisan mountain range, interspersed with small plantations of coconut and banana palms. On the foot hills, or uplands, vegetables such as chilli are grown together with potatoes, coffee, fruit trees and cinnamon. Livestock including cattle, goats, sheep and poultry are reared for meat and in the case of poultry (and particularly ducks) for eggs. According to the Regent, over 70% of the population are engaged in agriculture and over 80% of the regency's economy is based on agriculture[9].

Crop farming accounts for about 90% of agricultural activity in Kerinci, the remaining 10% being in livestock raising (Yanuar, 2005: 5). Crop farming in Kerinci can conveniently be divided into two categories: rice growing, which mainly takes place on the wetlands that form the valley floor and which is primarily for feeding the farmers' own households, and cash cropping which mainly takes place on the uplands on land that was originally forest.

The growing of cash crops on the Kerinci uplands has historically been the principle means of implementing the strategies of consolidation and accumulation, with cinnamon and coffee as the "star performers" as can be seen from table 5.

Product	Land area (Ha)	No of Households involved in cultivation
Cinnamon	50,769	25,151
Coffee	12,841	7,513
Cloves	253	308
Rubber	256	267
Coconut	124	1,019
Tobacco	170	156
Kemiri	939	2,560
Potato	803	*no data*
Chilli	597	*no data*
Kacang merah	114	*no data*

Table 5- Main types of cash crops cultivated in Kerinci
Source: Badan Pusat Statistik Kerinci, 2001 (from Burgers (2004)

[9] From meeting in Sungai Penuh on 11 December 2004.

Unfortunately, the international market prices for cinnamon and coffee have collapsed in recent years. The disappearance of good prices for cinnamon in particular has severely impacted on Kerinci's economic development, particularly with coffee also experiencing poor cash returns.

With the collapse of prices for the two main cash-crops, farmers have been forced to look to other livelihood strategies, migration being one such strategy, mainly involving women (Bergers, 2004: 85). It is estimated by the regency government that over 6,000 people from Kerinci are working either legally or illegally in Malaysia sending home over $US350,000 a month through official banking channels, plus possibly twice as much more in cash. According to the Regent, this is seen by many people as the only way to improve a family's standard of living but obviously involves a big personal sacrifice for both the individual and the family.

The other major player in the economy is the government sector, national and local, which provides employment over a wide range of activities from the army to health workers. While government sector workers are not well paid, they are nevertheless regarded as well-off as they have a regular source of primary income which typically is supplemented from other activities including, for example, farming. Based on information in the Kerinci Regency Investment Profile (2004) and employment data from the villages, I estimate that Government sector workers account for about 8% of the total number of people in employment.

The private sector provides incomes across a wide range from relatively well-off building contractors and transport operators to people eking out a living by setting up small stalls selling foodstuffs, such as duck eggs, fruit and soft drinks decanted from larger bottles. There is very little manufacturing or food processing other than small amount of mining and an abattoir.

Economic Development

The Kerinci Regency has prepared an economic development plan and from discussions with the Regent and his staff, the priority is to increase employment opportunities within Kerinci particularly for young people, which are extremely limited at present. Options available to young unskilled men are particularly limited and typically this group has to resort to seeking work in Padang or Jambi, in palm-oil plantations outside the province or as illegal migrants in Malaysia or elsewhere in the region.

According to the Regent, food processing and other industries associated with agriculture are identified in the regency's economic development plan as a priority since not only would this result in added-value in terms of locally generated income but would also create employment. The lack of electricity generation capacity is viewed by the Regent as a major impediment to the achievement of the development plan - according to the Regent, while generation capacity is 130 MW, estimated demand is 180 MW, ie a deficit of 50 MW. While studies have been carried out by potential private investors on the possibility of exploiting the geothermal and hydro-electric resources that exist in Kerinci, these have come to nothing and with PLN, the national power company under severe financial stress, the probability of any immediate upgrade is considered low[10].

Agriculture is clearly going to continue to be the dominant contributor to the Kerinci economy for the foreseeable future if only the reason that there is very little alternative for most people in terms of sources of livelihood. This fact is recognised by the regency and, as noted above, an objective of the regency's development plan is to add value by introducing downstream processing of the crops that are grown. There are obstacles to this objective, one being the lack of electric power capacity, but at a more fundamental level, from my observations during field visits, much of the farming is undertaken with very little mechanisation. Minimal processing of produce takes place, other than sun-drying of crops such as rice, cinnamon, chilli, coffee, sweet corn, fish (from rivers and lakes) and the like. Refrigeration facilities are understood to be virtually non-existent and therefore there is no alternative to sun drying as a means of preservation, characterised by high levels of spoilage.

The other priority for economic development is tourism associated with the National Park and the Kerinci Investment Profile (2004) identifies a number of sites with tourism potential. But again, the Regent expressed frustration that lack of an adequate power supply had discouraged potential investors[11]. From all accounts, tourism to date is limited to the niche "nature-tourism" market involving international tourists who are prepared to accept relatively basic accommodation, their main interest being to explore the National Park. This category of tourist typically leaves the smallest amount of cash in the local economy.

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[10] From meeting with the Regent on 28 March 2006
[11] *ibid*

THE ENERGY SUPPLY SITUATION IN KERINCI

As discussed above, the lack of an adequate power supply was identified by the regency government as a major impediment to economic development. The purpose of this section is to provide a brief outline of energy supply and energy resources in Kerinci, this being relevant to people in the six villages in that it has a direct impact on their livelihoods in terms of power supply for households and employment opportunities generally.

Energy supply

From discussions during visits in 2004 and 2006 and from the absence of any mention in the Kerinci Regency Investment Profile (2004), it is understood that there are no oil or gas fields in Kerinci. Other than the biomass (mainly woodfuel) which is used extensively for cooking, Kerinci is entirely reliant on petroleum-based fuels brought in by road from outside the regency.

Over the past two years, central government has progressively reduced subsidies on petroleum based fuels. In October 2005, the prices of gasoline and diesel doubled while that of kerosene nearly tripled (Sipress, 2005). In Kerinci, one consequence has been a switch from kerosene back to woodfuel[12], the impact of which is discussed below in the context of the six villages and the impact on livelihoods there. To a degree this has been forced on the government by the fact that Indonesia has been a net importer of oil products since 2004 (US Embassy Jakarta, 2006:23) and to be fair, central government has attempted to ease the financial burden imposed on poor households following the removal or reduction of subsidies by providing a means-tested cash benefit *(bantuan langsung tunai)* of Rp100,000 ($16) per month.

All electricity is generated in Kerinci using diesel-powered plant and given that the tariff is apparently remaining at levels set in early 2005 until 2007, it is clear that the price is subsidised. This has evidently put huge financial stress on the state-owned supplier of electricity, PLN, while also deterring potential private sector power producers from investing in new power generation (Situmeang, 2005)[13]. Kerinci is no exception and, as

[12] In Kerinci, the retail price rose from about Rp1,500 to Rp4,000 per litre.

[13] The current of electricity price is approximately 30 cents per kWh (late 2006). Based on the diesel price that was current in March 2006 of 60 cents/litre, I estimate that allowing for operating and maintenance costs and depreciation, the actual cost to PLN is in the order of 40 to 50 cents/kWh. This no doubt contributes to the parlous state of PLN's finances and its unwillingness to invest in new plant and distribution equipment on one hand and the reluctance of private investors to become involved in power generation.

noted above, is suffering from a lack of recent investment in upgrading the power supply system.

Energy Resources

While not possessing any identified oil or gas reserves, Kerinci has other energy resources available in the form of renewable energy. Only one of these, woody biomass, is used extensively in the form of woodfuel for household cooking following the increase in the price of kerosene discussed above. Urban households generally buy wood as do wealthier rural households or households in villages which do not include woodfuel resources. In villages that include forested uplands, wood is typically gathered from the forests by poorer households while in villages where boundaries do not include uplands, people, wealthy and poor, have little option other than to buy their woodfuel.

From discussions with LTA during my March 2006 visit, it was understood that there was no shortage of wood. However, given that much of the wood for sale was cinnamon apparently cut by cinnamon farmers to gain some income while cinnamon prices were low, this raised the obvious question as to how long this source would continue to be available before it ran out. During my November 2006 visit, there was evidence that wood supply was starting to come under some stress, the price of woodfuel having doubled over a period of seven months.

In addition to woodfuel, other identified renewable energy resources in Kerinci are:

- Biomass waste - crop waste (mainly rice straw), animal waste.
- Geothermal.
- Hydro-power.

These resources are understood to be fairly widespread throughout Kerinci and all of these resources can be used with conversion technologies - ie the process and equipment that can convert the energy source to a useful form such as heat or electricity - which can be operated and managed by a typical rural community.

While I have not been able to find any meteorological data for the Kerinci Valley, I have concluded from discussions with LTA, local government officials and the villagers that the wind resource appears to be below that considered viable for power generation, this being a function of average wind flow and the capital cost involved in the installation of the wind turbine and associated equipment[14]. I believe a similar situation exists with solar photovoltaic (PV) with the climate being reported as being relatively cloudy and certainly that has been my experience during my three visits. Solar PV power generation equipment is expensive[15] and I consider that solar PV power generation is unlikely to be financially justified except possibly for specialist low-demand applications such as telecommunication equipment in remote locations or village health post refrigeration. While solar hot water panels are less expensive, there is very little demand for hot water at household level.

Figure 5: Kerinci Villages- Geothermal Hot Spring (Sungai Medang)

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[14] The amount of power produced varies with the cube of the wind speed (ITDG, 2000: 3) and while wind generators can produce power at wind speeds of 4 metres/second, the amount of power produced at 7 metres/second will be five times greater. Given that the initial cost is the same regardless of wind speed, the average wind speed at a given site will determine the economics of wind power and enable a comparison with other energy resources. A typical rule-of-thumb is that the average wind speed should be in the order of 6 metres/second to justify the initial capital expenditure and to be competitive in economic terms with diesel generation.

[15] High global demand is keeping the cost of solar PV panels high (Jones, 2006:35)- a panel rated at 1 kW power output will cost in the order of $12,000. Based on a 25 year life, the cost of power produced is estimated to be in the order of 70 cents/kWh.

Figure 6: Kerinci Villages- Cinnamon Trees on Uplands

THE SIX VILLAGES

VILLAGE PROFILES

The village profiles in this section are based on a number of sources:

- In the case of the three villages that form the ADAF geothermal project (referred to as the "geothermal villages"), a socio-economic survey was undertaken by LTA in 2004 (LTA, 2005) followed by a baseline survey undertaken by LTA (2006) in 2006 in which sample information on household income and expenditure was obtained for the three villages.
- Information obtained during several visits to the geothermal villages including village meetings in November 2004, March/April 2006 and November 2006.
- Information obtained during visits to the other three villages including village meetings in November 2006.
- Official village statistics (*Monografi Desa*) (BPDSDKT, 2006)

The six villages are located within 10 km from Sungai Penuh and Table 5 sets out some basic statistics:

Village	Land Area (Hectares)	Number of Households	Population (2004)
Geothermal villages:			
Air Panas Baru	3,000	127	620
Sungai Medang	300	427	1,658
Sungai Tutung	1,350	844	3,782
Other villages:			
Muara Jaya	312	313	1134
Muara Semerah	5,211	510	1,980
Paling Serumpun	200	330	967

Table 5- Basic demographic data for the six villages

(from LTA (2005) and official village statistics (Monograph Desa)

In the case of the three geothermal villages, the baseline survey of 110 households across the three villages (LTA, 2006) indicated that the average per capita income was in the region of $500- about 60% of the average of $840 for the regency (Kerinci Regency, 2004:37). However, it is understood that the most wealthy households were excluded from this survey, ie it was skewed towards middle and low income households. It is likely therefore that the true average will be higher than $500. The average annual income per household was found to be $1,220. No data is available for the other three villages, but from the village meetings and transect walks, I formed the strong impression based on housing conditions in particular that the economic status of these villages was no better than the geothermal villages and in the case of Paling Serumpun, probably significantly poorer.

The People

According to LTA (2005), the villages are mainly populated by Minangkabau people who make up the largest ethnic group in Kerinci (Natividad and Neidel, 2003). Other cultural influences in Kerinci include Javanese and Chinese, these being a consequence of the Dutch bringing in labour from Java for the tea and coffee plantations (mainly located in the north of the regency) and Chinese as soldiers (Natividad and Neidel, 2003: 5), following colonial rule which in Kerinci's case, did not commence until early in the 20th century (Watson, 1992: 5).

The Minangkabau *adat*, or system of customary law and traditional practices, still has a strong influence in the villages and other Minangkabau communities throughout the

Kerinci Valley, although application may vary from community to community (Natividad and Neidel, 2003:5). Village life is governed by two parallel lines of authority: the traditional *adat* through customary chiefs and the civil law system through a village head. Customary law governs the way in which people relate to one another during day to day life including issues such as inheritance, marriage and access to land (Aumeeruddy, 1994: 8).

A village or *desa* is based on geographic boundaries for government administrative purposes while the jurisdiction of a particular customary leader may cover families in two or more villages. For example, a family may have moved from one village to another but still have ownership in whole or in part of land in their original village which will be subject to customary law (Burgers, 2004: 93).

In addition to the bonds of kinship that form the core of the *adat*, there is strong sense of community in the villages based on *Gotong Royong* which was defined by Martaamidjaja and Rikhana (1996) as "Indonesia's traditional spirit of mutual help among members of a community". An example of *Gotong Royong* is the concept of *kelompok* which can be loosely translated as meaning a group sharing a common interest or objective and which is common in many parts of rural Indonesia. In the ADAF geothermal project, *kelompok* have been formed in the villages to operate and manage the incubators. While a *kelompok* does not have any legal status or powers (as would be case with a cooperative, for example), it has the ability to exercise powers of reward or sanction on members. In the context of a development project, if the project is seen as being of benefit to the community as a whole, the setting up of *kelompok* can be a useful and self-regulating tool.

Islam has a strong influence in Kerinci and the villages are no exception, as indicated by the number of mosques which appear in some cases to be almost next door to one another. Our NGO colleagues are devout Muslims while espousing considerable tolerance to the views and beliefs of other religions and beliefs. In line with Indonesia's constitution which separates state and religion, the influence of the local religious leaders *(imam)* appears to be restricted to matters of religion - for example, during the field visits, the local *imam* did not appear at village meetings nor did it seem that their views were sought on village issues.

Gotong Royong is complimented by *zakat*, the obligation of all Muslims to give alms to those in need. From my observation, the most overt example of *zakat* working in the village environment was that the village poor, often elderly widows, while living in ramshackle accommodation, do not starve as other villagers ensure that they receive food. In the ADAF geothermal project, a decision was made by the communities to donate 10% of profits from the enterprises to village funds in place to help these needy.

In respect to gender roles, women perform the main household tasks including cooking and, in one village, the collection of woodfuel. Anecdotally, although I have no facts to prove this, families are less willing to pay for girls to attend senior high school (which is neither free or compulsory) than for boys. On the other hand, according to LTA (2005), day to day farming tasks are shared equitably between men and women. During the village meetings, women participated fully.

LIVELIHOODS

The six villages are typical of the Kerinci Valley in that the majority of households are engaged in farming. However, from information in LTA (2005) and from village meetings, a large number of households have more than one source of income, a situation that, as noted in Chapter 2, is common in rural areas in developing countries. In the three geothermal villages, the survey by LTA (2005) showed that between 20 and 35% of the total population had more than one source of livelihood. In terms of the working age population, ie if we exclude children and the elderly, these percentages will be higher.

In five of the six villages, arable farming was determined to be the main source of income, the exception being Paling Serumpun where livestock raising in the form of cattle and buffalo was found to be the main source of income.

Other primary sources of income were identified as working for the government, working in the private sector and labouring. Secondary sources were similar - for example, a farmer whose primary source of income is rice farming will probably also raise livestock. However, a significant source of secondary income was reported to be remittances from family members working overseas or in other parts of Indonesia.

Considering each category of livelihood:

- *Arable farming* includes the growing of rice, vegetables, fruit, coffee and cinnamon. In the case of rice, which is grown by virtually every household, the primary purpose is for own household consumption. While in the geothermal villages, growing fruit, coffee and cinnamon on uplands was found to be an important activity, the other villages are almost entirely located on the valley floor so arable farming is restricted to rice growing plus small amounts of vegetables primarily for own household consumption.

- *Livestock farming* includes the raising of cows, buffalo, goats and poultry, mainly for meat except that in the case of poultry, egg production is the main objective.
- *Government* employment includes public servants, army and police.
- *Private sector* includes traders, contractors, house builders.
- *Labouring* includes working for other people for wages or in food - typically in rice cultivation.
- *Working as a migrant* includes either working in a neighbouring country, typically Malaysia and mainly involving women, or working in another part of Indonesia, an example being oil palm plantations in neighbouring provinces.

In a typical rural society, livelihood strategies can be expected to comprise three types of strategy: survival, consolidation and accumulation (Burgers, 2004:143). In implementing these strategies, access to land is critical for the growing of crops for one's own household consumption (ie for survival) and for sale as a cash crop (for consolidation and accumulation). In Kerinci and including the six villages, all the land suitable for cultivation is heavily utilised (LTA, 2005) with a variety of customary land tenure arrangements including extended family ownership, private tenure, share tenancy and fixed-rent tenancy.

Rice is still seen as the most important food crop and the ability to grow rice is a key component of a household's survival strategy on the premise that in hard times, being able to grow one's own food guarantees survival (Burgers, 2004:89). From discussions with various informants, this includes households who are relatively wealthy and have an income that is sufficient to buy rice and other food. Households that belong to the Minangkabau culture generally have the benefit of *sawah giliran*, rice fields that are owned by the extended family and to which access is shared on a rotational basis or *gilir ganti* (Burgers, 2004:63). Better off households may also own their own private rice fields (Burgers, 2004:144) which provides a further level of security. Non-Minangkabau households who do not own rice fields have to resort to various access strategies such as renting or share-cropping or labouring for wages with which to buy rice.

The relatively wealthy households are typically headed by someone (usually male) having a government job such as in the police, army or as a school teacher, and with access to either privately owned or family-owned land for rice and crop growing.

Discussions at the village meetings and with LTA identified a number of barriers to increasing household incomes in the villages. These included:

- Lack of land suitable for agriculture - (remembering that the Kerinci Valley is an enclave in the Kerinci-Sablat National Park and clearing forest land to create more land for agriculture is now strictly illegal).
- Lack of financial capital - or lack of access to financial capital.
- Poor prices on the international markets for the main cash crops of cinnamon and coffee.
- Inadequate and unreliable electricity supply - while this was regarded by the villagers as primarily a quality of life issue, if the views of the local government are to be accepted, this factor is also inhibiting the development of new employment opportunities.
- High cost of petroleum-based fuels - in particular kerosene.
- 100% reliance on sun-drying for crop preservation, largely because of the high fuel costs, this reportedly resulting in an estimated 25% loss of produce.

Access to rice field land varies from village to village. In Air Panas Baru, access is restricted because a significant proportion of this land is owned and farmed by people from other villages. The land that is owned within the village is family land, ie is owned by extended families and access is on a "by-turn" basis. In the case of Sungai Medang, families within the village own most of the land and again access is by turn, while in Sungai Tutung, most of the land is owned by individuals. In Muara Semerah, 20 to 30% of households own rice fields, while the remainder have access by turn - but sometimes a turn may only occur every two years. In Paling Serumpun, nearly 50% of rice fields rely on irrigation, unlike most rice fields in Kerinci which are on natural wetlands, and following two years of lower than average rainfall, these irrigated fields are not in production in November 2006.

As noted earlier, uplands are used to grow a range of crops including cinnamon, coffee, fruit trees and vegetable cultivation, much of which is for cash, plus the raising of livestock. According to LTA, some of the uplands around the geothermal villages had become infertile, this possibly being a consequence of attempts in the 1960's to grow new upland varieties of rice on land that had been converted from forest, resulting in rapid soil depletion (Burgers, 2004:71). Good quality land is at a premium, leading to the temptation for farmers to illegally clear forest (ie National Park) land. On the other hand, some upland farm areas have been abandoned because of the low prices for cinnamon and coffee, particularly where access to or cultivation of the land is difficult.

Village buildings and facilities

According to the survey carried out in 2004 by LTA (ECL, 2005) in the three geothermal villages, about 80% of houses in the three villages are of sound construction, built using brick, stone and wood, the remaining 20% being in poor or dilapidated condition.

From my transect walk in November 2006, the proportion of houses in good condition in the other three villages appeared to be less and markedly so in Paling Serumpun. All villages except Paling Serumpun have a water supply to a community tap in the village centre although these supplies are not safe for drinking purposes without first boiling. Sanitation in the form of a sewerage system is non-existent; I understand that while many of the houses have septic tanks, many do not, the occupants using nearby streams for toilet purposes. It is probably not surprising therefore that diarrhoea is reportedly a big problem amongst children, particularly in the wet season (which lasts for eight to nine months of each year).

All villages have primary schools while Sungai Tutung has two junior high schools, providing nominally free and compulsory education to year 9, ie until the pupil is about 15 years old. However, According to LTA[16], various add-on charges that are made as the child moves in the last two or three years bring the actual cost to typically around Rp50,000 (approximately $US6) per month which can be beyond the reach of poor households and in these cases children do not attend, regardless of any nominal compulsion. Education beyond year 9 is neither free nor compulsory and in most cases only available to the better-off.

In Sungai Medang and Air Panas Baru, tourist facilities were built some years ago by the then local government based around the geothermal hot springs. These comprise swimming pools, bath-houses and accommodation. While happily used by villagers, during my visits there was no evidence of much use by anyone else and from all accounts, the accommodation is rarely if ever used.

[16] Communication from Rusdi Fachrizal dated 18 May 2006.

Employment Opportunities

From discussions with local government, LTA and during village meetings, it was clear that opportunities for employment in the villages outside of the farming sector are very limited. The most prized are in government positions which are limited in number and, I suspect, only available to families with good connections. Even the ability to gain a secure livelihood in farming will depend on whether the household has rights of access to land and the extent and security of that access.

In answer to a question on what would a young person with good secondary school qualifications do on leaving school, the answer given by all three informant groups was that they would have little choice other than to leave Kerinci to seek employment or, if they had access to funds, for further education in either a big city in Indonesia or overseas. For those with limited education - typically from poorer families who cannot afford to keep them at school beyond junior high school- opportunities are limited to working on the family farm if this is possible, labouring or as a motor cycle taxi *(ojek)* operator.

AIMS AND ASPIRATIONS (OR "NEEDS AND WANTS")

In each of the village meetings, the participants were asked the question "if you had additional income, what would be your priorities for using this income?" In the three geothermal villages, the response was the same:

1. To ensure that the household always has enough food.
2. Education for the children of the household – ie school fees for post-primary schools. Some participants specifically mentioned religious education.
3. To accumulate savings.

In the case of savings, different purposes were put forward including for capital to start up a business, to help survive a period of unemployment and for old age.

In the three "non-geothermal" villages, there was an interesting difference in that these villagers gave the purchase of woodfuel as the second priority followed by education and savings. This could have arisen for two reasons - firstly, in these villages most people have to buy their woodfuel rather than collecting as occurs in the geothermal villages and secondly, the timing of the question which was November 2006 as compared with March 2006 in the case of the geothermal villages, the price of woodfuel having increased substantially over the intervening period.

I also asked participants the question what are the three factors that could improve your lives the most- other than increased incomes, this being taken as a given. The answers were common to all six villages but not necessarily in the same order:

1. Better and more employments opportunities- especially for young people.
2. A return to cheap kerosene.
3. A more reliable power supply with improved capacity and greater availability.

ENERGY SUPPLY AND USE

HOUSEHOLD ENERGY

Household energy needs are met from three main sources:

- Electricity - from the Kerinci grid which is supplied from central diesel generator plant located in Sungai Penuh.
- Woodfuel.
- Kerosene.

In addition to the above, the hot springs in the geothermal villages are used to cook eggs and on an occasional basis, bananas and poultry. LPG is also used but only in wealthier households. Of these only woodfuel and geothermal can be regarded as coming from local sources.

Electricity

From the baseline survey carried by LTA (2006), the average annual power bill in the three geothermal villages was in the order of $70 per household, representing about 15% of income and 17% of expenditure. From discussions in the other three villages, a similar situation applies in these villages.

All six villages experience the same problems with the power supply as described above for the Kerinci Regency as a whole. Only between 50 to 60% of houses are connected to the electricity distribution system and there is a waiting list for connection to the supply. However, discussions at a series of village meetings I attended in March and November 2006 revealed that access to electricity is closer to 70 or 80% with many of those not connected to the "official" system being connected to a neighbour's mains power supply. These households pay their neighbours a fixed fee based on the number of lights connected, typically two 10 W bulbs[17]- but obviously these households cannot have a TV or other appliances. Kerosene lamps are used by households with

[17] The standard rate was reported as being Rp15,000 (about $NZ3) per month. The 10 W bulbs are compact fluorescent type and equivalent in light output to a 60 W incandescent light bulb.

no access to electricity. Of those connected to the distribution system, most use the power for lighting and TV while a small number of households have rice cookers[18]. It was clear from all the meetings that people in the villages regard access to electricity as very important and playing a major part in improving their overall quality of life. Furthermore, most people at the meetings wanted an increase in supply capacity, with most connections being limited by the power supplier to 400 Watts[19]. The lack of reliability with regular power outages lasting up to two days was generally accepted philosophically as a fact of life.

Woodfuel

When asked at the village meetings on which fuels they used for cooking purposes, the near unanimous response was that following the increase in the price of kerosene in October 2005, most village households now used woodfuel although at one village meeting, two participants said they used kerosene for cooking rice. Prior to this increase in the price, most used kerosene for cooking purposes for reasons of convenience, time saving and relative cleanliness (including lack of smoke). Most participants at the geothermal village meetings said that they gathered wood from around their village and needed to walk 1 to 1.5 km to find supplies, involving about six hours on three or four days a month. In two of the villages, the task of collecting woodfuel was shared between the men and women of the household but in one village, Sungai Medang, this task appears to be carried out by only the women[20]. In the other three villages, nearly all people at the village meetings told me that they buy woodfuel, this reflecting the fact that these villages have little or no uplands within the boundaries and therefore have no access to forests.

When asked about woodfuel consumption, the information was presented in various forms, eg number of sticks, cost (where bought) and rough estimates of weight. Using this mix of data, it was estimated that a typical five person household will use about 170 kg of wood a month, which if bought, would have cost around Rp650,000 or $100 a year.

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[18] Interestingly, at the village meetings in answer to my question as to what was top of their "wish list" if unlimited and affordable electricity to be available (after lighting and TV), the almost unanimous response was for an electric iron, followed by rice cookers. Possibly, this was because household energy matters seemed to be very much in women's domain in that they answered my questions on this topic rather than men.

[19] I understand that most connections have a circuit breaker fitted that shuts off supply if the set capacity is exceeded- eg by switching on too many lights or appliances.

[20] The men at the meeting were clearly embarrassed at this revelation but did not attempt to deny or justify.

In terms of useful energy, taking into account stove efficiency[21], this figure corresponds well with the advice that a similar household using kerosene uses 25 kg per month, costing $240 annually. From my observations and discussions with LTA, most wood stoves used are of the basic type, ie low efficiency, and are not fitted with chimneys, ie smoke discharges into the cooking area (refer Figure 8 over).

Figure 7: Kerinci Villages- Woodfuel (cinnamon) being prepared for sale

In terms of sustainability of the woodfuel resource, the impact of the reduction in the kerosene subsidy is significant. For example, Sungai Medang has over 400 households and if the average woodfuel consumption is taken as 120 kg/month (to allow for households of less than five people), the annual consumption will be in the order of 600 tonnes. While some of this is apparently sourced from cinnamon trees being cut early (see above), this supply is undoubtedly finite and this will eventually result in an increase in the cutting of natural timber. Villagers gathering timber may have to go further to source it (and possibly encroach into the national park) while those who buy timber will have to pay more.

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[21] Stove efficiency is a function of the heat content of the fuel and the useful heat that reaches the food being cooked. A simple woodstove may have an efficiency of 20% or less (WEC, 1999:60) while a kerosene stove can have an efficiency of over 40% (Smith et al, 2000:25).

Figure 8: **Kerinci Villages- Typical kitchen (Muara Jaya)**

Kerosene

Kerosene is used for lighting in houses with no access to electricity. It is also still used for cooking in some wealthier households but these are understood to be in the minority. While I have not been able to confirm this, I was told in the November 2006 visit that central government was rationing kerosene deliveries throughout Indonesia as part of the effort to reduce petroleum imports and if this is the case, this will no doubt result in a further price increase.

COMMERCIAL USES

Commercial activity in the villages is limited to shops, small stalls selling various products, geothermal bath-houses and motorcycle taxis (*ojek*).

The shops use electricity for lighting - I did not see any refrigerators. Some stalls sell hard-boiled eggs cooked in the hot springs.

AGRICULTURE

Very little (if any) mechanisation appears to be used by the farmers in the villages other than some use of motorcycles to transport produce. Buffalo or small horse-drawn carts are used for heavier loads. Energy use in agriculture is therefore small.

Sun-drying was confirmed at the meetings as the only method used to dry crops, notably rice, but also chilli, cinnamon, cloves, potatoes and sweet corn. In the three geothermal villages, when asked how much of the rice crop was lost during drying, due to sprouting, splitting, rot, fungus growth and birds, the estimate was 25% over a typical year and across both the wet and dry seasons. Discussions with the regency agriculture department confirmed that this 25% figure was a reasonable estimate. The sun drying of chilli is apparently particularly problematic and in spite of a reportedly good market for dried chilli, the losses that occur during drying prevent growers from being able to take advantage of this market opportunity. In the case of cinnamon, the quality (and therefore price) of the dried product is often reduced due to mould growth.

Figure 9: Kerinci Villages- sun-drying of rice (Sungai Tutung)[22]

It was recognised by the villagers that this product loss or deterioration during drying could be reduced substantially were crop dryers to be used. However, while an oil-fired dryer performed well when tried several years ago[23], the cost of the fuel made the exercise uneconomic for most farmers who preferred to continue using sun drying (Yanuar, 2005:19). On a positive note, a geothermal crop drier has been commissioned

[22] Note the ducks in the shadows at the background- they had just been happily feeding off the rice demonstrating another loss factor!

[23] I was told that the dryer and the diesel fuel that it used was provided as part of an aid project but I was unable to find out which agency was involved.

in Air Panas Baru as part of the ADAF geothermal project and while still very early days, the results using sweet corn were reported in November 2006 as being very encouraging in that the corn was being dried in 24 hours rather than over three days and with zero loss.

The lack of a reliable power supply discussed above was reported by LTA in 2004 to be a major factor in preventing farmers in villages that specialise in poultry raising from increasing their stocks of ducks and chickens[24]. Eggs are a major source of protein in Kerinci and according to a market study undertaken in 2005 (Yanuar, 2005), there was an unsatisfied demand for duck eggs in particular[25], but poultry farmers were unable to take advantage of this demand because they were unable to obtain sufficient ducklings for raising. One reason for this is that the most common and popular type of duck is a poor parent in that it does not take its hatching responsibilities seriously and eggs are neglected. As a consequence there is a heavy reliance on artificially incubated eggs to produce ducklings and chicks using electrically heated incubators. Unfortunately, with the unreliable power supply and increasing cost of kerosene (which is used as the stand-by fuel in the event of a power cut), many farmers have found hatching using incubators uneconomic. Increasing the price of ducklings and chicks was understood not to be an option as this would meet buyer resistance.

A response to this problem has been the installation of a geothermal egg incubator in each of the three geothermal villages as part of the the ADAF geothermal project referred to earlier in this chapter and in which I have a role as project engineer. The incubators are capable of incubating 5,000 duck or chicken eggs over a three to four week period (depending whether duck or chicken eggs are involved).

BIOFUELS- A FUTURE OPPORTUNITY?

As I intend confining my analysis of renewable energy resources to those that meet the criteria for local management and operation, this rules out technologies that are still under development or have yet to be sufficiently proven in practical application. However, I will briefly discuss one opportunity that may arise in the near future.

Biofuels are liquid fuels produced from vegetable or animal materials that can be used as a substitute for petrol and diesel. Increases in the price of oil has resulted in rapid growth of the biofuels industry worldwide, although production is miniscule compared

[24] This was verified in village meetings I attended in November 2004.
[25] From meetings with LTA in November 2006, I understand that this shortage still remains.

with oil-based fuels. Of the main types of biofuel, vegetable oils used as a diesel substitute in the form of straight vegetable oil (SVO) require the least processing and can use a variety of feedstocks such as palm oil, coconuts and peanuts (ITDG, 2000a:4). SVO's however, are limited in application to warm climates owing to the oil tending to form wax at lower temperatures (Joseph, 2004:16). In the short to medium term, I consider that SVO may offer potential in Kerinci including the six villages as coconuts appear to grow well. An example of the use of SVO produced from coconuts can be found in Namdrik Atoll in the Marshall Islands where coconut SVO is used for transport and power generation (ECL, 2005a).

According to LTA (2005), there were significant areas of degraded land in all three villages, probably as a result of attempts at upland rice growing (Burgers, 2004:71) and the possibility exists that this land could be used for the planting of oil-seed bearing crops of some kind[26].

SUMMARY AND CONCLUSIONS

On one hand, it could be argued that the people of in the six villages are fortunate. They live in a fertile valley with a benign climate that provides good rainfall without extremes of temperature and violent storms. The good growing conditions ensure that few people have inadequate food and in past times at least, have enabled people to produce cash crops that bring wealth into the region. The diseases that are endemic in many tropical areas such as malaria and dengue are rare.

Even the very poor have adequate shelter although this may be very basic. In rural areas, the majority of households have access to electricity and the general view is that it is affordable while unreliable and inadequate in terms of capacity. Infrastructure is reasonable - there is road access to most village centres although parts of villages may only be accessible by footpath. There is good access to communications with public telephone services available in the villages and a good mobile phone network for the better-off.

The Kerinci society is cohesive probably due to a range of factors including the relative isolation, the moderate Islam and cultural factors such as *Gotong Royong*and various forms of traditional *adat*. While women and girls are still at a disadvantage, I obtained

[26] This would be a good example of degraded land providing opportunities for poor people as there is no competition for it (Chambers, 1988b:12).

the impression that the situation is improving - the fair division of labour in the village households and the willingness of women to speak their minds at village meetings being signs of progress.

Yet for many if not most people, life is only a little above subsistence level. The priority for most rural households is obtaining enough food, either by their own labour or by working for wages to buy food. Any spare cash goes towards basic household needs and the education of children, leaving little for savings or discretionary spending. The situation has not been helped by the collapse in prices for cinnamon and low prices for coffee.

Options to gain the additional income to improve quality of life are limited. Land available for agriculture is strictly limited, and as a result increasing production by increasing the area of arable or pastoral land is not possible. In any event, the lack of modern food preservation facilities coupled with the relative remoteness of the Kerinci Valley raises some doubts as to whether the markets exist for any increased production within Kerinci or beyond. An option that is frequently taken up is migration, either to other parts of Indonesia or overseas, particularly Malaysia. While there is evidence that the money remitted by migrant workers can genuinely improve household wealth, there must be a cost in terms of family relationships.

A shortage of energy - and in particular, electricity - was blamed by the local government as being a major impediment to economic development. I believe that more correctly a lack of energy supply is one of several factors impeding economic development including the heavy reliance on agriculture, the relative isolation and a lack of any obvious resource or opportunity that would encourage investors to provide the necessary development capital.

At village level, the shortage of electricity is impacting on people's day to day lives with about 50% of the households in the villages having a supply that is inadequate for other than basic lighting or having no supply at all. If electricity could be produced at a price that was affordable to households or to commercial consumers, it is reasonable to assume that either PLN or a private power producer would be prepared to invest in new power supplies. However, the current tariffs for electricity are inadequate to cover the cost of diesel generation and, given the lack of investor interest, inadequate to cover the cost of constructing hydro or geothermal power stations to take advantage of Kerinci's renewable energy resources. Given the economic stress that many village households are under, increasing the tariff for electricity to a level that would provide a full economic return to a power generation company could well result in poorer families reducing their power usage.

The lack of affordable energy is reducing farmers' productivity by not providing the farmers with an alternative to sun-drying for crop preservation, resulting in significant losses and reduction in quality. In the geothermal villages, the ADAF geothermal project in which geothermal hot water will be used for egg incubation and crop drying may provide a partial solution.

At household level, the sudden and substantial increase in the price of kerosene was a severe shock in terms of peoples' livelihoods. Firstly, it forced a return to woodfuel with all the disadvantages associated with collection and usage, including the health problems associated with the unvented stoves in common use (and which mainly affect women who have the greatest exposure)- plus concerns at the sustainability of the wood resource with evidence that this concern may be warranted. Secondly, for those households who have to buy fuelwood, the cost of woodfuel in terms of useful cooking energy is now twice that of kerosene prior to the removal of the subsidy[27].

In line with the concept of "putting poor people first" (Chambers, 1986: 3), the questions put to villagers to ascertain their aims and aspirations were aimed at getting them to identify their wants and needs rather than me deciding what these were or asking LTA or the Bupati what they believed these to be. In fact, there was a good correlation which I found to be encouraging and indicative of a level of communication between the various parties. Of interest was the fact that energy issues featured relatively strongly, ie the concern at the return to woodfuel and the desire for a better supply of electricity.

Given these identified aims and aspirations, the existence of renewable energy resources may offer some opportunity to at least partially fulfil these. Those resources that can be readily accessed using proven technology include biomass (woodfuel and waste), geothermal hot water and streams (hydro power) and will be analysed in Chapter 5. Future opportunities such as biofuels however, given the increasing cost of conventional oil-based fuels, will very likely become of increasing interest in the near to medium-term future.

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[27] Prior to the increase in price, for a typical household kerosene would have cost around $60 annually.

CHAPTER 4: CASE STUDY- NIUE

INTRODUCTION

With an estimated population of around 1,700 (MFAT, 2006), Niue is one of the world's smallest self governing states (Europa, 2006). As shown in Figure 10, Niue is located in the South Pacific Ocean approximately 600 km east of Tonga. The population live in villages located around the perimeter of the island, the capital being the village of Alofi on the west coast. While self governing, Niue enjoys "free association" with New Zealand and Niueans are New Zealand citizens.

Figure 10: Map of the South Pacific Ocean showing location of Niue
(downloaded from www.polynesia.com)

The Niue economy is heavily dependent on financial assistance from New Zealand. Exports are limited to a small amount of specialist horticultural products with agriculture being mostly at subsistence level in the form of "bush gardens" mainly producing for people's own household consumption. Some improvement in export figures is anticipated, however, following the recent opening of a fish processing factory. Tourism is important to the Niue economy, but is limited in scope and capacity in terms of accommodation and the lack of sandy beaches..

Average per capita income is understood to be in the order of around $13,000 annually and $32,500 per household (SPC, 2003). People in Niue cannot be regarded as poor and enjoy a reasonable quality of life, not too dissimilar to that in New Zealand. Imported goods are expensive and the growing of food is an important factor in people's livelihoods.

Niue is almost 100% reliant on imported oil products for its energy supply. In 2002/3, these totalled 2 million litres[28] costing over $1.8 million, this historically amounting to over 40% of its total import bill[29] (Wade, 2004a: 6). Virtually 100% of households are supplied with electricity and while expensive by New Zealand standards, it is regarded as affordable by most people. However, the affordability is substantially due to a subsidy as the cost of generation is well above the price charged to consumers.

As with Kerinci in Chapter 3, the first part of this chapter will review Niue in terms of geography, politics, economics, energy resources, social conditions and culture and the influence these have on people's livelihoods together with the part that energy plays. The renewable energy resources available in Niue will be identified.

Although Niue is made up of 14 villages, I will treat it as a single culturally homogenous community. This is partly because of the small population of Niue but also because unlike the Kerinci villages, the Niue villages are not discrete economic units in that most households derive their main income from outside of their village, typically in Alofi and by working for the government. This is not to say that people do not identify strongly with their village - to the contrary with village life and the local church being stated by informants as forming an important part of their lives.

The conclusion reached is that people in Niue enjoy a good standard of living and a climate that is generally comfortable. The people that remain in Niue are mainly there by choice as being New Zealand citizens, they have the freedom to live and work in New Zealand. However, the standard of living is underpinned by the imported energy

[28] This excludes jet fuel, this all being sold to the airline (currently Air New Zealand) serving Niue and therefore effectively re-exported.
[29] With the recent steep increase in oil prices, I anticipate that the percentage of the total import bill attributed to energy will be higher than 25% .

supply and should this be disrupted or become unaffordable, this could have a profound affect on people's livelihoods and arguably, even on the future viability of Niue as an island state.

On the other hand, Niue has good renewable energy resources, mostly unused, particularly wind and solar resources which could be exploited using readily available technology and operated by the local community. In addition, biomass resources could become a useful source of household and transport energy as new or improved technologies become available. I conclude that these renewable energy resources provide Niue with the opportunity to reduce its heavy reliance on imported energy. In terms of livelihood outcomes, this would result in increased capital assets and reduced vulnerability.

NIUE- A SOCIO-ECONOMIC OVERVIEW

THE GEOGRAPHIC CONTEXT

As shown in Figure 10, Niue is located about 2,400 km to the north-east of New Zealand, roughly within a triangle formed by Tonga, Cook Islands and Samoa. Niue comprises a single island formed of uplifted coral following subterranean volcanic activity, the first of which formed the plateau which constitutes much of the island's interior while subsequent activity resulted in further uplift which created a terrace around the periphery (Chapman *et al*, 1982). The periphery terrace is about 50 metres above sea level while the interior plateau rises to a maximum elevation 68 metres (Wade, 2005a: 1). Figure 11 is a map of Niue and as can be seen, the main villages are located around the perimeter.

Niue is reputedly the world's largest example of an uplifted coral island with four times the land area of Rarotonga but with less than one fifth of the population[30]. The coral has transformed into limestone and the layer of topsoil is thin, composed of weathered limestone and possibly volcanic ash (Chapman *et al*, 1982: 83). As can be expected given its latitude, Niue has a warm and moist climate, with an average daily maximum temperature of around 28°C and an average annual rainfall[31] of 2,009 mm (Kreft, 1986:15). Droughts have occurred from time to time, resulting in significant hardship (Anthoni, 2004), however it was suggested to me during my first field visit that these appear to be less frequent in recent years.

[30] According to NZAID (2006), the population of Rarotonga is around 10,000.
[31] As measured in Alofi over the period 1905 to 1977.

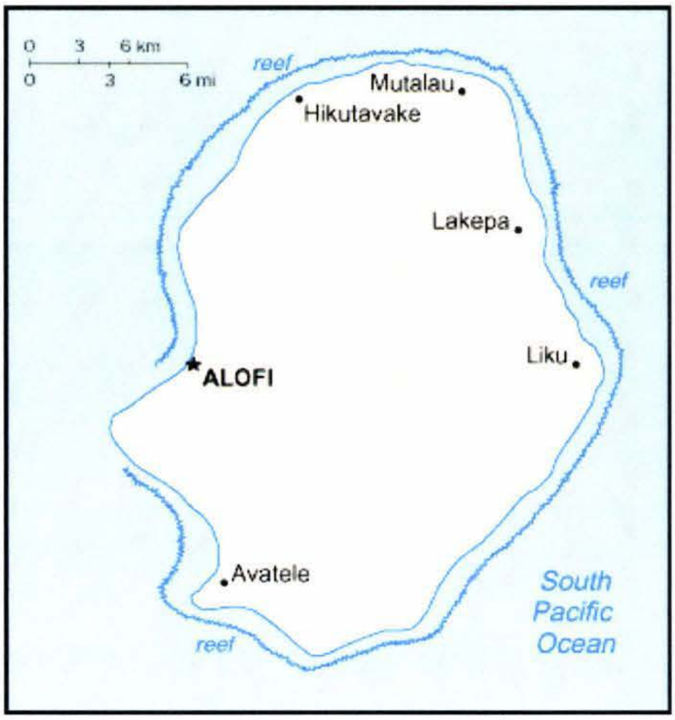

Figure 11: Map of Niue

(from www.mfat.govt.nz)

In spite of the thin layer of topsoil, the vegetation is lush with a substantial area of protected forest on the eastern side of the island. While rainfall is high, there are no rivers as the rain passes through the porous limestone to an underground lens from which the collected water flows out to the sea through underground channels and caves (Wade, 2005a: 1). Water is obtained from the lens by wells and is understood to be of good quality and of ample quantity to meet current demand (Government of Niue, 2000).

POLITICAL STATUS

Niue became self-governing in 1974 ending a period of 73 years of administration by New Zealand. Niue now maintains in "free-association" with New Zealand where New Zealand has the responsibilities for external affairs and defence of Niue. These responsibilities can only be exercised, however, at the request of the Government of Niue (Europa, 2006).

The Government consists of a cabinet comprising the Premier and three Ministers and the Legislative Assembly of 20 members plus a Speaker. The Assembly consists of 14 members elected from village constituencies and six elected from a general role: elections are held at intervals not exceeding three years (Europa, 2006). There is universal adult franchise.

HISTORY AND CULTURE

Early history

According to Chapman *et al* (1982: 83), carbon dating of human remains showed that Niue was populated about 500 AD. Based on analysis of the Niuean language by linguists, it was believed that there had been "waves of migration" from Tonga and Samoa, and possibly the Cook Island to a lesser degree, but with no clear proof as to who arrived first (Chapman *et al*, 1982: 84). In Niuean legend, the first humans to arrive in Niue were five people who came from "Fonuagalo", a lost or unknown land, followed by a man and a woman or alternatively just by a woman, also from Fonuagalo (Percy Smith, 1983: 76). The original five later took on the status of *tapua* or gods although only one, Tagaloa, was universally worshiped, the others being worshiped in specific villages together with a number of lesser gods (Percy Smith, 1982: 48).

In traditional Niuean society, the extended family (*magafaoa*) formed the central core, with the father (*takitaki magafaoa*) having supreme authority while the mother had very limited power (Chapman *et al*, 1982: 91). Status of people depended on the genealogical line or *mataohi* of the *magafaoa* with the highest castes being those of chiefly or warrior ancestry. Marriage tended to take place within castes to avoid diluting the status of the *mataohi*. (Chapman *et al*, 1982: 92). Women were subordinate to men in most respects: power and possessions always passed down through the male line.

Land ownership was very much a family affair and villages tended to be populated by members of the same extended family. Land for the growing of food crops was critical to survival and as families grew in size, disputes between families resulted in warfare and adjustment to boundaries (Anthoni, 2004). While land tenure was formalised under the Nuie Constitution Act of 1974 (Chapman *et al*, 1982: 137), land disputes still occur and knowledge of one's lineage is still of importance in such disputes, particularly as having access to family land to grow crops is still important both in economic and cultural terms. Warfare is no longer used to settle disputes, of course, with the legal process now being available.

The missionary period

The early Niueans apparently realised that isolation protected them from disease and visitors from other islands made were unwelcome (Chapman *et al*, 1982: 101). As a consequence, a distinct and very simple culture developed (Anthoni, 2004), a situation that remained in place until the 19th century. The first sign that the Niueans may have received that this isolation was threatened by Europeans was probably the appearance of the "Revolution" under the command of Captain James Cook in 1744. In line with their policy of isolation, Cook was given a very hostile reception and driven off, resulting in Niue being named by Cook as "Savage Island" (Percy Smith, 1983: 90).

The isolation policy however, was no match for the evangelising zeal of the missionaries operating in the South Pacific in the 19th century, especially John Williams from the London Missionary Society. It was therefore inevitable that serious efforts would be made to convert Niueans to Christianity, a process that started in the 1830's (Chapman *et al*, 1982: 111). By about 1860, the process of conversion was largely complete with a very organised church in place, the old pagan ways having been largely abandoned which, according to Chapman *et al* (1982: 117), was made easier by a lack of fanaticism.

The missionaries changed the lifestyles of Niueans in a number of ways including the regrouping of villages into coastal settlements, the introduction of European-style clothing and the provision of a basic education. Warfare as a means of resolving land disputes was replaced by negotiation. However, in the 1860's, a period of lawlessness commenced which Chapman *et al* (1982) attributed to a number of causes and in particular, men going to work in neighbouring Pacific islands and Queensland in the 1860's and bringing back 'bad ways'. The appropriation by traders and missionaries of most of the surplus income from trade with New Zealand, Australia and other Pacific islands, also gave rise to discontent. The setting up of a centralised authority or *fono* by the missionary George Laws in 1864 was an attempt to provide a form of law and order (Chapman *et al*, 1982: 119) as was the election of a king in 1876 (Chapman et al, 1982: 124).

The New Zealand period

A period of great power rivalry in the South Pacific commenced in the 1870's, giving rise to some nervousness in Niue (Chapman *et al*, 1982: 125) and the possibility of British protection of Niue was raised in 1879 followed by formal petitions to Queen Victoria in 1889 and 1895. A Treaty of Cession with Britain was signed in April 1900, but this was effectively transferred to New Zealand almost immediately[32], much to the annoyance of the Niueans and in 1901, a New Zealand Resident Commissioner arrived (Chapman *et al*, 1982: 126). This marked the beginning of the end for the effective control that the missionaries had over life on the island although the church, and particularly the Ekalesia, the descendant from the church set up by the London Missionary Society, still plays a very important part in peoples' lives.

According to Chapman *et al* (1982: 131), there was not a great deal of change to the way of life on Niue during the period 1901 to 1960. However, the two cyclones that struck during the period 1959-1960 did huge damage to homes and buildings on the island and caused considerable loss of life, drawing the attention of New Zealand public to Niue, just at the time that international pressure for de-colonisation was gathering momentum. The Niueans were not in a hurry to obtain self-government, however, and although the New Zealand government first proposed moving towards self-government in 1962, the referendum on the issue did not take place until 1974. The referendum outcome was in favour of self-government which was declared in October 1974 (Chapman *et al*, 1982: 134).

In the meantime, according to Chapman *et al* (1982: 135), the reconstruction that followed the two cyclones changed life in Niue dramatically. Not only was a programme for the construction of cyclone-proof housing implemented, but in the mid-1970's, the island was provided with an electricity supply that served virtually 100% of households and businesses. In the villages outside of the central part of Alofi, this meant that people no longer had to rely on kerosene lamps for lighting and wood fires for cooking. An airport suitable for medium sized jet aircraft was built, enabling regular Boeing 737 services, replacing sea transport as the only means for people to travel from and to Niue.

However, there was a downside- at least from the aspect of Niue's viability as an independent state: the improved transport, communications and education resulted in greater expectations in terms of lifestyle which, for many, could not be met from a "subsistence way of life" and within a "fragile" economy of limited capacity (MFAT,

[32] According to Chapman *et al*, 1982: 126), the handing over of Niue by the British to New Zealand was to meet New Zealand's desire for "Empire" and to compensate for not having been "given" Samoa as a colony. However, Chapman *et al* (1982:128) commented that this desire for Empire, far from making money for New Zealand, created an economic liability, a situation that remains to this day.

2006). As a consequence, the population of Niue dropped from around 5,000 in the 1960's to the present 1,700 (MFAT, 2006).

The present day

To me, Niue is reminiscent of New Zealand in the 1960's. In appearance, the shopping centre in Alofi would not be out of place in a small New Zealand town. The pace of life is comfortable and crime is minimal. Yet, it would be wrong to say that Niue is behind the times - most houses have refrigerators and freezers, there is a satellite TV service and in Alofi, a wireless internet service - and cafés where one can obtain good coffee. However, while the physical infrastructure is good, I noticed during my field visits signs of wear and tear in the electricity and roading systems.

Figure 12: Niue- cyclone damage (*Heta*- 2004)

THE ECONOMY

The isolation, the lack of resources and the small population combine to create an economy that is highly dependant on overseas assistance, mainly in the form of support from New Zealand which amounted to nearly $7 million in 2004/05 (MFAT, 2006). There is a large trade deficit: in 2002, the cost of imports totalled $3.245 million while the value of exports was $0.124 million (MFAT, 2006).

The agriculture sector is mainly at a subsistence level for personal or family consumption and includes the growing of crops such as taro, cassava and breadfruit. The setting up of the fish processing factory is a joint venture between a private investor, Reef Shipping, and the Niue Government and is intended to process all fish harvested in Niue's economic zone. Fish processing and *noni* juice were both regarded by MFAT (2006) as having the potential to significantly increase Niue's productive sector. Ironically, as an illustration of the problems that confront Niue, immigrants from neighbouring Pacific islands, India and the Philippines have had to be recruited to provide sufficient labour for the factory.

From my observations and discussions with staff at the main hotel in Niue, tourism has shown a marked increase in 2006 with accommodation and the weekly flights both at near capacity during the main tourist season (May to October). However, given that Niue lacks sandy beaches, restaurants and upmarket bars associated with mass tourism, the investment necessary to build additional tourist facilities would require significant faith in the future given that the current market is "niche", mainly associated with diving and fishing. Furthermore, the concept of mass tourism and its impact on life in Niue has, according to my informants, little appeal to most people in Niue.

The possibility that Niue may have uranium reserves has attracted some interest with an Australian company, Yamarna Goldfields announcing in 2005 that the company intends to initiate investigations into prospectivity (Yamarna, 2005). Also, and possibly even more controversial, there are rumours of negotiations with Malaysian timber companies who are apparently keen to carry out logging activities in the forests of inland Niue. These schemes, along with the rather dubious off-shore banking activities that took place until shut down a few years ago, are symptomatic of the problems that Niue faces with having minimal resources with which to pay for a lifestyle that while modest, is still better in terms of standard of living and quality of life than that experienced in most of the neighbouring Pacific islands.

Otherwise, tourism, fishing and vanilla farming were identified by NZAID (2004) as the areas of focus for future economic development.

LIVELIHOODS

Employment

Given that Reef Shipping has found it necessary to import labour, I assume that there is no unemployment as such in Niue. However, opportunities for a young person to follow a professional or other career options in Niue are extremely limited if for no other reason than a population of 1,700 does not constitute a viable market for most professional services, the exceptions being health professionals and teachers.

Typical incomes are understood to be in the range $10,000 to $40,000 per annum, with an average of around $13,000[33] and an average household income of $32,500 in 2003 (SPC,2003) .

The Government Sector

The government sector is the major employer with 432 employees on its payroll in July 2004 (MFAT, 2006) and according to Wade (2005a: 5), this accounts for about 50% of the workforce. The government sector includes not only administration, police, health and education but also the operation and maintenance of the infrastructure.

The Private Sector

Niue Fish Processors Ltd is the largest major private sector company and is a joint venture between the government and Reef Shipping Ltd, a New Zealand company. The objective of the joint venture was to enable Niue to benefit directly from the fish resources in its economic zone rather than simply extract royalties from foreign fishing companies.

Other businesses are mostly providing services of various types - retail, vehicle servicing, building contracting, cafés, a hotel, motels and several bed-and-breakfast/ guest houses.

Agriculture

As noted above, agriculture is mainly at a subsistence level in "bush gardens" for personal or family consumption and includes the growing of crops such as taro, cassava and breadfruit. There are small quantities exported and traditional exports include honey, passion fruit, lime oil and coconut cream (CIA, 2006) plus taro (mainly

[33] From discussions with various informants.

for the Niuean community in New Zealand) and new initiatives that include vanilla production, fish processing and noni juice production (MFAT, 2006).

INFRASTRUCTURE

Physical Infrastructure

Niue is well served with an extensive sealed road network and an electricity distribution system that is accessible to virtually every house or business (Wade, 2005a: 11). Both are seriously overdue for refurbishment[34].

Electricity is supplied from diesel generators located in a central power station. The power station and distribution system is operated by the Niue Power Corporation (NPC). The road network is managed by the Public Works Department (PWD).

Most houses have potable water supply either from a local well or a reticulated village system. The water quality is understood to be good although a report in 1999 expressed concern that there was a risk of contamination of the underground supply from septic tanks and agricultural chemicals and waste (Tukuitonga *et al*, 1999:32).

Transport

There is a monthly shipping service to Niue from New Zealand provided by Reef Shipping. There are no berthing facilities at the main port of Alofi, the containers being transferred to shore using barges.

Flights between Niue and Auckland are operated by Air New Zealand and operate on a once per week basis.

Other than school buses, there are no bus services on Niue. Car ownership is high, mainly in the form of second-hand Japanese imports. Petrol and diesel are expensive compared with New Zealand at $2.10 a litre (September 2006) - but on the other hand, distances travelled will typically be small.

Health and Education

Niue has a modern (2004) cottage hospital that provides free primary (GP), dental and maternity services to local people and at a small cost to visitors. The hospital also

[34] Following a serious fire at the central power station in June 2006, generation capacity is severely limited with no spare capacity in the event of breakdown. Urgent measures are being taken by NZAID and the Niue government to rectify this situation. In addition, the 11 kV cable is over 30 years old and at least two failures (so far) in 2006 have caused serious disruption.

provides limited secondary services and has an operating theatre, X-ray and accident and emergency facilities. People with serious medical problems are sent to New Zealand for treatment.

Education facilities comprise a high school (now up to form 7) and a primary school. These follow the New Zealand curriculum (MFAT, 2006).

AIMS AND ASPIRATIONS

Why people live in Niue?

Given the substantial migration from Niue, my first question to my key informants in Niue was why they remain in Niue when so many people have left. All of them told me that they live in Niue by choice[35]. Most have lived in New Zealand and attended school there for at least part of their education and all have close relatives who live in New Zealand. When I asked why they live in Niue, the answers were virtually identical:

- The village life.
- Local values - spiritual, religion, family, the lack of crime.
- Being able to grow their own food in their bush gardens - land ownership is therefore still important.
- Being able to hunt and fish (from the male respondents).
- The weather (compared with New Zealand).

Similar responses were reported in Lincoln International (2002: 9).

My follow up question was why do so many Niueans live in New Zealand? The typical (and expected) response was the lack of opportunity for young people and the attractions of city life, again for young people. As also reported in Lincoln International (2002: 12), the attraction of working on one's own land, hunting and fishing does not have the same appeal for young people. Living in New Zealand does not cut people off from the Niuean culture as the community is strong and many regularly visit Niue - some families move between New Zealand and Niue, living for some time in each.

My conclusion is that the Niue lifestyle appeals to some people and not to others - arguably this is no different to New Zealand where some people choose to live in the country for lifestyle reasons while others - the majority - opt for town or city life.

[35] It should be noted that these were mostly informants aged 30 years or over.

The downsides of living Niue.

My second follow-up question was to ask informants about the down-sides of living in Niue - other than the lack of opportunities (not to mention excitement) for young people. The replies were similar across all informants, were predictable and were mainly associated with the relative isolation and difficulties such as:

- Infrequent (once weekly) flights in and out of Niue.
- Lack of service technicians and trades-people to service home and business appliances.
- Difficulties and delays in obtaining house materials, household appliances, spare parts and the like.
- The cost of imported items including food; no concerns were expressed regarding the cost of energy, either electricity or transport fuel.
- The need to travel to New Zealand in the event of health problems requiring access to a medical specialist.

Aims and aspirations

My third follow-up question was what improvements my informants would like to see happen. Given that all my informants had just told me emphatically that they live in Niue by choice and gave me well expressed and clear reasons for this, their answers required some thought.

All informants said that they would like the dependence on New Zealand for financial assistance to reduce and there was a recognition of some vulnerability in this regard. Similarly, measures to stem further depopulation were seen as a priority as it was recognised that any re-kindling of the depopulation trend would be of serious concern; this also is a recognition of vulnerability.

With the above concerns in mind, the encouragement of tourism of the niche variety was seen as probably the most important step together with promotion of small businesses to encourage entrepreneurs, particularly Niueans, living in New Zealand. The setting up of Niue Fish Processing was seen as positive although there was concern that much of the labour both in respect to fishing and processing had to be brought in from outside.

ENERGY USE AND RESOURCES IN NIUE

ENERGY USE

Based on data in Wade (2005a: 9), I estimate that annual energy use in Niue is in the order of 58 MJ[36] per capita. While this is much lower than is the case in New Zealand where the equivalent figure is 193 MJ per capita[37], energy use more closely resembles that of New Zealand than Niue's Pacific neighbours with household electricity use including not only lighting and TV but also refrigeration and often cooking. In Samoa, for example, in 2001, it was estimated that only 11% of households used electricity for cooking, the remainder using woodfuel (about 60%), kerosene and LPG (Wade et al, 2005: 17).

As noted above, household electrification is essentially 100% and from discussions with key informants, I understand that in addition to electric lighting, most homes have TV, washing machines, small electric ranges, micro-wave ovens, electric irons and toasters. Hot water is typically provided by solar hot water panels and based on my observations, about 30% of homes have these fitted plus commercial buildings including hotels and motels; these generally are fitted with electric boost elements to cater for cloudy periods. Most houses without solar panels make do with cold water - very few houses have only electric hot water cylinders. Figure 13 shows solar water heating panels fitted to houses built by the French government following cyclone *Heta* in 2004.

The importance of electricity in household livelihoods in Niue cannot be understated. This was illustrated in May 2006 when a fire in the power station that supplies Niue with electricity destroyed or severely damaged most of the equipment and as a consequence, Niue was without power for about 10 days until a temporary supply was established. During this period, according to key informants, the main problem confronting households were freezers full of food followed by the problem of how to cook food without electricity. Fortunately, the fish processing factory came to the rescue by making freezer containers supplied with power from the factory's generator available to the public while householders returned to wood barbecues and traditional *umu*, or stone ovens (similar in principle to hangi) for cooking.

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[36] MJ = megaJoule= Joule x 10^6

[37] This is based on information from Statistics New Zealand (2006).

Figure 13: Niue- solar water heating panels

The standard electricity tariff is 37 cents/kWh with a premium rate of 48 cents/kWh for air conditioning. As a consequence (and as intended), the use of air conditioning tends to be limited to essential applications, eg telecom facilities and in the hospital, plus a few hotel rooms. The tariff includes a high element of subsidy - I estimate the real cost is close to 70 to 80 cents/kWh.

Road transport accounts for about 40% of total fuel imports (Wade, 2005a: 9), with a further 5% being used in fishing boats, possibly higher now following the opening of the fish processing factory.

CURRENT SOURCES OF ENERGY

Almost all Niue's energy needs are met from imported petroleum products: principally petrol, diesel and aviation kerosene brought in on the monthly shipping services in containerised tanks - or "tank-tainers " as shown in Figure 12 below. Relatively small quantities of LPG are imported in cylinder form. About 70% of the imported diesel is used for power generation with the remainder being used as for transport (Wade, 2005a: 9). Imported petroleum products account for around 40% of Niue's total imported bill (Wade, 2005a: 6).

Figure 14: Niue - Fuel supply "tank-tainers"

Wood is used on a limited scale for cooking, either in barbecues or in *umu*,[38] a form of traditional oven. Increases in the price of electricity in recent months has, from all accounts, resulted in some switching from electricity to gas and wood (on a very limited - and occasional - scale) for cooking.

Wind monitoring carried out between 1994 and 1997 on behalf of the South Pacific Forum Secretariat Energy Division indicated that "there probably is an economically developable wind resource at the measurement site..." (Wade, 2005a:17). This albeit somewhat cautious statement appears to have been justified as a European Union wind project is planned for 2007/2008 in which two 75 kVA wind turbines will be

[38] Similar in concept to the Maori *hangi,* however as there is only 100 to 150 mm of soil above the limestone rock, a pit cannot be made in the same way and the oven is created by piling stones over and around the food.

installed, capable of contributing a maximum of about 15 to 20% of peak electricity demand[39].

According to Wade (2005a: 17), solar radiation measurements were carried out in 1995/96 as part of the Southern Pacific Wind and Solar Monitoring Project which suggested that while solar water heating was justifiable on economic grounds, solar power generation may not be. However, given that the retail price of electricity has increased by 20% since 2004, there is a good possibility that selective solar generation could now be justified on economic grounds.

There are no rivers in Niue, ruling out hydro generation, nor is there any evidence of geothermal activity.

In the long term, harnessing wave power could be of great significance. During both my field visits in 2006 and also in most of my earlier visits, the seas around Niue were rough with large swells. If the technology develops to the extent that small-scale wave power generation becomes economic, then this could play a major part in Niue's energy future.

SUMMARY AND CONCLUSIONS

The decline in population that has occurred in Niue from the 1960's onwards has been a matter of concern to both the governments of Niue and New Zealand (Lincoln International, 2002: 1). From observations made during my recent visits to Niue, there is some hope that this decline has slowed over the past five years, but this will be confirmed - or otherwise - following the results of a census that is to take place shortly.

People who live in Niue are mostly there by choice, enjoying the warm climate and the culture. The standard of living is high by Pacific Island standards - most households have "mod cons" such as washing machines, refrigerators, freezers - and as pointed out by Chapman *et al* (1982: 138), Niueans have aspirations for a standard of living similar to that of New Zealand. At the same time, people who stay in Niue (as distinct from those Niueans that live in New Zealand) can still enjoy the traditional way of life. Lincoln International (2002: 12) referred to high value that Niueans put on the

[39] Based on discussions with the Manager, Niue Power Company, Mr Speedo Hetutu, on 22 September 2006.

traditional ways of life - weaving, bush farming and fishing - a fact that was confirmed by key informants during my visits.

However, there is a lack of opportunity for young people in particular who want to pursue a career in the professions or the trades as there is a limited demand for these services. Furthermore, Lincoln International (2002: 12) observed that the importance of those cultural factors valued by some living in Niue was not shared by the youth. The undeniably quiet life in Niue, while attractive to a middle-aged tourist, may well be regarded as boring by a young person living there and the joys of tending one's bush garden may not be seen as adequate compensation.

Much effort has been put in by the Niue and New Zealand governments to tackling and reversing the population loss. Both governments are committed to "the maintenance of a living community in Niue "(Lincoln International, 2002: 1). Obviously, these efforts could be wiped out very quickly if the current standard of living were adversely affected.

Given that this standard of living is underpinned by the highly subsidised supply of energy which provides 100% electrification and a high level of mobility, both in the form of travel within Niue and air travel to New Zealand, any long term interruption to this energy supply would inevitably have serious consequences. Before wide-spread electrification in the 1970's, the lifestyle in the villages outside of Alofi where a limited power supply existed, was very simple. Lighting was by kerosene lamps and cooking by wood fire; refrigerators, freezers and electric irons - now seen as essentials - could not be used as there was no power. While from all accounts, people have coped with short-term disruptions - such as those caused by cyclones or the recent power station fire - extremely well, if such disruptions became permanent or even very regular, I suspect that many would start to weigh up the benefits of staying on Niue and continuing to enjoy the traditional way of life versus life in New Zealand and being able to continue the modern lifestyle they have become accustomed to.

The economic assistance received from New Zealand is a major factor in enabling Niue to continue to import the oil products to meet its energy needs. Any cessation in the provision of this assistance would obviously have a severe impact and while there is no suggestion or sign that a New Zealand government would contemplate such an action in the foreseeable future, this nevertheless constitutes a significant vulnerability for Niue- and the livelihoods of the people that live there. Another risk is that the price of oil could continue to rise to the extent that it is no longer affordable.

The renewable energy resources that exist in Niue offer an opportunity to reduce this vulnerability that potentially threatens the way of life. This opportunity has been recognised by Wade (2005a) and the European Union with their funding of the two 75 kW wind turbines. Furthermore, the Niue government has made a commitment to become solely reliant on renewable energy and is working with Greenpeace Australia in developing the plan to achieve this (CiD, 2006: 19).

In the next chapter, these renewable energy resources are evaluated and included in a sustainable livelihoods analysis with the objective of gaining an understanding of whether these resources can be exploited and the benefits these could bring to Niue in terms of reduced vulnerability and improvements to the lifestyle.

CHAPTER 5: ANALYSIS

THE APPROACH

This chapter will comprise an analysis of the livelihoods of the people in the Kerinci Villages and Niue using the information gathered during the field visits and from secondary data and as discussed in Chapters 3 and 4.

The approach that will be used in this analysis will be based on the DFID Sustainable Livelihoods Guidance sheets (1999). Capital assets will be identified together with the main vulnerabilities and livelihood strategies. The transforming processes and the structures and institutions in which the people live will be discussed.

The output from the sustainable livelihoods analysis will then be used to examine the part that energy plays in people's livelihoods, both conventional - ie derived from a fossil fuel - and renewable, of which some already form part of the energy "mix" while others remain untapped. The role that these available renewable energy resources could play in people's livelihoods if used to a greater extent than at present will be examined and the potential benefits identified. These potential benefits will then be used in a second, hypothetical livelihoods analysis to estimate the positive livelihood outcomes that the increased use of renewable energy could have in terms of progress towards the achievement of sustainable livelihoods.

The analysis assumes three criteria:

- There will be no significant changes to the existing livelihood paradigm. In the Kerinci villages, farming will continue to be the main livelihood and rice the main crop supplemented by livestock raising and cash crop production. In Niue, most paid employment will continue to be in the government or service sector.
- The renewable energy technologies used are proven and already extensively used in other developing countries.
- The technologies used must be suitable for operation and management at community level- this is to ensure that local support and control of the energy produced can be achieved. However, capability building including technical and management training will be an essential requirement in any implementation programme.

My reason for imposing these conditions is to avoid the analysis and the conclusions reached being too speculative or requiring changes in livelihoods that may take some years to implement or requiring extensive government involvement or intervention.

My analysis will follow the approach suggested in the DFID Sustainable Rural Livelihoods Framework (DFID, 1999b) and will consider four inter-related livelihood factors:

- Livelihood capital assets.
- The vulnerability context.
- Transforming processes and structures.
- Livelihood strategies.

Two sets of livelihood analysis will be carried out: one based on the existing (*before*) situation and the second based on the hypothetical (*after*) situation where the renewable energy resources are used. I will conclude with some observations on what I believe to be the strengths and weaknesses of the DFID framework in practical application.

ANALYSIS OF EXISTING LIVELIHOODS

CAPITAL ASSETS

Table 1 in Chapter 2 set out the six core capital asset categories and was the basis for Table 6 which identifies the capital assets that are held across the Kerinci Villages and Niue. These are largely based on research carried out during field work plus statistical and background data from LTA(2005), LTA(2006) and BPDSDKT(2006) in the case of the Kerinci villages and CIA (2006), Europa (2006) and MFAT (2006) in the case of Niue. I note that my findings in terms of the identified assets in Niue are similar to those in Lincoln International (2002: 28).

In many respects, livelihood assets are similar for both sites with the major difference being in the financial capital category, Niue being a recipient of significant funding from New Zealand and to a lesser degree, other international agencies. On the other hand, the Kerinci Villages have minimal access to development funding of any kind.

Capital asset	Definition	Situation in Kerinci villages	Situation in Niue
Natural capital	Natural resource stocks	• Warm climate with long wet season. • Fertile soil generally- but some degraded areas. • Access to land varies from village to village being dependant on traditional family ownership (eg *sawah giliran*), • Some groups have limited or no direct access to land. • Kerinci-Seblat National Park- limits the ability of communities to expand area of land for agriculture. • Adequate supplies of woodfuel- but indications that the resource may be coming under some stress. • Geothermal hot water in some cases. • Mountain streams in geothermal villages.	• Warm climate with approximately equal wet and (relatively) dry seasons. • Fertile land but thin layer of soil. • Bush gardens commonly cultivated for household food supply. • Land tenure largely based on lineage but understood to be complex and often leading to dispute. • Good fishing available. • Wild livestock available for hunting- chickens and pigs • Good supplies of woodfuel- but hardly used.
Social capital	Social resources	• Strong sense of community- eg *Gotong Royong.* • Strong kinship ties. • A reasonable level of gender equality.	• Strong sense of community, still based around villages and church. • Strong kinship ties. • A good level of gender equality.
Human capital	Skills and knowledge	• Traditional farming skills. • Improving education system - but inhibited by cost at senior high school level. • Limited opportunities for employment.	• A good education system, free to 7^{th} form level. However, for further education students have to go overseas- typically NZ and Fiji. • Limited opportunities for trades-people, technicians and professionals because of small population. This leads to limited availability. • Full employment but subsidised- government main employer.

Table 6a: Capital Assets- Kerinci Villages and Niue

Capital asset	Definition	Situation in Kerinci villages	Situation in Niue
Physical capital	Infrastructure	• Reasonable roading access. • Basic transport services. • Grid electricity supply -but limited availability and capacity. • No piped water supplies other than a single tap, waste water treatment or rubbish collection. • Increasing costs of household and transport fuels. • Free (but limited) healthcare.	• Good roading access. • Grid electricity supply with near 100% availability. • Good water supplies (in terms of both quality and quantity), waste water treatment, rubbish collection. • Good and free health services. • Limited air transport. • Infrastructure in need of major refurbishment (eg roads and power supply). • Good communications infrastructure. • Increasing costs of household and transport fuels- but still shielding from full impact by subsidies.
Financial capital	Financial resources	• Very limited- reliance on remittances from migrant workers commonplace. • Some assistance provided by government or international agencies from time to time.	• Heavy reliance on financial assistance from New Zealand with additional assistance from other agencies, eg AusAid, EU. • Recent private sector investment- eg Reef Shipping in fish processing and *noni* juice.
Personal capital	Culture, beliefs, rights	• Strong cultural identity. • Moderate form of Islam. • High level of spirituality. • Following *reformasi*, increasing democracy and awareness of human rights. • Universal adult franchise. • *Relative* gender equality.	• Strong cultural identity- eg language, bush gardens, hunting, fishing, traditional dancing. • Majority of people are practising Christians. • High level of spirituality. • Democracy with universal adult franchise. • Near gender equity.

Table 6b: Capital Assets- Kerinci Villages and Niue- continued

VULNERABILITIES

DFID (1999b: 2.2) defined the vulnerability context as "framing the external environment in which people exist". Vulnerabilities were identified by DFID under three headings:

- Shocks - these include a range of events, typically unpredictable, that can destroy peoples' assets to the extent that in some cases, people may have to abandon their homes. While the most obvious shocks can be categorised as "natural disasters", eg storms, earthquakes and droughts, there are those that can be termed as "manmade', eg economic and conflict (international or local).
- Trends - changes that impact on peoples' livelihoods, positive and negative.
- Seasonality - seasonal shifts in availability of food, prices (both in terms of income received from selling produce and outgoings for household essentials) and employment.

Table 7 over sets out vulnerabilities identified for the Kerinci Villages and Niue. The vulnerabilities common to both locations are associated with energy supply. However, there is significant difference in that I conclude that the impact of an energy supply disruption on livelihoods (and I include in the term disruption a price increase that makes an energy product unaffordable) would be more severe in Niue than the Kerinci Villages. As demonstrated by the increase in the price of kerosene that resulted in most households reverting to woodfuel for cooking purposes, life in the Kerinci Villages otherwise carried on largely as normal albeit with a reduction in the quality of people's livelihoods.

However, as demonstrated by the recent power station fire in Niue, the impact of a power supply disruption that lasted for more than a few days would be very disruptive to livelihoods at both household and commercial levels, given the heavy reliance on electricity. If the power supply disruption was due to a failure in the fuel delivery system (ie by tanker), then the islands' transport system would also be affected.

TRANSFORMING STRUCTURES AND PROCESSES

Kerinci Villages

As noted above, *Reformasi* has had positive impacts in reducing the role of central government. In particular, moving the responsibility for economic development to local government has brought the decision making process much closer to the potential beneficiaries.

Vulnerability	Situation in Kerinci villages	Situation in Niue
Shock	• The risks of earthquake and volcanic eruption are both real having occurred in the recent past. • Risk of pandemic- probably no greater in Kerinci than elsewhere in Indonesia and possibly less, given the relative isolation. Arguably of more immediate concern would be the impact of wide spread avian flu on the poultry industry, given the importance of duck eggs in particular as a low cost source of protein. ▪ The collapse of the prices received for cinnamon and to a lesser degree, coffee, has had a severe affect on peoples' lives. To give some indication of this impact, based on the 1999 production of cinnamon of 22,000 tonne (Kerinci Regency, 2004:54), the price collapse represented a reduction in annual income of over $38 million[40] or $128 on a per capita basis, which, on an average annual per capita income of $840, was significant. From discussions in the villages, it was clear the three geothermal villages in particular were badly affected by these shocks. • The increase in the price of kerosene which occurred in October 2005 has had a severe impacts on livelihoods with the majority of households in the villages reverting to fuelwood with all the associated disadvantages in terms of inconvenience and negative health impacts, particularly for women. While the gathering of woodfuel is common in the geothermal villages, most households in the other villages have to buy their fuelwood which on average will cost about $60 a year more than for the subsidised kerosene.	▪ Cyclones are without doubt the most obvious shock in terms of the impact on life in Niue. In earlier years, these have involved great loss of life, eg the cyclones of 1959 and 1960 (Chapman et al, 1982: 131), but following the cyclone proof housing projects of the 1960's, the loss of life in the more recent cyclones of 1994 (*Ofa*) and 2004 (*Heta*) was much less. • The impact of a cyclone on agriculture can be severe. Salt spray can damage vegetation and crops even in inland areas, destroying the bush gardens on which people rely for their staple food. People then have to buy imported food which is considerably more expensive. • Niue is entirely reliant on imported petroleum products for its energy supplies and any interruption would result in a shock if other than of short duration. This was demonstrated by the impact of the power station fire in May 2006 which was discussed in chapter 4 in terms of disruption to households. However, it also had an impact on commercial activity as the power supply disruption meant that a number of tourists cancelled bookings for accommodation, fishing and diving, a significant source of income during the tourist season on May to October. • Niue is heavily reliant on financial support from New Zealand and any interruption to that support would have a severe impact on life in Niue.

Table 7a: Vulnerabilities- Kerinci Villages and Niue- continued

[40] The price drop was in US dollar terms was from US$1.50 per kg in the 1990's to US$0.35 in 2004.

Vulnerability	Situation in Kerinci villages	Situation in Niue
Trends	• Removal of subsidies on energy- this has given rise to significant shock- see above. The likelihood is this trend may continue. • *Reformasi*, the reform and democratisation process that followed the demise of the Suharto regime in 1999, can be considered to be a positive trend with many of the functions previously carried out by central government in Jakarta were devolved to local government, including the responsibility for local economic development. There is evidence that *Reformasi* is resulting in an improved level of democracy and the move of central to local control appears to be having positive results.	• Migration to New Zealand has reduced population from around 5,000 to 1,700 over a period of 30 to 40n years. This may have stabilised. • Subsidies remain on energy- electricity, petrol and diesel- and may have to be reduced or removed at some stage. • A major shift in New Zealand's policy to Niue could result in a reduction to or cessation of financial support. While recent discussions with NZAID and MFAT indicate that such a shift is not contemplated, it cannot be said that this could not happen at some stage in the future.
Seasonality	• Drought has not historically constituted a major vulnerability with a climate that is relatively predictable and from discussions with local government and the communities, there is not a history of regular drought. However, rainfall during 2006 has, according to LTA, been less than usual and in the village Paling Serumpun, 30 hectares of a total 70 hectares of rice fields could not be planted in November 2006 owing to low river levels preventing the necessary irrigation. • The wet season normally takes up nine months of the year with a short dry season of three months but this appears to make little difference to rice production which is a year-round activity. The dry season however does allow for better sun-drying conditions and reduced crop losses.	• Drought has reportedly been a problem in the past, ruining both crops grown for household consumption and the small amount grown for export. In the pre-colonial era, a drought could result in famine (Chapman *et al*, 1982:100), while now the impact is more likely to be financial with people having to buy imported and expensive food. Anecdotally, droughts are not occurring as frequently as in the past- but even if true, there is insufficient evidence to judge whether this is a permanent change in Niue's weather or just a short term trend.

Table 7b: Vulnerabilities- Kerinci Villages and Niue- continued

Together with increased democratisation (eg the election of the Regent rather than appointment by a ministry in Jakarta), this should enable outcomes that have a much better chance of meeting people's needs and therefore poverty alleviation objectives. Evidence that this has not always happened in the past under central government control exists at Sungai Medang and Air Panas Baru with "white elephants" in the form of unused "tourism facilities" and irrigation schemes which, in themselves were not necessarily bad ideas but were clearly undertaken without consideration of issues such as marketing/support linkages.

The strong impression gained during visits to Kerinci was that local government was committed to poverty alleviation through economic development. For example, with the ADAF geothermal project, the local government has been supportive in a number of ways and discussions with the Regent and his team indicated that they would facilitate projects that have a poverty alleviation objective. However, the funding available is strictly limited and tends to be thinly spread.

Within the communities themselves, I was told by LTA that people were still becoming used to the new political environment and that some scepticism remained as a result of the old days where government poverty alleviation measures were in the form of handouts that mainly benefited the village elite. With this in mind, the approach adopted in the ADAF geothermal project was to involve the communities very closely at all stages in project planning and implementation. Unfortunately from the communities' point of view, *Reformasi* also includes a downside in the form of reduced or removed subsidies, particularly on household fuel needs.

A market economy exists for agricultural products and obviously farmers have to operate within this market if they wish to sell produce for cash. As noted earlier, the cinnamon and coffee markets are globalised and I understand that the rice, tea and chicken markets are controlled by large Indonesian corporations. Markets for other produce operate on a local supply and demand basis.

Major impediments exist to achieving the aim of economic development: predictably, the local government does not have anything approaching the funds necessary to implement a poverty alleviation programme that could transform people's lives. Also, there is a lack of investment available from the private sector, this probably a reflection of the fact that poor people only have limited ability to pay for new or improved services- including energy- and that Kerinci is largely populated by poor people.

Niue

The major transformation issue for the Niue government is undoubtedly the reduction of dependency on financial assistance from New Zealand (Europa, 2006). This issue has received and continues to receive considerable attention from both governments.

In terms of structures, the government of Niue is pivotal, not only because of its role in administering, legislating and regulating, but because it is also the major employer (Europa, 2006). With the arrival of Niue Fish Processors, the role of the private sector has increased.

The relationship with New Zealand is a critical process, given that decisions made by the New Zealand government could profoundly affect life in Niue.

LIVELIHOOD STRATEGIES

Table 8 over compares the livelihood strategies adopted in the Kerinci Villages and Niue. As with other livelihood categories, there are similarities- working for the government, setting up small businesses and migration.

On the other hand, most people in Niue rely on one source of income- although growing crops, hunting and fishing to meet household food requirements is important. While migration is a strategy common to both locations, a major difference is that according to my informants, remittances from migrants to families in Niue are very uncommon- and, of course, migration to New Zealand and Australia from Niue is often permanent and always legal while migration from Kerinci to Malaysia- the most common destination- is usually temporary and sometimes illegal.

THE ROLE OF ENERGY IN LIVELIHOODS

In Chapter 2, the relationship between energy and sustainable livelihoods was discussed and Table 2 was developed. This table, which was adapted from Barnett (2001: 2), identified a number of outputs from a reliable and affordable energy supply.

Kerinci villages	Niue
▪ Rice farming primarily for one's own household consumption plus some income from sale of surplus. ▪ Having multiple sources of income. ▪ Livestock raising- mainly poultry in the geothermal villages mainly for own household consumption and mainly cattle, buffalo and goats in the non-geothermal villages mainly for income. ▪ Production of cash crops- mainly in the geothermal villages. ▪ Working in the government sector. ▪ Operating small businesses- a wide range of activities, eg small shop in village centre, stalls selling hard-boiled duck eggs, stalls selling litre bottles of petrol. ▪ Operating motorcycle taxis or *ojek* – this is entirely the domain of young men. ▪ Remittances from migrant workers in other regions of Indonesia or overseas (mainly Malaysia).	▪ Working in the public service Lincoln International (2002: 28). ▪ Migration to New Zealand Lincoln International (2002: 28). ▪ The setting up of small businesses- eg cafés, shops, guided tours (from my observation, this has increased over the past five years). ▪ The growing of crops, hunting and fishing for household food consumption plus the sale of any surplus on the local market.

Table 8: Livelihood Strategies

These can be summarised as facilitating improvements in employment opportunities, education, increased skill levels and access to technology, health, communications and sense of security and well-being which collectively can increase household incomes and improve the overall quality of life - thereby contributing to the achievement of wellbeing (Chambers, 1995: 33).

In this section, the role of energy will be examined for both sites by firstly examining the current situation in terms of supply and utilisation and secondly, the situation that could hypothetically apply were the existing identified renewable energy resources used.

Table 9 below summarises the current household energy supply and usage situation in the Kerinci Villages and Niue.

As mentioned earlier, in the Kerinci Villages, there is very little mechanisation in farming activities with much of the work being carried out by hand with buffalo sometimes assisting with ploughing. The cost of diesel, even before the recent price rises, has meant that the use of crop driers using diesel was seen as too expensive by farmers (Yanuar, 2005: 19) and there is total reliance on sun-drying which, while free in terms of energy cost, by general consensus results in losses of around 25% of the crop being dried. This loss of produce results in lost income- either because households have to buy rice or other food crops where losses mean they do not have sufficient for their own needs or they have less to sell.

On the other hand, the role of energy in the daily lives of Niueans is not significantly different from New Zealand. Unlike the situation in Kerinci, people are used to adequate supplies of electricity, petrol and diesel and while more expensive than in New Zealand, this appears to be factored into the day to day expenditure- ie these products are still regarded as affordable. For example, I drove through three villages at 9 pm and most houses had several lights on, plus the TV. Vehicle ownership is high.

Energy Resources

Both the Kerinci Villages and Niue lack fossil fuel resources- or at least, none have been discovered to date. As a consequence, the requirements for oil-based fuels have to be met from external sources and as stated in Table 7, both the Kerinci Villages and Niue share vulnerability in this respect.

RESOURCE	KERINCI VILLAGES		NIUE	
	HOUSEHOLD USAGES	SUPPLY STATUS	HOUSEHOLD USAGES	SUPPLY STATUS
Electricity	▪ Household lighting ▪ TV, radio ▪ Rice cookers (some)	▪ Inadequate. ▪ Unreliable. May become less affordable if/when subsidy reduced.	▪ Household lighting ▪ TV, radio ▪ Refrigerators, freezers ▪ Cooking (some)	▪ Totally generated from diesel. ▪ Will become less affordable if/when subsidy reduced. ▪ Single source- vulnerable to disruption.
Woodfuel	▪ Household cooking.	▪ Free good in some cases. ▪ Lowest cost cooking fuel- but price has doubled over six months. ▪ Indications that the wood resource may be under stress.	• Limited use mainly in traditional *umu* or for barbecues. • Regarded as an important emergency fuel in the event of a prolonged power outage.	• Good wood resource available.
Kerosene	▪ Cooking. ▪ Lighting in houses without electricity.	▪ Regarded as too expensive by many households. Supply not always reliable and rationing in place.	▪ Not commonly used	
Solar	▪ Crop drying	▪ Freely available but unreliable	▪ Hot water heating (by about 20% of households).	▪ Good solar resource.
Diesel	▪ Occasional use for personal transport- ie by bus if travelling to distant destination.	▪ Generally available but regarded as expensive.	▪ Transport.	▪ Imported using ISO "tank-tainers".
Petrol	▪ Local transport, typically by motorcycle taxis (*ojek*)	▪ Generally available but regarded as expensive.	▪ Transport	▪ Imported using ISO "tank-tainers".
LPG	▪ Cooking.	▪ Rarely used in villages and then use limited to "wealthy" households.	▪ Cooking (some).	▪ More expensive than electricity but if/when subsidy on electricity removed, LPG may be a less expensive option. ▪ Supply is unreliable.
Geothermal springs	▪ Cooking eggs, poultry, bananas. ▪ Bathing.	▪ Good.	▪ Not available.	

Table 9: Household Energy Usage and Supply

However, following the kerosene price shock, people in the Kerinci Villages have adapted albeit with a negative livelihood outcome in the form of a reduced quality of life and use of oil-derived fuels is limited to electricity (produced from diesel powered generators) and small quantities associated with transport needs. On the other hand, Niue has a heavy reliance on oil-based fuels.

However, both the Kerinci Villages and Niue have renewable energy resources as discussed in Chapters 3 and 4. Tables 10a and 10b matches the resources in the Kerinci Villages and Niue with available technologies and also with other critical characteristics as identified in Table 3 in Chapter 2. In all cases, only resources and technologies which are able to be operated, managed and maintained by householders or a community-based organisation are included - although in all cases capability building and training will be required. For the purposes of tables 10a and 10b - and elsewhere in this chapter- the term "geothermal villages" includes Air Panas Baru, Sungai Medang and Sungai Tutung while "non-geothermal villages' includes Muara Jaya, Muara Semerah and Paling Serumpun.

RENEWABLE ENERGY RESOURCES- ANALYSIS

In the next part of this chapter, each of the resources identified in tables 10a and 10b will analysed in terms of quantity, potential applications and possible benefits- particularly in respect to the current energy supply and affordability problems being experienced. This is not intended to be a technical or economic feasibility study: rather, it will be an attempt to identify the benefits that renewable energy resources could bring to people in the Kerinci Villages and Niue in terms of increased income and improved well-being. As noted at the beginning of this chapter, the analysis is intended to be within the existing livelihood paradigm- ie no significant changes to existing income generating activities, farming methods, crops grown or lifestyles. Details of the calculations, data and assumptions on which the estimates of energy use, biomass quantities and cost benefits quoted below are based are set out in Appendices A and B for the Kerinci Villages and Niue respectively.

The analysis will include both resources currently unused and resources that are currently used inefficiently or ineffectively and where the application of improved technology will be of benefit.

Resource	Kerinci Villages				Niue			
	Current Uses	**Access**	**Sustainability**	**Relevance**	**Current Uses**	**Access**	**Sustainability**	**Relevance**
Biomass- woodfuel:	Widespread use for cooking using simple stoves.	Can be readily bought or in geothermal villages collected as "free good".	Signs of stress are appearing.	Essential energy source for household cooking	Minimal utilisation at present.	Good	Good	Used only for recreational cooking (*umu* or barbecues) or in emergency.
Biomass waste- rice straw, animal manure, vegetable residues.	▪ Some use of manure as fertilizer. ▪ Some use of vegetable residues as stock feed.	Good- straw discarded or burnt at present.	Excellent.	Potential use as: ▪ Cooking fuel (direct in stove). ▪ Biogas for cooking or crop drying. ▪ Gas from gasifier for cooking, crop drying or power generation.	Minimal utilisation at present.	Limited quantities only.		Small quantities only.
Biomass- other forms.	Small number of coconut groves- used only for food.	Limited quantity		Anecdotally- plan in place to plant oil seed trees on degraded land.	Coconut plantations and groves- largely unused except in small quantities for food.	Good	Good	Potential use as diesel oil replacement.
Streams	*Not used at present.* .	Good- but only available in the geothermal villages.	Excellent- good rainfall.	Possible use in micro- hydro power plant to produce electricity	*None- no rivers or streams*			

Table 10a: Renewable Energy Resources in the Kerinci Villages and Niue

Resource	Kerinci Villages				Niue			
	Current Uses	**Access**	**Sustainability**	**Relevance**	**Current Uses**	**Access**	**Sustainability**	**Relevance**
Wind	*Not used at present.*	Resource appears to be inadequate.			*Not used at present.*	Excellent.	Excellent	Potential as major resource for power generation.
Solar	Used only for drying of crops.	Unreliable resulting in crop losses.	Good	Important as it provides the main means of crop preservation.	▪ Water heating.	Excellent	Excellent.	Potential as major resource for power generation- cost of PV power panels is the main barrier.
Geothermal	Currently used for: ▪ egg incubation. ▪ For cooking eggs and poultry. Possible use for power generation.	Good- but only in available in the geothermal villages.	Good- but will require management if used on larger scale.	Now being used to increase poultry numbers possibly for crop drying. Potential source of power.	*Not used at present.*	No geothermal resources have been found.		

Table 10b: Renewable Energy Resources in the Kerinci Villages and Niue (continued)

THE KERINCI VILLAGES

Biomass- Woodfuel

As previously discussed, woodfuel is used as "traditional" biomass and burnt in simple stoves to meet household cooking requirements. While woodfuel is undoubtedly the "traditional" fuel for cooking, it would be wrong to assume that it is the fuel of choice as most villagers used kerosene before the subsidy was reduced in late 2005. Rather, this decision has been forced on the communities by the high price of kerosene. This represents a step-down in the "energy ladder" from a commercial fuel to a semi-commercial fuel with lower convenience and efficiency factors.

Given that the wood is now much cheaper than the alternatives or in some cases, a "free good", wood is likely to be the main source of household cooking energy for the foreseeable future- barring a collapse in the supply or government intervention.

I have estimated that between them, the six villages consume just under 4,000 tonnes of woodfuel annually, ranging from 180 tonnes in Air Panus Baru to nearly 1,300 tonnes in Sungai Tutung[41].

From my observations during field visits and confirmed in discussions with LTA, woodstoves range from very basic 'three-stone" types through to small cylindrical stoves which I would judge to be of medium efficiency. I did not see any stoves that were fitted with chimneys. A kitchen and cooking appliances were shown in Figure 8 (page 47); I was assured by the villagers and LTA that this kitchen and the appliances are typical of most in both rural and urban households, including the soot deposits on the kitchen walls. The negative impacts on health from regular exposure to woodsmoke are well known, particularly the effect on women who carry out most if not all cooking, eg Kammen *et al* (2002: 12)[42].

From data in WEC (1999: 60), I estimate that stove efficiency will be in the order of 20% and when comparing with typical kerosene consumption and taking into account the higher efficiency of a kerosene stove, this efficiency assumption appears to be reasonable.

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[41] This assumes 90% of households use fuelwood. Refer also to Appendix A.

[42] While I was unable to obtain any data from health professionals on any increased incidence of respiratory illness following the switch back to woodfuel, in one village (Paling Serumpun) in response to a question regarding health problems in general, I was told that there had been an increased problem with coughs in recent months.

If the existing stoves were to be replaced with improved efficiency stoves of say 25%, this would reduce overall woodfuel consumption by about 20%, an improvement which is in line with that suggested as achievable in WEC (1999: 59). Such an improvement could, at the woodfuel price applying in November 2006, reduce the average amount of woodfuel used by over 400 kg annually and save over $19 for households where woodfuel is bought.I have consulted a range of literature on the issue of stove cost, including WEC (1999), TRUST (2004), Shastri *et al* (2002: 64) and RWEDP (1993), and I believe an installed cost[43] of around $40 would be achievable and the fuel savings from installation of such a stove could provide householders with a simple "payback" of two years. Even if the cost were double, ie $80, the return would still be reasonable.

While I emphasise the cost benefit that could result from installing the improved woodstoves- because I believe this would be the main incentive for change- there is evidence that the health of the women in the household would improve and also the time involved in cooking would reduce (TRUST, 2004: 20).

Both TRUST (2004) and WEC (1999) emphasised the need for appropriate training in the use of high efficiency woodstoves in terms of installation, operation and maintenance and this would need to be part of any programme to introduce these stoves on a wide scale.

Other Biomass

In terms of biomass waste volume, by far the largest source is rice straw. According to the local government agricultural agency[44], some 450,000 tonnes of rice straw are produced annually, most of which is burnt (see Figure 15 over). In the case of the six villages, the amount of recoverable rice straw is estimated to be just over 2,000 tonnes annually[45].

Other vegetable waste will include leaves and stalks from crops such as sweet corn, chilli and beans. I understand that some of this material is used as stock or poultry feed but in any event, no reliable data was available as a basis to estimate the quantities of waste available.

[43] The figure in Shastri et al (2002) is $US12, ie around $20; the $50 allows for installation and chimney.
[44] In presentation to workshop in Sungai Penuh on 24 November 2006.
[45] This assumes that 50% of the amount produced is collectable- see Appendix C.

Animal waste available includes dung from cattle, buffalo, goats and poultry and estimates of numbers of livestock were available from LTA (2004) and BPDSDKT (2006). While cattle and buffalo graze around the villages during the day, they are generally penned at night and it is assumed that 50% of the dung produced would be collectable. On the other hand, goats and poultry tend to roam 24 hours and dung would be difficult to collect in meaningful quantities. On this basis, I estimate that just over 1,200 tonnes of dung would be available from the six villages. However, the amount varies considerably reflecting the nature of farming in each village with cattle numbers in the three non-geothermal villages being much higher (and especially so in Paling Serumpun) than in the geothermal villages where poultry raising and cash crops are the principal sources of income from farming.

Figure 15: Kerinci Villages- burning rice straw following the rice harvest

While the woodfuel resource can continue to be used in the unprocessed state, the other biomass will require some degree of conversion into a usable form. The simplest conversion process would be to dry and burn waste such as rice straw in a stove but from discussions with LTA and villagers, while this would be an obvious recourse in a woodfuel crisis situation, the difficulties associated with drying the rice straw to an appropriate level and cutting the straw to enable it to be fed into a stove meant that this option was clearly not seen as feasible by LTA and the villagers.

There are two other conversion options: gasification and biogas. In very simple terms, the gasification process involves "cooking" the waste material with minimal air present, and drawing off the gas produced which can be used in the same way as natural gas or LPG (Kammen *et al*, 2002: 19). Gasification technology still poses some health and safety problems with toxic residues and a risk of explosion (Stassen, 1995: 53), but if these can be overcome, this technology could be particularly useful where woody waste exists (eg rice husks). However, as noted previously, my approach in this thesis is only to consider in detail proven technologies suitable for use in rural communities.

Where waste is predominantly "soft" biomass, such as crop and animal waste, this is an appropriate "feedstock" for biogas generation through anaerobic digestion. In this process, the waste is fermented in the absence of air to produce biogas, a mixture of (mainly) methane and CO_2. Given the nature of the biomass waste in the six villages, biogas generation is clearly an option.

Of the two technologies, biogas by far the most widely used with several million biogas digesters producing gas for mainly household use in China, India and Nepal (Martinot *et al*, 2002: 317) although the high percentage of rice straw that would apply in the six villages would mean a different approach in respect to bio-digester design from that used in China, for example, where the feedstock has a high animal dung content.

In the six villages, there are a number of ways in which the biogas could be used:

- As a fuel for cooking, which from the literature is probably the most common use (eg WEC, 1999: 85)
- As a source of heat for agricultural processing- ie crop drying.
- For electricity generation (Kammen, 2002: 20).

While the use of biogas for electricity generation is technically feasible and proven, I have some doubts whether would be a practicable option in rural communities such as the Kerinci Villages. For satisfactory operation of the generator plant, the biogas would need to be of consistent quality (which requires the feedstock to be of consistent composition) and cleaned up, ie provided with some form of primary treatment to remove much of the moisture and impurities contained in the "raw" product.

(a) Cooking

Use of biogas as a fuel for cooking is an attractive concept as it would eliminate a number of the undesirable characteristics associated with the use of woodfuel for cooking, ie poor indoor air quality, the time taken to collect the woodfuel (ITDG, 2002) and the potential for deforestation. However, my estimates show that the biogas produced from the estimated waste quantities varies considerably over the six villages with the three non-geothermal villages being able to produce substantially more biogas on a per household basis than the geothermal villages. This difference is due to the non-geothermal villages being located on the valley floor with larger areas of rice field and a greater reliance on livestock raising for income purposes while the geothermal villages have relied on cash crops from upland farming as the main source of income.

In the three geothermal villages the biogas potential would only be enough for about 10% of households[46]. Another factor is that the use of woodfuel is well entrenched in these villages and at least currently, easily obtained as a "free good" or relatively cheaply, and I suspect that most villagers would ask why they should change to biogas. This gives rise to the question: under these circumstances, would it not be better to assist households to buy new more efficient woodstoves that (a) use less fuel (perhaps up to 50% less) and (b) vent to the outside and therefore largely eliminating the health risks associated with un-flued woodstoves (WEC, 1999: 60)?

In the other three villages, the situation is different and the number of households that could be supplied with biogas increases to between 20% and 50%. Discussions with villagers during November 2006 indicated considerable interest, particularly from women (as would be expected). However, preliminary estimates of the cost of the digesters and associated equipment indicate that allowing for depreciation of plant but assuming the initial loan is at say 5% or less interest, the cost of biogas will be marginally below that of woodfuel. However, in the event that low interest funding were not available, the cost could be expected to rise to above that of woodfuel depending on the interest that would be charged. While this would still be below the cost of kerosene, the issue becomes whether or not households would understand or regard the benefits in terms of reduced health risk and convenience as sufficiently worthwhile.

[46] The estimates of gas demand are based on the typical woodfuel consumption figure of about 170 kg per month established during the field visits in discussions with LTA and the villagers and allowing for the greater efficiency of a biogas stove. The calculations on which these estimates are based are provided in Appendix A.

Figure 16: Penned cattle- Paling Serumpun

(b) Crop drying

An alternative approach would be to use the biogas as a source of heat for crop drying. As noted earlier, the traditional method of preserving produce is sun-drying, a process that results in crop losses in the order of 25%. Not surprisingly therefore, during geothermal village meetings held in March 2006, villagers were enthusiastic at the concept of geothermal driers, not just for rice but for use with other crops such as chilli, coffee and cinnamon.

If (say) 50% of farmers chose to use a biogas crop dryer to dry their rice crop, with the loss being reduced from 25% to 5%[47], I estimate that the increase in income from the reduced losses based on a selling price of Rp3,000 per kg for hulled rice (LTA, 2004) will range from an average of $20 per household in the geothermal villages to over $300 in Muara Semerah, the difference representing the amount of rice grown per household. In terms of an average household annual income of $1,220 (LTA, 2006), the significance in the case of Muara Semerah is very high (estimated at an average over $350 per household).

[47] My estimate from discussions with rice farmers.

Being based on rice, this estimate is likely to be conservative as farmers in the geothermal villages could be expected to use the driers also for higher value crops such as chilli, corn, cinnamon and coffee. For example, in November 2004, I was told that a market for dried chilli existed but could not be supplied owing to the fact that chilli is a fragile crop that has to be dried at the right stage of ripeness and that sun-drying was too unreliable. Given that Yanuar (2005:19) reported that the selling price for chilli was Rp8,000 per kg, if biogas drying were available, farmers would be likely to want to grow higher value crops such as chilli. No figures were available for the quantities of crops produced in the villages and only in the case of rice is it possible to estimate the annual crop in the six villages based on the rice field area for each village as provided by LTA (2004) and BPDSDKT (2006) while the total regency rice production figures and rice field area were provided by the Kerinci Regency (2004: 4).

The use of human waste was discussed with LTA not so much in terms of the increased biogas production that could result but more in terms of the improved sanitation that would result if communal toilets could be constructed and the effluent piped into a digester. Such facilities would reduce the use of streams as open-air toilets. The view of LTA was that this would probably be seen as culturally unacceptable by the villagers, particularly by people involved in operating the digesters and possibly by users of the biogas. However, it was agreed that once a digester was operating and people became more aware of the effectiveness of the anaerobic digestion process, these objections may disappear.

Geothermal Energy

While in New Zealand geothermal energy is very much associated with power generation, its use as a heat source is far more common, output being twice that of generation on a worldwide basis (WEC, 2001: 9). With the exception of one site, the geothermal resources in the three geothermal villages are in the form of hot springs, producing water at just under 100°C. Electricity generation, given the small scale and the relatively low temperature, is not an option without resorting to complex technology. The exception is a small steam field in Air Panas Baru but this would require extensive testing before its use for power generation could be confirmed and even if this shown to be the case, operation of the plant would require skills well beyond those available in the villages, ie not appropriate for a community based organisation.

Two opportunities to use the heat from the heat from the geothermal resources in the villages have been identified, egg incubation and crop drying:

(a) Egg incubation

As dicussed in Chapter 3, the ADAF Geothermal Project funded by NZAID is underway and is aimed at increasing the poultry flocks in the three geothermal villages to meet a large unsatisfied demand for duck eggs in particular (ECL, 2005).

A feasibility study was carried out Empower Consultants Ltd (ECL, 2005) and as part of this study, it was estimated that the geothermal springs in each of the three villages were well suited to providing the necessary heat for hatching and also for the first three days of “post-natal care” (ECL, 2005: 36). Considerable attention was paid to the market for eggs given that the proposed incubators were expected to increase the poultry flock to a level that would bring an additional 35,000 eggs per week into the market, estimated to be 125,000 eggs per week (Yanuar, 2005: 18). As Dorward (2001) pointed out, in activities aimed at achieving sustainable livelihoods by producing new goods or increasing quantities of existing goods, careful attention to the market for these goods is essential. In this case, Yanuar (2005: 18) concluded that the market could absorb this amount of additional product without disruption to existing suppliers in Kerinci. The feasibility study estimated that the cost benefit of the geothermal incubator project would be in the order of $33,000 per village after one year of operation (ECL, 2005:35). The additional income per household ranges from $40 in Sungai Tutung to over $250 in Air Panus Baru.

At the time of my November 2006 visit, all three incubators had been built and trials recently completed. Full commercial production was delayed, however, because of a lack of suitable eggs, a situation expected to be rectified in December 2006.

(b) Crop drying

The ADAF Geothermal Project feasibility study also considered crop drying using geothermal water but did not study this option in any detail (ECL, 2005: 42). Rather, it was recommended that a small crop dryer be constructed for use by the villagers on a trial basis (ECL, 2005:42); this recommendation was accepted by NZAID and the prototype crop drier was completed in October 2006. During my visit in November 2006, I visited Air Panus Baru where the dryer was located and at that time it was being used to dry corn. It was reported that the corn could be dried in 24 hours instead of three days using sun drying and with “much less” spoilage.

Using a similar approach to that used in the analysis of biogas crop drying potential, I estimate that the net additional income per household will be marginally higher than with biogas at just over $20 because the capital cost of equipment can be expected to be lower as a digester is not required. The potential benefits therefore appear small and somewhat less than the benefits estimated from egg incubation. However, as can be seen from Appendix A, in the case of Air Panas Baru, the constraint would be not the capacity of the geothermal resource but the availability of crops for drying. An opportunity might therefore exist to dry crops for other nearby villages.

Figure 17: Kerinci Villages- crops being dried by geothermal heat - Air Panas Baru

Micro-hydro Power Generation

The use of water to provide useful energy is not a new technology. The traditional water wheel driven mill used to grind grain was in use in Europe over 900 years ago (ITDG, 2000d: 1).

Hydro electricity generation plant is available across a very wide range of power outputs ranging from several 100 MW down to 500 W or less. Micro-hydro generation, defined by UNIDO as plant of generating capacity of up to 100 kW (Junejo, 1997:4), is of the greatest interest in the context of rural communities as the power output is well suited to the requirements of a small community or a rural industry in a remote area isolated from an electricity grid. Unlike larger plant, micro-hydro generation does not involve the construction of large dams or significant civil engineering, which are not only expensive but also potentially highly disruptive in terms of environmental impact (ITDG, 2002: 15).

During the field visits, brief surveys were undertaken to identify the streams flowing off the hills that are part of three geothermal villages in order to estimate the possible power generation opportunity. From this survey, I estimate that there is sufficient micro-hydro potential to increase access to electricity by 10% in Sungai Medang and Sungai Tutung and 70% in Air Panus Baru, this last figure reflecting the fact that this village has the lowest population and the best micro-hydro potential. In terms of cost and affordability, I estimate that the cost per kWh will be less than 20 cents/kWh which compares favourably with the estimated cost of diesel generation at 21 cents/kWh.

KERINCI VILLAGES - SUMMARY

The above analysis indicates that the application of renewable energy technologies to convert existing resources that are unused, under-used or used inefficiently would provide some benefits to peoples' livelihoods in the Kerinci Villages.

- Arguably, the installation of fuel efficient woodstoves could have the greatest impact because it can be universally applied, there would be a robust economic return, positive health impacts and a reduction in woodfuel consumption would reduce stress on the this resource.
- The use of biogas to replace woodfuel for cooking would achieve similar impacts plus further reductions in woodfuel consumption- but estimates indicate that it is unlikely that there will be sufficient biogas available to meet more than 50% of households at best and much less in some cases. Cost benefits are marginal.
- The benefits in terms of potential increased incomes by using the biogas for crop drying are better and may be more attractive - and fairer - to farming households which form the majority.
- In the three geothermal villages, the use of geothermal energy could increase household incomes by an average of about 15% while in the other three villages, the use of biogas for crop-drying could increase incomes by an average of 18%. It is stressed that these are averages and in both categories of village, there is considerable variation from the best to worse case.

- Table 11 summarises the results of the analysis of the benefits from using biogas for crop drying and geothermal energy for egg incubation and crop drying on a village by village basis.

The estimates on which Table 11 are based (refer Appendix A) are indicative only and major assumptions have been made in respect to the amount of rice that farmers would dry using the crop dryers. On the other hand, the cost benefits from the use of the geothermal egg incubators were established using a relatively rigorous economic analysis (ECL, 2005: 35). Overall, I consider that the estimates are conservative - ie on the low side- because I have not included opportunities such as the drying of higher value crops or drying crops for farmers in neighbouring villages. These factors are particularly relevant for biogas drying as in all cases, there would be significant amounts of biogas potential unused.

VILLAGE	ADDITIONAL ANNUAL INCOME FROM BIOGAS UTILISATION	ADDITIONAL ANNUAL INCOME FROM GEOTHERMAL UTILISATION	TOTAL ADDITIONAL ANNUAL INCOME	AVERAGE ADDITIONAL ANNUAL INCOME PER HOUSEHOLD
Air Panas Baru	$2,641	$36,150	$38,791	$305
Muara Jaya	$56,835	$0	$56,835	$181
Muara Semerah	$220,360	$0	$220,360	$355
Paling Serumpun	$13,593	$0	$13,593	$41
Sungai Medang	$9,962	$43,502	$53,464	$125
Sungai Tutung	$23,586	$43,961	$67,547	$80

Table 11: Kerinci Villages- estimates of potential additional income from use of biogas and geothermal energy for agricultural processing.

The additional income per household averaged over the six villages is $180. This is somewhat deceptive as there will be households that are unable to benefit directly in that they do not participate in farming activities or who do not wish to participate as was found with the geothermal project. Income data from the baseline survey of 106 households carried out by LTA (2006) in the three geothermal villages revealed an average annual income figure of $1,220 per household and in these households, an additional $180 would represent an increase of 15%.

Costs that are internal to the villages have not been deducted from the additional income estimates on the grounds that these remain within the village. These include costs such as payment for labour (eg gathering and transporting rice straw, operating the incubators) and payments made to farmers for waste, assuming that once rice straw is being utilised it will assume a value- and, of course, animal dung already has some value. Similarly, any income from the sale of sludge from the biogas digesters as fertiliser has been assumed to be "internal" income.

Micro-hydro generation resources are relatively small and as such will only increase electric power availability by about 10% in Sungai Tutung and Sungai Medang but in the case of Air Panas Baru, theoretically all households could be supplied. As with geothermal resources, this is a result of the relatively small population while occupying a larger land area in comparison with the other two villages. While in the case of Sungai Medang and Sungai Tutung only 64% of households would be connected to either the PLN supply or from the micro-hydro supply, the likelihood is that the number with access to electricity will approach 80 to 90% in Air Panas Baru. This assumption is based on the current situation where according to information provided at the village meetings during March 2006, around 20% of households had access to electricity via a neighbour.

NIUE

Biomass

Given the small population and the relatively large land area, I consider it likely that all cooking energy needs could be met on a sustainable basis from biomass in the form of wood or wood waste[48]. However, given the way of life in Niue, it is very unlikely that a switch to woodstoves for cooking would be acceptable except in an extreme situation- eg a major and extended breakdown in the island's power supply, a severe shortage of diesel fuel for the island's power generation or a major increase in diesel prices. Whether such a situation would be regarded as tolerable is a moot point and a consequence could be further migration from the island.

As in Kerinci, coconut trees grow well in Niue both wild and in plantations, the latter dating from the copra industry that existed until the 1970's when prices declined together with the availability of labour as the great migration to New Zealand gathered momentum. As noted in earlier in this chapter, there is a shortage of labour in Niue, particularly for what may be regarded as menial or unskilled activities. This factor would probably be a barrier to the production of coconut oil using what appears to be the

[48] To confirm this one way or another, it would be necessary to carry out an inventory of biomass resources and to estimate the rate that forest resources can regenerate given on one hand, a climate that encourages growth and a thin topsoil layer on the other.

reasonably abundant coconut resource[49] on Niue and which could be used to reduce diesel imports, which in 2002/3 totalled (approximately) 1,500,000 litres (Wade, 2005a: 9). Based on discussions with colleagues who carried out a study on the use of coconut oil in the Marshall Islands (ECL, 2005) the processing of copra to the stage when it can be pressed to produce oil is labour intensive and time consuming and in the current situation, I consider it is highly likely that the necessary labour would have to be imported. According to Wade *et al* (2005: 32), there was some investigatory work being carried out in Samoa on the commercial use of coconut oil or its esters as a diesel substitute and if the results are positive, then this could be relevant to Niue. However, there are other types of oil seed which may be suitable for cultivation on Niue and require less labour-intensive processing.

Figure 18: Niue- disused coconut plantation

While a widespread switch to woodstoves and the use of coconut oil or other oil seed as a diesel substitute or extender can be regarded as not feasible at this stage, both these options are available should Niue be faced with a fuel crisis at some stage in the

[49] This includes both "wild" and plantation coconut palms, the latter being a legacy from the pre-1980's when there was a copra industry.

future. Also, the feasibility of using woody biomass could improve should gasification technology develop to a stage where it is safe and practicable for small scale operation.

Wind

With an average annual wind speed of 6.48 m/s (NASA, 2006), Niue has a wind power resource that can provide a worthwhile economic return. To assist further, the records show minimal variation on a month by month basis or over a 24 hour period.

A European Union funded wind power project[50] is under development and it is understood from discussions with NPC that this will comprise the installation of two 75 kW turbines with a predicted commissioning date sometime in 2009. I estimate that at the average wind speed noted above, these turbines could contribute about 15% of the annual power consumption based on the 2002/3 figure of 3,368,888 kWh (Wade, 2005a: 12) which at the estimated cost of power generation, could save NPC up to $200,000 annually in diesel fuel. Based on an estimated construction cost of around $400,000[51] and savings ranging from (say) $150,000 to $200,000, the estimated rate of return is between 30% and 50%. To sum up, the economics of wind power in an environment such as Niue (ie with a good wind resource and a heavy reliance on imported diesel fuel) are excellent.

In a situation such as Niue where the power is generated at a central point and distributed through a grid, technical difficulties limit the size (ie power output) of the contribution that wind power can make. Because the output from a wind turbine will fluctuate considerably as the wind speed fluctuates, the proportion of wind generation in a diesel power network has to be limited to about 20% of the demand as the diesel plant is unable to cater for the sudden fluctuations in demand should the wind component be higher than 20%.

A possible approach to increase the overall contribution of wind power would be to install a number of small turbines (say up to 20 kW) with battery storage dedicated to specific loads, such as a village. To ensure that power was available at all times, a small diesel generator would be necessary plus possibly a solar PV module[52] and this arrangement would supply the houses in the village through a "micro-grid". In Appendix

[50] This is part of the EU's Pacific Regional Programme involving six island states (including Niue) and which includes assistance with the development of renewable energy resources.
[51] From EWEA (c2004:3).
[52] Generally referred to as "hybrid" generation plant.

A, I have analysed a model where 12 of the 13 villages serving 80% of the population are supplied with power using such an arrangement and while this model and the analysis makes a number of broad assumptions, with the good wind resource available I estimate that the diesel consumption used to generate power for these 12 villages could be reduced by 80% with annual savings of about 250,000 litres, which would be a little over 25% of the total diesel imported for power generation in 2003 (Wade, 2004a: 9), and in terms of cost would save over $300,000 annually at today's landed price of diesel.

The cost of small diesel-wind-solar hybrid plant would be large- I estimate that this would be in the order of $5.5 million for 12 micro-grids serving 80% of households. However, from the analysis in Appendix B, the price of the electricity produced would be in the order of 80 cents/kWh, allowing for some diesel use, depreciation, maintenance and operation, about the same as the current actual cost, which I estimated to be between 70 and 80 cents/kWh in Chapter 4.

While the analysis in Appendix B applies to households, there is no reason why similar but possibly larger hybrid installations could not be used to meet government and commercial power requirements which according to Wade (2004: 12) used 2,000,000 kWh in 2003.

Solar

There is already a significant use of solar water heating in Niue. In households or hotel/motel accommodation where hot water is considered a necessity, the economics are extremely favourable compared with electrically heated hot water given that in New Zealand, solar water heating is considered economically justified at a power price of 16 cents/kWh.

Even though the installation costs are high, solar PV power generation is an option for Niue, albeit marginally at this time. NASA databases indicating a solar resource of 4.8 kWh per kW installed for the island and, as an example, it is estimated that a 50 kW solar array would produce nearly 90,000 kWh annually. The initial cost would be high- about $600,000- but based on the actual cost of diesel generated power of between 70 and 80 cents, the installation would provide an internal rate of return of about 10%.

Emerging Technologies

In the longer term, there is the possibility that ocean energy technologies could be developed that can be economically applied on a small scale. In the case of Niue, this can be regarded as a potential source for the future rather than for immediate application.

SUMMARY

Summarising the results of the above analysis:

- Biomass has limited application at present in that it would not meet current lifestyle requirements. In the event of a crisis that interrupts the supply of oil products on a long term basis, either due to a supply shortage or due to high cost, biomass would become a valuable energy resource as a household fuel and as a source for producing transport fuels. However, some advances in the technologies associated with these resources would be required before being an acceptable substitute for existing energy sources.
- Given the good wind resource in Niue, wind power offers an immediate opportunity to use this resource to meet up to 50% of Niue's power needs and to reduce diesel use by a similar amount. In fact, other than the availability of funding and people with the necessary technical skills, I consider that there is no reason why the percentage could not approach 90% in the medium to long term. Given that the cost of imported diesel for power generation is in the order of $1.16 million[53], this would have a big impact on the cost of imports overall (estimated to be $3.245 million for year ending 2002 (MFAT, 2006)).
- Solar energy is already used extensively for hot water production. Solar PV power generation while marginal in economic benefit terms, will be available to supplement wind generated power particularly should the price of diesel fuel increase further.

LIVELIHOOD OUTCOMES

In this section, the livelihood outcomes that could result from of greater or improved (ie more efficient) use of renewable energy resources are discussed in terms of changes to the capital asset bases and any reductions in vulnerabilities in the Kerinci Villages and Niue. These outcomes are based on the analysis described above. Any identified changes to transforming processes and structures that I consider would be necessary if the outcomes are to be achieved are discussed.

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[53] This is based on the amount of diesel sold to NPC for power generation in 2002/3 which was approximately 965,000 litres (Wade, 2005a: 9) at the 2006 price of $1.21 per litre.

CAPITAL ASSETS

A number of additional or enhanced capital assets would result from development and use of the renewable energy resources that exist in the Kerinci Villages and Niue as discussed above. Some of these are a direct result- eg:

- Increased income from increased agricultural production in the Kerinci Villages, ie eggs and poultry from the geothermal incubators, reduced crop wastage when using the biogas or geothermal driers and (possibly) the ability to produce higher value crops such as chilli where affordable crop drying can be provided.
- Reduced household costs- eg less woodfuel used with efficient woodstoves in the Kerinci Villages, cheaper electricity (in real terms) from community managed wind-diesel hybrid generation plant in Niue.

There are some potential "flow-on" increase in assets-

- Increased employment opportunities in the form of the labour needed to operate the renewable energy systems and the associated increased incomes.
- Increased human capital resulting from the training that people will have to be provided with in order to operate the renewable energy systems.
- Given that both Kerinci and Niue already attract "eco- tourists", the provision of tourist accommodation supplied with renewable energy would be an additional attraction.

Table 12 sets out and discusses livelihood outcomes in terms of additions or changes to capital assets that I have estimated would occur were the identified renewable energy resources to be effectively utilised. The asset headings are those used in Table 6 and I have used the DFID sustainable livelihood objectives for each asset (DFID, 1999b).

VULNERABILITIES

Table 13 sets out and discusses livelihood outcomes from increased use of renewable energy in terms of changes to vulnerabilities. Again using the headings in DFID (1999b: 2.2), vulnerabilities are grouped under the three headings: *shocks, trends* and *seasonality.*

Capital asset	Livehood Outcomes – Kerinci Villages	Livelihood Outcomes- Niue
Natural capital: *DFID objective- "More secure access to, and better management of, natural resources"*	▪ The use of fuel-efficient woodstoves and/or biogas from biomass waste would reduce woodfuel consumption and the stress on this resource. ▪ At present, biomass waste has minimal value and, in the case of rice straw, negative value as it has to be collected and burnt. Using the waste for biogas production will turn it into a capital asset. ▪ On the other hand, geothermal resources and the streams that will be used for micro-hydro generation already have some value, with the geothermal springs being used for cooking eggs and poultry and bathing while the streams are used for water supply and irrigation. Using these resources as sources of renewable energy will increase the value of these assets especially as this can be achieved without adversely affecting these current uses- but care will be required to ensure that the new uses will not have a negative impact on these existing uses.	▪ With the exception of what appears to be a small use of woodfuel and some solar water heating, the natural renewable energy resources that exist in relative abundance in Niue are unused and are perceived to have no value at present. The use of these resources on a larger scale would mean that they have value, ie become a capital asset.
Social capital: *DFID objective- "A more supportive and cohesive social environment".*	▪ A strong sense of community was identified during field visits and is being used in the management and operation of the ADAF geothermal project, the project being recognised as of benefit to the community as a whole. This is not an *increase* in social capital- but is identified an important factor in ensuring the success of community-based renewable energy projects. ▪ However, as pointed out by DFID (1999:2.3.2), working together with a common goal can be "self-reinforcing", enhancing supportive relationships within a community.	▪ In the event that the concept of setting up village micro-grids using wind-diesel hybrid generation were to be adopted, this would require a high level of working together towards the common goal. As strong communities already exist at village level (Lincoln International, 2002:9), this would form a good base for the formation of community based groups to provide the necessary management and technical support that would be required to operate the micro-grids. Such groups can be "self-reinforcing" (DFID,1999:2.3.2), enhancing supportive relationships within a community. ▪ A similar situation could arise if the biomass resources were to used successfully with the need for community based groups to manage the use of the biomass resource,

Table 12a: Livelihood outcomes- Capital Assets: Kerinci Villages and Niue

Capital asset	Livelihood Outcomes – Kerinci Villages	Livelihood Outcomes- Niue
Human capital: *DFID objective-"improved access to high-quality education, information technologies and training and better nutrition and health".*	▪ The introduction of renewable energy technologies including both conversion and utilisation equipment would require the operators in the villages to be trained in the operation and maintenance. In some cases this will involve building on existing skills, eg training the village electrician to maintain a micro-hydro generator, while in other cases completely new skills will need to be acquired. ▪ The renewable energy schemes will provide additional employment opportunities- eg collection of waste, operation of equipment- and additional sources of income- eg poultry raising and egg production from geothermal incubation, increased crop productivity from drying. ▪ Given that villagers put a high priority on education, improved education would therefore be a consequence that could be attributed high school education becoming affordable to more families owing to the additional income from use of the renewable energy resources. ▪ The collection and use of animal waste would help to remove the health hazard that this waste creates when left lying around. ▪ The replacement of inefficient and un-flued woodstoves either by fuel-efficient woodstoves or biogas stoves would reduce health risks from poor indoor quality and carrying heavy loads of woodfuel could be eliminated; this would be of particular benefit to women who carry out cooking activities and are most exposed to the smoke from the un-flued stoves.	▪ If renewable technologies are to be applied successfully, new skills will be required to operate and maintain the plant and equipment. This will raise the general level of technical skills in Niue while providing new employment opportunities for young people.

Table 12b: Livelihood outcomes- Capital Assets: Kerinci Villages and Niue (continued)

Capital asset	Livelihood Outcomes – Kerinci Villages	Livelihood Outcomes- Niue
Physical Capital: *DFID objective: "Better access to basic and facilitating infrastructure".*	▪ Improved access to electricity through micro-hydro generation. ▪ Improved sanitation in conjunction with biogas production.	▪ Given that Niue already has a good physical infrastructure, I see the main benefit of renewable energy as being to reduce the reliance of the power supply infrastructure on imported diesel fuel.
Financial Capital: *DFID objective: " More secure access to financial resources"*	▪ Increased income from additional employment opportunities and increased agricultural production (crops, poultry and eggs). ▪ Increased tourism potential- "eco-tourists" attracted by accommodation supplied with renewable energy.	▪ At present, Niue is almost entirely dependent on imported petroleum products to meet its energy needs. I estimate that this costs about $2.8 million[54] annually of which the share for power generation is $1,165,000. Conservatively, the use of wind and solar could reduce this cost by around $300,000. ▪ Increased tourism potential- "eco-tourists" attracted by accommodation supplied with renewable energy.
Personal Capital:	This will include a general increase in a sense of well-being from: ▪ Increased incomes. ▪ Improved cooking facilities either by use of improved stoves or biogas, resulting in better conditions and reduced risk of respiratory and eye disease, mainly benefiting women. ▪ Improved access to electricity- this which will result in not just better household lighting and access to information (eg radio and TV) but also some relief from household chores for women, eg enable use of rice cookers and electric irons, both nominated as "highly desirable" at village meetings.	In terms of a tangible increase in personal capital, it is difficult to claim any measurable impact. However, I suggest that a reduction in fuel imports that could be achievable by use of wind and solar energy will increase the sense of well-being mainly because it will be perceived as reducing Niue's financial dependence on New Zealand while by no means eliminating this dependence. From my discussions with key informants, I became very aware that Niueans are concerned at the level of their dependence on New Zealand if their current livelihoods are to be maintained.

Table 12c: Livelihood outcomes- Capital Assets: Kerinci Villages and Niue (continued)

[54] This is based on a total cost of fuel imports for 2002/03 of $1.876 million (Wade, 2004:6) and adjusting for an increase in the cost of refined product of about 50% from 2002/03 to 2006 (from Delbruck, 2005:10).

Vulnerability	Situation in Kerinci villages	Situation in Niue
Shock	• The use of fuel efficient woodstoves would assist villagers to mitigate the impacts of having to revert to woodfuel as a consequence of the increase in the price of kerosene. A similar result would occur if biogas produced from biomass waste were to be used as a cooking fuel. • Crop dryers using geothermal energy or biogas and geothermal egg incubators would assist farmers to increase productivity and therefore incomes, thereby reducing the heavy reliance on one or two cash crops - eg cinnamon and coffee- particularly where the prices are largely governed by international markets.	• Development of local renewable energy resources will reduce dependency on imported petroleum products with ever present risk of interruption or disruption and vulnerability to sudden price increases.
Trends	• The development of community based renewable energy resources would mitigate the impacts of fossil fuel price increases (or rationing) due to removal of subsidies or increase in international prices.	• The development of community based renewable energy resources would mitigate the impacts of fossil fuel price increases (or rationing) due to removal of subsidies or increase in international prices. • Producing energy from local renewable resources would reduce imports of oil products and thereby reduce the huge trade deficit and the vulnerability to any change in New Zealand government policy in respect to financial assistance.
Seasonality	• The use of geothermal or biogas crop dryers would be of additional value in the long wet season when sun-drying is particularly difficult.	

Table 13: Livelihood outcomes- Changes to Vulnerabilities: Kerinci Villages and Niue

TRANSFORMING PROCESSES AND STRUCTURES

In this section, the question I will address is whether the existing structures are favourable to the use of renewable energy resources.

Kerinci Villages

From discussions with local government officials, I believe that it is unlikely that community based renewable energy projects will meet any "official" obstacles as such. For example, in the ADAF geothermal project, the local government while claiming ownership of the geothermal resource made it clear that it had no intention of restricting access to or charging for use of the resource as long as the use did not impact on other users or affected the sustainability of the resource.

Furthermore, the local government stated that it will support the development of other renewable energy developments such as biogas and micro-hydro power generation by the free provision of technical advice where available from within its own resources. However, from my discussions, there is a lack of people within the local government workforce with either theoretical or practical knowledge in renewable energy technologies, the main skill base being in agriculture. I anticipate that a similar situation applies in the private sector.

In the villages, there is considerable knowledge associated with traditional agricultural activities. However, obviously as with local government, there is little knowledge of renewable energy technologies. On the other hand, experience with the geothermal driers has demonstrated a keenness to learn.

Lack of the necessary funds to construct the necessary equipment was emphasised by local government and from my observations, Kerinci is "off the beaten track" when it comes to any interest from the international agencies other than those whose main interest in conservation, the Kerinci-Seblat National Park being the focus of these agencies. Finding the necessary funding would therefore be the priority if a renewable energy programme were to be implemented with the inclusion of appropriate capability building at all levels being critical to success.

Niue

The Niue government is committed to increased use of renewable energy (Government of Niue, 2005: 8) and given that the population could be described as well educated and appreciative of the overall vulnerability of Niue, I would expect the government to receive wide support for this policy.

As for Kerinci, capability building would need to be part of any programme but from my knowledge of Niue, the basic skills already exist. The problem would more likely be insufficient labour resources should a major programme be undertaken- particularly if the work might be regarded as "menial".

Funding is obviously critical, but Niue is better off than Kerinci with a range of potential donors including not only New Zealand, but Australia, the EU and in the longer term, one suspects China, given its interest in the South Pacific.

LIVELIHOOD STRATEGIES

I consider that no significant changes to the strategies set out in Table 8 would be likely in either the Kerinci Villages or Niue. There would be changes at the margins resulting from increased employment opportunities and increased incomes.

CONCLUSIONS

THE KERINCI VILLAGES

As I stated in Chapter 3, the lifestyles of the people living in the Kerinci Villages can be described as "basic" with subsistence farming being the main source of livelihood.

There are positives, however: from all accounts, no one starves owing to a benign climate and fertile soils together with cultural and religious factors that have a strong tradition of charity. There is universal free and compulsory education and free health services. There is universal adult franchise and in recent years, increasing democracy and awareness of human rights.

On the other hand, there are limited opportunities for employment with people seeing migration to other parts of Indonesia and overseas, mainly Malaysia, as being one of the few ways to accumulate sufficient financial resources to achieve a better lifestyle. While the local government has an economic development plan in place with employment creation a high priority (Kerinci Regency, 2004), implementation of the plan will be a major challenge given the heavy reliance on traditional agriculture and the vulnerability to external factors as demonstrated by the cinnamon and coffee price collapses and fuel price increases.

A lack of affordable energy is a factor in keeping people's lives at a basic level. In fact, the situation has become worse over the last two years with the large increase in the price of kerosene forcing most households to revert to woodfuel for cooking. As discussed in Chapter 3, this has a number of negative impacts particularly in respect to the health of women exposed to wood smoke, and undoubtedly results in a significant reduction in wellbeing. Electricity is regarded as a valuable livelihood asset- but lack of capacity means that not all households are able to be connected and where households are connected, the appliances that can be used are limited.

Agricultural productivity is also being constrained by the lack of affordable energy. Farmers' reliance on sun drying for crop drying results in (reportedly) a 25% loss and the unreliable power supply has made egg incubation- necessary if the poultry flock is to be increased to meet egg demand- uneconomic.

The analysis indicates that the use of the available renewable energy resources has the potential to produce positive livelihood outcomes. It is estimated that the average household income across the six villages could increase by about 15 to 18% from the use of biogas and geothermal hot water for crop drying and geothermal hot water for egg incubation. However, I stress this is an average and there would be considerable variation from village to village and from household to household. While this level of increase will not transform peoples' lives, it should at least assist at the margins- eg help pay school fees or permit some savings to be accumulated. There would also be spin-off benefits in the form of some additional employment opportunities associated with the operation of the renewable energy plant.

The use of fuel efficient stoves fitted with flues or the use of biogas for cooking would both reduce woodfuel consumption, thereby reducing stress on the resource and eliminate smoke in the kitchen.

My assessment of micro-hydro generation potential indicates that it while not sufficient to supply power to all households in all three geothermal villages, it would at least supplement the existing inadequate power supply.

I conclude that the use of the renewable energy resources - and in the case of woodfuel, more efficient use - would have a number of positive outcomes by adding to the villages' capital assets. Also of significance in livelihood terms, would be a reduction in vulnerability as the villagers would have greater control over their energy supplies.

NIUE

People in Niue enjoy a good standard of living, not dissimilar from that of New Zealand. There is minimal unemployment and as citizens of Niue also have New Zealand citizenship, they are free to live and work in New Zealand and Australia. As a consequence and as I noted in Chapter 4, most adult Niueans remain in Niue for lifestyle reasons.

The lifestyle enjoyed by people in Niue is underpinned by affordable (subsidised) and reliable energy, both at household level and for their continued employment. Electricity is used widely not just for lighting and TV but also for refrigerators and freezers and for cooking in an estimated 80 to 90% of households.

However, the good standard of living - and the affordable energy that helps maintain it - is made possible by the financial assistance received from New Zealand.

The power station fire in May 2006 brought home the reliance on the electricity supply- while people were able to make do using wood or LPG for cooking and candles and kerosene lamps for lighting, it was only the availability of temporary refrigerated storage which enabled people and businesses to avoid losing all the food stored in household refrigerators and freezers. A long term disruption to the supply of electricity would have a profound impact of peoples' livelihoods with major changes to lifestyles. If the disruption was due to a failure of the power supply system, then the importing of small diesel engine powered generators could provide some relief- but were the problem to be an interruption in the supply of the diesel oil used to generate the power, then this solution would not be available.

Unlike the Kerinci Villages, people in Niue rely heavily on motor vehicles for transport from their homes to and from work and to and from school for their children. Without petrol and diesel supplies, people would have to resort to other forms such as bicycles, horseback or walking.

The source of virtually all the energy used in Niue is imported in the form of diesel and petrol plus jet-fuel for the weekly flight to and from New Zealand. Small quantities of LPG are also imported and there is some use of solar water heating.

In Niue, the relationship between the current energy supply situation and livelihoods is quite different from that of the Kerinci Villages. During the visits, no one complained about the price or the supply of energy, other than LPG where imports are handled by two retailers rather than the government department that handles other oil product imports and which are understood to be somewhat haphazard.

Rather, in terms of livelihood impacts, the issue is one of vulnerability given the heavy reliance on imported oil products. A long term disruption to the supply of oil products would cause far more than a reduction in wellbeing in Niue. It would profoundly change peoples' livelihoods by returning to at least the situation that applied pre-1970 before the central power supply was established but probably more like the situation that applied in the 19^{th} century. Such a situation could effectively create a situation of poverty for most people in given the profound impact on livelihoods with subsistence farming becoming the main source of livelihood rather than a useful supplement as at present.

While disruption could occur due to an international crisis that affected oil supplies world-wide, a more likely situation would be an increase in the price of oil-based fuels that would test New Zealand's ability or willingness to fully meet the additional cost by increasing financial assistance. As noted in Chapter 4, people I spoke to in Niue live there because they enjoy the way of the life and the culture- the question that this raises is whether these factors would be sufficient for people to stay on Niue in the event that much of the modern lifestyle conveniences that are possible because of the availability of affordable energy would no longer exist. Nuieans, as New Zealand citizens, can live and work in New Zealand and Australia without restriction, so, unlike the situation for the people in the Kerinci, migration is an easy option.

I conclude that the use of the renewable energy resources will as for the Kerinci Villages provide a number of positive outcomes by adding to Niue's capital assets. The bill for the diesel used to generate electricity could quite easily be reduced by $300,000. But of equal significance would be a reduction in vulnerability to interruptions to power supplies which are currently based entirely on imported diesel oil, payment for which relies at least partly on financial assistance from New Zealand.

THE DFID FRAMEWORK – EXPERIENCES WITH PRACTICAL APPLICATION

Is it sufficiently "people-centred"?

As a tool for analysis, I found the DFID framework and the associated Guidance Sheets (DFID, 1999b) to be useful in that these go a long way towards ensuring that the analysis covers (as far as is practicable) all aspects of people's livelihoods and the linkages between the components that make up these livelihoods. The process is undeniably complex, but as I noted in Chapter 2, this is inevitable given that people's livelihoods are complex.

As discussed in Chapter 2, IFAD reconfigured the framework with the objective of creating a more "people-centred" framework (Hamilton-Peach and Townsley, 2003). After using the DFID framework, I can understand the basis of the criticism that led IFAD to create their version of the framework. While the DFID framework focuses on people's livelihoods, it could be argued that it does not emphasise sufficiently the need to consult people on what they see as their needs and the solutions they see as necessary to satisfy their needs.

However, I believe that the DFID framework is a more practical tool than the IFAD framework which I see as more of a "statement of intent". The DFID framework puts the onus on the practitioner to keep the "people-centred" nature of SLA to the forefront - in my opinion a reasonable approach - and if this done, then finding out people's aims and aspirations and giving these priority should be given.

The role of "culture"

The other criticism discussed in Chapter 2 was that the framework did not adequately take account of cultural factors, eg in Cahn (2002) and Hamilton-Peach and Townsley (2003). I agreed with this criticism and added "Personal Capital" as an additional capital asset to those nominated by DFID (1999b). Following practical application, I consider that this was justified for the reasons discussed below.

Interestingly, the cultural factors identified were very different in each study site but equally important because these factors will determine people's attitudes and approach to change – including the introduction of new forms of energy. For example, in the Kerinci Villages, people wanted change to their day to day lives to make them better and were open to suggestions as long as they can understand and see sense in any proposed changes. On the other hand, in Niue, there was a strong desire to retain their current lifestyle - or culture – and it was made clear that any proposed changes that would reduce dependence of funding from New Zealand would be received with considerable interest.

At both study sites, I found the cultures to have a strong local community focus and believe that this would be of assistance if community-based organisations were required to manage and operate renewable energy systems as would be very likely.

CHAPTER 6: CONCLUSIONS

THE ROLE OF ENERGY

In both the Kerinci Villages and Niue, energy is a critical factor in maintaining livelihoods. However, while the energy supply in Niue can be described as both affordable and meeting peoples' needs (and even wants), the situation in the Kerinci Villages is quite different. As discussed in Chapters 3 and 5, the heavy reliance on woodfuel poses a number of problems including negative health impacts and resource sustainability issues although people's concerns as expressed during village meetings were arguably more associated with inconvenience and cost factors. A common complaint at the meetings was that the electricity supply does not meet peoples' needs in terms of reliability and capacity. Furthermore, the lack of affordable energy is reducing productivity by forcing farmers to rely on sun drying for the preservation of crops, a process that results in significant losses. The energy supply in the Kerinci Villages clearly does not meet the criteria for sustainable livelihoods.

The main energy-related livelihood issue in the case of Niue is the virtually 100% dependence on imported oil products. The energy supply that maintains Niue's standard of living is vulnerable to external factors and as such does not meet the criteria for a sustainable livelihood. However, during discussions during my field visits, I did not get the sense that people recognised directly Niue's vulnerability to fuel supply disruptions, this probably due to the fact that disruptions have historically been rare and short-lived. On the other hand, as I noted in Chapter 4, people expressed a sense of vulnerability as a consequence of the heavy reliance on financial assistance from New Zealand and concerns regarding the consequences of further depopulation.

IMPACTS OF CHANGES IN ENERGY SUPPLY

Given the important role that energy plays in the maintenance of livelihoods, it is obvious that if the supply of energy changes either in terms of availability or affordability, this will have livelihood consequences. Both the Kerinci Villages and Niue have recently experienced changes in energy supply although in Niue, the change that resulted from the power station fire (as described in Chapter 4) was fortunately very short lived- but it did demonstrate the heavy reliance on electricity in people's day to day lives.

In the Kerinci Villages, the increase in the price of kerosene in late 2005 (Chapter 3) meant that this fuel became unaffordable for many and this had a negative livelihood outcome. While I have stressed the adverse health impacts that result from exposure to wood smoke, the issue of the stress on the woodfuel resource is also of concern. If the doubling of the price of woodfuel over a period of six months in 2006 (Chapter 3) is indicative of a looming shortage, then this would add to the villagers' problems. While no doubt the villagers would cope – they have little choice - such a situation would inevitably represent a further decline in livelihoods.

Given the role of that energy plays in the maintenance of the lifestyle in Niue, a long term reduction in energy supplies would have a severely negative livelihood outcome. As discussed in Chapter 5, I believe that many people living in Niue would find coping without electricity and transport fuels - or even with restricted supplies of these fuels - unacceptable and would leave Niue for New Zealand or Australia. A significant further decline in population would aggravate a situation that is already of concern to the Niue Government and New Zealand (MFAT, 2006).

Both the Kerinci Villages and Niue benefited from electrification programmes in the 1970's. Arguably, the positive impact on lifestyle and livelihoods was greater in Niue because from discussions with key informants, life in the villages outside of Alofi (where a small electricity grid already existed), was very basic. My informants recalled the smoky wood fires and kerosene lamps with a complete lack of nostalgia. While informants in Kerinci were certainly enthusiastic about electrification, the use of kerosene stoves for cooking was regarded as equally important.

An interesting question is what would be the outcome in the Kerinci Villages and Niue if unlimited and affordable energy became available? In the case of Niue, I suspect that it would not make a major difference as during my visits, no one expressed any concerns about energy supplies in terms of availability and affordability - although there was an appreciation of overall vulnerability to external factors. On the other hand, in the Kerinci Villages, people made it clear to me that they would like more electricity not necessarily to increase household incomes but to make life pleasanter- eg the women and their desire for electric irons and rice cookers and the men for TVs (in houses with a limited power supply). And from the analysis in Chapter 5, agricultural productivity could be improved and incomes increased by about 16% were an affordable source of energy available for crop drying and egg incubation.

My conclusion is that even an unlimited supply of affordable energy would not by itself transform peoples' livelihoods in either the Kerinci Villages or Niue. As ITC (c2002: 5) point out, a reliable and affordable supply of energy will not guarantee economic development. Certainly, it will play a significant part in a development process but still only a part. An important example of how energy and other technologies play a part in the development process was the Industrial Revolution that took place in Britain, followed by northern Europe in the 18th and 19th centuries. According to Ashton (1968: 48), the changes that took place resulted from social and economic factors, including a pool of available labour from an increasing population and, critically, the availability of capital, with the technical innovations in energy and manufacturing technology assisting the process rather than causing it.

RENEWABLE ENERGY AND SUSTAINABLE LIVELIHOODS

In the previous sections of this chapter, I have concluded that:

- Energy plays a critical part in peoples' livelihoods.
- In the Kerinci Villages, existing energy supplies do not meet peoples' needs and this is a factor in maintaining peoples' livelihoods at a basic subsistence level.
- In Niue, the situation is different with the energy supply being considered to be both adequate and affordable. However, because of the high level of subsidy, the situation is intrinsically unsustainable.
- Both communities are vulnerable to any adverse changes in energy supplies. In the Kerinci Villages this would result in a decline in livelihoods, especially in wellbeing, but the impact in Niue could be far more severe and endanger the viability of the Niue community.
- On the other hand, a positive change in energy supply would be of value to the Kerinci Villages by improving living conditions - and wellbeing - and providing the opportunity to increase farm productivity and incomes. Transformation of the livelihoods in the villages would not occur however, simply by providing unlimited and affordable energy.
- In Niue, given that people see the energy supply situation as satisfactory, significant change to livelihoods would be unlikely from any improvement in energy supply.

And in Chapter 5, I concluded that in terms of livelihood outcomes, the use of, or more efficient and effective use of, renewable energy resources would:

Kerinci Villages:

- Increase village incomes, resulting in positive livelihood outcomes.
- Reduce vulnerability in terms of energy supplies.
- Overall, there would be an improvement in peoples' livelihoods and quality of life.

Niue:

- Increase the community's financial assets by reducing expenditure on imported energy supplies.
- Reduce vulnerability in respect to energy supplies.
- While livelihoods may only improve marginally in terms of financial assets, social sustainability would improve as a result of the reduced vulnerability.

AIMS AND ASPIRATIONS

The above conclusions were reached based on my analysis using the DFID framework as the guide. Given the importance in the context of sustainable livelihoods of meeting people's needs and to avoid the "normal professional biases" (Chambers, 1986: 9), it is important to review those conclusions in terms of the aims and aspirations expressed by people in each study site as discussed in Chapters 3 and 4.

In the Kerinci Villages, responses to my question regarding how people would use any increased income included improved food security, children's education, the accumulation of savings and, in the non-geothermal villages, the purchase of woodfuel. More income from improved farming productivity would go some way to meeting these needs. The responses to a second question regarding which three factors would improve people's lives the included a return to cheap kerosene and a better power supply. While renewable energy resources would not satisfy the first of these, they would go some way to mitigating the impacts of unaffordable kerosene (ie the use of fuel efficient stoves or biogas) while in the geothermal villages, micro-hydro power generation would at least provide some improvement to the power supply.

Concerns regarding incomes or energy supplies did not feature in the responses received to similar questions addressed to informants in Niue. Rather, people were concerned about Niue's high dependence on financial support from New Zealand and recognised that this was a vulnerability (although not necessarily expressed using that term). Also, the need to need to encourage tourism and small businesses were regarded as important as a counter to further depopulation. Obviously, the use of the available renewable energy resources would not directly address either of these issues but it would reduce the import bill as a consequence of reduced diesel imports and thereby reduce vulnerability. A possible indirect benefit could be that visiting an island where a high proportion of energy needs are met from renewable resources could be of appeal to the eco-tourism sector given that Niue already has some appeal in that regard, eg diving and whale watching.

CONCLUSIONS

In both the Kerinci Villages and Niue I conclude therefore that the development and use of renewable energy resources - including new technologies that make existing uses more efficient - would make a contribution towards the achievement of sustainable livelihoods, including the meeting of the expressed aims and aspirations.

However, this contribution should not be overstated as any significant progress towards full achievement would also have to involve economic and social changes. In both cases the barriers are formidable and while as discussed in Chapters 3 and 4 there are potential economic development opportunities, such as tourism and agricultural processing in the Kerinci Villages and tourism in the case of Niue, the development of these, particularly in the Kerinci Villages, is likely to be a slow process.

While not wishing to overstate the livelihood benefits from the development of the available renewable energy resources, it would be wrong to assume that development would be of insufficient value to make it worthwhile. To the contrary, the benefits in terms of reduced vulnerability that comes from increased local control over energy supplies would be benefit to both sets of communities.

The Barriers and Pitfalls

A reasonable question raised by my conclusion that renewable energy can contribute to the achievement of sustainable livelihoods would be "why is it not already used extensively in the Kerinci Villages and Niue?"

In the Kerinci Villages, renewable energy is already used in the form of woodfuel (extensively), solar energy (for crop drying) plus limited use of geothermal energy. However, none of these resources are used effectively or efficiently and in the case of woodfuel, this resource can only be classified as "renewable" if the source is "continuously replenished" and "will never be exhausted" (Elliot, 1997:129), a situation that I consider unlikely in Kerinci if wood cutting continues at the present rate. Furthermore, burning the woodfuel in a traditional un-vented stove or open fire cannot be regarding as contributing to sustainable livelihoods given the resultant negative health impacts.

In both the Kerinci Villages and Niue the benefits that renewable energy technologies could bring were well recognised and understood at "official" level. In the case of Niue, increased use of renewable energy is a key part of the government's energy policy (Government of Niue, 2005:8) and in fact, as noted in Chapter 4, Niue is committed to becoming the world's first nation to be fully reliant on renewable energy resources (CiD, 2006).

During discussions in Kerinci with local government, lack of funding and the non-availability of technical expertise were cited as the main barriers and for this reason, the funding by NZAID of the ADAF geothermal project was especially welcome. According to the *Bupati,* what development assistance they have received from international agencies in Kerinci tended to be for conservation activities associated with the Kerinci-Seblat National Park, and while the regency was grateful for this assistance, development projects with a focus on poverty reduction were rare.

Niue is more fortunate. As discussed in Chapter 4, the EU are funding a wind power project which will reduce diesel imports for power generation and technical advice and assistance is readily available from New Zealand and from the various South Pacific agencies. The fact that Niue has not made greater advances in introducing renewable energy is probably partly due to cost factors - it is only relatively recently that the increases in the price of oil has made renewable energy technologies such as wind power economically sensible. Whether funding will be available to help Niue meet its goal of total reliance on renewable energy resources remains a moot point, however.

A possible source of future funding of renewable energy projects for both Kerinci and Niue exists in the form of the Clean Development Mechanism (CDM). The CDM was established under Article 12 of the Kyoto Protocol[55], one of the purposes being to "facilitate investments in greenhouse gas (GHG) emissions reduction projects in developing countries". Such projects were required to contribute to sustainable development in the developing country while assisting the partner developed country to

[55] The Kyoto Protocol was the outcome of the Third Conference of the Parties to the United Nations Framework Convention on Climate Change in 1997.

achieve its emission reduction targets (ADB, 2006: 3). In simple terms, the CDM provides a means for developed country to purchase "carbon credits" from developing countries, these credits being used to fund projects that reduce carbon emissions in the developing country (ADB, 2006: 8). An example would be replacing diesel power generation with wind power.

However, the process of obtaining carbon credits can be time consuming and inevitably bureaucratic. Simplified guidelines[56] were produced in 2003 for small-scale projects but "simplified" is in my view, a relative term!

Technical pitfalls

As noted previous chapters, I have only considered proven technologies in the analysis. However, it is important to note even proven technologies will fail if implementation is not properly carried out using people with appropriate skills and experience. Equally important is the capability building required to ensure that communities are able to manage and operate the renewable energy systems plus "after-sales" technical support. A failed renewable energy project can set a programme back considerably as it can destroy confidence.

An example was the biogas programme in China which started in the 1970's with over seven million digesters. However, there were many failures owing to lack of quality control and management. A coordinated effort has since been made and appropriate support organisations set up which has enabled the programme to make a substantial recovery (Kammen *et al*, 2002: 20).

Relevance to Other Parts of South-East Asia and the South Pacific

As noted in the Introduction to this thesis, the title refers to South-East Asia and the South Pacific. This raises the question as to what extent the results from the Kerinci Villages and Niue will also apply to other parts of the region.

From my visits to other parts of Indonesia and to the Philippines in particular, I am aware that similar livelihood conditions are experienced by many rural communities who rely on rice growing, livestock raising and cash cropping as the main means of livelihood. Also, both countries have mountainous regions with micro hydro power potential and volcanic regions with geothermal potential. Other developing countries in

[56] See http://cdm.unfcc.int for latest version of the small-scale project guidelines.

South-East Asia including Laos, Cambodia and Vietnam have similar livelihood characteristics in that a high percentage of people are engaged in agriculture, rice growing is an important activity and rural poverty is high. Table 14 over shows selected economic data for these five countries.

Based on this data, I consider that similar renewable energy resources to those in the Kerinci Villages are likely to be available in rural areas in these neighbouring countries, ie rice straw and animal waste and in some cases, micro-hydro although geothermal resources are probably restricted to Indonesia and the Philippines. Given the high percentages of population judged to be in poverty and employed in agriculture, I consider that the use of renewable energy resources are likely provide similar potential benefits to those projected for the Kerinci Villages.

Country	**GNI[57] per capita ($US)**	**Percentage of Rural Population in Poverty**	**Population employed in agriculture**	**Rice production per capita (kg)**
Cambodia	$270	40%	75%	283
Indonesia	$690	21.1%	42%	245
Lao PDR	$300	41%	78%	436
Philippines	$1,030	47.4%	38%	162
Vietnam	$422	44.9%	70%	427

Table 14: Selected economic data for five South-East Asian countries[58]

(source: ADB, 2003)

In the case of Niue, the main vulnerabilities are associated with the heavy reliance on imported energy and financial assistance from New Zealand, the latter a reflection of Niue's lack of the resources that would enable it to "pay its way'. The criteria used in Table 15 to compare the situation in Niue with that in the other immediate neighbours therefore focus on energy use and economic factors. From Table 15, it is clear that while neighbouring island states are not so heavily reliant on financial assistance from New Zealand as is Niue, they share a similar problem in that they also import much of their energy needs and are therefore vulnerable to oil price increases or supply disruption.

[57] Gross National Income.

[58] The year in which the various data was collected varies between countries and categories and ranges from 1995 to 2002.

Country	Population	Oil Product Imports		Electricity Generation	
		Litres ('000)	litres/capita	Diesel	Renewable Energy
Cook Islands[59]	18,000	11,000	600	92%	8%
Niue[60]	1,700	2,000	1,176	100%	0
Samoa[61]	176,000	76,000	432	50%	50%
Tonga[62]	98,000	40,000	408	NDA	NDA

Table 15: Selected Energy Data[63] for Niue and Neighbouring Island States

THE RESEARCH QUESTION

In Chapter 1, I determined that the research question to be addressed was:

"In the context of rural south-east Asia and the South Pacific, can community- based renewable energy supply systems contribute to the development of sustainable livelihoods?"

Based on the analysis and the summaries above, I consider the answer is yes, community-based renewable energy supply systems can contribute to the development of sustainable livelihoods. However, there are caveats:

Firstly, renewable energy schemes will not by themselves create sustainable livelihoods. These do not transform livelihoods- but they can facilitate transformation.

Secondly, the conversion technology must be appropriate – technically proven and able to be operated and managed by a rural community with limited access to other than basic technical support. Implementation must include a carefully designed capability building programme that covers not just technical aspects but also operation and management.

Thirdly, there must be access to funding. In the Kerinci Villages in particular, this is a major barrier.

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[59] Data from Wade and Johnston (2005)
[60] Data from Wade (2005a).
[61] Data from Wade *et al* (2005).
[62] Data from Wade (2005b).
[63] Figures are rounded as the years on which data are based vary between locations.

APPENDIX A

KERINCI VILLAGES: ENERGY USE AND COST ESTIMATES

This Appendix A comprises spreadsheets summarising the methodology and calculations used to estimate energy use and the cost benefits that could accrue from implementation of the various renewable energy opportunities identified in Chapter 3 and analysed in Chapter 5.

APPENDIX A:
A1 - FUEL EFFICIENT WOODSTOVES

Current estimates of woodfuel usage:

Household Cooking Energy Requirements- four to five person household

Based on discussions at villages and with LTA

a typical household uses:	180	sticks/month woodfuel	at		0.95	kg/stick
Total weight burnt=	171	kg			5.7	kg/day
Typical CV for hardwood[1]	15	MJ/kg			2,565	MJ/month
Simple stove efficiency-	assume[2]		20%	useful heat=	513	MJ/month
Cost of woodfuel (November 2006) Rp:	300	per stick	or annually Rp 648,000		or NZD	$106
If using kerosene to produce same amount of useful energy:						
Kerosene stove efficiency-	assume[3]		45%	heat input required=	1140	MJ/month
Typical CV for kerosene[4] =	46.5	MJ/kg		kerosene required=	24.52	kg/month[5]
					0.82	kg/day
Cost of kerosene (November 2006):	5000	per kg	or annually Rp 1,470,968		or NZD	$242
If using biogas to produce same amount of useful energy:						
Biogass stove efficiency-	assume[3]		50%	heat input required=	1026	MJ/month
Typical CV for biogas =	20	MJ/m^3		gas required=	51.3	m^3/month
					1.71	m^3/day

NOTES:

1: Based on data in Rose and Cooper (1977:304)
2: WEC (1999:60).
3: Based on data in Smith et al (2000:25)
4:Based on data in Rose and Cooper (1977:283)
5: This corresponds closely with reported kerosene consumption

Energy inputs:

VILLAGE	POPULATION[1] (from LTA, 2005 and BPDSDKT, 2006)	HOUSEHOLDS[1]	COOKING ENERGY NET GJ/ANNUM	HEAT INPUT WITH WOODFUEL (20% STOVE EFFICIENCY)- GJ/ANNUM	HEAT INPUT WITH KEROSENE (45% STOVE EFFICIENCY)- GJ/ANNUM
Air Panas Baru	620	127	782	3,909	1,737
Muara Jaya	1,134	313	1,927	9,634	4,282
Muara Semerah	1,981	518	3,189	15,944	7,086
Paling Serumpun	967	328	2,019	10,096	4,487
Sungai Medang	1,658	427	2,629	13,143	5,841
Sungai Tutung	3,782	844	5,196	25,978	11,546

Table A1.1

APPENDIX A: Page 2

A1 - FUEL EFFICIENT WOODSTOVES (continued)

Fuel inputs- assumes that 10% of households use kerosene (based on information from village meetings)

VILLAGE	WOODFUEL REQUIRED FOR 90% HOUSEHOLDS TONNES/ANNUM	KEROSENE REQUIRED FOR 10% HOUSEHOLDS LITRES/ANNUM
Air Panas Baru	235	4,670
Muara Jaya	578	11,510
Muara Semerah	957	19,049
Paling Serumpun	606	12,062
Sungai Medang	789	15,703
Sungai Tutung	1,559	31,037

Table A1.2

Impact of Fuel Efficient Stoves

Assume efficiency improves from 20 to 25%

Useful heat remains constant at	513	MJ/month	Cost per stick	(Rp)=	300
Woodfuel input =	2052	MJ/month	Cost per kg	(Rp)=	316
At 15 MJ/kg	136.8	kg/month	Cost per kg	=	$0.052

Annual consumption with fuel efficient stoves:

VILLAGE	WOODFUEL REQUIRED FOR 90% HOUSEHOLDS TONNES/ANNUM	REDUCTION IN CONSUMPTION TONNES/ANNUM	ANNUAL COST SAVING	ANNUAL COST SAVING PER HOUSEHOLD
Air Panas Baru	188	47	$2,434	$19.17
Muara Jaya	462	116	$6,000	$19.17
Muara Semerah	765	191	$9,930	$19.17
Paling Serumpun	485	121	$6,287	$19.17
Sungai Medang	631	158	$8,185	$19.17
Sungai Tutung	1,247	312	$16,179	$19.17

Table A1.3

APPENDIX A: Page 3
A2 – BIOGAS PRODUCTION AND UTILISATION

(1) BIOMASS WASTE QUANTITIES:
(IGNORES WASTE FROM CROPS OTHER THAN RICE[5])

VILLAGE	POPULATION[1]	HOUSEHOLDS[1]	RICE FIELDS AREA- HECTARES[1]	RICE YIELD[2] KG/ANNUM	RICE STRAW[3] KG/ANNUM	CATTLE	
						NUMBER[1]	DUNG-KG/ANNUM[4]
Air Panas Baru	620	127	*15*	63,900	97,500	*8*	35,040
Muara Jaya	1,134	313	285	1,214,100	926,250	92	402,960
Muara Semerah	1,981	518	1,105	4,707,300	3,591,250	160	700,800
Paling Serumpun	967	328	70	298,200	227,500	725	3,175,500
Sungai Medang	1,658	427	50	213,000	325,000	*20*	87,600
Sungai Tutung	3,782	844	120	511,200	780,000	90	394,200

Table A2.1

NOTES:

1: Data from village profiles (LTA, 2005) and survey (LTA, 2006).

2: Based on an annual yield of 4,260 kg/ha from data in Kerinci Regency (2004:40).

3: Based on 3,250 kg/ha twice annually- data from Kerinci Regency Livestock Department (meeting on 23/11/06). This assumes 50% of total yield is collectable.

4: Based on 12 kg/day per cattle unit from LGED (2000:3)- this allows for mix of cow and buffalo.

5: No data was available on likely waste quantities from other crops such as chilli, corn.

(2) BIOMASS WASTE- BIOGAS POTENTIAL:

The waste quantities above are estimates of total production. Only a proportion of these will be recoverable and the following recoveries are assumed:

Rice straw: 50%

Cattle dung: 50%

VILLAGE	BIOGAS FEEDSTOCK		ESTIMATED BIOGAS POTENTIAL- M^3/ANNUM		
	RICE STRAW KG/ANNUM	CATTLE KG/ANNUM	RICE STRAW[1]	CATTLE[2]	TOTAL
Air Panas Baru	48,750	35,040	7,313	1,402	8,714
Muara Jaya	463,125	201,480	69,469	8,059	77,528
Muara Semerah	1,795,625	350,400	269,344	14,016	283,360
Paling Serumpun	113,750	1,587,750	17,063	63,510	80,573
Sungai Medang	162,500	43,800	24,375	1,752	26,127
Sungai Tutung	390,000	197,100	58,500	7,884	66,384

Table A2.2

NOTES:

1: Based on a biogas production rate of 0.15 m^3/kg rice straw, derived from LGED (2000:10) and assuming 80% total solids.

2: Based on a biogas production rate of 0.04 m^3/kg cattle dung (from CMS, 1996:11).

APPENDIX A: Page 4

A2 – BIOGAS PRODUCTION AND UTILISATION- continued:

(3) ESTIMATES OF BIOGAS DEMAND

(a) Household

From above , average useful cooking energy = 513 MJ/month

If using biogas to produce same amount of useful energy:

Biogass stove efficiency-	assume[2]	50%	heat input required=	1026 MJ/month
Typical CV for biogas[1] =	20 MJ/m^3		gas required=	51.3 m^3/month
				1.71 m^3/day

Note:

1: Based on 60% methane and CV of 38 MJ/m^3

2: From Smith *et al* (2000:25).

Based on the above consumption per household, the number of households that could be supplied in each village are as shown:

VILLAGE	BIOGAS POTENTIAL M^3/ANNUM	BIOGAS POTENTIAL M^3/MONTH	NUMBER OF HOUSEHOLDS	NUMBER OF HOUSEHOLDS SUPPLIED BASED ON 1.7M^3/DAY	PERCENTAGE OF HOUSEHOLDS
Air Panas Baru	8,714	726	127	14	11.1%
Muara Jaya	77,528	6,461	313	126	40.2%
Muara Semerah	283,360	23,613	518	460	88.9%
Paling Serumpun	80,573	6,714	328	131	39.9%
Sungai Medang	26,127	2,177	427	42	9.9%
Sungai Tutung	66,384	5,532	844	108	12.8%

Table A2.3

Reduction in Woodfuel Usage

In the case of Muara Semerah, the layout of the village means that it is unlikely that more than 50% of houses can be served from biogas plant.

VILLAGE	NUMBER OF HOUSEHOLDS SUPPLIED WITH BIOGAS	CURRENT MONTHLY WOODFUEL USAGE AT 171 KG/MONTH	WOODFUEL SAVED TONNES/ANNUM
Air Panas Baru	14	2,421	29.0
Muara Jaya	126	21,536	258.4
Muara Semerah	259	44,289	531.5
Paling Serumpun	131	22,381	268.6
Sungai Medang	42	7,258	87.1
Sungai Tutung	108	18,440	221.3
TOTALS:		116,324	1,395.9

Table A2.4

APPENDIX A: Page 5
A2 – BIOGAS PRODUCTION AND UTILISATION- continued:

COST OF PLANT and PLANT OPERATION

From CMS (1999:5-6) and Baron (2003), initial cost for digester will be around $1.25 per m^3/annum.

Assume each house will require pipework of	25	metres
From information on local costs, rate per m will be	$4	
Per household say	$100	
Plus stove at	$40	
Cost per household for pipework and stove=	$140	

VILLAGE	HOUSEHOLDS SUPPLIED	INTIAL COST-PIPEWORK AND STOVES
Air Panas Baru	14	$1,982
Muara Jaya	126	$17,631
Muara Semerah	259	$36,260
Paling Serumpun	131	$18,324
Sungai Medang	42	$5,942
Sungai Tutung	108	$15,097

Table A2.5

PLANT COST PER VILLAGE:

VILLAGE	GAS THROUGHPUT M^3/ANNUM	INITIAL COST DIGESTER (based on throughput)	TOTAL INTIAL COST- INCL PIPEWORK AND STOVES	O & M COSTS (assumed 5%)
Air Panas Baru	8,714	$10,893	$12,874	$644
Muara Jaya	77,528	$96,910	$114,541	$5,727
Muara Semerah	161,655	$202,069	$238,329	$11,916
Paling Serumpun	80,573	$100,716	$119,039	$5,952
Sungai Medang	26,127	$32,659	$38,601	$1,930
Sungai Tutung	66,384	$82,980	$98,077	$4,904
TOTAL	420,980	$526,226	$621,461	$31,073

Table A2.6

APPENDIX A: Page 6
A2 – BIOGAS PRODUCTION AND UTILISATION- continued:

COST OF BIOGAS

This will comprise the cost of the initial capital plus operating costs

Cost per cubic metre can be calculated from:

$$\text{Cost} = \frac{\text{NPV (capital cost plus O and M)}}{\text{NPV(biogas output)}}$$

Allow major refurb (25% initial cost) every 5 years

Based on a 20 year plant life and 5% interest, cost =	$0.13	per m^3		
Annual cost per household =	$81		Annual cost of kerosene=	$242
Annual cost of fuelwood =	$106		If stove and pipes to house excluded, cost reduces to	$0.11 per m^3

(b) Crop drying

Drying analysis- based on rice:

From Yanuar (2005) commercial

oil fired rice drier had dimensions of: **2 m wide**, **6 m long**, **1 m high**

Assume bed of:	200	mm
Volume =	2.4	m^3
At bulk density of:	580	kg/m^3
	1392	kg
Assume initial moisture content =	30%	
Assume final moisture content[1]=	14%	
	258.98	kg water

mass (kg)			
initial moisture	bone dry	moist after	moist remved
417.600	974.400	158.623	258.977

Final mass= 1133.023 kg

Heat required to evaporate water:		
Assume OAT =	25	°C
Say drying time=	48	hrs
Warm up from	*25*	*to 45 °C*
Initial mass=	1392	kg
Assume sp ht as for water:	116.928	MJ
Evaporation of water content to 14%:		
hfg=	2370	kJ/kg
Heat input=	613.77	MJ
TOTAL HEAT INPUT:	730.70	MJ
add margin for losses:	25%	
	913.38	MJ
Biogas CV- assume	20	MJ/m^3
Gas required per batch=	**45.67**	**m^3**

Assume rice temp= 45 °C

19.03 MJ/hr 5.3 kW

0.95 m^3/hr over 48 hrs

APPENDIX A: Page 7
A2 – BIOGAS PRODUCTION AND UTILISATION- continued:

Estimation of maximum amount of produce that can be processed using biogas available

VILLAGE	BIOGAS POTENTIAL M^3/ANNUM	RICE CROP AVAILABLE KG/ANNUM	50% OF AVAILABLE RICE CROP KG/ANNUM	BIOGAS REQUIRED FOR 50% CROP M^3/ANNUM	SESSIONS PER ANNUM	OUTPUT RATE M^3/HOUR	MAX NO OF CROP DRYERS
Air Panas Baru	5,251	63,900	31,950	1,048	23	0.599	1
Muara Jaya	77,528	1,214,100	607,050	19,916	436	138.596	5
Muara Semerah	283,360	4,707,300	2,353,650	77,219	1,691	537.363	21
Paling Serumpun	80,573	298,200	149,100	4,892	107	34.041	2
Sungai Medang	16,736	213,000	106,500	3,494	77	24.315	1
Sungai Tutung	39,730	511,200	255,600	8,386	184	58.356	3

Table A2.7

NOTES:

1: Based on 80 sessions per drier per annum- 1 day to load, 2 days to dry, 1 day to unload with balance for cleaning and maintenance.

Estimation of potential benefit in terms of reduction in crop loss.

VILLAGE	RICE PROCESSED[1] KG/ANNUM	CURRENT LOSS DURING DRYING[2] KG/ANNUM	ESTIMATED LOSS BIOGAS DRYING[3] KG/ANNUM	LOSS REDUCTION KG/ANNUM	ADDITIONAL INCOME[4]	
					Rp	NZD
Air Panas Baru	31,950	7,988	1,598	6,390	19,170,000	$3,150
Muara Jaya	607,050	151,763	30,353	121,410	364,230,000	$59,859
Muara Semerah	2,353,650	588,413	117,683	470,730	1,412,190,000	$232,086
Paling Serumpun	149,100	37,275	7,455	29,820	89,460,000	$14,702
Sungai Medang	106,500	26,625	5,325	21,300	63,900,000	$10,502
Sungai Tutung	255,600	63,900	12,780	51,120	153,360,000	$25,204

Table A2.8

NOTES:

1:Refer table A2.1 above.

2:Assumed to be 25%- refer chapter 3.

3:Assumption.

4:Based on price for hulled rice of Rp3,000 (LTA, 2004)

APPENDIX A: Page 8
A2 – BIOGAS PRODUCTION AND UTILISATION- continued:

COST OF PLANT and PLANT OPERATION

From CMS (1999:5-6) and Baron (2003), initial cost for digester will be around $1.25 per m^3/annum.

From above, cost per m^3 biogas =	$0.11	
Cost of drier (based on ADAF Geothermal Project)	$3,500.00	
Gas required per drying session:	45.67	m^3
Number of sessions per annum:	80	
Gas throughput per annum:	3654	m^3
Assume O and M at	5%	
Assume interest/discount rate at	5%	
Assume major refurb of drier (25% initial cost) at	5	years
Tariff calculated from:	NPV drier + gas cost / NPV biogas	

PLANT COST PER VILLAGE:

VILLAGE	GAS THROUGHPUT M^3/ANNUM	INITIAL COST of DRIER	GAS TARIFF		ANNUAL COST
Air Panas Baru	1,048	$3,500	$	0.49	$509
Muara Jaya	19,916	$19,079	$	0.15	$3,024
Muara Semerah	77,219	$73,974	$	0.15	$11,726
Paling Serumpun	4,892	$7,000	$	0.23	$1,110
Sungai Medang	3,494	$3,500	$	0.15	$539
Sungai Tutung	8,386	$10,500	$	0.19	$1,618

Table A2.9

NET COST BENEFIT PER VILLAGE

VILLAGE	NUMBER OF HOUSEHOLDS	ADDITIONAL INCOME GROSS/ANNUM	LESS ANNUAL GAS AND DRIER COSTS	NET ADDITIONAL ANNUAL INCOME	NET ADDITIONAL ANNUAL INCOME PER HOUSEHOLD
Air Panas Baru	127	$3,150	$509	$2,641	$20.80
Muara Jaya	313	$59,859	$3,024	$56,835	$181.58
Muara Semerah	620	$232,086	$11,726	$220,360	$355.42
Paling Serumpun	330	$14,702	$1,110	$13,593	$41.19
Sungai Medang	427	$10,502	$539	$9,962	$23.33
Sungai Tutung	844	$25,204	$1,618	$23,586	$27.95

Table A2.10

NOTE:

The additional net income does not take into account operating labour as it is assumed that this will be drawn from the village, ie ie all payments made will be retained within the village.

APPENDIX A: Page 9

A3 – GEOTHERMAL RESOURCES- UTILISATION

(1) EGG INCUBATION

Based on additional income available to villages from sale of eggs from the additional poultry being raised, ECL (2005a:35) estimated that the net increase will be $110,000 annually or approximately $33,000 per village after allowing for the initial capital cost and O and M costs.

Given that this is market restrained (ie producing more eggs may not result in more income), installing more incubators was not considered an option.

(2) CROP DRYING

From drier calculations carried out for biogas and assuming drier of similar dimensions:

Crop (rice) processed per session:		1392 kg		
Heat required per session:		913 MJ		
Heat rate for		48 hr	drying	
	=	19.03 MJ/hr		5.3 kW
Water flow for		20 °C	temperature difference	
	=			
		0.06 l/s		
		3.8 l/min		

From observation at Sungai Medang and Sungai Tutung, it is likely that at these sites, there is only enough geothermal water flow for one drier plus an incubator. At Air Panas Baru, one site could take two driers and the other site up to (say) four driers of "standard" size- but rice availability is small.

GEOTHERMAL HEATING INCOME GENERATION CAPABILITY

AS FOR BIOGAS DRIERS ASSUME 50% OF RICE CROP AVAILABLE FOR DRYING

VILLAGE	EGG INCUBATION AND POULTRY ADDITIONAL INCOME[1]	50% OF TOTAL RICE CROP KG/ANNUM	ANNUAL CROP DRYING SESSIONS[2]	NO OF GEOTHERMAL DRIERS	CROPS DRIED[4] PER ANNUM KG[3]
Air Panas Baru	$33,000	31,950	23	1	31,950
Sungai Medang	$33,000	106,500	77	1	106,500
Sungai Tutung	$33,000	255,600	80	1	111,360

Table A3.1

NOTES:

1: From ECL (2005a:35).

2: Assumed to be 80 sessions annually with each session taking 1 day to load, 2 days to dry, 1 day to unload with balance for cleaning and maintenance

3: Based on a rice load of 1,392 kg (as for biogas drying)

4: In the case of Sungai Tutung, the limitation is the availability of geothermal hot water.

APPENDIX A: Page 10
A3 – GEOTHERMAL RESOURCES- UTILISATION- continued

Estimation of potential benefit in terms of reduction in crop loss.

VILLAGE	RICE PROCESSED[1] KG/ANNUM	CURRENT LOSS DURING DRYING[2] KG/ANNUM	ESTIMATED LOSS BIOGAS DRYING[3] KG/ANNUM	LOSS REDUCTION KG/ANNUM	ADDITIONAL INCOME[4] Rp	ADDITIONAL INCOME[4] NZD	TOTAL ADDITIONAL ANNUAL INCOME INCLUDING INCUBATION NZD
Air Panas Baru	31,950	7,988	1,598	6,390	19,170,000	$3,150	$36,150
Sungai Medang	106,500	26,625	5,325	21,300	63,900,000	$10,502	$43,502
Sungai Tutung	111,360	27,840	5,568	22,272	66,816,000	$10,981	$43,981

Table A3.2

NOTES:

1:Refer table A1.1 above.
2:Assumed to be 25%- refer chapter 3.
3:Assumption.
4:Based on price for hulled rice of Rp3,000 (LTA, 2005)

COST OF PLANT and PLANT OPERATION

Cost of drier (based on ADAF Geothermal Project) (includes pipework)		$3,000.00
Assume O and M at		5%
Assume interest/discount rate at		5%
Assume major refurb of drier (25% initial cost) at		5 years
Tariff calculated from:	NPV drier / NPV throughput tonne	

PLANT COST PER VILLAGE:

VILLAGE	NUMBER OF DRIERS	INITIAL COST	ANNUAL RICE THROUGHPUT TONNE	COST PER TONNE	TOTAL ANNUAL O & M COSTS
Air Panas Baru	1	$3,000	32	$14.88	$47
Sungai Medang	1	$3,000	107	$4.34	$111
Sungai Tutung	1	$3,000	111	$4.15	$116

Table A3.3

NET COST BENEFIT PER VILLAGE

VILLAGE	NUMBER OF HOUSEHOLDS	ANNUAL O & M COSTS FOR DRIERS[2]	NET INCOME FROM DRIERS	NET INCOME FROM DRIERS PER HOUSEHOLD	NET ADDITIONAL ANNUAL INCOME[1]	ADDITIONAL INCOME PER HOUSEHOLD- INCUBATION	NET ADDITIONAL ANNUAL INCOME PER HOUSEHOLD
Air Panas Baru	127	$47	$3,104	$24	$36,104	$260	$284
Sungai Medang	427	$111	$10,391	$24	$43,391	$77	$102
Sungai Tutung	844	$116	$10,865	$13	$43,865	$39	$52

Table A3.4

NOTE:

1: The additional net income does not take into account operating labour for the driers as it is assumed that this will be drawn from the village, ie all payments made will be retained within the village.
2: O & M costs for the incubators are included in the net income of $33,000 per village.

APPENDIX A: Page 11
A4 – MICRO-HYDRO POTENTIAL

Assessed potential resource per village is based on flow and head measurement at Sungai Medang which indicated that small stream of this type could provide between 5 and 10 kW. Assume average of 7.5 kW.

As a basis, it is assumed that each village has a number of streams flowing through as shown below. This was based on a brief survey and in the case of Air Panas Baru, takes into account grouping of houses relative to potential hydro sites. Some streams were ruled out as being too remote.

VILLAGE	TOTAL VILLAGE LAND AREA (HA)	NO OF STREAMS	POTENTIAL POWER OUTPUT KW
Air Panas Baru	3,000	5	37.5
Sungai Medang	300	2	15
Sungai Tutung	1,350	4	30

Table A3.1

Household power demand:

Based on discussions at village meetings and Mulugetta *et al* (2005:15):

Most connections in villages are for a maximum load of:	400 W
Above this load, circuit breaker on h/hold connection will trip.	
Likely connected load:	
Lighting	75 W
Radio/tv:	150 W
Rice cooker- optional	300 W
Max load- w/out rice cooker:	225 W
Max load- with rice cooker:	525 W

Therefore people can only use rice cooker with TV off.
Also, a number of households sell load to neighbours w/out connection. This is typically a load of: 20 W

If we assume that rice cooker is a necessary improvement to peoples' livelihoods (especially women) and given the efficiency of even a good woodstove, is not necessarily energy inefficient, then a maximum load of 400 W is achievable with some load management by the h/holder.

APPENDIX A: Page 12
A4 – MICRO-HYDRO POTENTIAL- continued

The table below shows the number of additional connections that would be possible if micro-hydro power installations were in place:

VILLAGE	NUMBER OF HOUSEHOLDS	MICRO-HYDRO POTENTIAL KW	ADDITIONAL HOUSEHOLDS AT 400W/HH	CONNECTED HOUSEHOLDS	TOTAL CONNECTED WITH M/Hydro	% CONNECTED
Air Panas Baru	127	37.5	94	70	127	+100%
Sungai Medang	427	15	38	235	273	64%
Sungai Tutung	844	30	75	465	540	64%

Table A3.2

From discussions with Tony Woods, simple 10 kW micro-hydro turbine with inverter and batteries would cost in order of $45,000. Allow further $15,000 for connection and integration into existing village distribution system.

Cost per kWh:

1. Water flow understood to be reasonably constant year round.
2. Assume availability of 80%
3. Assume maintenance of 5%
4. Assume life of 15 years
5. Interest/discount rate of 10%
6. Battery replacement 5 years

Tariff calculated from: NPV cost / NPV kWh

VILLAGE	NO OF INSTALLATIONS	INSTALLATION COSTS	kWh ANNUALLY	COST PER KWH
Air Panas Baru	4	$240,000	262,800	$0.19
Sungai Medang	2	$120,000	105,120	$0.24
Sungai Tutung	3	$180,000	210,240	$0.18

Table A3.3

APPENDIX B

NIUE: ENERGY USE AND COST ESTIMATES

This Appendix B comprises spreadsheets summarising the methodology and calculations used to estimate cost benefits that could accrue from implementation of distribution wind-diesel hybrid power generation as identified in Chapter 4 and analysed in Chapter 5.

APPENDIX B
B1- WIND POWER OPTION

The wind-diesel hybrid installation configurations used below are for cost estimate purposes- no attempt has been made to optimise!

As first phase, supply villages other than Alofi North and Tuapa with local diesel-wind hybrid plant:

				Wind-diesel hybrid						All diesel
		estimated	annual energy	wind	diesel	wind	estimated	diesel fuel		annual fuel
Village	**Population**[1]	**households**[2]	**kWh**[3]	**kWh**	**kWh**	**plant**	**cost**	**litres**	**cost**	**litres**
Avatele	173	51	139,598	110,571	29,027	2 x 40kW	$470,098	8,178	$9,895	39,330
Hakupu	203	60	163,805	124,392	39,413	2 x 20kW+10kW	$577,021	11,104	$13,436	46,151
Hikutavake	64	19	51,643	41,464	10,179	1 x 20 kW+10kW	$265,454	2,868	$3,470	14,550
Lakepa	80	24	64,554	55,285	9,268	1 x 40 kW	$235,049	2,611	$3,160	18,187
Liku	72	21	58,098	55,285	2,813	1 x 40 kW	$235,049	793	$959	16,369
Makefu	64	19	51,643	41,464	10,179	1 x 20 kW+10kW	$265,454	2,868	$3,470	14,550
Mutalau	102	30	82,306	69,107	13,199	1 x 20kW+10kW	$341,972	3,719	$4,500	23,189
Namukulu	17	5	13,718	10,366	3,352	1 x 7.5 kW	$89,519	944	$1,143	3,865
Tamakautoga	125	37	100,865	82,928	17,937	3 x 20kW	$475,594	5,054	$6,115	28,418
Toi	28	8	22,594	22,594	-	1 x 20kW	$158,531	-	$0	6,366
Vaiea	53	16	42,767	41,464	1,303	3 x 10 kW	$320,769	367	$444	12,049
Alofi South	390	115	314,700	248,784	65,916	4 x 40kW+ 20kW	$1,098,727	18,571	$22,471	88,664
	1371	**403**	**1,106,292**	**903,705**	**202,587**		**$4,533,239**	**57,077**	**$69,063**	**311,686**

Notes: **Cost all diesel: $377,141**

(1) From Population Estimates for 2006 (Government of Niue, 2006)

(2) Based on 3.4 people per household (from Wade (2005a: 2).

(3) Annual energy assumes energy efficiency measures have <u>not</u> been adopted- it is estimated that this would reduce consumption by 120,000 kWh

From Wade (2005a), domestic consumption in 2003 was: 1,380,000 kWh

and diesel fuel used to generate this was: 388,801 litres — based on average of 3.55 kWh/litre

Number of households in 2003 was: 503 — from table 2.2 in Wade (2005a: 12)

Consumption per household (average): 2,744 kWh

The above scenario indicates that diesel generation could be reduced by about 80% and at current diesel price, reduce the cost of diesel imports by about $300,000.

Basis for wind turbine selection:

From Bergey:

			seasonal factor	availability	actual	
10kW wind turbine will produce:	23,036	kWh/annum				
assume that with seasonal variation, maximum in practice:	*17,277*	kWh/annum	75%	80%	13,821	kWh/annum
assume 7.5kW wind turbine will produce:	*12,958*	kWh/annum		80%	10,366	kWh/annum
assume 20kW wind turbine will produce:	*34,553*	kWh/annum		80%	27,643	kWh/annum
assume 40kW wind turbine will produce:	*69,107*	kWh/annum		80%	55,285	kWh/annum

APPENDIX B – Page 2
B1- WIND POWER OPTION- continued:

COST ESTIMATES:
Using Bergey prices:

	USD	NZD
10kW	$30,000	$46,154
tower	$13,000	$20,000
wiring, batteries, inverter	$20,000	$30,769
diesel gen set (10 kW)		$10,000
(from Sulco Tools and Equipment)		
		$106,923
5 kW	$20,000	$30,769
tower	$10,000	$15,385
wiring, batteries, inverter	$12,000	$18,462
diesel gen set (5 kW)		$7,500
(from Sulco Tools and Equipment)		
		$72,115

Using above to estimate prices for 7.5, 20 and 40kW:

Assume 7.5 kW is mid way between 5 and 10 kW:		$89,519
For double the output, increase in installed cost=	148%	
Based on this approximation, the cost of 20 kW installation will be:		$158,531
Based on this approximation, the cost of 40 kW installation will be:		$235,049

ESTIMATE OF REQUIRED TARIFF:

Tariff = $\frac{\text{NPV costs}}{\text{NPV kWh}}$

TOTAL CAPITAL COST =	$4,533,239	
Assume maintenance at	3%	(note that diesel/battery costs separated out)
Assume battery replaced	5	years
Total battery cost=	$344,000	
Diesel refurbishment	7	years
Total diesel refurb cost=	$462,500	

NPV costs=	$6,098,403
NPV kWh=	7,649,584
Tariff =	$0.80

APPENDIX C

KEY INFORMANTS

Key informants are listed below. I acknowledge with gratitude the valuable information that these informants provided and the time they gave me.

Kerinci:

Rusdi Fachrizal

Emma Fatma

Hamdani Alwi

Bupati Fauzi Siin

Deputy-Bupati Hasami Hamid

Niue:

Marie Etuata

Bob Talagi

Deve Talagi

HE Mrs Sisilia Talagi (High Commissioner to New Zealand)

Hema Douglas

Davene Vroon (NZAID)

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