FINANCIAL AND ECONOMIC ANALYSIS OF WILD HARVEST AND CULTURED LIVE CORAL AND LIVE ROCK IN FIJI

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ACRONYMS

AFF	Aquarium Fish Fiji
CITES	Convention on International Trade in Endangered Species
FLMMA	Fiji Locally Managed Marine Area Network
FOB	Free on board
FSPI	Foundation of the Peoples of the South Pacific International
GM	Gross margin
LA	Los Angeles
MAC	Marine Aquarium Council
NB	Net benefits
PCDF	Partners in Community Development - Fiji
PV	Present value
WSI	Walt Smith International

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FOREWORD

The South Pacific Regional Environment Program (SPREP) has funded the Foundation of the Peoples of the South Pacific-International (FSPI) to conduct the 'Socio-economic and Financial Viability Assessment of the Marine Trade in Corals in the Solomon Islands and Fiji'.

The reasoning for the assessment stems originally from a request by the Fiji government to ascertain non-detrimental findings to meet the Convention on the International Trade in Endangered Species' (CITES) requirements for coral exports .

Until recently, very few studies have seriously investigated the scope, potential, impacts, cost-benefits or long-term financial and bio-economic viability of wild collecting over the culture of marine aquarium commodities, particularly coral, or a combination of both activities.

This report covers the Fiji Islands component of the project. It addresses the issue of the financial viability of coral culture and compares its financial profitability with net financial returns villagers receive from the harvest of coral products from the wild and the economic viability of wild and cultured live rock and live coral products.

DISCLAIMER

This report is the outcome of numerous consultations and contains data from many sources including at least two stakeholder meetings. However, the usual caveat applies about the responsibility of the research team for data, analysis and conclusions reported here.

EXECUTIVE SUMMARY

International interest in marine aquarium products - coral, fish, invertebrates and live rock - has steadily increased over time. Coral, fish and invertebrates are sought after for their variety, colour and beauty, while live rocks are used in aquariums as artificial reef substrate for other organisms to dwell in. Live rocks in aquariums also help maintain water quality because algae on the surface of the rocks metabolize nutrients in the water into plant growth.

In terms of volume, live rock and coral are two of the most important products in the marine aquarium trade, and interest in these two products, and in other ornamental species, is growing world-wide. In 2004 Fiji supplied about 161,927 pieces of hard and soft coral and 1.36 million pieces of live rock to overseas markets, mainly in USA, Hong Kong, Japan and Europe. Fiji also exported 169,143 pieces of ornamental fish and 31,900 pieces of invertebrates (CITES database with the Fiji Fisheries Department, July 2005).

There is a growing international concern over the environmental effects of live coral and live rock harvests from the wild. Worldwide, harvest of these products from the wild is generally considered to have detrimental effects on the ecology of coral reef ecosystems and on the coastal fisheries supporting many rural communities. Scientific evidence of the extent of ecological impacts is limited, although wild harvest of coral and live rock particularly is discouraged. To reduce pressure on coastal resources, and ultimately to reduce the level of harvest of coral and coral products from the wild, culture of live coral and live rock is promoted as an alternative.

Despite increasing interest and the promotion of culture of coral and live rock as an alternative source of products for aquarium trade, it is not known if coral and live rock culture is financially viable? Or if cultured products can compete with wild harvest as a source of income for rural communities? Nor is it known if cultured coral and live rock can be financially feasible for villages located both on the mainland and on outer islands.

The objective of this study is to assess the financial and economic desirability (as defined below) of the cultured coral and live rock products as compared with those obtained from the wild. Specifically:

- Determine the financial viability of cultured coral, cultured rock and a mixture of rock and coral products using the low technology approach used in Fiji.
- Assess the net economic benefits to local communities of live rock and coral culture and the net economics benefits generated from the wild, including considerations of the ecological costs of wild harvest.

Additional questions addressed in this study include:

- For villagers, under what circumstances can cultured products compete with those harvested from the wild?
- What is the net, as compared with gross, benefits of marine aquarium trade to rural communities and exporters?

Financial and economic analysis - methodology

An activity is financially viable in the short term if its gross margin is greater than zero; gross margin is total revenue minus all operating costs but excluding costs of family labour. In the long run, a project is considered to be viable only of its financial net return is greater than zero; financial net return is defined as total revenue minus all costs, including equivalent cost of family labour.

Relative profitability of wild harvest of live coral and live rock over cultured coral and rock is the measure used by individuals to choose between the options. In the short term the activity that produces higher gross margin is preferable over the alternative activity with lower gross margin. In the longer term the activity that produces higher financial net return[1] is preferable over an alternative activity that produces lower financial net returns; Ecological costs and other non-out of pocket costs, other than depreciation, are not included in financial analysis. Economic analysis, on the other hand, takes a national (social) perspective in which all benefits and costs - direct and indirect - are explicitly considered. Total economic benefit is the economic market value of product plus economic value of non-marketed products resulting from the same activity.

To compare the profitability of wild harvest of coral and live rock with their respective cultured products, a 'with and without' analysis is used. A 'with and without' analysis is based on the assumption that when one wants to replace wild harvest of live coral and live rock with cultured products, then the only thing that changes is the process used to produce the products of the same quality.

In this study a financial analyses from the point of view of an individual villager is first undertaken to identify financial viability of wild fishery versus that of the culture based fishery. Then the net financial returns of the wild products are compared to those of the cultured products in order to assess whether individual villagers would have financial incentives to switch from wild to cultured products. Secondly, a social perspective is taken and analysis is also carried out using an economic net benefit approach, in which all benefits and costs – direct and indirect – are considered, including environmental externality costs. Because costs and benefits are spread over time, net present (economic) value estimates is used to compare the two production process.

The financial profitability of wild fishery for exporters is also assessed. Exporters are expected to use the same process of handling, packaging and transport of cultured as for the wild products, their profitability of the cultured products is assumed to be the same as that of the wild products; provided there is no change in the product price.

This study is based on primary and secondary data collected from several different sources using a mixed methodologies, including structured questionnaires. Primary data was collected by interviewing coral and live rock harvesters/ collectors, exporters, non-government organizations working with communities to promote cultured rock and coral products, government officials involved with licensing and export permit and CITES documentations. Two villages involved in live coral and live rock were selected for in-depth survey: Uluibau, which is a typical of villages on outer islands and Namada/ Vatukarasa on the other hand are typical of villages located on the mainland. Villagers from Uluibau collect live coral and aquarium fish for sale to Ocean 2000. Namada and Vatukarasa villagers harvests live rock harvest for sale to Walt Smith International[2].

These two companies, Walt Smith International and Ocean 2000, which together represented in 2004 about 76 percent of the live rock trade and 75 percent of live coral exports from Fiji, were also selected for in depth study of the export component of the supply chain of aquarium products.

Using the results of these interviews and data collected from other sources, 'typical' production-supply models were constructed for coral harvest from the wild, live coral culture, live rock harvest form the wild and live rock culture. These models were used to assess the financial and economic viability of wild versus cultured live rock and live coral. .

Results and conclusion

Coral and live rock (and other aquarium products) based aquarium trade are without doubt important sources of income for exporters and resource custodians. Total FOB value of live rock and coral products exported in 2004 was about $ 4.4 million, in addition to $1.8 million in ornamental fish and invertebrates[3]. Rural resource custodians from 25 *qoliqolis* where live rock and coral are extracted received a total gross income of about $1.4 million, $1.1 million from live rock and about $323,900 from coral. *Qoliqoli* chiefs of the areas where aquarium products are collected are estimated to have received about $155,400 in goodwill payments.

Annual net financial returns to collectors from the mainland and from nearby islands is a little more than three

[1] In this report all net returns are before tax.

[2] There is an informal agreement in Fiji about 'one area-one company' operation, although not always is this 'policy' followed with some customary owners choosing to permit more than one exporter to collect aquarium products.

[3] Note this industry value differs from the officially recorded $14 million reported by the Fisheries Department because the latter includes landed value of live rock as well as FOB value of coral, fish and invertebrates.

quarters of a million dollars, with people living on the islands being the main benefactors from the harvest of coral. On the other hand, for mainlanders, the harvest of live rock from the wild is the main activity. The financial net returns for the exporters of live coral and live rock products is estimated to be about $ 1.3 – 1.8 million. They bear the risk of fluctuations in exchange rates and international market supply and demand. The total net financial returns to exporters and *qoliqoli* harvesters is a little less than fifty percent of gross income, or $2.1-2.6 million, as compared to a gross income of about $ 4.4 million in 2003 (Table A).

Table A: Gross and Net Financial Income of Village Collectors, Exporters and Industry of Live Rock and Live Coral Harvested from the Wild, 2004.

	Live rock	Live coral	Total
Quantity	1,361,004 kg	161,927 pcs	
FOB value of exports (Exchange rate FJ$ 1=US $0.6)	$3,024,879	$1,351,261	$4,376,140
Collectors' Gross Income	$1,088,803	$323,854	$1,412,657
Collectors' Net Income, including goodwill	$692,968	$143,428	$836,396
Goodwill payment (about 11%)	$119,768	$35,624	$155,392
Net Exporter Financial Return (@ 30% - 40% 'profit' margin)	$0.9 – 1.2 million	$0.41 – 0.54 million	$1.34 – 1.75 million
Industry Net Benefit (collectors, chiefs and exporters)	$1.61 – 1.90 million	$0.55 – 0.68 million	$2.14 – 2.59 million

Collectors' price relative to FOB value

Payment to villagers for live coral and live rock relative to FOB price varies. Price of live coral paid to villagers varies with exporters. Some exporters, such as Oceans 2000, pay a fixed amount per coral piece supplied regardless of specie or colour, giving on villagers on average about 5-30 percent of FOB value of live coral (and live fish and invertebrates). On the other hand, exporter such as Walt Smith International pays villagers according to species, size and color of live coral supplied by villagers, with villagers receiving on average about 15-25 percent of FOB value; importers of live coral meet the cost of freight.

Price of live rock to villagers is fixed at $0.8/ kg, whereas exporters price (FOB) varies from shipment to shipment because of fluctuating exchange rate as well shipment size affecting freight charge; exporters of live rock generally pay freight charges. Thus, live rock payment to villagers as a percent of FOB of live rock would vary from consignment to consignment because the FOB price received by the export would varies not only due to size and quality of live rocks but also exchange rate and freight costs.

At 2005 exchange rate of $FJ1= US$0.60; villagers would have received about 36 percent of FOB. If on the other hand, the exchange rate were to decrease by 13 percent (that is, FJ$ 1= US 53, as was the case in 2003), then the exporter's FOB value of live rock increases by almost 30 percent, and the price received by villagers reduces to 27 percent (LA landed price of$116.8 for a 22.2 kg box of premium live rock). If the low exchange rate were combined with high freight charges, then exporters can expect to even make a loss; this however, will be rare because it is in an exporter's interest to send larger volumes because unit freight cost is lower.

Gross margin and financial net returns of live and cultured coral

At the current scale of operation, villagers working part-time, make reasonable gross margin from the harvest of coral from the wild. A typical villager can expect to earn a gross margin of $3,814 a year from live coral, assuming a person makes 2-3 trips a week, or 65 trip-equivalent and collects 3,396 pieces of coral; this output is the average number of coral pieces exported per 45 collectors in year 2003. If labour costs and depreciation are considered, then a village can expect to earn a financial net return of about $3,000 a year. However, if the same volume of coral were collected by villagers working 'full time equivalent', a household could expect to earn an equivalent of about $11,000 in gross margin or $9,100 in net financial return before tax income.

On the other hand, producing the same quantity of coral as a part time operator from coral farms using the coral culture technology used by Walt Smith International at the Hideaway and also trialed by PCDF/FSPI at Moturiki, a villager can expect to earn a financial net return of only $1,085. The technology adopted in Fiji involves pieces of coral glued onto cement bases and placed on specially constructed racks of 1.4m x 2.8 m

in dimension. The racks containing 200 pieces of coral are placed in sea for the grow-out to marketable size. The grow-out period assumed in this study is 12 months, although this assumption is relaxed in the sensitivity analysis.

Only if employment is treated as a benefit, and the costs of all fixed inputs are not included, a villager can expect to earn $3,441, which is about $370 less than what could be expected form the wild. However, if labour costs and depreciation of capital items are considered then the financial net return is less than half of what could be expected from the wild, assuming all the cultured products are of marketable quality. If there is rejection of some of cultured products, then the expected return to villagers could even be less.

Taking national perspective and a five year period (five years is chosen because some of the fixed inputs are expected to last for no more than five years) is assumed, a villager can expect to receive a net present value (resource rent) of $12,855 from the wild harvest. If the cultured coral were to replace the wild harvest, a villager can expect to only earn $5,936 from the production of the same volume of coral over a five year period. That is, economic net benefit of cultured live coral is about half of the net benefits of the wild harvest. This then suggest that only if the ecological effects of the coral harvest from the wild were equal or greater than about $6,920 per collector over a five year period, then stopping the harvest of coral from the wild will make economic sense.

Gross margin and financial net return of live and cultured live rock

A similar conclusion is also arrived at when one compares the financial profitability of wild versus cultured live rock. The culture of live rock involves strings of rock base being placed in coastal waters for coralline algae and other organisms to 'grow' on. Colourful algae and other organisms are allowed to grow on the rock bases for about 12 months, before being harvested for export. The post harvest processes for cultured rock are very similar to that of the live rock harvested from the wild.

With gross margin, where employment is treated as a benefit and fixed costs are treated as sunk costs, a villager could expect to earn $10,833 from cultured rock as compared to about $23,187 from the wild harvest of live rock. That is, the gross margins of cultured rock are thus less than half of what could be earned from the wild. Taking into account all costs, including family labour and depreciation, the financial net return from cultured rock is about $1,077, as compared with $21,771 from the wild as summarized in the following table.

Table B: Summary of Financial Net Returns from Wild Coral, Cultured Coral, Wild Live Rock and Cultured Live Rock Per Household.

	Wild Coral	Cultured Coral (plus live rock)*	Cultured Coral (2 crops a year)	Wild Rock	Cultured Rock
Volume per HH	3,393 pieces	3,393 pieces	6,786 pieces	34,210 kgs	34,210 kgs
Total Revenue	$6,792	$6,792 (7,586)*	$13,585 (15,172)*	$27,368	$27,368
Gross Margin	$3,814	$3, 441 (3,778)*	$9,505 (10,179)*	$23,187	$10,833
Financial Net return	$3,008	$1,085 (1,203)*	$4,793 (5,044)*	$21,771	$1,077

* Higher gross margin and financial net return reflects the situation where villager takes advantage of the space below the coral rack to produces live rock (suitable for mainland villagers only)

Concluding remarks

Aquarium trades based coral and live rock fisheries are financially viable and can provide a source of livelihood for the indigenous Fijian. However, the financial and economic net returns from cultured products are significantly less than that obtained from the wild for it to be attractive to villagers already involved in the fishery.

Financial net returns earned from cultured coral and cultured rock can be comparable to the financial net returns earned from the products harvested from the wild, if a price increase for cultured products could be assured. Furthermore, the difference between the economic net returns from the wild and cultured products is expected to decrease if cultured products can fetch higher prices on account of environmental friendliness, and if these price increases were directly passed onto the rural villagers.

The possibility of cultured coral and live rock fetching high prices is unclear. Anecdotal evidence form MAC certified fish from Philippines suggest that 30-40 percent premium is possible. Such a high premium is difficult to believe when the more settled certification system in forestry from the Solomon Islands provide about 23 percent in price premium for logs (Pesce and Lal 2003). It is, also dangerous to conclude that such a price premium can be achieved for all species and all products exported from Fiji because of the domestic and international competition from places like Indonesia. Today, cultured products from other parts of the world, such as Bali, seem to be preferred over products from Fiji because suppliers from Indonesia produce species and sizes demanded by market (David Palmer, Pacific Aquafarm, LA, pers comm. June 2005).

Alternatively, if faster growing species of coral could be cultured, gross margins and financial net returns can be comparable to the financial returns obtained from the wild. Walt Smith International has recently harvested and exported 6 month cultured coral. If this were to become the norm, and the demand for cultured coral from Fiji remained constant, the annual gross margin of cultured coral is estimated to be about $9,505 and with a financial net return of about $4,793. Such benefits are possible only if the current demand for Fiji coral and prices are maintained, which as discussed earlier is unlikely when other countries, such as Indonesia, have adopted a more targeted culture strategy, producing higher demand species and larger sizes than Fiji.

In conclusion, the culture of aquarium products is financially viable, although not as attractive as the wild harvests. The profitability of cultured products for villagers and the exporters will ultimately depend on the demand of Fiji's cultured product relative to products from elsewhere in the world, exchange rate and freight charges. Furthermore, for the aquarium trade based on cultured products to be sustainable, key feasibility conditions need to be met.

These include:

- the simple low-technology based culture is maintained
- costs of live rock and live coral base substrates are kept low
- villagers cooperate and take advantage of economies of scale and share certain costs while continuing to operate as individual 'firms'
- product quality is maintained
- market prices remain stable
- exchange rates remain favourable.

In addition, villagers would need to be prepared to put in regular effort required to establish, maintain and replace each batch of live rock and live coral cultured. Experiences in the Pacific suggest that this is one of the most critical factors in the long term sustainability of aquaculture activities. Without meeting such feasibility factors, culture of live rock and live coral may meet a similarly dismal fate as other aquaculture ventures in Fiji and the Pacific.

1. INTRODUCTION

Aquarium trade, which started in about 1930s in Sri Lanka, is a multimillion dollar business today involving many developing countries in the tropics where coral reefs are found, including the Pacific. Globally, the gross value of the aquarium trade is estimated to have been FJ $350-530[4] million in 2003, and growing. Worldwide, it is estimated that 1.5-2 million people keep marine aquaria, with countries such as the USA, Hong Kong and Japan being the largest importing nations (Wabnitz, et al 2003). Most of the marine aquarium products are sourced from coral reefs throughout the world.

Marine aquarium trade comprises coral, live rock and ornamental fish and other invertebrates sourced from the tropics. Annual trade of live coral is about 11-12 million pieces and 9-10 million pieces of marine ornamental invertebrates harvested wild. Live rock trade is about 3.9 million pieces or about 2.1 million kilograms (kgs) (Wabnitz et al. 2003). Coral and invertebrates are sought for variety, colour and beauty, while live rocks are used in aquariums as artificial reef substrate for other organisms to dwell in. Live rocks in aquariums also help to maintain water quality, as algae on the surface of the rocks metabolize any excess nutrients in the water.

Interest in marine aquarium trade has increased in recent years not only because of the growing interest in hobby aquariums in homes and businesses in the developed world but more importantly because of concerns over its potential environmental effects of uncontrolled harvests. For the Pacific, which recently became an important source of marine ornamentals, there is also a growing interest because of its potential as a source of income for coastal people who often do not have any other source of livelihood.

In the last five years, the Pacific island nations are reported to have supplied about 18 percent of 3.5 million fishes traded internationally, with Solomon Islands contributing 12 percent[5], Fiji 5 percent and Palau 2 percent (Wabnitz wt al 2003: 19). On the other hand, live coral exports from the Pacific is reported to be 25% of live coral pieces traded internationally, with once again Solomon Islands reported to have supplied 18 percent, Fiji 4 percent and Tonga 3 percent of the global trade (Wabnitz et al. 2003). It may be noted Fiji statistics are an overestimate for two key reasons. Earlier data were based on permitted quantities rather than actual export statistics and the pre 2002 export statistics also included curio coral exports (Ed Lovell, University of the South Pacific, pers comm. June 2005).

Harvest of live rock may affect complex web of interdependence in reef ecosystems, thus reducing biodiversity. Experiences elsewhere in the world show that diversity and abundance of fish are lower in areas harvested for live rock/coral than when compared to adjacent un-mined areas (Dawson-Shepherd et al. 1992; Hawkins and Roberts 1994). A similar pattern is also observed in relation to the overall value of the coral's fish-habitat function. In areas from where live rock is harvested, a decline in recreational dive value has also been recorded (Hawkins and Roberts 1993; Hawkins and Roberts 1994).

Live rock harvests in particular may also affect subsistence, artisanal and commercial fisheries on which many coastal communities rely for their livelihood. In Fiji, for example, after nine years of live rock harvest, villagers noticed that quantities of fish and other marine species commonly collected from areas used for rock harvest had reduced. Some communities, such as Tagaqe village in Fiji, took steps to not allow live rock extraction from their waters as a precaution. They are also currently involved in live rock culture experiment in partnership with Walt Smith International.

Scientific analysis of recent field data is inconclusive (Lovell 2001). There is also some disagreement about the extent of impact that harvest of live rock has on the coral ecosystem. (Lovell and Tumuri 1999), for example, note that it is difficult to ascertain the exact effects that live rock harvesting have on the overall health of the coral reef ecosystem. The extent of the net effect of rock harvesting no doubt would depend on the type of reef (deeper reef flat lagoons are most susceptible to greater negative impacts), the size of reef from where live rock is harvested and the rate of harvest. Furthermore, Lovell (2001: 42) note that only a small percentage of live rock is collected from any one reef and that live rock collection is very selective and that it is difficult to generalize about the impacts because of the diversity and composition of reefs.

Vaughan quoted in Lovell (2001) found no significant differences in the diversity of corals or substratum composition between areas subjected to collection activities and areas without collection. He found, though, that the size frequency distribution of corals was 'significantly different and there were indications to suggest that collection does reduce coral cover and alters species richness and evenness (p 39). Nonetheless, concerns over the negative effects of live coral and live rock harvests persist in the absence of adequate robust scientific evidence from a diversity of reefs, countries and ecological situations.

[4] Exchange rate: FJ$1 = US$0.6

[5] This figure is believed to be an over estimate for the Solomon Islands, given the fact that there is only one fish and coral company of small to med size operating and with one flight per week to Australia. It is possible that these reflect permitted figures rather than actual exports (Ed Lovell, pers comm, pers comm).

Aquaculture as an alternative to wild harvests of coral and live rock

To reduce pressure on coastal resources, and ultimately to reduce the level of harvest of coral and coral products from the wild, culture of ornamental species is promoted as an alternative. Internationally, interest in live rock and live coral culture is not a recent occurrence. Public aquarium staff in Hawaii have experimented with asexual propagation of fragmented corals for at least four decades (Delbeek 2001). More recently, experiments with cultured coral for reef rehabilitation has been carried out in Tanzania (Franklin et al. 1998); Costa Rica (Guzman 1991); Philippines (Alcala and Gomez (1982) and the Pacific (Bowden-Kirby 1999a; Bowden-Kirby 1999b; Bowden-Kirby 1999c).

Non-government organizations (NGOs), and exporters, too, in the Pacific have begun experiments with low technology based cultured products in collaboration with local communities. Some non-governmental organizations, such as PCDF (Partners in Community Development - Fiji) and FLMMA (Fiji Locally Managed Marine Area), have encouraged local communities to use their traditional systems and place a ban on wild harvest. There has also been promotion of culture of coral and live rock as alternative sources of income by some NGOs and *exporters* who have experimented with low technology based culture of selected species of coral and live rock in customary waters close to the shore.

From the information available, it appears that only Walt Smith International has actually exported cultured products from Fiji. Their culture operation is an adjunct to their main operation based on the export of live ornamental fish and other invertebrates, coral and live rock harvested from the wild. Recently, two main exporters in Fiji made an agreement to phase out live rock harvest from the wild over the next eight years or so to 10 percent of the current harvest, with the rest being sourced from live rock culture farms (Department of Fisheries, pers comm. Dec 2004). The exporters, however, note that such a phase out is likely to become a reality only if the Pacific region as a whole agrees to phase out harvests from the wild (Tim McLeod, Walt Smith International, pers comm. June 2005).

Despite increasing interests and promotion of culture of coral and live rock as an alternative source of products for aquarium trade, it is, however not known if coral and live rock culture is financially viable. Or if cultured products can compete with wild harvest as a source of income for rural communities. Nor is it known if cultured coral and live rock can be financially feasible for villages located both on the mainland and on outer islands.

A recent financial analysis of live rock and coral culture for the Pacific islands (and more high technology models for Asia and USA) concluded that the culture of live rock and coral was not financially viable, with the rock model particularly producing large losses (Parks et al. 2003). Pomeroy et al (in press) note that culture of live rock and live coral products could be an important alternative to wild harvest only if one assumes, amongst other things, that cultured products receive preferential treatment over products caught from the wild; there is subsidy from the Government and or donor assistance (Pomeroy et al. in press).

Using financial analysis method to determine the financial viability of the culture of coral, Pomeroy et al. assumed that a complete new venture needs to be established, including the establishment of aquarium warehouses where cultured products are kept till export. This approach to financial/ economic analysis is valid if a totally new venture is being considered, and no wild harvest currently operates. However, if a wild harvest based fishery exists then the relevant question is whether cultured products will be financially viable and attractive for existing operators. The answer to such a question the use of a 'with and without' benefit cost (marginal) analysis is appropriate (see Perkin 1994 and Sinden and Thampapillai 1995 for more details on the appropriateness of 'with and without' analysis.)

Financial analysis, as discussed below in detail, does not include considerations of externality costs, such as environmental costs of coral harvest. Externality costs are imposed on others which the person does not directly pay for. To reflect such costs to society, economic analysis is appropriate.

Thus, before rural communities are encouraged to take up commercial culture of coral and live rock for aquarium trade, it is important to determine:

(a) whether live coral and live rock culture(s) is/ are financially viable?

(b) if so, if they can compete with the wild harvest in terms of net household income?; and

(c) whether the economic net benefit of cultured products is greater than the economic net benefits derived from the wild fishery?

The objective of this study is to assess the financial and economic desirability (as defined below) of the cultured coral and live rock products as compared with those obtained from the wild. To address this objective the project will more specifically:

- determine the financial viability of cultured coral, cultured rock and a mixture of rock and coral products adopting the low-technology approach used in Fiji.
- assess the net economic benefits to local communities of live rock and coral culture and the net economics benefits generated from the wild, including considerations of the ecological costs of wild harvest.

Additional questions addressed in this study include:

- for villagers, under what circumstances can cultured products compete with those harvested from the wild?
- what is the net, as compared with gross, benefits of marine aquarium trade to rural communities and exporters?

2. METHODOLOGY

The appropriate analytical framework to address the broader research question identified in this study is a 'with and without' benefit cost analysis (BCA). This involves estimating the net benefits of wild harvests of live coral and live rock ('with' scenario) and comparing it with the net benefits of the 'without' wild harvest scenario (i.e. culture-based fishery). If the net benefit from cultured products is positive, then the culture based activity is considered to be financially viable. However, for communities and exporters to switch to cultured products, then the net benefits derived from cultured products would need to be at least equal to or greater than the net benefits derived from wild harvested products. For this comparison, a 'with and without' based analysis is appropriate.

A 'with and without' analysis in this case is thus based on the assumption that when one wants to replace wild harvest of live coral and live rock with cultured products, then the only thing that changes is the process used to produce the products of the same quality. Demand, price and quality are assumed to remain unchanged. This is an important, but not an unrealistic, assumption.

Exporters already own processing warehouses, including all the necessary equipment for cleaning and holding of the organisms, packing and transporting the products to the markets. And the products – live coral from the wild and live coral from culture farms; and live rock from the wild and cultures live rock - are not dissimilar as far as the exporter is concerned. No changes are required in the holding and maintenance of coral products. Nor are there any differences in packaging and freight of the two categories of products. The only thing that differs is the supply of products from culture farms as opposed to the harvest from the wild. Consumers of marine ornamentals may have different preferences for wild versus cultured products, and thus cultured products may fetch different prices to the wild ones. The costs of production for the villagers for the cultured products will be different from the cost of wild harvested products. Thus, villagers can expect to see a large difference in their net income, if they were to convert from the wild fishery to a culture based activity, as seen in this study.

Financial and economic net benefit analyses

Financial analysis focuses on the financial interests of individuals, families and/or the community directly involved in a project. It comprises considerations of only monetary costs of all inputs used and paid for, depreciation costs, and returns (Box 1).

An activity is considered to be financially viable if the financial net return is greater than zero. In the short term, an activity may be considered to be viable if gross margin is greater than zero.

When comparing between options, for an individual, the activity that produces higher gross margin is preferable in the short term over an alternative activity with lower gross margin. In the longer term the activity that produces higher financial net return is preferable over the alternative activity that produces lower financial net returns. Ecological costs and other non-out of pocket costs, other than depreciation, are not included in financial analysis.

Economic analysis, on the other hand, takes a national (social) perspective in which all benefits and costs - direct and indirect - are explicitly considered. Total economic benefit is the economic market value of product plus economic value of non-marketed products resulting from the same activity. Economic value of a product is measured in terms of unit willingness to pay, or price times the quantity of the products sold. Total economic cost is the sum of direct and indirect costs, including externality costs on other users and the environment.

The criteria used to compare the two alternative sources of the aquarium products is the difference between the net economic benefit of the two products - economic benefits minus economic costs of the wild harvest and the economic net benefit of the cultured product. Generally, the activity that produces higher net economic benefits is preferable to those producing lower net economic benefits, including ecological costs. Therefore, if the NB (wild coral) is greater than the NB (cultured coral) then wild coral harvest is preferable because it produces a higher economic (social) benefits for the society than the cultured product.

When costs and returns flow over time, the appropriate measure for comparison is the net present value of the two activities.

In this study a financial analysis from the point of view of the individual operators is first undertaken to identify whether individual villagers would have financial incentives to switch from producing wild to cultured products. Secondly, a social perspective is taken and analysis is also carried out using an economic net benefit approach. To analyse financial and economic net benefits of 'with and without' wild harvest of live coral and live rocks, technical production, together with financial and economic, models for each scenario is defined. For these analyses, information/ data are gathered using different approaches and methodologies.

Box 1: Financial Analysis Formulae

Financial Net Revenue (NR)
= Total Revenue – Total Costs

Total Revenue = Price * Quantity

Total Costs = Sum (unit cost of input * quantity of inputs) + Depreciation Cost

Operating (Variable) Costs = Costs of all inputs which varies with quantity of output produced

Gross Margin
= Total Revenue minus Operating Costs

Net Financial Profit = Total Revenue – Total Costs

Financial Criteria:
Two activities A (wild), B (culture), if: Gross Margin (A) > Gross Margin (B) than A is preferable over B

Economic Net Benefits (NB)
= Total Benefits - Total Costs

Total Benefits
= Total market benefits + total nonmarket benefits

Total Costs = Direct Costs + Externality Costs
= Sum (unit opportunity cost of input * quantity of inputs) + Externality costs

Opportunity cost
= cost of the input in the next best use

Externality costs = costs born by other users and not paid for by the coral harvester – such as costs on fishermen, diver operators, costs of loss in biodiversity

Economic Criteria:
Two activities A (wild), B (culture), if NB(B) > NB(A) than B is preferable over A

This study is based on primary and secondary data collected from several sources. Primary data were collected by interviewing coral and live rock harvesters/ collectors, exporters, non-government organizations working with communities to promote cultured rock and coral products, government officials involved with licensing and export permit and CITES documentations. A mixed methodology was used to suit both the interviewee and the nature of information that was sourced.

Box 2: Net Present Value (NPV)

When benefits and costs occur over time, then the appropriate measure is the present value of benefits minus the present value of costs:

PV (Net Benefits) = NB_t

The present value (PV) of net benefits, NB, that is earned in time t is calculated as:

$$PV = NB \times [1/(1+r)^t]$$

Where $[1/(1+r)^t]$ represent the factor by which individuals discount the future.

Sum of present value of net benefits over, say year 1 to 5 , is = $\sum_{1}^{5} \frac{NB_t}{(1+r)^t}$

A structured, semi-structured, and open ended interview format was generally used to elicit information but the process was guided by written questionnaires that had been pilot tested. An open ended interview format in a *talanoa*[6] session was most suited when approaching villagers, putting them at ease and without appearing to be prying. In the case of *exporters* too, semi structured and open-ended interview format was found to be most suitable, with open ended questions used to obtain general information about the commercial business, and semi-structured questionnaire used when asking specific costs and returns information. With NGOs and government officials a more discussion format was found generally to be more effective.

Separate questionnaires were designed to survey villagers/communities involved in live rock/coral and coral product harvest from the wild and *exporters* collecting/ purchasing aquarium products for export.

For the villagers, questionnaire was designed in English and then translated into Fijian to obtain information such as:

- who is involved in the harvest (or culture), processing and marketing and what does each stakeholder do along the harvest-processing-marketing-export chain
- do collectors receive training from the traders who buy their products
- what products and which species do they harvest, how much coral and live rock is extracted on each trip, and how many trips are made in a year
- what costs are involved in extracting, processing, shipping and export
- how much income does the individual villager derive over and above their costs of harvesting and transporting and what other sources of income do the family have
- what is the arrangement between the villagers and the exporters for the supply of the products
- what alternative source of livelihood is there if, say for some bureaucratic reason, live coral/ rock harvest were restricted.

Two villages were selected for detailed household interview: Uluibau and Namada. Uluibau is located on the outer island of Moturiki and is involved in live coral and life fish harvest[7] and Namada, which is located along the Coral Coast on the mainland of Viti Levu is involved in live rock harvests from their own and neighbour's customary *qoliqoli* waters.

For the interview of *exporters*, a questionnaire was designed to obtain:

- basic background information on the nature of the company's operations
- information about inputs used at different stages of the supply chain and their respective costs
- outputs produced and export quantities, and Free On Board (FOB) prices of key products
- the arrangement between the villagers and the exporters for the supply of the products.

One large, Walt Smith International, and one medium size company, Ocean 2000, were selected for detailed study. They were chosen not only because they represent 67 percent of the live rock trade and 77 percent of hard and soft coral exports from Fiji, but also because they were willing to discuss their operations. Walt Smith International is an American company with its Pacific node based in Fiji. Ocean 2000 involves a foreign interest and an indigenous partner. Efforts to interview other, at least one other smaller, company were not successful because operators were not willing to reveal details about their business.

Information was also obtained from Walt Smith International and FSPI involved in coral/ live rock culture, including about:

- who is involved in the culture (or harvest), processing and marketing
- what products and which species are cultured
- what does each stakeholder do along the culture-processing-marketing and export chain
- how much time is spent by each stakeholder in their respective activity
- how much coral and live rock is in each farm, how much coral / live rock is harvested per trip and how many trips are made in a year
- what is the arrangement with the *qoliqoli* owners in relation to the culture site
- what inputs are used in the culture, harvest , processing, shipping and export, and what are their respective costs.

In most cases the recall method was relied on to obtain information for the previous year's activities from communities involved with coral and live rock harvest because very few, if any, villagers kept written records. In the case of the exporters, while recall method was also relied upon, some access to business records was also obtained. Official company records helped us to develop more realistic production supply models. Where such official records were not available researchers were forced to rely on oral information provided

[6] Fijian term for discussion

[7] Villagers involved in live coral harvest were often also involved in live fish harvest for aquarium trade.

by operators. In a few cases, the exporters freely helped to verify assumptions and projections made in the study. Data obtained was also validated using information collected from other operators, as well as from government and non-government stakeholders. Differences, when found, were cross checked and verified using secondary information and other stakeholders familiar with the coral trade in Fiji.

In addition to the oral and written information obtained from various stakeholders, much of the aquarium trade-related background information was obtained from published reports, such as those from the World Wildlife Fund (WWF), World Resources Institute (WRI), Fiji Fisheries Department and the Marine Aquarium Council (MAC), as well peer reviewed journal articles and conference proceedings. Some of the international trade statistics were obtained from the CITES database with the assistance of TRAFFIC staff in Fiji.

Financial costs and price information were collected from the villagers, exporters, MAC staff and Fisheries Division staff, websites of companies and commercial traders in the USA. Input prices, if not available from villagers or operators, were obtained from local retail stores in Suva/ Lautoka and were used to develop the financial model.

Using the results of these interviews and data collected from other sources, 'typical' production-supply models were constructed for 'typical' coral harvest, 'typical' live coral culture, and 'typical' live rock culture. These models were then used to assess the financial viability of wild versus cultured live rock and live coral.

3. WILD HARVEST BASED AQUARIUM TRADE IN FIJI

International aquarium trade is based on coral, rocks, fish and other invertebrates, with a large number of species involved (Table 1).

Table 1: Types of aquarium products traded in the world

Aquarium product	Identified number of species or varieties traded globally	Comments
Live corals	102* to 140** species	There is some differences in statistics depending on the source of data (see Wabnitz, et al 2003)
Live rocks	3 types being traded**	2 from wild Pacific and Atlantic and cultured rock
Live fish	1,471 species**	90 percent believed to be freshwater species, 10 percent marine species
Invertebrates	293* - 500** species	Include trochus shells, shrimps, clams, crabs, star fish, snails, mushroom, anemone, worms, etc.

Source: * Green in Cato and Brown, 2003;
** Wabnitz et. al, 2003

Fiji, Solomon Islands and Tonga are amongst the top ten exporters of marine aquarium products, including curio coral, in the world, with Fiji ranking fourth after Indonesia, China[8] and Philippines. Major consumers of live rock and live coral are in USA, Hong Kong, Japan and Europe.

Pacific aquarium trade products are highly regarded and sought after by aquarium hobbyists internationally because of the brighter colors. Although many Pacific Island nations have been involved over time, Fiji has recently become a dominant player (See Box 3).

[8] While Wabnitz et al notes China, it is very possible that they mean Taiwan.

Box 3: Aquarium based trade from the Pacific

The Pacific has grown to be an important source of marine aquarium products, supplying about 18 percent of 2.5 million fishes and 25 percent of live coral trade. Over the years, aquarium organisms have been collected and exported from Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga and Vanuatu (Baquero, 1999). In the early 1990s, the region supplied around 200,000 – 250,000 fish (around 150 fish species) and around 60 species of live coral (Robinson. 2000).

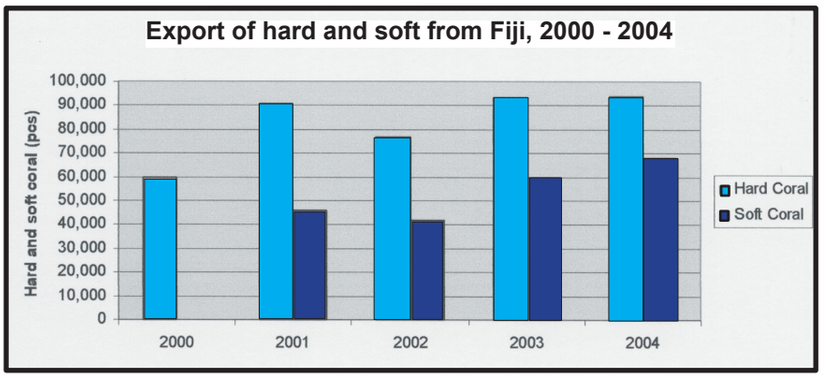
Traditionally, aquarium fish and live coral were the main products collected from the region with countries other than Fiji and Solomon Islands being the main source of the products. In the eighties, for example, New Caledonia was a major exporter of the 'brain coral' (Family: Faviidae). It also exported value-added objects such as lathe-worked coral lamp bases and decorative shapes (Lovell, 2001). In the late 1980's Samoa exported coral for medical purposes, but has stopped since. Likewise, Vanuatu exported coral in 1991 and 1992. In 1990, the Marshall Islands exported 18 tonnes and Kiribati exported 2,000 pieces. The Solomon Islands exported 6 tonnes to the United States in 1991. Tonga exported 6 tonnes of live coral in 1991 (Baquero, 1999) and attempted to export coral for medical purposes but the government banned all harvest in late 1993 (Lovell, 1999). The Federated States of Micronesia has exported ornamental coral.

Recently, Fiji has become the major supplier of live coral, fish and live rock largely because of its ability to export quality products and the regularity of flights to major export destinations.

More recently, although trade in live coral and ornamental fishes is still important, it is the live rock that provides the large proportion of volume exported form the region. Live rock (and live sand)[9] act as structural/decorative material for the 'mini reef' and as bioactive material for the recycling of nutrients and waste products. Live rock is light in weight, commonly sold as branches or slabs, and is pink, orange or purple color makes it very attractive. Their demand is increasing as 'mini-reefs' become more trendy and financially attractive.

Today, the aquarium trade industry in Fiji is based on live rock, coral, fish and other invertebrate exported to northern hemisphere buyers from mainly USA, EU, Japan and Hong Kong. Market studies suggest that aquarium hobbyists, particularly in the USA and Europe are willing to pay premium prices for quality Fijian and Tongan rock above others due to the high coralline algae growth on each rock, covering over 80 percent of the rock surface (Lovell, 1999). Consequently, the demand for live coral and Fiji rock has grown steadily, particularly since late 1990's, (Figure 1 and 2). The demand for live rock from Fiji would have continued to increase further had it not been for the establishment of a quota by the Fiji Government[10]. However, Fiji rock trade has never reached the quota limit, either because of the limitations on airline space or competition which brought down the price for live rock exports. In 2004, the live rock exports came close to about 90 percent of the quota.

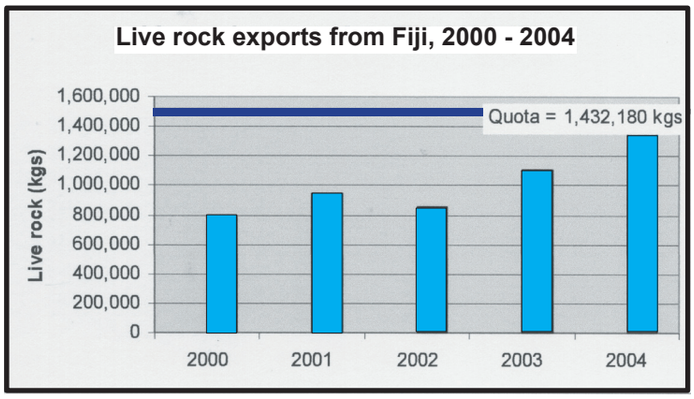
Figure 1: Volume of live corals and live rock exported from Fiji, 2000 – 2003



[9] Refers to coral rubble/reef rock or reef sand coated or permeated with living organic material such as algae.

[10] According to Rob Parry Jones of TRAFFIC Pacific, the establishment of quotas enabled the continuation of trade in the absence of scientific data to determine whether impact it had negative impact on the environment. Without such scientific information, exports of the live rock would be considered illegal under the CITES and its parallel Fiji Law (pers comm. February 2005).

Figure 2: Live rock exports from Fiji(kg), 2000-2004



Wild Harvest

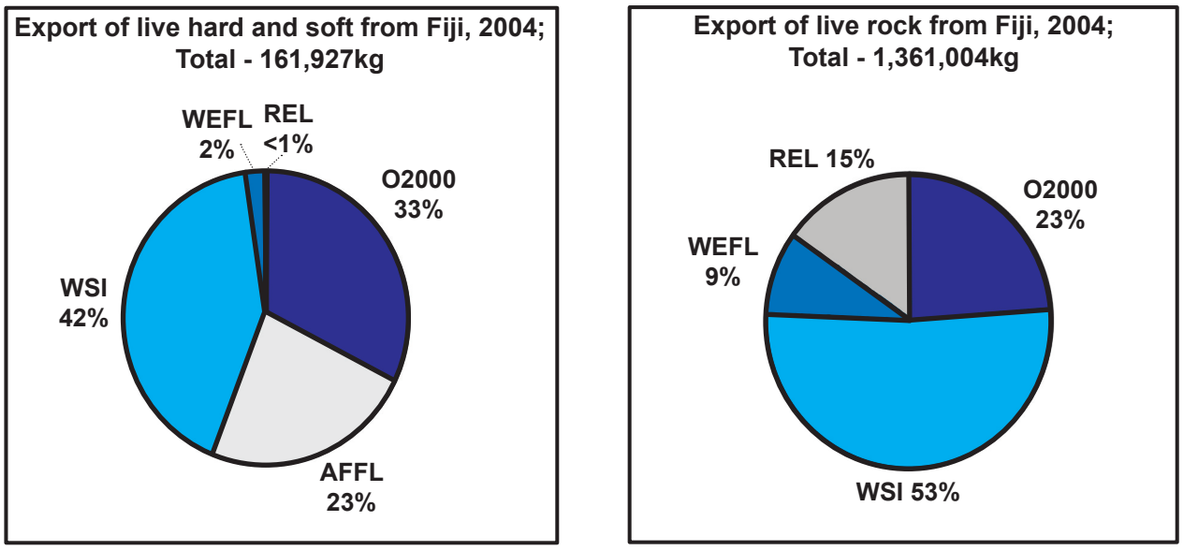
There were five active companies operating in 25 customary owned coastal waters, *qoliqolis* (Box 4), around Viti Levu and islands off the Western Division (Table 2). Of these, Walt Smith International, Oceans 2000 and Aquarium Fish Fiji Ltd (AFF) are the three larger exporters of coral. Walt Smith International, Ocean 2000 and REL are the major suppliers of live rock (Figure 3).

Table 2: Active companies operating in Fiji in 2004 and their aquarium products

Company	Years of operation in Fiji (Year incorporated)	Products harvested by companies	*Qoliqolis*	Products harvested from *qoliqolis'*	Export Destination
Ocean 2000	9 (1995)	Live coral, live rock and aquarium fish	Nabukavesi Moturiki Malomalo Kaba Nabukebuke Momi Bay Vuda	Live rock Live coral and fish Live rock Live rocks/corals, fish Live corals Live corals, fish Live corals	USA England Canada France Singapore
Walt Smith International	9 (1995)	Live coral, live rock, aquarium fish and other invertebrates	Marou Naviti Vatukarasa Vitogo Namada Malevu Namalata	Live corals, fish and invertebrates Live corals and fish Live rock Live corals and fish Live rock No longer harvest No longer harvest	Canada Germany UK USA Singapore Japan
Waterlife Exporters Fiji Ltd.	16 (1988)	Live coral, live rock	Bativudi Suva Navukavuka Navunisoco Muaivuso	Live rock and corals Live rocks Live rocks and corals Live rocks Live rocks	USA Canada England Singapore France Korea
REL	4 (2000)	Live rock, some live coral	Bativudi Kiuva, Nasilai	Live rock and some live corals	USA
Aquarium Fish Fiji Ltd.	21 (1984)	Live coral, aquarium fish	Galoa Culanuku Yanuca Nasorowaca Sawau Burenitu	Live corals and fish Fish Live coral and Fish Live corals Live fish Live fish	USA Canada Germany Japan UK

Source: Fiji Fisheries Division and Exporters of the aquarium products.

Figure 3: Distribution of commercial exports of live hard and soft coral & live rock, 2003



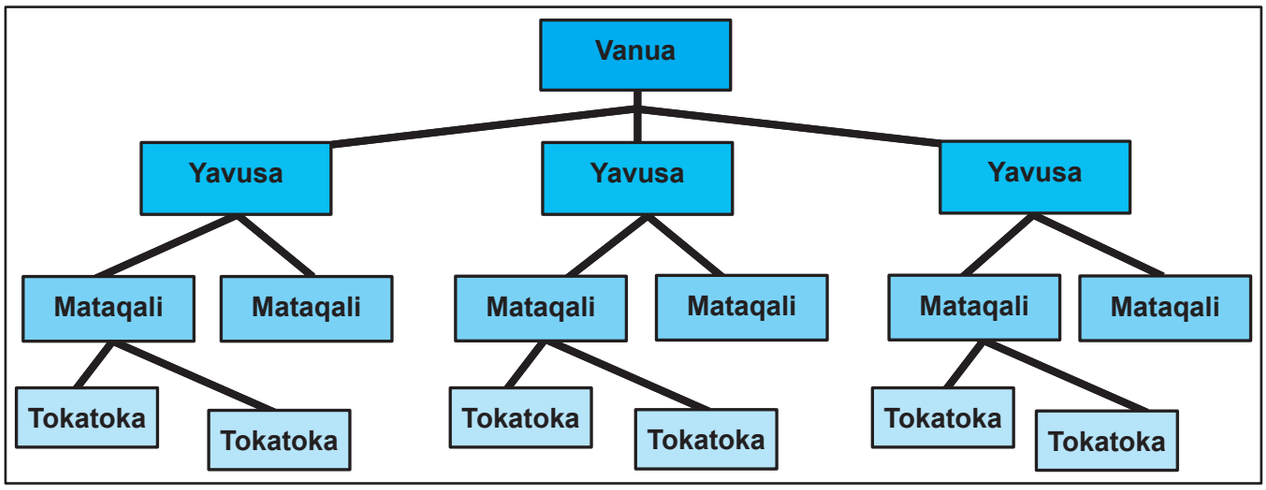
Box 4: Traditional *qoliqoli*

A *qoliqoli* is defined as the traditional customary rights area- from mean high water mark to the outer boundaries of fringing reefs, over which members of the *qoliqoli* have exclusive use rights and is recognized in a defacto form under the Fiji Fisheries Act.

A *qoliqoli* may be registered under one of the levels of social units (Figure 4). The smallest social unit is *tokatoka*, which is the family unit. A number of *tokatoka* from the *mataqali*, which is a clan or tribe. A collection of *mataqali* forms the *yavusa*. A number of *yavusa* together form a *vanua*, which is a socio-political association bound together and constantly strengthened by social and political ties of one kind or another and paying homage to a leading *turaga* (chief) (Tuwere 2002:35). It is worth noting that the nature of these rights were never and still are not clearly defined, with the indigenous Fijians claiming them to be ownership rights whereas various Governments have interpreted them differently, sometimes as use rights and other times as ownership rights (Lal 1983).

Although the Fiji Government has established a system requiring developers to compensate *qoliqolis* for any loss of fishing rights and resources due to development, extraction of sand etc, it had explicitly noted that the traditional fishing rights are not compensable rights (Lal 1990). Following the 1987 coup, the then InterimGovernment passed a decree transferring fishing rights across to the Indigenous Fijians, which became null and void after the High Court Decision in 2001 (1st March, 2001). This uncertainty and lack of clarity about the nature of property rights is also reflected in the level of upfront payment and the arrangements made by different operators to obtain access to *qoliqoli* waters (discussed below). The current Government has a draft Bill in preparation recognizing customary fishing rights as one of ownership, just as the native land rights have been regarded as ownership rights, but owned communally.

Figure 4: Basic traditional structure social unit levels in a Fijian society.



Local members of *qoliqolis* harvest live coral and live rock on the basis of a supply contract or by indigenous Fijians employed by exporters. Supply contracts are usually informal arrangements where exporters provide a licensed collector a purchase order. Villagers are then organized by the licensee and they harvest quantities often greater than the order because of some rejects due to poor quality. Payment is on the basis of a piece of coral or fish. In the case of live rock, payment is based on weight.
The second largest company, Oceans 2000, on the one hand pays villagers per piece of live coral (and live fish) they collect on order and accepted. On the other hand, Walt Smith International, which is the largest company, operates in 8 different *qoliqolis* and collects live coral, live fish and other invertebrates using their own boats and members of the *qoliqolis* where collection is carried out. Thus, income from marine aquarium trade flows directly back to the *qoliqoli* owners.

Marketing of Fiji Products
In 2004, commercial operators from Fiji exported 161,927 pieces of live hard and soft coral and 1361 tonnes of live rock (Table 3), with FOB value of FJ $4.4 million[11]. Fiji also exported 169,143 pieces of fish and 31,900 pieces of invertebrates valued at $1.8 million, giving a total value of $6.2 million for the live marine aquarium export from Fiji.

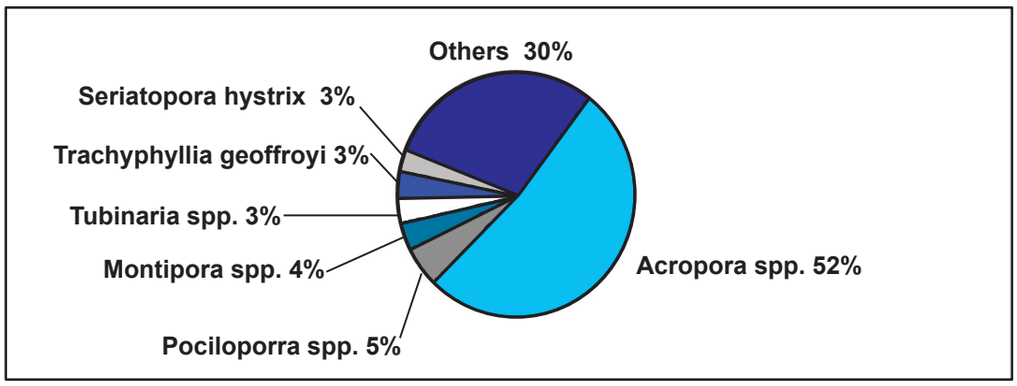
Table 3: Coral and live rock export and import statistics for Fiji, 2000 – 2004

Year	Corals Exported (pcs)			Total Corals exported (pcs)	Live Rock (kg)	Corals Imported (pcs)	Live Rock Imported (kg)	Corals re-export (pcs)	Live Rock re-export (kg)
	Hard	Soft	Curio						
2000	59,997	na	107,407	167, 404	793,929	23,380	13,269	16,323	11,837
2001	90,642	46,116	106,385	200,981	939,720	6,726	8,280	11,749	7,089
2002	76,910	41,842	59,961	178,713	859,131	1,837	4,600	1,612	4,600
2003	93,165	59,665	na	152,830	1,069,144	na	na	na	na
2004	93,751	68,176	na	162,927	1,361,004	na	na	na	na

Source: CITES database, Fiji Fisheries Department, 2004; **na** – not available

Around fifty five percent of coral exported are reported as *Acropora* and *Pocillopora species* of all corals exported from Fiji (Figure 5).

Figure 5: Species distribution of hard and soft coral 2004
Total = 161,927 pieces



Source: CITES Database from Fiji Fisheries Division, July 2005.

[11] Note this figure differs from $14 million recorded by the Fiji Fisheries Division. It is not unusual for data obtained from different sources to differ, as discussed at length by Wabnitz et al 2003. In this case, officially recorded statistics from Fiji is based on export value recorded in the export permits, which includes FOB value for coral, fish and invertebrates and landed value for live rock. Lovell (2001: 29-31) also discusses problems with pre 2001 export and harvest statistics for different types of aquarium trade products from Fiji.

Local exporters deal directly with wholesalers in the country of destination with some limited onward sale to places like Canada. They also tend to deal with a limited number of wholesalers in the countries of destination.

Live coral are sold free on board (FOB) and importing companies pay for packaging, freight, insurance and custom documentation on both ends. These wholesalers then distribute the aquarium products to retail stores, including specialized pet stores. Aquarium hobbyist and other consumers then purchase these products for their aquariums.

On the other hand, for live rock, local companies generally pay for freight, although in some cases importing companies may pay for freight, packaging, etc. Companies were, however, unwilling to give detailed information about this aspect of the business as marketing arrangements is believed to give the companies their competitive edge. Information about landed value, freight and other export related costs are thus obtained from several different sources, including exporting companies, importing companies, and the main airline, Air Pacific.

The supply chain of custody for Fiji products is thus: *qoliqoli* owners –licenced collectors/ villagers – exporters – wholesalers in port of destination – retailers – consumers. Where an exporter does his/her own collection of coral and ornamental fish, the chain of custody is slightly shorter: *qoliqoli* owners – exporter – wholesalers in port of destination – retail pet stores – consumers. The length of the chain of custody determines the costs involved at each stage and the market power of each link ultimately determines the purchase/ sale price, and profit margin, at different stages along the chain.

Internationally, while market supply and demand determine the price received by the exporters, domestically exporters generally control the price they pay the villagers. More recently with increased competition and a greater awareness of the importance of Fijian products internationally, villagers have been able to negotiate higher prices then before.

For coral (and live fish since villagers are paid the same unit rate for coral piece), payment to villagers varies with exporters. Some exporters, such as Ocean 2000, pay villagers a fixed amount of about FJ $2 per piece regardless of species, whereas others pay according to the species, size and color. FOB price of coral which are paid in US dollars varies. FOB price could range anywhere from FJ $ 3 -14 a piece (Tim Mcleod, Walt Smith International June 2005)[12]. Villagers are estimated to receive an average price of 10-20 percent of the FOB prices for live coral, depending on the species, size and colour, as well as exchange rates. This is comparable to what is paid in Cebu for example, where collectors of live coral were reported to have received 15 percent of FOB (Green and Shirley 1999:51).

Price of live coral in the USA shows a large variation between species, size and colour (Table 4). Caution is emphasized when comparing prices along the chain of custody because the price of product at each stage depends not just on the price paid to the previous seller but also on the risks of losses along the chain and the cost of maintaining the products till their sale. Such risks are borne by respective companies along the chain.

Table 4: Local and FOB price of selected species of coral exported from Fiji

Medium Size	Local Collector Price	Export (FOB) Price $FJ (US$)
Gonipora stoksii	$0.58 (0.35)	$3.3 – 6.7 (2.00-$4.00)*
Acropora spp.	$1.00 (0.60)	$7.5 – 14.2 (4.50-8.50)*
Euphyllia spps.	$1.42 (0.85)	$5.83 – 14.17 (3.50 – 8.50)*
Tubipora musica	$1.00 (0.60)	$5.83 – 7.5 (3.50-4.50)*
Favia sp	$1.08 (0.65)	$6.67 – 9.17 (4.00-5.50)*

*figures in bracket are in US $
Source: Tim Mcleod (pers comm.July 2005); and undisclosed industry data

[12] It is difficult to provide an average price for coral because prices vary with not only species but also size and colour diversity. For example, David Palmer of Pacific Aquafarm, USA (pers comm., June 2005) indicated average FOB prices of US$4.50 for small, US $5.50 for medium and US $8.50 for large Acropora.

For live rock, villagers receive an average price of about FJ $0.80 delivered to the warehouse. The price of live rock received by the villagers, as a proportion of FOB price, could vary considerably between consignments due to fluctuation in freight rates and exchange rates; although the landed price paid by importers may remain fixed, once an agreement is reached between an exporter and his importing partner in the country of destination.

Using the landed LA price for a 22.2 kg box of premium live rock of $FJ 5.90/kg (USA importers, pers comm., June 2005)[13], freight rate could vary from $3.04/ kg of less (for consignments greater than 4,000 kg) to $4.75 or more (for consignment of 500 kg or less) (Air Pacific, pers comm., June 2005). Expected FOB price may thus range from $1.20 – 2.5 / kg, at the exchange rate of FJ$1=US$0.6. The price received by villagers for live rock, as a proportion of FOB, would thus range from 33 percent to 66 percent with consignments; the former ratio more likely to be the norm since it will be in exporters interest to send larger consignments than the smaller volumes at any one time.

Exporters bear all the risk of fluctuations in freight cost and as well as exchange rate. At the freight cost of $3.04, and exchange rate of $0.6, the FOB price will be $2.22/kg. On the other hand, at the same exchange rate but at a higher freight charge of $4.75 /kg then the FOB price of live rock will $.51/kg, which is less than what the exporter pays villagers. On the other hand, if the exchange rate were to increase by 13 percent (that is, FJ$ 1= US 53, as was the case in 2003), then the exporter's FOB value of live rock increases by almost 30 percent. At higher exchange rate, the price a villager would have received would thus be about 27 percent of the FOB value, as compared to 36 percent of FOB when the average exchange rate is FJ$1=US$0.60.

If the low exchange rate were combined with high freight charges, then exporters can expect to even make a loss; this however, will be rare because it is in an exporter's interest to send larger volumes because unit freight cost is lower.

Price received and costs of operation at each stage then determine profitability of the activity. For the community, the financial net benefit of collection and/or culture will thus depend on the price received from the exporter and their own cost of operation.

Other benefits to *qoliqoli* owners

Qoliqoli approval is issued by a chief often only after an operator pays 'goodwill'. Although there is no objective basis for *qoliqoli* payment, it seems to vary according to size and productivity of the coastal area and the specific terms and conditions negotiated between the *qoliqoli* chief and the commercial operator. The quantity of goodwill payment also depends on the level of social unit under which a *qoliqoli* is registered, and whether collection is done by a member of the *qoliqoli* and/or the exporting company.

Thus, for example, Walt Smith International paid a lump sum of $2,000 to Vitogo and Naviti chiefs to obtain annual permit to collect coral and ornamental fishes from their *qoliqolis* using divers from their local communities (Table 5). Ocean 2000 on the other hand paid $2,000 every six months to the chief in nearby Malolo *qoliqoli*, where three of their boats also collect coral ornamental fish for export. In some cases, *exporters* pay a fixed amount per month to obtain *qoliqoli* permission for collection. For example, in Moturiki the Chief is paid $150/ month by Ocean 2000, regardless of the quantity of coral and fish collected by the *qoliqoli* members.

In other cases where a villager has a licence to collect coral, fish and live rock, and also employs other members of the *qoliqoli* to harvest them, a *qoliqoli* chief may obtain an annual 'rent' from the village collectors. This is usually in the form of a share of the actual catch, which is deducted at source by the exporters before paying the collectors. For example the chief of Vatukarasa *qoliqoli* obtains $3/box of 22.2 kg of live rock, or 3-5 percent of the gross revenue of the Fijian collectors. In other cases, such as in Moturiki, collectors pay the *qoliqoli* chief $0.15 /kg or 21 percent, plus another 10c/kg or 15 percent of the gross collectors revenue to the yavusa/ vanua. This adds up to about 35 percent of the gross value of the products paid to the chiefly hierarch. Collectors thus obtain 65 percent of the gross payment made by the operators. This is very similar to the different layers of chiefs, and the Native Land Trust Broad, deducting up to 48 percent of agricultural land rent in Fiji (Kamikamica and Davey 1988; Lal et al. 2001).

Income earned by collectors as well as payment made to *qoliqoli* owners are important components of the financial benefits of aquarium trade to customary resource owners.

[13] Premium live rock price is US $70.18 for a box of 22.2 kg.

Table 5: Profile of *exporters*, products harvested and coastal *qoliqolis* involved and goodwill payment.

Company	Locally registered arm of a foreign company (HQ)	Product (No of Collectors)	No of employees	Goodwill (upfront + proportion of gross revenue	Average collector's income per week	Reported export value#
Ocean 2000 Ltd	Sri Lanka	Fish & coral (9) Rock (8)	24	1,800 (Moturiki)	$280	$2.6 million
Walt Smith International	USA	Fish & coral (15) Rock (140 in 6 *qoliqolis*)	65	$2,000 (Vitogo & Naviti) $20,000**	$250	$6 million
Tropical Fish (Fiji) Ltd ***	-	Fish (8) Rock (2)	9	$6,000	$230	$912,000
Acropora International Ltd ***	-	11 (people who bring curio coral to doorstep)	4 15(packers)	$20,000 *	$180 (collectors) $90 (packers)	$350,000
Waterlife	-	15	10	na	na	na
REL		na	na	na	na	na

Note this reflects what is officially recorded. But as seen in the text, this includes FOB value for coral, fish and invertebrates FOB plus freight and other costs for live rock

* Could not be confirmed.

** estimated from per month payment received by the qoliqoli chief

*** these companies were no longer operating in 2005

na – not available

Source: Company interviews, export statistics and other information from the Fisheries Department (pers. comm. October 2004).

4. FINANCIAL ANALYSIS OF WILD VERSUS CULTURED PRODUCTS

Financial net return (defined as total revenue minus costs of all inputs, including depreciation) is, as mentioned earlier, what a villager or a collector is interested in when considering financial viability of collection. An activity is considered to be financially viable if its net return is greater than zero, and an activity is more desirable than another, if its net return is greater than that of the alternative activity. Then, for a villager to switch to producing cultured products, its financial net returns would need to be at least equal to or greater than the financial net return from producing wild products. From the perspective of the society, as also discussed earlier, net economic benefit is the measure relevant for choosing between alternatives.

To compare financial and economic net benefits, 'typical' production model for each of the products – wild coral, cultured coral, wild live rock and cultured live rock - was constructed, as discussed next.

Wild Coral Harvest Model

Collectors of marine products for aquarium trade use a variety of methods to harvest marine products. Either free diving or using scuba gear, coral pieces are jimmied off the reef with base and placed in a holding net. For fish and other invertebrates, collectors may use hand-held scoop nets. Scuba gear is usually used by divers directly employed by exporters, such as Walt Smith and Ocean 2000. On the other hand, villagers, such as those from Moturiki, who supply coral, fish and other invertebrates, often free dive but still use scoop nets for fish and ornamentals. The production process for live coral (and ornamental fish) is summarized in Figure 6.

As summarized in Table 5, there were 45 registered collectors of live coral (WSI -15; Ocean 2000 – 9; AFF – 15 and Waterlife 8), and they collected 152,830 pieces in 2003, giving an average of 3,396 pieces of live coral per collector. Most of the collectors do not work full time, spending 2-3 days a week.

Based on the interviews of Uluibau collectors on Moturiki island harvesting coral (and ornamental fishes), the following wild production model is identified.

- Collectors own their own dive gear, such as mask, snorkel, dive shoes, knife and shear, each lasting between 2-5 years (see Table 6)
- Four collectors collectively hire a boat from the village for the harvest and delivery of coral products to the selling destination.
- Collectors use minimal gear and free-dive (do not use scuba tanks) to harvest coral and ornamental fish
- Each person collects his own fish and coral
- To benefit from economies of scale, each collector share the larger cost item of transport to and from the reef site and to and from the point of collection by the exporter
- Average number of coral pieces harvested per person per trip is 50 and making 67 trips a year for coral only (this is equivalent to prorated 'coral only' aspect of their activity).

Figure 6: Live coral production model

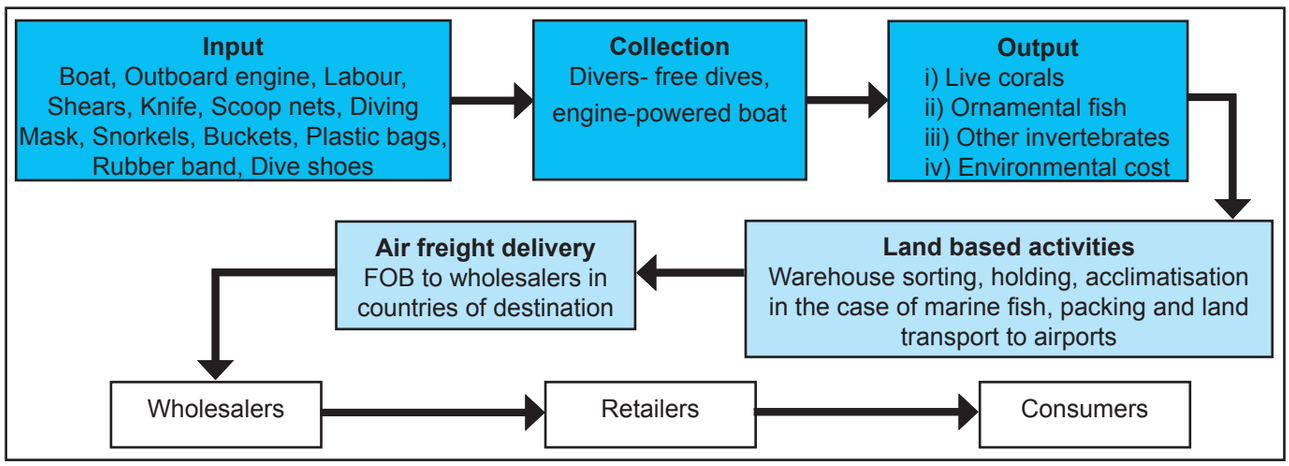


Table 6: Input, output, and their unit prices per household involved in live coral harvest from the wild.

Activity		Unit/ comments
No. of coral pieces on average harvested per person/trip	50	Pieces*
No. person average/trip	4	households
No of trips	2	Trips per week
No. of trips/year/person	67	Trips
Price per piece	2	$/piece
Total Revenue per person/trip	160	$/trip/day
Labour rate	15	$/day
Fixed Cost		
One pair of shears	$6	/unit and lasts for 3 years
Knife	$4	/unit and lasts for 3 years
Masks	$65	/unit and lasts for 2 years
Snorkels	$20	/unit and lasts for 2 years
Diving shoes	$65	/unit and lasts for 1.5 years
Operating Cost		
Hire of boat for collection ($175/ four persons)	44	$/household/trip
Fuel (Fuel cost for four $60/trip : 40 litres @$1.5/litre)	15	$/household/trip

*This is 50 percent of what the villagers reported as the maximum number of pieces per trip.

Where an exporter does his own collection of live coral and ornamental fish and other marine invertebrates, the practice is essentially the same, except that the divers may use scuba gear and often wear dive suits. Usually, 3-5 divers operate out of a single boat and harvesting about 100-200 pieces per trip. This scenario is not analysed since in the future *qoliqoli* owners are more likely to be directly involved in the actual harvest of coral and live rock and they are more likely to obtain higher returns on their effort as they become more aware of the value of their resources and seek greater involvement in the fishery.

Live coral pieces (and fish and other invertebrates) harvested are brought up to the boat where they are placed in individual plastic bags filled with sea water and secured with rubber bands. These bags are then stacked in 'buckets', or large plastic tubs, and then transported by outboard engine powered boats to points of collection on shore.

Once on shore, buckets are then transported to the warehouse by trucks hired by villagers. At the warehouse, products are checked for stress and these are then emptied into holding aquarium tanks before being air freighted to markets in USA, Europe, Hong Kong and Japan (Figure 7). Live coral usually is exported within 24 hours of collection. (Fish species on the other hand are kept long enough, two to three days depending on the feeding habits of the different species, to ensure that the organisms have defecated, in order to ensure that they do not pollute their water during transshipment to export destinations.)

Travel time for aquarium products can range from 10 hours to Los Angles to over 24 hours to the EU markets. It is no doubt a function of availability of direct flights between Nadi and the port of destination, connecting flights enroute and or the need for transshipment.

Figure 7: Typical holding tank set-up for a company that exports live coral and aquarium fish products.

While exporters may collect or purchase aquarium products in anticipation of orders, they generally wait for forward orders from importers before asking collectors to harvest and deliver the desired quantity of products and species to the warehouse. As required coral products are packed in individual plastic bags with seawater, aerated using medical quality oxygen, and tied using rubber bans. These bags are then carefully stacked in styrofoam lined export boxes in which some ice packs may also be placed to keep the temperature down.

Financial model

WWild harvest of coral products by villagers is a highly profitable venture. A villager collecting 50 pieces of coral per trip that is accepted, making 8 trips per month and 67 trips per year, can expect to incur an operating costs (fuel and transport) of $2,978 (Table 7). Employment is assumed to be a benefit, thus labour costs are treated as zero. For 3,396 pieces of coral, a villager can expect to earn a gross income of $6,792 giving a gross margin of $3,814. Considering depreciation cost of capital items, and if he were to 'pay' for his own time, a villager can expect to make a financial net return of $3,008 a year. That is, at the small scale operation used in Fiji, where villagers share a boat hired from another villager or owned communally and harvested 50 pieces per trip or about 3,396 pieces a year, a villager can expect to make a net returns of $0.89 /piece, or 45 percent of the gross price.

Table 7: Financial Costs, Revenue and Net Return Flow Per Villager for the Wild Harvest of Live Coral (Uluibau village, Moturiki Island)

	Years
No of pieces	3,396
Fixed Costs	$160
Depreciation	$46
Labour	$760
Fuel	$760
Transport	$2,218
Operating Costs(excl labour)	$2,978
Financial Costs (incl depreciation)	$3,784
Financial costs per piece	***$1.11***
Total Revenue @ $2/piece	$6,792
Gross Margin (excluding cost of labour)	$3,814
Financial Net Return	$3,008
Financial net return per piece	***$0.89***

Thus, on average a part time villager's gross revenue is $6,792 while his financial net return is $3,008 for wild harvest of coral. What follows is an exploration of a culture based villager's business producing cultured coral equivalent to the number of pieces of coral per person. That is, the coral culture model constructed below assumes a production scenario where the villager would produce same gross income as the villagers engaged in the wild harvest of coral.

Cultured coral

The coral culture model used in this study is based on the culture program adopted by Walt Smith International at the Hideaway Resort and culture farms in Moturiki established with the help of a non-government organization, Foundation for the People of South Pacific (FSPI) and Partners in Community Development Fiji (PCDF).

Both of the coral culture farms are based on simple technology suitable for rural coastal villagers on the mainland or small islands in the Pacific. Coral fragments of *Acropora* species and other fast growing species with good market demand are collected from the wild, either by snipping pieces off mother coral or pieces that may have naturally broken off from the mother colony. Walt Smith International has at its coral farm *Acropora spp., Pocilopora spp., Hydrophora spp., Millepora spp., Caulastrea spp., Favites spp., Euphyllia spp.*, and *Seriatopora spp.* Only branching coral, *Acropora spp.,* has been imported into the USA, as *Favites spp.,* and *Euphillia spp.* are found to grow very slowly (CITES Animals Committee 2002). At Moturiki, FSPI and PCDF are experimenting with coral belonging to nine genera, including *Pocilopora, Pavona, Montastrea, Porites, Stylophora* (Austin Kerby-Bower, pers comm, February 2005).

In the Hideaway farm, fragments of coral, or nubbins, are glued on to specially constructed cement bases which are then 'planted' in 8' x 4' (or 2.8 m x 1.4 m) racks. A rack is constructed by welding 2.8m x 1.4 m metal grid tray sheets onto galvanized metal rods, designed as a table (Table 8). Glued coral pieces are placed in the wire grids in the table, which can hold about 200 pieces. The time taken to glue each piece of nubbin and place it in the rack is about 5 minutes, with 200 pieces of coral taking about two person days. Coral on racks need periodic 'cleaning' of other growths, such as of algae, and which takes about an hour a week, giving a total of 6-7 days of person days per rack of 200 pieces for cleaning These coral products are harvested after they have reached marketable size, usually within about 12 months of planting. Corals grow best in environments which have a good flow of coastal waters and are free of pollution and sediments.

Table 8: Characteristics of the Culture of Coral Species Equivalent to the Quantity harvested from the Wild per Household

Length of rack	2.8 metres
Width of rack	1.4 metres
No of rows in an area of 3.92 sq.m	20
No of coral pieces per row	10
Area of coral farm per rack	3.92 sq.m
No of pieces in 3.92 sq.m rack	200 pieces
No of pieces equivalent to wild harvest	3,396 pieces
No of racks required to produce quantities equivalent to wild harvest per person per year	17 racks
Life of racks	5 years
No of person days required to glue, clean (of weeds), and harvest	9 days per rack
Period between 'planting' of coral to harvest	12 months

Other inputs and activities associated with cultured coral are the same as those with the wild harvest. Villagers use masks, snorkels and reef shoes. Coral pieces, once harvested are transported to the warehouse in their individual plastic bags, filled with water and secured with rubber bands. These coral pieces are then transferred to holding tanks. Once an export order is received, coral pieces are individually packed in plastic bags filled with sea water and aerated with medical quality oxygen and secured with rubber bands. The plastic bags of coral pieces are then packed in styrofoam lined boxes and transported to the airport and air freighted to export destinations.

To produce equivalent quantity of coral harvested in the wild, a villager must install 17 racks and on average 'plant' and harvest 3,396 pieces of coral. It is assumed that the exporter provides the material at cost, and the villager 'provides' the space. That is, the villager only pays for the actual cost and not interest on 'borrowing', and the exporter does not pay 'premium' on the use of the *qoliqoli* area.

The total financial cost of setting up 17 racks and producing 3,396 pieces of coral to marketable size is $5,708, including cost of material, glue, labour and transport to warehouse (Table 9). It may be possible to increase the scale of his operation, they though may be constrained by the amount of area that is available for the purpose, since coral farming may preclude other uses of the area, except perhaps ecotourism based on culture farms.

Cultured corals are assumed to be bought at the same price as the wild ones, which is on average $2 /piece. At these costs and prices, financial net return per culturing villager is less than $1,085 a year, which is about a third of the financial net return earned from wild harvest of coral (Table 9). However, if we exclude the cost of labour and treat employment as a benefit, and exclude all fixed costs and depreciation, gross margin per villager is $3,441. In the short term, fixed costs are regarded as already sunk and they do not influence his decisions about viability. A villager would continue producing cultured corals as long as the operating costs are covered.

Table 9: Financial Costs, revenue and net returns from the culture of coral, and live rock (Walt Smith Operation, at Hideaway)

	Costs and returns ($)
Fixed Inputs	$4,917
Depreciation	$2,231
Operating Costs	
Coral Base	$1, 920
Labour	$2,356
Glue	$1,868
Transport to Warehouse	$723
Total Financial Costs	$5,708
Total Revenue	$6,792
Gross Margin (excluding labour, fixed costs, and depreciation)	$3,441
Financial Net Return	$1,085
Live coral plus live rock	
Gross Margin Live Coral + Live Rock	$3,778
Total Financial Benefit Live Coral + Live Rock	$1,203

If the physical space beneath the top shelf of the coral culture rack is opportunistically used to culture live rock[14] (see below for more details), then the villager can expect to also make a net return of $118 for 679 rocks per farm of 17 racks. This is based on the assumption that the rock base costs 50 percent of the final product price (as it does today), and the live rocks are bought by exporters at FJ$0.80/kg, as it is today. This gives a total financial net return for live rock and live rock culture venture of about $1,203 and an annual gross margin (assuming employment as a benefit) of about $3,778.

Wild and Cultured Coral Products - Comparison of Financial Performance

There is no doubt that, based on the simple technology used in Fiji, financial net return from the wild harvest is greater than the net returns expected from equal quantity of cultured products. In the case of wild harvest, a villager can expect to earn a financial net return of $3,008 a year as compared with $1,008 from cultured corals only or $1,203 for live coral and rock farms. This suggests that from a purely financial perspective, a villager would have large incentives to continue harvesting coral from the wild because the private benefits of doing so are almost three times that he would expect to make from culture; even if he knows that the wild harvest is producing some negative impact on the ecology of the coastal system.

Only if employment is treated as a benefit, that is, the opportunity cost of labour is assumed to be zero, and depreciation cost is excluded, the difference between wild and cultured coral is small. The gross margin of cultured coral per year is $3,441 as compared with $3,814 obtained from the wild harvest, involving much less capital outlay and less effort.

In the case of wild harvest, an individual spends about 3-5 hours a day trip and 2 trips a week and an equivalent of 67 trips in a year, to collect 3,396 pieces of coral. In contrast, production of cultured coral is very labour intensive and time consuming. A villager will need to spend time to construct racks, glue coral fragments on to base and place them in the rack, and also clean the coral racks on a regular basis. The villager will need to obtain additional help because of extra work involved, and which is not likely to be available without additional cost. Therefore, the gross margin calculation without considering labour costs is not likely to be a realistic scenario.

If villagers take advantage of space below the coral rack and produce live rock, they can expect to make

[14] A recent study suggests that growth rate of live rock varies with site. The growth rate was found to be relatively higher in open channel areas as compared with inshore waters that may be subject to sedimentation (Kaur, 2005 #1663).

an additional $337 in gross margin (based on current cost of live rock base and live rock product discussed below, and assuming labour costs are zero), or a total gross margin for the culture farm of about $3,778. This is only about $36 less than the gross income earned from the wild (Table 9). On the other hand, financial net return of culture based activity is about $1800 less than from the wild fishery. Financial net returns do not include considerations of ecological effects of wild harvest or coral culture farms. The effects of externality costs are considered in the next section.

This analysis is based on the assumption that exporters receive the same price for cultured as for the wild harvested products and that the villagers receive the same price, as they do today. Financial profitability and thus the attractiveness of the culture of live coral will be different if villagers receive a higher price. The increase in price received by villagers would need to be close to 28 percent for farmed coral to be as financially as attractive to villagers as the wild products.

Alternatively, if faster growing marketable species of coral could be cultured, producing two crops a year, expected gross margin and net financial net return is comparable to the financial returns obtained from the wild. Walt Smith International recently had harvested and exported 6-month cultured coral, receiving the same price as for species harvested over 12 month. If such growth rates were to become the norm, and the demand for cultured coral from Fiji remained constant, and villagers continued to receive $2/piece of coral, villagers could expect to receive an annual gross margin of about $9,505 and with a financial net return of about $4,793.

For fast growing species, cultured coral activity is financially more profitable than from the wild. However this is based on the assumption that villagers are prepared to put in the effort required to maintain the farms, villagers keep the racks and coral seeds clean of algae, and 2 crops a year can be obtained for all species required in the export market. It also assumes that the demand cultured coral from Fiji is maintained and that the international supply of cultured coral does not disadvantage local products, which as discussed later may not be sold as readily.

Wild and Cultured Live Rock

Wild and cultured rock analyses are based on the technology currently in use in Fiji. These are described below.

Rock Harvest from the Wild

Live rock model for wild harvest used in this study is based on the activities of two villages, Namada and Vatukarasa, on the mainland of Viti Levu which were actively involved in live rock harvesting from the wild. These two villagers represented almost 54 percent of live rock exports from Fiji in 2003.

Wild Live Rock Harvest Model

Harvest of coral and transport is done collectively by a group of villagers once a harvest order is received from the exporter. Live rock is harvested from reef beds in shallow lagoons by jimmying pieces with a crowbar or a screw diver and hammer (Figure 8). Rocks, 10-15 cm in diameter, covered with light to dark pink coralline algae, are targeted by villagers because of their market appeal.

Figure 8: Coral substrate from where pieces of live rock are harvested

A group of villagers (4-5) would typically make about 4 trips per week and collectively harvest about 1400 – 1500 pieces of rock when on order, each weighing about 1.5 kg.

Extracted live rock is placed on traditional bamboo rafts or *bilibili* and poled to the nearby beach. At the beach, rock pieces are cleaned, partially graded for size, shape and percentage of algae cover. These rocks are placed in 'buckets' supplied by the exporter, loaded onto hired trucks and then transported to processing warehouses, where the exporter checks for quality.

At times licensed collector is not the same as the person who does the collection, just as the person who is certified under the MAC does not necessarily harvest the rocks. A licensed harvester may act as the

middle-man between the exporter and the villagers who do the collection. Middle-men may also organize the villagers and keep a record of their individual harvests and pay them accordingly. For this effort, a middle-man is reported to earn somewhere between $0.10- 0.15/ kg. In addition, as discussed earlier, chiefs receive a payment such as about $3/box or $0.1-0.15/kg in payment from the collectors harvesting rock from the Vatukarasa *qoliqoli*.

At the warehouse, exporter checks and further grades the rocks supplied by the villagers. Rock pieces accepted for export are then washed of unwanted seaweed and other organisms and then packed in styrofoam lined boxes and damp newspaper. Rocks are packed in different size boxes depending on the destination and may contain 22- 45 kg of live rock. Boxes are then trucked to the airport in time for them to be loaded onto outward bound airplanes. Live rock is exported immediately after the products are brought in by the villagers. If not exported immediately, the rocks are placed in holding facilities that spray the rocks with salt water occasionally to keep it moist and as a curing process to remove other peripheral infauna, such as mantis shrimps, bristle worms and encrusting sponges (Green and Shirley 1999). At times, exporters may put the rocks through the 'curing process' for particular markets which are prepared to pay higher prices for the cured rocks.

Products not suitable for export are rejected. A few years ago, the final selection and grading was done at the shore where villagers landed their rocks and any rejected rocks were put back in the shallow waters near the village. More recently, villagers now deliver the products to the warehouse, rejection takes place at the warehouse. Rejected rocks today are dumped in shallow waters close to the warehouse. Rocks not packed and shipped immediately, are stored in large tanks at the warehouse and kept damp with frequent sprays of seawater (Figure 9).

The ease of air freighting products from Nadi, and the regularity of direct flights between Fiji and main airports, such as Los Angles, San Francisco and Tokyo, together with good connections onwards to Europe, make Fijian products highly desirable than from other sources. The time between the delivery of live rock and packing in Fiji, loading onto outward bound plane and unpacking in the port of destination in the USA is often less than 24 hours. With such a short transit time, death on arrival (DOA), and hence rejects, are less than 2-5 percent. Pacific rocks are also more desirable because they are porous, light and with a good cover of algae compared to products from elsewhere (Marks 2003).

The live rock production model for wild harvest is summarized in Figure 10, and used in the financial and economic analyses.

Figure 9: Live rock in their holding tanks before being packed and export

Financial costs, returns and net return of wild harvest of live rock

In 2003 collectors from Vatukarasa and Namada earned a gross income of $742, 515 for harvesting 1,135 tonnes of live rock harvested from their *qoliqoli*[15]. Each of the 15 collectors from Namada village earned an average gross income of $12,750 for 18,694 kgs of live rock. On the other hand, each of 25 collectors from Vatukarasa village earned an average gross income of $22, 500 for 34,210 kgs of live rock. It is possible that the income earned is shared with other members of the household that may have helped to collect the rock. In this study, a conservative figure of 34,210 kgs is used, noting that some economies of scale may still be possible.

A villager, if engaged on a 'fulltime' basis, can typically expect to earn an average gross margin of about $23,187 for one households'/ two persons effort, or about 85 percent of the total gross revenue, before goodwill payment to the chief. If family labour is treated as a cost, and considering depreciation costs, the total financial net return is $21,771 for a two-person household. Each live rock harvester paid to the *qoliqoli* chief a goodwill of $3/box for a box of 22-35 kg. Using the larger box as a conservative figure, collectors would have paid about 11 percent of their income as 'goodwill' payment. Taking the goodwill into account, a household's net financial return is $18,839 (Table 10).

[15] Note this is the actual quantity of rocks purchased from these two villagers and exported in 2003. This however is greater than 1098 tonnes officially recorded for all live rock exports by the Fisheries Department and summarized in Table 4 above.

Figure 10: Live Rock harvest production model

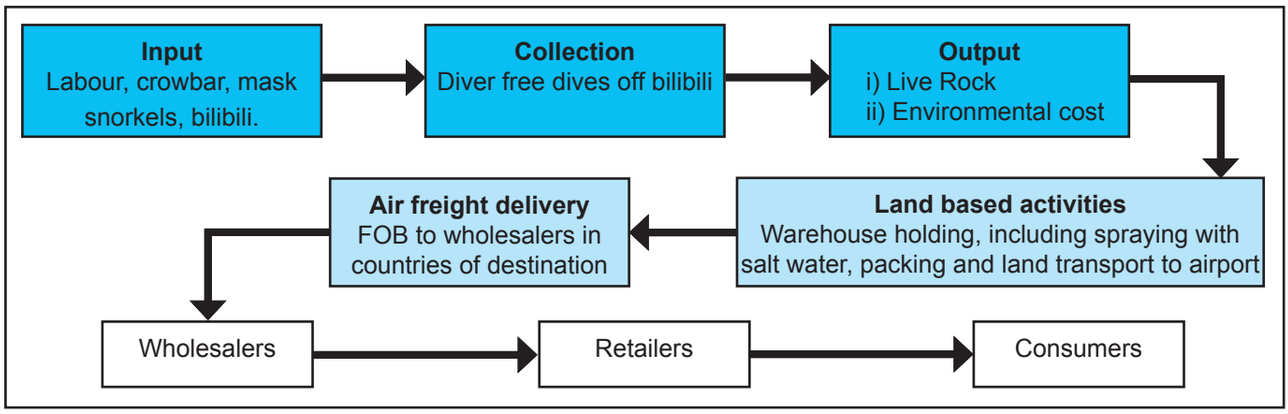


Table 10: Financial Returns, Costs and Net Returns from Wild Harvest of Live Rock per Household*

Year	Costs and Returns
Weight of rocks	34, 210 kg
Fixed costs	$315
Depreciation	$57
Labour	$1,398
Transport	$4,308
Costs excl labour	$4,359
Total Costs	$6,016
Total Revenue	$27,368
Gross Margin	$23,187
Net Financial return	$21,771
Goodwill Payment to Chief & 11 percent of GVP	$2,932
Financial Net return after Goodwill payment to Chief	$18,839

*Based on the Costs of Collection by Namada/Vatukarasa Village but producing 34,210 kg per household.

Live Rock Culture

Live rock culture is based on a simple technology suitable for rural coastal villagers. Each 'farm' comprises of 12 sets of 20 rows of rock substrate. Live rock substrate is made by Walt Smith International from cement, gravel, sand and pumice (see Figure 11) and molded into shapes and sizes that is preferred by aquarium trade. These substrates are sold to villagers at $0.40/kg. These rock substrates, each of about 1.5 kg[16], are strung together with galvanized wires. Each row is 20 metres long and contains 100 rock substrates. The row of rock is pegged down with metallic rods. Rocks are left in coastal waters for about 12 months. Thus a household can expect to establish around 2000 rocks per month for 12 months. To string, transport, peg and harvest 20 rows or 2000 rocks, 4 person days are required (Figures 11-12).

Recently, Walt Smith International entered into a Memorandum of Understanding with Korolevuiwai, Tikina and University of the South Pacific to establish live rock culture farm of 5,000 pieces. Although village based scheme is proposed, involving some 10 persons, it is possible, according to Walt Smith International, a 5,000 piece-a-month live rock farm could be effectively 'managed' by 4 business minded villagers. For Korolevuiwai Tikina, WSI had proposed to employ 2-5 villagers at $200/month to undergo training while working at the Hideaway farm and to work on the Korolevuiwai Tikina farm. This suggests that it may be possible to essentially run the 5,000 piece-live rock farm involving around 4 persons only, or about 2 person per 2,500 piece farm.

In this study, individual household (involving 2 persons) based activity is assumed because in the past most of the communal income generating activities had failed (Schoeffel 1996; Veitayaki 2000) and such communal ventures are not recommended because of the free rider problem (Lal and Keen 2002) Furthermore, a culture model based on 2,000 rock substrate[17] used in the Hideaway Resort experimental farm is assumed, together with the level of effort based on the Hideaway farm and proposed for Korolevuiwai Tikina. Characteristics of live rock culture, inputs used and their respective unit costs are summarized in Table 11.

[16] Note, exporters report different weights for live rock pieces, ranging form 1.4 kg/piece to 1.8 Kg/piece. In a Memorandum of Understanding between Walt Smith International and the Institute of Applied Studies, University of the South Pacific, an average substrate of 1.5 kg/piece is used Walt Smith International and University of the South Pacific, nd (ca 2005). 'Memorandum of Understanding between Korolevuiwai Tikina, the University of the South Pacific and Walt Smith International', Suva.

[17] 2000 piece farm, rather than the proposed 5000 piece farm, is assumed based on the proven Hideaway live rock model.

Figure 11: Pieces of rock base put on table of coral sand to dry

Figure 12: Rock substrate strung together using galvanized wire

Table 11: Characteristics of Live Rock Farm – Hideaway Rock Culture

Physical Characteristics	
Rock frame Dimensions	3m x 20m
Length of each row	20m
No of rows in an area of 3x20m	20
No of rock pieces per row	100
No of pieces in a 3x20 m	2,000
Weight of rocks from a 3x20 m farm	2,933 kg
Area per kg of rock	0.02 sq m
Material	Costs per 2,000 rock farm ($)
Galvanised wiring @ $5.50/kg	$5.50
Metallic rods @$8 /6m-length	$40.00
Maul (new item) @ $30 / unit	$30.00
Total cost of farm materials	$75.50
Mask	$60.00
Snorkel	$20.00
Dive shoes	$65.00
Cost of artificial substrate (cement, & labour)	$0.4/kg
Labour	
No of persons per 2,000 piece farm equivalent	2
Stringing, transporting and pegging 4 person days @ $200/ month	200
Transport	
No of transport trips per 2000 pieces of rock (for delivery of rock substrate and purchase of cultured rock)	1
Hire cost per trip	$135
Fuel cost	$40

Financial net return that a household f two persons can expect for their effort is about $1,077 per year. However, if the labour required to string, establish, transport etc and depreciation costs were excluded, then the gross margin per household is $10,833, with the cost of rock substrate being the single largest item (Table 12).

Table 12: Financial, costs, returns and net returns from live rock culture per household

Year	
No of rocks	24,000
Weight of rocks	34,210 kg
Fixed Costs	$1,051
Depreciation	$37
Cost of rock substrate	$ 13,684
Labour costs	$ 9,720
Transport costs	$ 2,851
Total financial costs	$ 26,291
Total operating costs (excl labour and depreciation)	$ 16,535
Total Revenue	$ 27,368
Gross Margin	$ 10,833
Financial Net Return	$ 1,077

Comparison of financial net returns of cultured rock versus wild harvested rocks

As far as the individual household is concerned, net financial return expected from cultured live rock can not compete with the financial net return earned from the harvest of the same quantity of live rock from the wild. The net financial return for the culture of rock is less than five percent, or $1,077 as compared with about $21,771 from the wild harvest.

However, if the family labour is not treated as a cost, and depreciation is excluded, then the gross margin of cultured rock is about a half, or $10,833, as compared with $23,187 possible from the wild harvest. Only if substrate cost was to reduce by almost 90 percent can cultured rock compete with wild harvested rocks, in the short run. Alternatively, if the price of cultured rock received by villagers were to almost double to $1.76 /kg, then net financial return per household could approximate that earned from the wild harvest.

Such increases cannot be envisaged at this stage, considering the freight and other costs borne by exporters. Current freight costs are $3.04/kg for consignments greater than 4,000 kgs to $4.75/kg for 500 kg, with exporters often sending larger consignments. The FOB price for live rock is thus expected to be FJ $1.25 – 2.5/ kg, with the upper price expected to be the norm; a commercial operator would in his own interest export goods in large consignments because that reduces their unit cost of export and increases their profit margin. Unit cost of warehouse operations associated with live rock or coral, including fixed costs, is estimated to range from 60-70 percent of the FOB price, leaving a net return before tax margin for exporters of about 30-40 percent of the FOB prices. Occasionally, exporters may incur a loss, particularly when small consignments are delivered.

It is highly unlikely that exporters would realize large enough increases in their FOB prices because of the downward impact of international and domestic competition, as illustrated by recent price wars for Fiji live rock which led to a lowering of prices for live rock form Fiji. In 1999, nominal FOB price of live rock was reported to be $US 3.2 (or $FJ 6.04)/ kg (Green and Shirley 1999: 45) as compared with current nominal price of $FJ2-2.5/kg.

Thus although, live rock culture is financially viable, it is unlikely to be attractive to villagers when compared to the wild harvest. Rock culture activities may not be attractive because it also involves regular and sustained effort. Villagers may not have much financial incentive to switch to cultured rock production even though they recognize the negative environmental effects of live rock harvests from the wild. Financial attraction of wild rock over cultured rocks ignores ecological cost of the removal of live rock from coastal reef beds.

To explicitly include considerations of ecological and social externality costs, one needs to compare net economic benefits of wild versus culture-based business ventures, which is what we discuss next.

5. ECONOMIC NET BENEFITS OF WILD AND CULTURED PRODUCTS

Economic net benefit estimation would ideally include consideration of not only the costs of all inputs but also the social cost of 'working full time on income generating activities and foregoing some communal work,

and the economic cost of the environmental impact of wild coral harvest. In order to estimate economic net benefits, a number of issues first need to be addressed. Firstly, ecological effect, as discussed earlier, of the harvesting of live coral is not known with any certainty. Nor is there any information available on social effects, if any, of working 'full time' on income generating activity and not being there for other village social work. Therefore, true economic net benefit of wild coral trade is difficult to estimate. Instead, a shadow value[18] of ecological and social effects is determined below to give some additional information on the desirability of wild harvest of coral products versus cultured products.

Secondly, in economic analysis, the future is discounted to reflect peoples' preference for income today rather than income in the future. In this study a low discount rate is used in line with the general consensus for the use of low discount rates (usually five percent or less) when environmental resources are involved. Thirdly, in economic analysis, economic cost of labour is equal to its opportunity cost, which is assumed to equal $15/day, the wage that could have been earned from working in a hotel as a laborer or as a kitchen hand.

The flow of economic costs, and benefits and net economic benefits for wild coral and cultured coral products (plus joint product live rock) are summarized in Table 13.

Table 13: Economic costs, returns and net present value of wild versus cultured coral and associated products for a 'typical' household producing equivalent quantity of output harvested from the wild

Wild Harvest of Coral	Year 1	Year 2	Year 3	Year 4	Year 5
Number of coral equivalent pieces	3,396	3,396	3,396	3,396	3,396
Total Revenue @ $2/piece	$6,792	$6,792	$6,792	$6,792	$6,792
Total Economic Cost (excluding externality costs)	$3,944	$3,784	$3,794	$3,784	$3,794
Net Economic Benefits	$2,848	$3,008	$2,998	$3,008	$2,998
Cultured Coral					
Number of coral pieces	$3,396	$3,396	$3,396	$3,396	$3,396
Total Economic Costs	$6,792	$6,792	$6,792	$6,792	$6,792
Total Revenue	$6,289	$5,287	$5,443	$5,287	$5,287
Net Economic Benefits	$504	$1,506	$1,350	$1,506	$1,506
Cultured Rock in coral rack					
Number of rocks	679	679	679	679	679
Total Revenue	$793	$793	$793	$793	$793
Economic Costs	$735	$660	$660	$660	$660
Economic NB	$58	$133	$133	$133	$133
Economic NB of cultured live coral and live rock)	$562	$1,639	$1,483	$1,639	$1,639
NPV of Wild Harvest of Coral, excluding ecological effects	$12,855				
NPV of Cultured Coral and live Rock	$5,936				

Comparison of Wild Harvest and Cultured Live Coral

Economic net benefit estimation includes considerations of negative long term effects of live coral harvest on coastal fisheries and biodiversity, opportunity cost of labour and excludes depreciation costs. Since ecological effects of live coral harvests is not known, the present value of economic net benefit of wild harvest, excluding ecological effects, of 3,396 pieces of coral harvested per household over a five year period[19] is about $12,855.

[18] When a market does not exist for a product, a shadow value is used, and is defined as a proxy value determined using methods other than a market value.

[19] A five year period is chosen because some of the fixed costs last for 2-5 years.

This is about twice the $5,936 expected from an equivalent number of cultured products. That is, economic net benefit of live coral over a five year period is about half of the net benefit of wild harvest. If ecological effects of the harvest of coral were equal or greater than about $6,919 per collector, then banning harvest of coral from the wild will make economic sense.

Comparison of Wild Harvest and Cultured Live Rock

Economic net benefit estimation includes considerations of negative long term effects of live rock harvest on coastal fisheries and biodiversity. As is the case with coral data, detailed information on the ecological impacts of live rock harvest on the coastal ecosystem is not known. Nor is it possible to quantify the decrease in coastal fisheries because of the unavailability of appropriate quantitative data about the relationship between rock harvest and decline in fisheries outputs. Excluding the ecological costs, the net economic benefits from the wild was $21,655 annually or a net present value over a 5 year period is $93,735. On the other hand, the annual economic net benefit of cultured rock per villager is $11,257 or a present value of $48,576 over a five year period.

Therefore, in the absence of good ecological information on the impact of wild harvest of live rock, cultured rock would be preferable if it is considered that the net ecological costs caused by each rock collector is at least $11,398 a year or about $45,160 over a five year period (see Table 14). However, in the absence of robust scientific information, banning live rock harvest would affect the livelihoods of many rural villages living along the Coral Coast, areas where alternative sources of income are limited.

Table 14: Economic Net Benefits of Wild and Cultured Rocks per HH

Year	1	2	3	4	5
No of rocks	24,000	24,000	24,000	24,000	24,000
Weight of rocks	35,200	35,200	35,200	35,200	35,200
Total Revenue	$28,160	$28,160	$28,160	$28,160	$28,160
Wild Rocks					
Total Economic Costs	$5,855	$5,640	$5,790	$5,640	$5,640
Net Economic Benefits	$21,513	$21,728	$21,578	$21,728	$21,728
Culture Rocks					
Total Economic Costs	$27,306	$26,255	$26,255	$26,255	$26,255
Economic Net Benefits, with employment as benefit	$9,782	$11,625	$11,625	$11,625	$11,625
Discount rate	5%				
NPV					
Wild Rock	$93,735				
Cultured Rock	$48,576				

6. FINANCIAL NET RETURNS TO EXPORTERS

Exporters make a reasonable net return from export of aquarium products. The gross income derived from the export of 1,361 tonnes of live rock and 161,927 pieces of coral in 2004 is estimated to be about $4.4 million, assuming an average FOB price of $2.22/kg for live rock and $8.34/piece for coral. It is not possible to give detailed breakdown of cost of each step in their commercial operations because of commercial confidentiality. However, based on actual detailed information gathered from exporters, the total costs of all activities associated with warehouse, aquarium, local transport and labour costs, fixed costs, as well as the product purchase costs, is estimated to be 60-70% of the FOB price. That is, average expected profit margin for an exporter is 30-40 percent of the FOB price. Therefore, financial net return for warehouse stage of aquarium trade, assuming FOB for live rock is $2.22/kg, is expected to be about FJ$ 0.9 – 1.2 million, at the exchange rate of FJ$1= US$0.60 (Table 15).

Table 15: Gross and Net Financial Income for Village Collectors of Live Rock and Live Coral harvested from the Wild, 2004

	Live rock	Live coral	Total
Quantity	1,361,004 kg	161,927 pcs	
Collectors' Gross Income	$1,088,803	$323,854	$1,412,657
Collectors' Net Income, including goodwill	$692,968	$143,428	$836,396
Goodwill payment (about 11%)	$119,768	$35,624	$155,392
FOB value of exports (Exchange rate FJ$ 1=US $0.6)	$3,024,879	$1,351,261	$4,376,140
Net Exporter Financial Return (at 30% - 40% 'profit' margin)	$0.9 – 1.2 million	$0.41 – 0.54 million	$1.34 – 1.75 million
Industry Net Benefit (collectors, chiefs and exporters)	$1.61 – 1.90 million	$0.55 – 0.68 million	$2.14 – 2.59 million

If the exchange rate were higher, say at FJ$1= US$0.53, then the industry net returns will be about $1.2 – 1.6 million. If, as the industry claims, that to retain their customers, a price discounts of around 15 percent is the usually the norm, the industry net returns would then be reduced by about 13 percent to about a million dollars (Table 16).

Table 16: Gross and Net Financial Returns for Commercial Exporters of Marine Aquarium Products at 15 percent bulk purchase discount and exchange rate FJ$1=US$0.6

	Live rock	Live coral	Total
Quantity (pieces)	1,361,004 kg	161,927 pcs	
FOB value of exports	$2,562,726	$1,349,392	$3,912,117
Exporter Net Returns (net returns = 30-40 percent gross revenue)	$0.8–1.0 million	$0.4-0.5 million	$1.2-1.6 million

7. DISCUSSION

Aquarium trade based on coral and live rock harvests is a highly profitable venture for both the exporters and the *qoliqoli* members involved in the wild fishery. The culture of coral and live rock is also financially viable both for villagers and exporters. However, villagers are not likely to have the incentive to switch from wild harvest of coral and live rock to cultured products, because of lower relative profitability (both in terms of gross margin as well as total financial net return) of cultured products as compared to the gross margin of wild products.

Industry net returns

Total export FOB value of live rock and coral products is about $4.4 million for Fiji. The rural resource custodians from 25 *qoliqolis* received a total gross income estimated to be about $1.4 million, $1.1 million from live rock and about $323,900 from coral (villagers also would have obtained an additional income of about $1.7 million from 201,000 pieces of fish and other invertebrates exported in 2004). *Qoliqolis* chiefs received $55,392 in goodwill payment for live rock and live coral exports.

Annual financial net return to collectors of live rock and live coral from the mainland and nearby islands is about three quarters of a million dollars, with people living on the islands mainly benefiting from the harvest of coral and aquarium fish. On the other hand, for mainlanders living within couple of hours travel distance from Lautoka warehouse/ Nadi airport, harvest of live rock from the wild is the main activity. Live rock culture will not be suitable for islanders living off the mainland largely because of the cost of transport from further a field. The financial net return for the exporters of live coral and live rock products from the wild is estimated to be about $ 1.3 million – 1.8 million (Table 15).

The total net financial returns to exporters, villagers and chiefs from the aquarium trades of live coral and live rock in 2004 was about $2.2 – 2.6 million, as compared to industry gross income of about $4.4 million.

Individual household involved with the harvest of coral and live rock form the wild can expect to earn a gross income of $ 6,792 and $27,362 respectively, and a gross margin of $3,814 from wild coral harvest, and $23,187 from live rock harvests.

Viability of Cultured Coral and Live Rock

Both, the production of cultured coral and cultured live rock are financially viable ventures, with gross margin and financial profits being greater than zero. Coral culture has an expected gross margin of wild coral is $ 3,441 and a financial profit per household of $1,085. However, assuming fast growing species are cultured, as is the case in Hideaway coral farm, and the market price of cultured coral remains the same as that of the wild products, villagers can expect to obtain gross margin of $9,505 and financial net return is $4,793 per coral farm producing 3,696 pieces of coral per six month. Cultured live rock is also highly profitable, with a gross margin of $19,144, and a financial net return of $9,287.

This conclusion contrasts with the study reported by Pomeroy et al (in press), which found that culture of coral and live rock were feasible only if extensive subsidy were provided by the government or donors. The analysis was based on the assumption that a new commercial operation needed to be established, including the establishment of aquarium warehouses where cultured products are kept till export. However, if one takes a 'with and without' benefit cost analytical approach, where the source of the products – wild versus culture – is the only aspect of the industry that changes, then culture based business for the rural households is a viable alternative. This is the appropriate analytical framework to use to address the common question under consideration in both studies.

Comparison of net returns from wild and cultured products

The aquarium trade based coral and live rock fishery can provide an important source of livelihood for the indigenous Fijian, although villagers will not have the financial incentive to switch from wild to culture based activity. The financial net return, and economic net returns, from cultured products will be lower than in the case of the wild fishery. Financial net return of cultured coral is a little less than half of the financial net return of wild harvested coral activity (Table 18). On the other hand, the financial net return of cultured rock is about 5 percent of what could have been earned from the wild.

Table 17: Summary of HH Financial Net Returns from Wild Coral, Cultured Coral, Wild Live Rock and Cultured Live Rock

	Wild Coral**	**Cultured Coral (plus live rock)***	**Cultured Coral (2 crops a year)**	Wild Rock	**Cultured Rock**
Total Revenue	$6,792	$6,792 (7,586)*	$13,585 (15,172)*	$27,368	$27,368
Gross Margin	$3,814	$3, 441 (3,778)*	$9,505 (10,179)*	$23,187	$10,833
Financial Net Returns	$3,008	$1,085 (1,203)*	$4,793 (5,044)*	$21,771	$1,077

** Assuming part-time operations; for fulltime operations a household could expect to make $11,000 in gross margin or $9,100 in net financial return before tax income.

* Higher gross margin and financial net return reflects the situation where villager takes advantage of space beneath the coral rack to produce live rock (suitable for mainland villagers only).

For wild and cultured coral, the difference in financial returns is small, when employment is treated as a benefit and depreciation costs are not considered. However, if fast growing species of coral were cultured and prices received for them remained the same as for wild harvested coral, gross margin of cultured product is almost three times greater than the wild harvested coral.

In the case of live rock, even where employment is treated as a benefit, rather than a cost, the gross margin of cultured live rock activity is almost half of what would have been received from the wild harvest of live rock. The main reason for this is the high cost of live rock base.

Therefore, it would only make financial sense for villagers to switch from wild harvest to cultured live rock if the cost of live rock base were drastically reduced.

Alternatively, for villagers to switch from wild live rock harvests to cultured live rock, price of the cultured products must be greater than that of the wild harvested products.

That is, it would make financial sense, if consumers are willing to pay higher prices for cultured and more environmentally friendly products[20]. A price increase of about 40 percent is required for individual collectors to maintain their net gross margin of about $23,000 received from wild rock (and employment is treated as a benefit rather than a cost.

Anecdotal evidence for MAC certified ornamental fish from Philippines suggests that a price premium of 30-40 percent is possible (Michelle Lam, MAC, pers comm. December 2004). This is however, likely to be

[20] Assuming cultured products are environmentally friendly.

the extreme upper limit of 'green premium', if at all possible. As a comparison, for more established certified timber products from the Pacific (Solomon Islands), maximum price premium possible was about 23 percent (Pesce and Lal 2003). Furthermore, Fiji products already fetch a premium prices of up to 40 percent over the Philippines prices (Tim Mcleod, WSI, pers comm.. July 2005), and thus such price premium for 'green' Fiji products may not be feasible.

It is highly unlikely that exporters could realize such large increases in their FOB prices, even if consumers were willing to pay a green premium and it were passed back to wholesalers and exporters. The effect of 'green premium' is not expected to be large enough for exporters because not all the increases in consumer willingness to pay would be passed onto the exporters. Furthermore, given recent trends in freight costs the net effect on FOB price of green premium for live rock may be small. Furthermore, exporters bear the risks associated with currency exchange rate fluctuation. Therefore, the flow on effects of any 'green premium' to the collectors may not necessarily be large enough to make the live rock culture an attractive alternative for villagers engaged in wild harvests of live rock.

Similarly, for villagers to switch from wild harvest of coral to culture of coral species, farming would need to be as attractive financially, and for which price of farmed coral would need to be higher than the wild products. The possibility of villagers getting such a higher price is, however, unclear. On the one hand, villagers currently receive about 20-40 percent of the FOB of the coral, and the exporters have an average net return margin (over and above their total financial costs including cost of products, labour depreciation, management, etc) of about 30-40 percent[21], including occasional negative net returns.

In the long run, cultured products may fetch higher prices because they handle better in transit and survive better in aquariums. However, the demand for cultured coral from Fiji is uncertain, as competition for cultured products from other parts of the world could be stiff, particularly from Indonesia. According to an importer in LA (David Palmer, Pacific Aquafarm, pers comm. June 2005), cultured products from Bali, for example, are preferred over cultured coral from Fiji because of their size and species. According to Palmer, Bali producers are targeting high valued species and supply larger sizes products that are found to be more attractive to consumers than the Fiji cultured products. Species and sizes supplied from Fiji do not appear to be strategic enough in response to market requirements!! As a result, importers may find it harder to sell cultured coral from Fiji unless the industry changes its coral culture strategy.

8. CONCLUSION

The results of this study suggest that culture of coral and live rock is a financially viable venture in Fiji if the low technology based culture is maintained, and if rural households take advantage of economies of scale opportunities that exist in some aspects of the activity.

Villagers at present have little incentive to switch over from wild harvests of coral and live rock to culture based activities, because doing so today would incur a cut in their gross and financial incomes. Thus regardless of the fact that cultured products are more durable and last longer in aquariums, villagers currently involved in wild fishery are not likely to switch to mariculture. For villagers with no other source of income, however, the culture of coral and live rock could possibly be an attractive option.

These conclusions rest on key feasibility conditions being met, including :

- the simple low technology based culture is maintained
- costs of live rock and live coral base substrates are kept low
- products quality is maintained
- villagers cooperate and take advantage of economies of scale and share certain costs while continuing to operate as individual 'firm'

Most importantly, it is premised on villagers putting in the regular effort required to establish, maintain and replace each batch of cultured live rock and live coral. Experiences in the Pacific suggest that this is one of the most critical factors in the long-term sustainability of aquaculture activities. Without meeting such feasibility factors, the culture of live rock and live coral may meet a similarly dismal fate as other aquaculture ventures in Fiji and the Pacific.

On the other hand, for exporters cultured products could be attractive venture, if it can compete in the international market. To do so, it may need to change its strategy and target products which are in high demand, attracting higher prices. Cultured live rock can gradually replace the wild harvested rocks, if consumers can differentiate the products and over time can come to prefer cultured products. Such a change in mindset could be a slow process, suggesting that a cautious approach should be mariculture of live rock is warranted.

[21] Industry sources refute this estimate of the profit margin, claiming that their profit margin is around 5 percent. The figures used in this study is based on commercial-in confidence sources.

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