PRIVATE AND SOCIAL BENEFITS OF AGROFORESTRY:

A FIJIAN CASE STUDY

Tin Hta Nu, J Brian Hardaker and Jack A Sinden[1]

Department of Agricultural and Resource Economics
University of New England, Armidale NSW 2351

Paper Contributed to the Thirty-Eighth Annual Conference of the Australian Agricultural Economics Society, Wellington, February 1994

---

[1] Special thanks are due to Dr Wieland Kunzel, GTZ adviser on Agroforestry and Environmental Education, and Mr Amar Sigh, National Agroforestry Coordinator of the Ministry of Agriculture, Fisheries and Forests and Mr Nemani Buresova, Permanent Secretary, Ministry of Agriculture, Fisheries and Forests.

PRIVATE AND SOCIAL BENEFITS OF AGROFORESTRY: A FIJIAN CASE STUDY

Tin Hta Nu, J Brian Hardaker and Jack A Sinden

Department of Agricultural and Resource Economics
University of New England, Armidale NSW 2351

In implementing environmental protection projects, the objectives of society and of farmers may diverge. Such divergences are illustrated by a pilot agroforestry project in Lomaivuna resettlement area, north-west of Suva, Fiji. The benefits from the project perceived by the farmers are different from those perceived by planners acting on behalf of the society. From the farmers' (private) point of view, biophysical benefits such as soil enrichment, soil protection, increasing and diversifying output and economic benefits such as raising incomes and saving costs prevail. From social point of view, biophysical benefits are to stabilise land use and to diminish environmental and resource damage. Economic benefits to society include costs saved for not dredging and increased exports or reduced imports.

Current farming practices at Lomaivuna are not sustainable. However, if the benefits to farmers from agroforestry are too small, the project may be delayed or fail, regardless of benefits to the society. Imperfect markets for capital and land, and aversion to risk, cause farmers to take a shorter view of land-use decisions than do policy makers. Other forms of market failure, such as the existence of externalities relating to-off-site costs of sedimentation, mean that farmers receive incentives that are not in line with policy makers' objectives. Policy interventions to bring private interests into better congruence with those of the society are canvassed in the paper.

1. Introduction

Soil erosion is a widespread and serious environmental threat in Fiji (Watling and Chape 1992). The principal causes of this erosion are deforestation for conversion of land to agriculture, poorly managed logging, shifting cultivation and over-grazing of steep lands, and the use of land beyond its capability to sustain production (von Maydell 1991). Thus, it is clear that agriculture is a main reason for soil erosion.

Over the past decade, developing country governments and aid donor organisations have renewed their interest in agroforestry. They have begun to see the benefits of agroforestry as a means to attaining sustainable land use and of promoting the welfare of rural people. Some perceived benefits of maintaining sustainable land use via agroforestry are:

- If agroforestry technology is appropriately followed, benefits accrue in reducing off-farm costs.

- Sustainable land use enables continuing farm production.

- Through the continued provision of rural livelihoods, there will be less out-migration to urban areas, reducing social costs and tension.

The perceived benefits from agroforestry as a promoter of rural development are:

- The costs of farming inputs can be reduced, especially if the tree component can lead to soil improvement.

- Diversified production of woody and non-woody crops reduces risk of monocropping and, if there is complementarity, leads to increased farm production and income.

- Welfare of the farm family can be increased through utilisation of the products of agroforestry. Nutrition can be improved through the availability a wider range and increased quantity of foods. Woody products for household use, such as fuelwood and building materials, provided by the forest component, can increase household utility.

Fiji is no exception in trying to achieve benefits from agroforestry. An agroforestry project has been launched as part of a technical cooperation project between the Government of Fiji and the Federal Republic of Germany.

The agroforestry project site is in the Lomaivuna Resettlement Area, north-west of Suva on the island of Viti Levu. The ginger growing farmers in Lomaivuna cultivate some steep land. With the high rainfall of about 3000 mm per year (Buresova 1988), the soils are very readily eroded. James (1992) quoted that 'the best estimates' made by Morrison on the rate of erosion is 100 to 300 t/ha per year. This rate far exceeds the recommended maximum rate for sustainable land use in tropical regions of only 13 to 15 t/ha per year (James 1992, Watling and Chape 1992).

The introduced agroforestry system is to alley crop the land with the exotic tree species *Calliandra calothyrsus* along with ginger and other seasonal crops. The system is based on hedgerows of Calliandra which are planted across the slopes, 6 m to 12 m apart, depending on the gradient. The hedges can slow down the speed of surface run-off and therefore reduce soil erosion. Mulch from the Calliandra, which is a legume, protects the soil surface from damage by heavy rain and adds to soil organic matter and soil nitrogen. More fertile soil, carrying better crops, is less vulnerable to erosion.

Early results from some on-farm trials of the Calliandra indicate that the hedges have directly trapped 86 tonnes of soil per hectare per year. The ultimate reduction in soil loss is expected to be more than this if the system is adopted due to expected improvements in soil structure from mulching with the Calliandra cuttings. Soil lost from the Lomaivuna area enters the Rewa River, which bears a heavy sediment load. Much of the silt is thought to be deposited at the mouth of the river where dredging is necessary to maintain the flow and reduce flooding in times of heavy rain. (During the recent cyclone Kina, all but one of the bridges across the mouths of major rivers in Viti Levu were destroyed, with a loss of many millions of dollars.) With the variable cost of dredging of about $2.50/t, the agroforestry system may be assumed

to save in the order of $200/ha per annum[2]. But in addition, by retaining the soil in situ through agroforestry, agricultural production in Lomaivuna may be sustainable. According to expert panel, ginger, which is the cash crop in Lomaivuna, will not be able to cultivate after 10 years, at present rates of erosion.

The research reported in this paper is to be developed into a doctoral thesis concerning socioeconomic aspects of agroforestry. In this paper, a preliminary analysis of possible benefits to be gained from government intervention in introducing agroforestry in Lomaivuna is presented. The analysis is conducted at both the farm level (private benefits) and the national level (social benefits).

2. Different Emphases on Agroforestry Due to Different Objectives

More agrotorestry projects have been introduced in developing countries in the past decade than previously (Nair 1990). In implementing these projects, project personnel have often emphasised the forestry component, for two reasons:

- Since a primary objective of introducing agroforestry is for conservation, i.e., resource protection purposes, farmers need to receive special technical information on how trees should be intercropped with seasonal crops for conservation purposes. Also, intercropped trees are usually exotic species with which farmers are unfamiliar.

- Inputs (mainly land and labour) must be allocated to best advantage between two products (tree and seasonal crops) Of the two, farmers are more familiar with seasonal crops. Also, because they can get quicker returns from seasonal crops, they tend to allocate more of their time to the agricultural component, with possible neglect of the tree component. The result can be sub-optimal resource use, even non-adoption of the agroforestry system. Therefore, extension personnel may feel they should give farmers more guidance on the tree component.

When a new technology is introduced, farmers who have become interested and perceive the technology to be advantageous may adopt on it a trial basis (Rogers 1962). Governments and NGOs promoting agroforestry often encourage farmers to adopt by running on-farm trials (Nu et al. 1990, Beer 1991)

As noted, such trials have been introduces at Lomaivuna In the adoption phase of agroforestry, the Lomaivuna farmers may give priority to seasonal crops (the agricultural component), for two reasons

- First, they will have to consider their immediate needs, and so concentrate on crops that can give quick returns The first question farmers will ask before they establish an experimental agroforestry trial on a given piece of land is whether the technology will affect their income-earning (but also soil-depleting) seasonal crop, ginger If the current program of on-farm trials suggests they will experience reduced returns from ginger, they are less likely to adopt

---

2 One Fiji dollar is worth approximately one Australian dollar

- Second, farmers will have to put in additional resources which they may or may not be able to provide. The most difficult input for farmers to provide is cash. And the capital investment has an additional 'waiting cost' of at least three years for the trees (Barbier 1990). In Lomaivuna, the farmers will have the positive returns from agroforestry only after the tenth year.

The differences in emphasis placed on the two components of agroforestry by farmers and extension personnel may also be due to differences in objectives:

- The objectives of the government in implementing agroforestry projects are to stabilise land use, to diminish environmental and resource damage, and to develop forest resources (Arnold 1984).

- The objectives of farmers in considering adopting agroforestry are to maximise their private benefits. Farmers will look for higher financial and material benefits from the new technology. Financial benefits can be in the forms of increased farm family income or reduced farm production expenditures. Material benefits can be in the forms of increased food and fuel production. Farmers will adopt the technology if they perceive that these benefits can be obtained.

3. Private Benefits

The material (physical and biophysical benefits) and financial benefits gained by farmers from agroforestry can be specified.

3.1 Material Benefits

Physical benefits:

(a) increasing total output of the land - by intercropping with trees, giving complementary use of different layers of surface land and soil;

(b) diversifying the range of outputs - a number of products from tree species can increase the range of products for household consumption.

Biophysical benefits:

(a) soil enriching impact - from mulch, by the addition of nitrogen through use of leguminous tree species;

(b) protection of the soil - providing shade, shelter from wind, reducing the destructive impact of rain on the soil, reducing soil loss through row plantings to check runoff.

3.2 Economic Benefits

Economic benefits arise due to physical and biophysical benefits.

Due to physical benefits:

(a) raising incomes by increased output with the new technology - the yields are usually expected to increase;

(b) reduction in risk by diversified output;

(c) saving farm-household expenses - firewood, fodder, wood for housing;

(d) capital reserve for emergencies - trees can be converted to cash when exceptional cash outlays are needed

Due to biophysical benefits:

(a) saving input costs such as inorganic fertiliser costs;

(b) avoiding a decline in productivity by protecting the soil;

(c) improved quality of output (particularly for ginger) due to improved soil fertility

4. Social Benefits

National benefits (social) are also calculated in terms of net present value. Benefits can be in terms of costs saved both on-site and off-site. In the Lomaivuna case, in addition to the on-site benefits to farmers, which are also social benefits, erosion rate, flood risks, damage to aquatic resources and beaches and (thus to the tourist industry) are expected to be lessened.

4.1 Material Benefits

Physical benefits:

(a) improved forest resources through reduced pressure on existing forests directly due to Calliandra production replacing some forest production and indirectly from more sustainable farming systems which mean a reduction in the need to clear land for farming.

Biophysical benefits

(a) diminished environmental and resource damage through

(i) reduced erodibility of land - agroforestry technology can help retain soil and sustain the productivity of the farming system even after the time horizon of the present farmers,

(ii) reduced damage to river and marine environments from less sedimentation, including reduced damage to beaches and reefs important for the tourist industry.

4.2 Economic Benefits

Economic benefits arise from physical and biophysical benefits

Due to physical benefits:

(a) Existence benefits from knowing that additional forest resources have been conserved.

Due to biophysical benefits:

(a) increased income through stabilised land use leading to increased income from exports, or to import savings, helping with balance of payments,

(b) costs saved for dredging, repairing roads, etc. due to reduced off-site sedimentation.

In addition to the above, if farming becomes uneconomic due to soil degradation, there may be social costs involved in relocating Lomaivuna farm families to urban areas.

5. Concepts behind the Different Objectives

As mentioned above, farmers will adopt agroforestry if it maximises their private benefits, i.e., material and financial benefits. On the other hand, governments promote agroforestry with an objective to maximise social benefits, i.e., protection environment, saving costs and increasing production.

The conflicting objectives can be illustrated by using production possibility curve (Fillus 1982) as shown in Figure 1.

The socially optimal point to produce is at point C, where the production possibility frontier is tangential to the higher iso-revenue line. However, farmers may produce at a point such as D, on a lower the iso-revenue line. The combination of agriculture crops and tree crops also differ from the society's preference and the farmers.

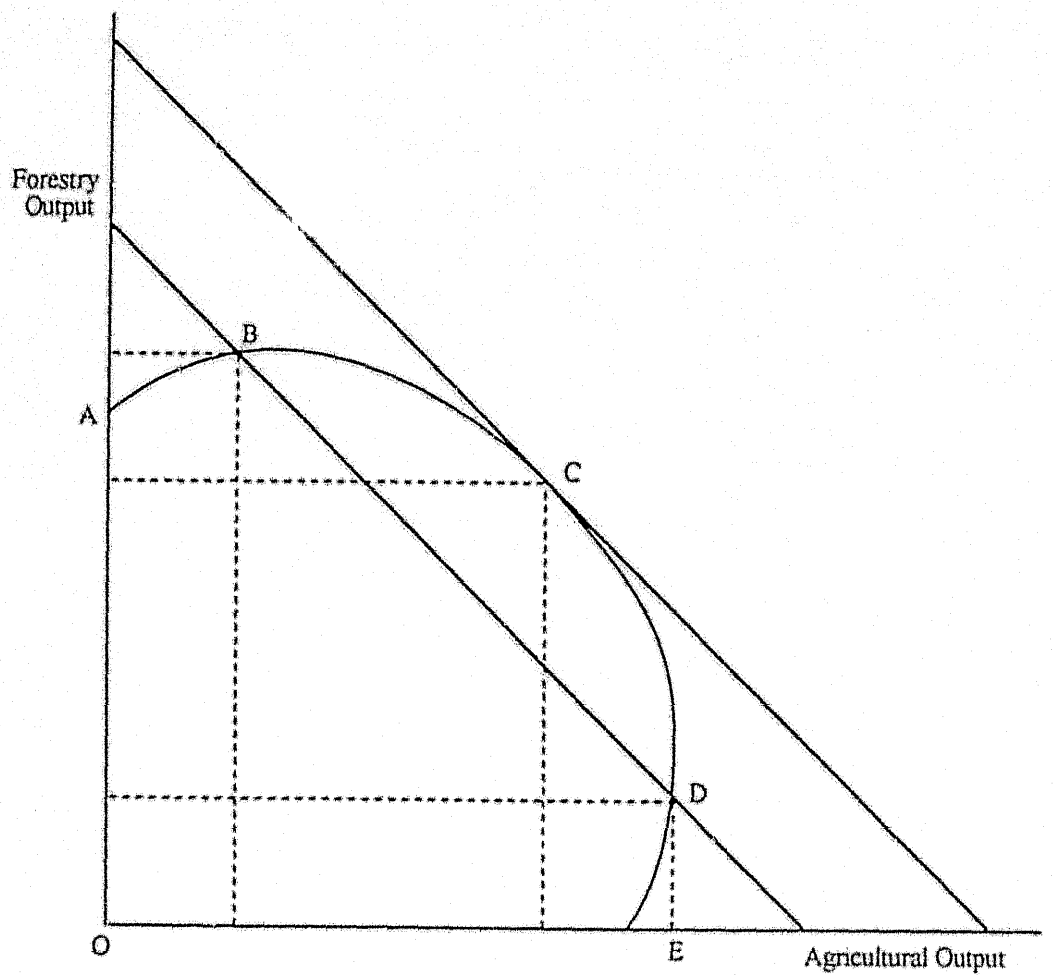
The difference may arise because the valuation of tree and cash crops by society and farmers are different. The society may want more trees for conservation, whereas farmers may have to depend on agriculture or seasonal crops for immediate cash returns. One reason may be that the prices faced by farmers are different to social shadow prices.

If farmers pursue the objective of maximising income in the short run, there is a possibility of environmental deterioration. Planting less hedgerows in Lomaivuna may give inadequate erosion control, leading to excessive downstream sedimentation. If no hedgerows are grown, farming at Lomaivuna may not be sustainable. It was estimated by the expert panel that with the present system and rates of soil loss, the land will be uncultivable except for cassava by 2010.

As part of the land must transfer to tree crops which take some years to produce benefits, a financial loss occur for farmers in the first five years. Firstly it is due to loss of production. The Calliandra competes for nutrients, light, and soil moisture with crops grown, so there is a yield reduction at first, until the benefits of improved soil fertility from the Calliandra come into play. Secondly, the farmers must incur establishment costs for Calliandra.

Thus it is clear that farmers objective to maximise profits does not coincide with society's objective.

Figure 1. The Optimum Crop Combination



6. Conditions that Create Different Objectives

6.1 Market Failure

Differences in objectives can be traced to failures of markets and the government. Market failure arises on two grounds.

Firstly, it is due to external costs created by farmers. The nature of the differences in costs faced by farmers (private) and the society (social) as illustrated in Figure 2. The farmer seeking to maximise his or her private benefit produces at the volume where private marginal costs are equal to the value of the marginal product at point D. However, the desirable amount of production by an individual farmer from the viewpoint of the society is where social marginal cost is equal to the value of marginal product, at point C. The social marginal costs curve can be steeper than the private marginal cost curve because additional production by an individual farmer can have adverse effects (or external costs) on other farmers or on the society.

Thus, if each farmer is to produce at the point where social marginal cost is equal to marginal product, the amount produced may have to be reduced. Because there is no market for those who bear the external costs to pay off the farmers who create the costs, individual farmers continue to produce at point D, unless government intervenes to change farmer behaviour.

Filius states that either reduced production or changes in production techniques (such as agroforestry) can reduce the external costs. In the Fijian case, as farmers are poor, it is unrealistic to seek to reduce production. Thus the other alternative, change in production methods, is indicated as best.

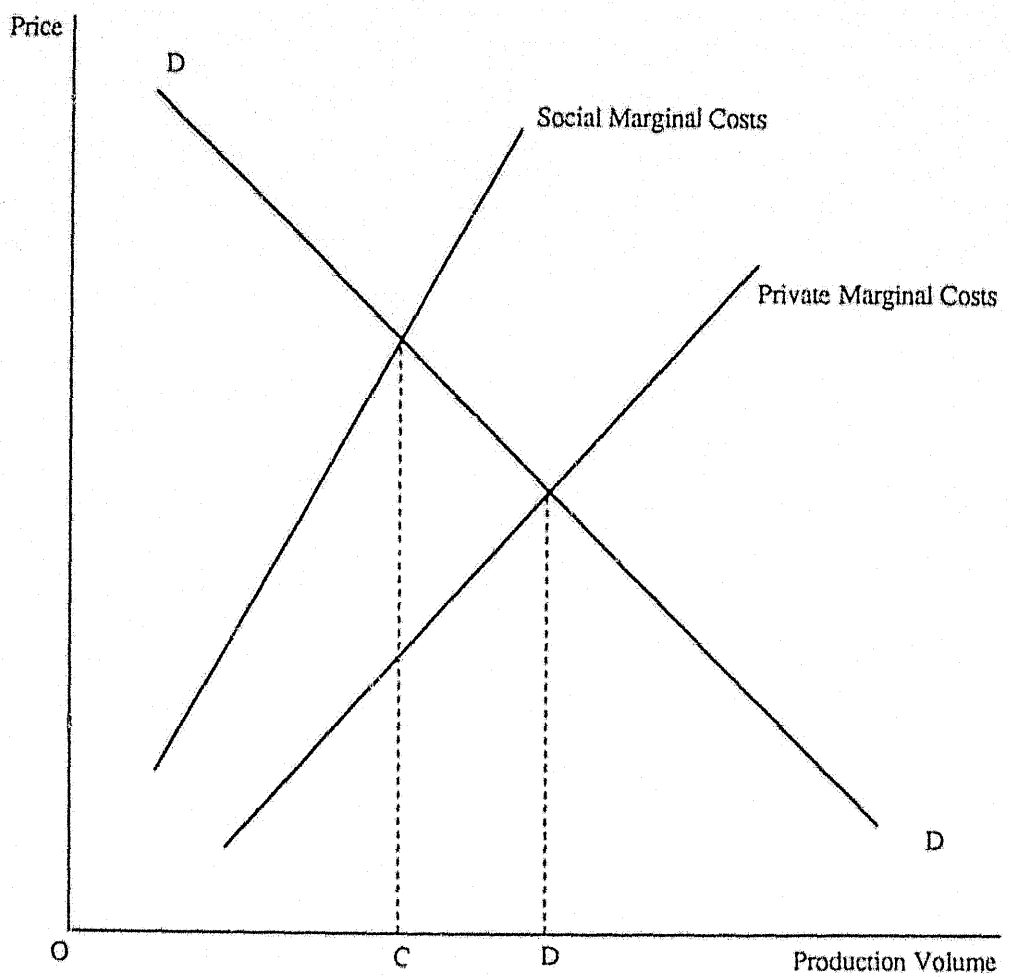
Secondly, most farmers in developing countries face a capital constraint, implying a high opportunity cost of funds. Moreover, capital markets are not well organised in these countries. Poor farmers may not have the collateral to borrow. Their capacity to repay is limited, and they may be judged by formal-sector lenders to be 'poor risks'. Consequently, they may be forced to turn to the informal credit sector where interest rates are high and well above the social cost of capital. Moreover, the remoteness of rural areas compounds the above problems acquiring credit at reasonable cost. Consequently, the farmers cannot afford to invest in long-term land-conserving projects such as agroforestry.

By contrast, the Government of Fiji can borrow on international capital markets at reasonable interest rates. Thus the social cost of capital will be much lower than that faced by farmers at Lomaivuna. Indeed, it is recommended that social investment appraisal be carried out using a discount rate of 10 per cent (Crown Agent 1983).

6.2 Government or Institutional Failure

The land tenure must offer security for farmers. Even if there are sound financial markets and sources of funds available for improving the land, farmers may have very little incentive to do so if their tenure is insecure.

Figure 2. Private and Social Optimum Production



In Lomaivuna, the settlers lease their land from the Native Land Trust Board. Most leases were originally for 30 years and will expire after 15 years from the time the project starts full swing in 1995. Moreover, there is no provision in the leases to compensate lease holders for any improvements such as the establishment of hedgerows, nor, under normal circumstances, to penalise those who farm in a way that degrades the land. Since there is no assurance that they will be allowed to re-lease their present blocks, farmers will be unlikely to give much consideration to benefits arising from agroforestry that are reaped after the present leases expire.

The time horizon of the society is longer. The government, on behalf of the society at large, is likely to want the land in Lomaivuna to be sustainable for future generations, long after the lease expires.

7. Preliminary Results

On the basis of the information collected within a two-week visit to the Fiji-German Forestry project based in Suva, an evaluation of private and national level profitability on the agroforestry system introduced in Lomaivuna has been carried out. Due to limited time constraints, there are severe limitations to the analysis, which should be viewed as very preliminary. Information was collected from farmers on field surveys. Technical information was from a panel session of experts and also from Ministry of Agriculture, Forests and Fisheries. The key assumptions in the analysis are as follows.

7.1 Key Data and Assumptions

7.1.1 Assumptions for the Farm-Level Analysis

1. The rotation, both with and without Calliandra, is ginger, taro, cassava, followed by a two-year fallow

2. The same areas of 0 333 ha each of ginger, taro and cassava are grown with and without agroforestry.

3. Under agroforestry, 0 111 ha of Calliandra hedgerows are grown for each 0 333 ha of the above crops and fallows

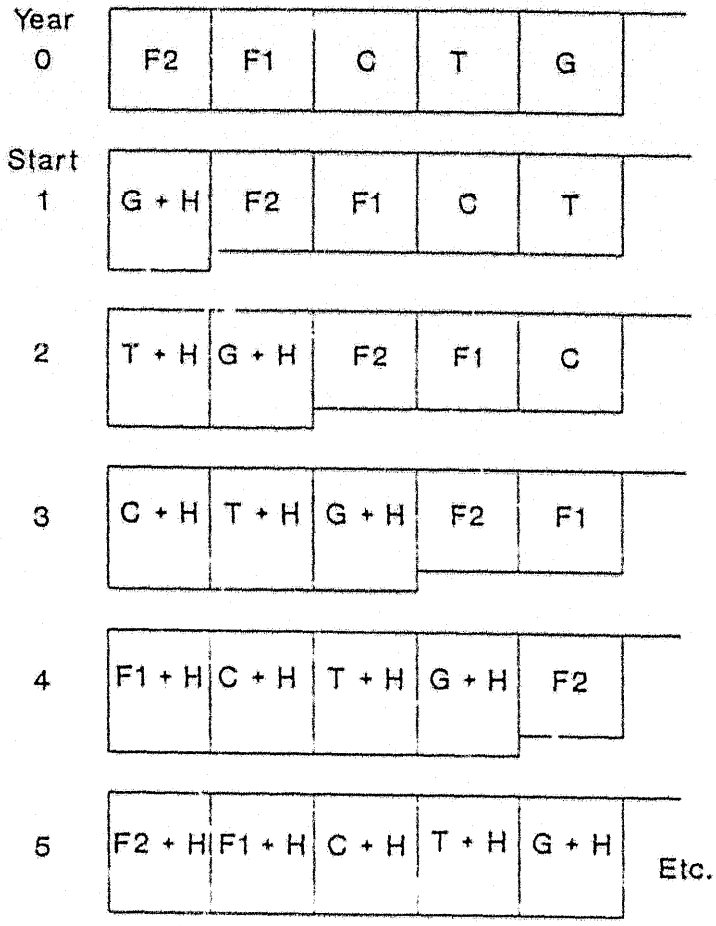
These assumptions are illustrated in Figure 3 which shows the pattern of land use on five plots as the hedgerows are progressively established. Each plot is initially of 0 333 ha, giving a total cropped area of 1 0 ha each year plus 0 666 ha a year in two fallow plots. Other fallow land is assumed to be available and is brought into the rotation as the Calliandra is established, leaving the net areas of the three crops unchanged.

4. Because there is abundant land in Lomaivuna, any extra land used under the agroforestry system has no opportunity cost. Moreover, there are no costs or benefits associated with variations in the amount of land left idle.

5. Differences between the two systems are reflected by:

   - Decreases or increases in crop yields through time according to type of crop and how long agroforestry has, or has not, been practised.

Figure 3: Crop Rotation Assumed



Key: F2 = 2nd year fallow
F1 = 1st year fallow
C = cassava
T = taro
G = ginger
H = hedgerows

- Consequential differences in revenues from crop sales and in yield-related harvesting and marketing costs.
- Differences in the amounts and costs of fertiliser applied under the two systems (in addition to crop yield differences).
- The costs of Calliandra establishment and maintenance.
- Reduced land preparation costs after fallow with agroforestry due to the shading effect (time needed to cut the hedgerows back is included under the previous category).
- The value of the firewood produced, measured in terms of time saved for collection.

6. Under the two systems, production costs of the crops are identical except for differences in fertiliser application, and differences noted above in harvesting and post-harvest costs due to yield differences.

7. Farmers can be taught to manage the Calliandra as an appropriate way to maximise benefits.

8. The extra or reduced amounts of production of all three crops may be treated as parts of the marketed surpluses, and markets exist for any extra production at prices unaffected by level of sales.

9 Any labour provided by unpaid family members may be valued, from the point of view of farmers, at the local wage rate.

10 The fodder produced by the Calliandra is of no value in Lomaivuna.

11. Any cash needed to establish the system must be borrowed at commercial interest rates, and must be repaid from extra cash income.

12. The farmers will require a rate of return on inputs of at least of 25 per cent to cover the opportunity costs of their investment and the risks involved.

13 Farmers will assess the profitability of investments in agroforestry over a time horizon of 15 years (1995 to 2010), which period approximates the remaining term of existing leases from the date when field-scale adoption of agroforestry could be expected to begin.

7.1.2 Assumptions for the National-Level Analysis

The Little and Mirrlees (1974) method has been recommended for use in the economic and social appraisal of projects in Fiji (Crown Agents 1983). The method involves a number of adjustments to the private or financial analysis:

1. Transfers between various agents which do not represent real flows of resources or commodities are omitted. Transfers include taxes and subsidies and credit transfers.

2. Corrections are made for distortions in the local prices of real inputs and outputs. Tradeables are valued at border (import or export) prices, adjusted for the costs of transport to or from the project site. Goods and services which are not directly traded are ideally broken down into their tradeable and other components with the tradeable components valued at border prices. Since this can be a data-demanding task, it is common to use a standard conversion factor (SCF) for the valuation of non-tradeable inputs. (The valuation of non-tradeable outputs involves consideration of possible impacts on domestic prices. However, since all the outputs at Lomaivuna are tradeable, such adjustments are not considered in this case.)

3. Labour is valued at the shadow wage rate (SWR), reflecting the real value of output forgone elsewhere in the economy from the use of labour in the project. Usually, skilled labour is valued at the relevant market wage rates (MWRs), but the SWR for unskilled labour is often taken to be less than the corresponding MWR.

   There is no recent estimate of the social opportunity cost of unskilled rural labour in Fiji. However, there are reasons to suppose that labour at Lomaivuna has an alternative use value less than the prevailing wage rates. Local employment opportunities are very limited and there are significant private and social cost to be met if local workers were to relocate to areas where employment chances are better.

   For the SWR for unskilled rural labour, the Crown Agents (1983) proposed a value of 50 per cent of the market wage, 'not because such a SWR can be justified from first principles, but because it is advantageous to use this SWR as a sensitivity factor'. Buresova (1988) deduced values for the SWR of 48 per cent of the MWR with the project and 24 per cent without.

   In these circumstances, the SWR has been set at 50 per cent of the MWR.

4. Adjustments are also made in the budget to exclude taxes and other transfer payments that do not reflect real resource flows.

5. Possible distributional impacts of the project may be accounted for. First, the macro-economic need to encourage savings at the expense of consumption means that, for example, a dollar in the Government coffers may be more valuable than a dollar in the hands of a poor family who would spend it all on consumption. On the other hand, it may be a national priority to increase the consumption of poor people, so that a greater weight may be placed on incremental consumption of poor rather than rich people. A consumption conversion factor (CCF) may be applied for the social appraisal on the analysis of the project.

   In the absence of any 'official' up-to-date estimates of national parameters on the standard conversion factor and consumption conversion factor, two sources were consulted. Crown Agents (1983) suggest setting both SCF and CCF at 1.0, with an SCF value of 0.909 used as an alternative in sensitivity analysis. The same source recommends against any use of poverty weights, other than the neutral 1.0. Buresova (1988), in a benefit-cost analysis of a soil conservation project for the Waibau ginger-growing area, used values of SCF = 0.88 and CCF = 0.98. Subsequently, there has been further deregulation of the Fiji economy, suggesting that the SCF may now be closer to

1.0. Hence, it seems not unreasonable to set both parameters at 1.0. With these assumptions, economic and social project appraisals collapse into one assessment.

6. On the advice of the Central Planning Office (Pita Wise, personal communication), the discount rate used for the economic analysis is 10 per cent. This rate is within the normally-used range. Buresova (1988) used 9.81 per cent. For a banana export project in Tonga, Felemi (1990) estimated the discount rate to be 6.83 per cent.

Further assumptions made for the economic analysis are:

1. Off-site costs of soil erosion are measurable as the increased dredging costs in the mouth and lower reaches of the Rewa river due to increased sedimentation. Possible damage to the reefs is ignored, as are on-farm and up-stream costs of sedimentation.

2. The time horizon for the economic analysis is assumed to be infinite in the sense that the terminal value of the project in year 15 is estimated as the capitalised value of the annual net benefit from that year onwards.

3. There was an advice of the expert panel (which consisted of agronomists, an agricultural chemist, two exporters, two agricultural officers and a forester) stating that farming will be unsustainable if soil erosion prevention measures are not implemented. However, in this study, farming is supposed to be possible at Lomaivuna with no agroforestry system (or other soil conservation measure) in place, albeit with reduced yields. Consequently, public and private costs of relocation of the existing population are ignored.

4. The costs incurred to date on research and development related to the agroforestry system at Lomaivuna are sunk costs and so are not included in the budget dealing with the net benefits from continuing the work. In addition, no further research and extension costs are included since it is likely that at least as many services would be required to help the Lomaivuna farmers with the problems they would face should no sustainable farming system be developed and introduced there.

8. Results

The investment appraisals suggest that there is a wide discrepancy between the benefits accruing to the farmers (private) and to the nation (society). Agroforestry at Lomaivuna appears to be beneficial for the society, but not for the individual farmer.

The results of the analysis from the private perspective are as follows:

	NPV	IRR
Private		
Base case	-$2133	10.1%
With hired labour	-$2315	9.4%

The results in the analysis from the national perspective are as follows:

	NPV	IRR
Social		
Base case	$7641	21.1%
SWR = MWR	$5811	18.9%

8.1 Private Net Benefits

Overton (1989) states that average farm family income is $2908 per annum in the Lomaivuna area before the introduction of the agroforestry system. If agroforestry is to be adopted, the net present value to the farmer, including labour time valued at the wage rate, was calculated as -$2133, i.e., a significant loss to the average Lomaivuna farm family. The internal rate of return is 10.1 per cent, well below the assumed required rate of 25 per cent. Even if it is assumed that most of the labour used is family labour that would be valued by the farm family at less than the assumed wage rate of $12 per day, the position is only slightly improved. With labour valued at $6 per day, the net present value is -$1802 and the internal rate of return 12.7 per cent, both figures still suggesting little incentive for the farmer to adopt the practice. With these levels of profitability, the establishment of Calliandra is unlikely to be attractive to farmers.

The high discount rate of 25 per cent discriminates very strongly against a project such as this. As Figure 4 shows, the net benefits are negative over the first five years while the Calliandra is being established. A benefit of $1 in year 6 is worth only some $0.25 in present value terms at a 25 per cent interest rate, while the present value of $1 received in year 10 is barely $0.10. Not surprisingly, therefore, the sensitivity analysis shows that the negative profitability to farmers is not strongly affected by making more or less optimistic assumptions about the eventual size of the yield increases achieved.

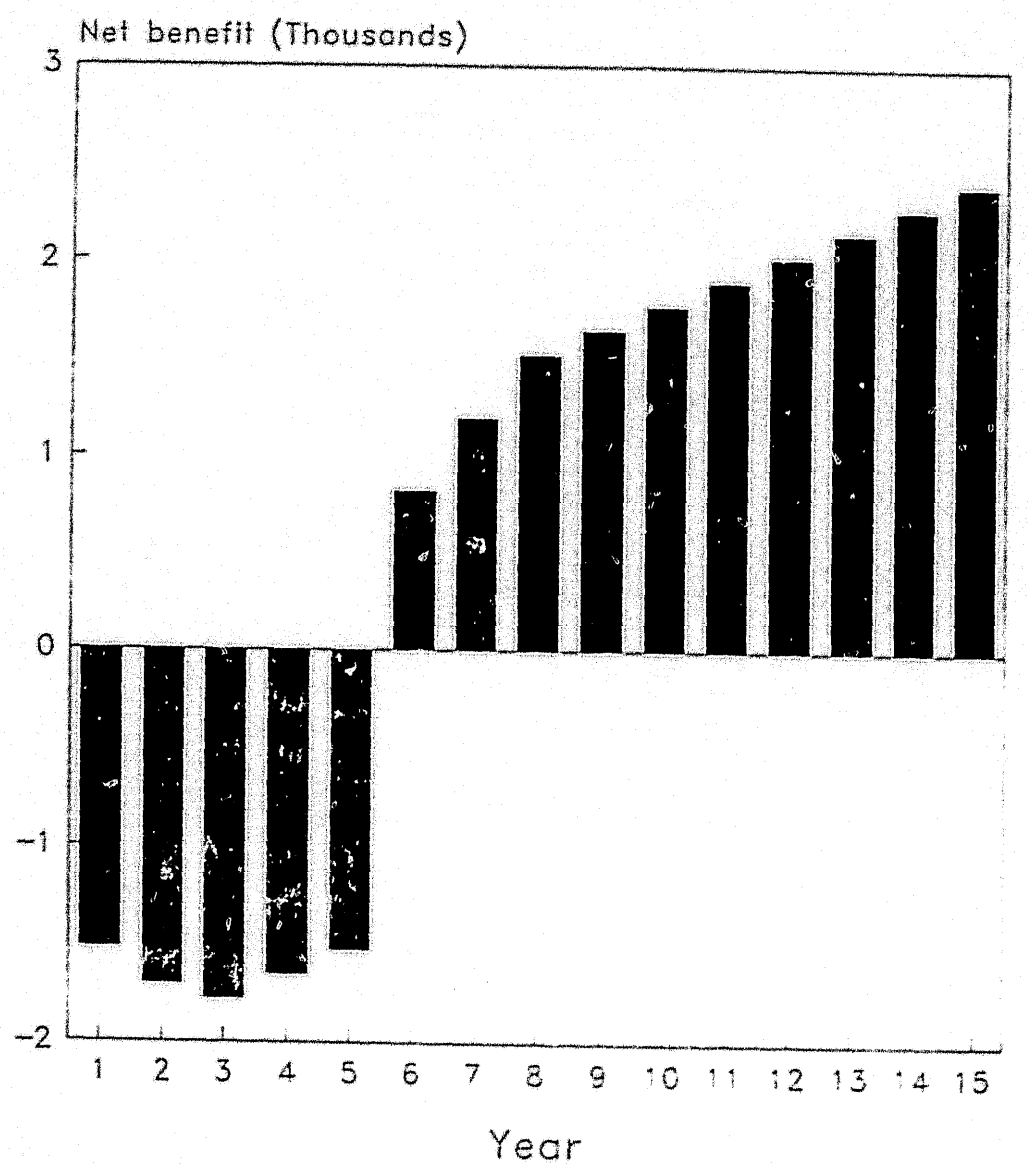
One further feature of interest to farmers is that, over the whole 15 years of the project, there is a significant increase in average annual work loads of about 32 days. This is due to land preparation for the hedgerows and crops as well as pruning the Calliandra. This might be particularly important to farm households where the number of adults available to share the farm work is low, so that extra labour would have to be hired.

8.2 Social Net Benefits

The analysis of the agroforestry system from a national perspective is different from the analysis for farmers' perspective. The aim is to obtain a measure of the contribution of the project to the welfare of the society as a whole. To this end, indirect (including environmental) and off-site costs and benefits need to be considered (James 1992, 21). In addition, all project inputs and outputs have to be valued in terms of their real opportunity costs to society.

The results suggest a very different view of the agroforestry system at Lomaivuna when it is evaluated from a national perspective. The estimated net present value is $7641, and the internal rate of return is 21.1 per cent. Given the other unmeasured benefits of agroforestry, these results suggest that the system would be well worthwhile for the nation.

Figure 4: Net benefit to farmer by year from agroforestry



The off-site cost considered most important for inclusion in the economic analysis is that of sedimentation. Clearly, farmers do not bear the costs of sedimentation of the river that their farming operations create. Yet the costs of dredging the lower reaches of heavily silted rivers in Fiji are considerable, and damage from excess silt to reefs may significantly reduce the productivity of the fisheries (Watling and Chape 1992). Typically, such indirect costs are hard to estimate. In the event, it was possible to place an estimate on only the dredging costs, and even here there were no data to indicate what proportion of the soil eroded from the fields would end up in the river mouth. Moreover, as James (1992, 24) notes, it is not possible to say whether the rates of dredging of the river are optimal. However, the heavy damage from flooding in the lower reaches during cyclone Kina might indicate that the rate has been too low. In all the circumstances, the off-site costs of erosion included in the analysis should be viewed as a minimum estimate.

The possibility of farming at Lomaivuna becoming uneconomic without some soil conservation measures in place is very real and, ideally, the economic analysis should therefore include the costs of relocation of any families who would be displaced. Unfortunately, neither the social costs nor the numbers can easily be estimated, and so this component of cost has been omitted. A rough estimate of the cost to the Fiji society of an additional family relocating to the Suva urban area is in the range of $50 000 to $100 000 (estimate reached in discussion with Dr Jenny Bryant of the Department of Geography, University of the South Pacific). Such costs, although speculative, are of such an order as to swamp all other components if applied to every farmer not taking up agroforestry.

Other off-site costs omitted include possible damage to potable water supplies (or increased filtration costs) due to high silt loads in the river, losses or damage from sedimentation (or from increased runoff from denuded and degraded land) in other parts of the watershed, silt damage to reefs and mangrove swamps, and costs of further land clearing (including reduced biodiversity and more erosion) should farming on the existing land at Lomaivuna become unsustainable. On the other hand, no value is included for any new land created by sedimentation or using material dredged from the river.

8.3 A Divergence in Net Private and Social Benefit

Sensitivity analysis shows that the main cause of the difference between the results from the private and national perspectives is inclusion of the value of the increased productive capacity of the land at the end of the lease.

Because farmers' time horizons for use of the land are relatively short, their incentive to conserve it are reduced. Added to their short time horizon, their relative poverty and poor cash management skills often mean that they have neither the funds nor the access to credit to invest in land improvements. If agroforestry is to be adopted the farmers face losses over the first five years. The reasons are due to yield reductions in the first years of cultivating Calliandra attributable to competition for shade and soil nutrients, and also to extra costs incurred in establishing Calliandra.

The nation has a longer time horizon for the management of the land. Future generations are expected to use the land even after the present leases of the Lomaivuna farmers have expired. If soil erosion can be substantially reduced by agroforestry, sustainable use of the land may be achieved. Moreover, if externalities created by soil erosion can also be reduced, there will be

savings of government funds and other costs The funds saved can be channelled into other long-run development programs

The Department of Finance (1991) has also discussed the possible differences in calculations for benefit-cost analysis. Valuation of the product can depend on displacement effect or incremental effect. If a government project can make more output, then there is an incremental effect. For this case, outputs should be valued at market price. However, if the output displaces other output being sold, then there is a displacement effect. Then the output should be valued at market price with inclusion of subsidies. These different methods of valuation may lead to divergence if the calculated net benefits for the social and private analyses. The applicability of these arguments for the present analysis have not yet been fully investigated.

9. Discussion

The Fijian example of divergence between private and social benefits and costs shows that the market may not always work to produce acceptable long-term use of natural resources. The failures of the market and institutions (government) need to carefully examined to see whether so form of government intervention is possible and appropriate

9.1 Possible Solutions for Market Failure

9.1.1 Taxes and Regulations

A theoretical solution to overcome the external costs of erosion caused by farmers in Lomaivuna is the polluter-pays principle Pearce and Turner (1990) states that Pigouvian taxes should be set to cover the external costs In the Fijian case, farmers might be taxed the cost of dredging of silt in the Rewa River However, it is presently too difficult to find out which farmers pollute what amounts of silt into the river Moreover, even if the tax base could be worked out, the farmers in Lomaivuna are too poor to pay such taxes

An alternative to taxes is setting regulations A complete ban on cultivating in the area is one option that has been canvassed If farmers are to stop growing for their consumption and income, they will have to move elsewhere Most will probably migrate to Suva, and a social cost of relocating farm families will be incurred

Another option is to make agroforestry compulsory in Lomaivuna This option will be hard to carry out by the farmers alone The profitability of the agroforestry system to the individual representative farmer was assessed from the budget assuming a discount rate for the cash and labour inputs required at least 25 per cent This rate is needed to cover the high opportunity costs of funds for capital-starved small-scale farmers, to cover the high risks involved in adoption of new technologies, and to provide a good incentive to adopt (Hardaker 1993). On this basis, agroforestry is not attractive to farmers Moreover, cash flow calculations suggest that, if funds for investment are borrowed, it is unlikely that many farmers would be able to repay the loans.

9.1.2 Subsidies

If the polluter-pays principle or regulations cannot be implemented, other ways to narrow the divergence between the private and social optima should be considered. Sinden (1993) has compiled the welfare effects of regulations, taxes and subsidies in managing land degradation. From this analysis, it was found that all three policies give the same welfare effect. However, the distribution of costs is different. With full subsidies there is no net cost to farmers. There are usually some costs to farmers if regulations are introduced. Taxes burden the farmers with the highest cost among the three policies.

The above analysis is applicable to the Fijian case. The cash-starved farmers do not have the means to pay taxes. Even without paying taxes, the farmers are struggling to pay off debts - about 50 per cent of farmers in Lomaivuna are in debt, and many previous lease holders have left their land due to their inability to service loans. Most farmers will need to borrow to finance soil conservation measures. Even if labour is unpaid family labour, extra income from agroforestry is not great enough to pay off the required loan in a reasonable time. Given the financial hardships the farmers face, they cannot reasonably be asked to follow regulations that will force them into debt to a level that they are unlikely to be able to service.

From the allotted farm size of 4.05 ha, assuming 1.2 ha of crops per farm and an average erosion rate is 200 tons per hectare, half of which ends up in the river mouth, and further assuming the external costs involve dredging costs only ($2.5 per tonne), the 200 farm families at Lomaivuna will create off-site costs of at least $60 500 annually. The estimate rises if on-site and other off-site costs such as damage to the bridges and reefs can be estimated.

From the national point of view, if conservation measures are not subsidised, farming will still create soil erosion which will cause external costs and affect the sustainability of land use. Under such conditions, Lomaivuna is a case, therefore, for examining the merits of intervention by providing financial assistance for conservation.

9.2 Possible Solutions for Government Failure

The problem remains that the agroforestry system being advocated seems at best to be only marginally attractive to farmers. The possibility of altering either the system itself, or the institutional arrangements under which it is carried out, could change that and bring private and national profitability more into line.

9.2.1 Promotion of Relevant Institutions

Successful implementation depends mainly on the end users - the farmers. Socioeconomic and financial conditions influence the acceptability of the agroforestry system by the farmers. Institutions that promote socioeconomic incentives should be encouraged.

Fiji, like other third-world countries, has high population growth. Because of this demographic problem, environmental resources are being exploited and financial resources are inadequate, finally leading to social problems. Institutional measures to slow the rate of population growth are strongly indicated. These may include not only advice and assistance with family planning, but also measures to improve the status, education and employment prospects of women.

9.2.2 Providing Capital Markets

Any attempt to get farmers to take a longer view relates to the imperfections of the capital and land markets. In relation to capital, small-scale farmers in third-world countries need a high rate of return on investments because they are largely isolated from effective finance markets. The problem with this diagnosis is that the prescription that should flow from it is not clear. In the past, the approach taken in many countries, including Fiji to the present, has been to offer subsidised credit. But there is now accumulating evidence to suggest that this is counter-productive, since little of the credit goes to those who need it, and the subsidised competition inhibits the growth of a commercial finance sector that could mobilise local savings and deliver credit more effectively than public institutions (World Bank 1989, 36). The view of many economists today, therefore, is that the best approach is to encourage the development of rural banking, principally by eliminating 'unfair' competition from state subsidised development banks and the like, and by eliminating restrictions on interest rates, which also repress the growth of the commercial financial sector.(Adams and Graham 1981, 347-66).

Other initiatives such as rotating savings and credit associations (ROSCAs) should be also encouraged. Such informal finance arrangements are popular in some developing countries. Members typically range between six to forty. The money collected is given in rotation to each member of the group without interest. This can help farmers to have some capital without a heavy debt servicing burden. (World Bank 1989, 114)

9.2.3 Changing the Land Tenure System

The limited-term lease arrangements, without any provision for tenants to be paid compensation for improvements (nor for them to be charged for land degradation they have caused) are clearly not in the best interests of either the land owners or the nation as a whole. Moreover, the distorted incentives offered to tenants with land settlement leases to conserve the land resource are nothing compared with the signals sent to tenants on short-term sub-leases, or tenants at will. For these farmers, who have little or no security of tenure, and who occupy land in and near Lomaivuna, the message is clear - take what you can from the land while you can. Although land tenure matters in Fiji are intensely political and very sensitive, it seems clear that the present arrangements are not sensible. The problems of land degradation are unlikely to be tackled in a effective way until the deficiencies of the tenure system are confronted.

9.3 Other Solutions

9.3.1 Creating Demand for Wood

One way to improve the private profitability of agroforestry is to improve the method itself. The present system is financially unappealing to farmers because a significant investment is required, and it is not recovered for several years. Ways are needed of reducing the investment, or to bring the benefits forward in time. It would be ideal, for example, if there were some way in which at least part of the produce of the trees could be sold, and indeed this may be possible in places (including parts of Fiji) where there is a market for firewood. If firewood can be converted to charcoal, it might be used cooking in urban areas in place of kerosene or electricity. Moreover, if a demand for Calliandra wood can be created for export

(Anon. 1993), for example as woodchips, farmers' acceptance on the technology may be improved.

The supply potential is quite strong, as Calliandra can start producing firewood two years after the establishment of Calliandra. Average household demand for firewood is estimated at only 1.82 ton per year. This amount can easily be achieved by growing Calliandra as hedgerows among an area of crops of only 0.07 ha. Starting from the sixth year fuelwood output from Calliandra is estimated to be 25 t/ha of crops. If all 4.0 ha can be used, the firewood supply for sale would be approximately 73 tonnes per year per farm family.

9.3.2 Changing the Cropping Pattern

A further problem with the system is that, during the first couple of years after the Calliandra is established, it reduces crop yields, but is not yet producing sufficient biomass to improve the soil. The expert panel was of the view that only after the fallow would the soil-ameliorating effects of the added biomass from Calliandra begin to offset the yield depression from competition. This suggests an interesting possibility. If the Calliandra were planted at the end of the cropping rotation, say as the cassava was being harvested, the two-year establishment phase could occur during the subsequent fallow, with no impact on crop yields. Then, at the end of the fallow, the established Calliandra could be cut back and the crops then planted would get the full benefits from large amounts of mulch and accumulated nitrogen fixed by the trees in the fallow phase. If this were possible there would be earlier positive returns from ginger and other crops. Yields might be increased by about 50 per cent for ginger, 30 per cent for taro and 17 per cent for cassava compared with what without agroforestry situation, over 15 years.

It is not clear that this proposal would work, since it has not been tried. Perhaps the young Calliandra would be smothered by the fallow. Even if it does work, there are no reliable observations on which to base a revised budget. Keeping these limitations in mind, the yield and budget has been modified to see what might be the implications for farmers of following such a program. The result is a dramatic difference, as illustrated below:

	Normal establishment	Pre-fallow establishment
Net present value	-$2133	+$758
Internal rate of return	10.1%	36.1%

These optimistic results suggest that the feasibility of the idea presented above, or some variant of it (such a establishing the hedgerows when the cassava is planted) could warrant some field testing.

10. Conclusion

The finding that the agroforestry system is profitable to the nation but not to individual farmers is typical of many land conservation measures. It suggests a need to find ways to make agroforestry more attractive to farmers so that they will be more likely to adopt it, thus serving the national interest.

11. References

Anon. 1993, 'Wood from coconut trees?' *FORSPA Quarterly Newsletter*, Oct-Dec, Kuala Lumpur.

Adams, D.W. and Graham, D.H. 1981, 'A critique of traditional agricultural credit projects and policies' *Journal of Development Economics* 8(3), 347-66.

Arnold, J.E.M. 1984, 'Economic constraints and incentives in agroforestry', in J.K. Jackson (ed.), *Social, Economic and Institutional Aspects of Agroforestry*, United Nations University, Tokyo.

Barbier, E. 1990, 'Economics for sustainable production', in R.T. Prinsley (ed.), *Agroforestry for Sustainable Production: Economic Implications*, Commonwealth Science Council, London.

Beer, J. 1991, 'Implementing on-farm agroforestry research. lessons learned in Talamanca, Costa Rica', *Agroforestry Systrems* 15(3), 229-243

Buresova, N.V. 1988, Economic evaluation of a soil conservation project in Fiji, unpublished MEc dissertation, University of New England, Armidale.

Crown Agents 1983, *A Guide to Project Planning in Fiji*, Central Planning Office, Suva.

Department of Finance 1991, *Handbook of Cost-Benefit Analysis*, Australian Government Publishing Service, Canberra

Felemi, M. 1990, An evaluation of the Tongan Banana Export Scheme, unpublished MEc dissertation, University of New England, Armidale

Filius, A.M. 1982, 'Economic aspects of agroforestry' *Agroforestry Systems* 1(1), 29-39

Hardaker, J.B. 1993, *Economic Assessment of Agroforestry Work in Fiji*, Technical Report No. 16, Fiji German Forestry/Agroforestry Project, Suva

James, D. 1992, *Achieving Sustainable Development in Fiji: Integration of Economics and Environment*, National Environmental Management Project, Suva.

Little, I.M.D. and Mirrlees, J.A. 1974, *Project Appraisal and Planning for Developing Countries*, Heinemann, London

Nair, P.K.R. 1990, *The Prospects for Agroforestry in the Tropics*, World Bank Technical Paper No. 131, The World Bank, Washington, D.C.

Nu, T.H., Thein, M., Nyunt, L., Oo, K.P., Maung, M., and Tun, K. 1990, *Socioeconomic Survey of Kinda Watershed Area*, Technical Report to UNDP/FAO, Rangoon.

Overton, J. 1989, *Land and Differentiation in Rural Fiji*, Pacific Research Monograph 19, National Centre for Development Studies, ANU, Canberra

Pearce, D.W. and Turner, R.K. 1990, *Economics of Natural Resources and the Environment*, Harvester Wheatsheaf, London.

Rogers, E.M 1962, *Diffusion of Innovations*, Free Press, New York.

von Maydell, H.J. 1991, 'Agroforestry for tropical rain forests', *Agroforestry Systems* 13(4), 259-67.

Watling, D. and Chape, S. (eds) 1992, *Environment: Fiji - The National State of the Environment Report*, IUNC, Gland, Switzerland.

World Bank 1989, *World Development Report*, The World Bank, Washington, D.C.

Sinden, J.A. 1993, Natural Resource Economics, Agricultural Economics 404-1 Study Guide, University of New England, Armidale.