

## VETIVER AND CASH CROP EROSION CONTROL SYSTEMS FOR SUSTAINABLE SLOPING LAND FARMING IN FIJI

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### Abstract

There is a need to address the degradation caused by unsustainable smallholder agriculture in Pacific island countries, especially on marginal steeply sloping lands, as is the case in Fiji. Like most developing countries, Fiji faces the crucial issue of sustainable management of its scarce land resources. From 1956 to 1991 land use was greatly influenced by: (1) a 200-% increase in land used for agriculture, and (2) a population increase of about 100 percent. More people have turned to the land for their living; this is alarming given Fiji's small size, topographical harshness and land-ownership realities.

In collaboration with IBSRAM, GTZ/SPC, Landcare Research NZ and EU-PRAP, Fiji's Ministry of Agriculture, Fisheries and Forests (MAFF) is undertaking development activities with farmers to identify technologies to minimize erosion and agricultural soil degradation. At the PacificLand site, typical soil losses from farmers' practice plots are 20-50 t/ha/yr whereas losses from plots with contour hedgerows of vetiver and pineapple are under 2 t/ha/yr, i.e. less than 95% of losses from farmers' plots.

From this lesson learned, MAFF is demonstrating SLM through field days, farmer training and PRA activities in areas affected by and prone to erosion and fertility decline. Currently 152 farmers have adopted a low cost SLM "vetiver + cash crop" system with contour plantings of vetiver at the base of the garden and cash crops, i.e. pineapple, banana, kava, bele, coconut, citrus and pigeon pea, at 10-20 m between rows up the slope. This combination has proved successful especially with low-income rural communities. The effectiveness of the transfer reflects the extent of farmer involvement with flow-on benefits to the farming community through: (i) increased environmental protection, food security, production diversity and economic development; (ii) reduced poverty with greater equity and social cohesion; and (iii) better government policies, institutions better able to manage land resources and a more effective national science, technology and education programme.

### Introduction

The use of vetiver (*Vetiveria zizanioides*) for erosion control has a long history in Fiji. As early as 1946, the Department of Agriculture was actively encouraging the use of a range of conservation measures. These included vegetative barriers planted along the contour using vetiver grass and pigeon pea (Howlett et al. 1997). Also at the cane belts of Fiji, Greenfield first used vetiver for erosion control in 1956 (National Research Council 1993). Due to the lack of arable flat lands and the need for more cane to be produced, the only other option for expansion was to move sugarcane planting to the marginal steep slopes. However, a problem was envisaged, particularly when in certain months of the year the soil is too dry and erodible. According to Greenfield, putting cane fields on the slope could be disastrous to the company, the cultivators and the country (National Research Council 1993). Also promoted heavily by the Department of Agriculture and the sugar industry was the use of mechanical barriers. Bulldozers were used to cut broad dirt barriers (bunds or berms) along the contours, which was a standard process for controlling erosion in the commercial croplands of most parts of the world. Vetiver fared well during heavy rain and according to the National Research Council (1993),

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bulldozed earthworks did not fare so well. Water built up behind them until the weakest spot could hold no longer, then the dammed-up body of runoff cascaded through the breach, gashing jagged gullies into the erodible slopes.

The seventies and early eighties have seen a shift in the focus of the Department of Agriculture on the promotion of conservation. The focus is now based on cash-crop commodities for export. This all led to the less focus on conservation and vetiver in the farming system and more to the development of commodities such as rice, taro, ginger, sugar and, recently, kava (*Piper methysticum*).

Repercussions of development for the past 40 or so years in Fiji does support the assertion by many that sustainable land management or integrated land use management is crucial if cropping is to be sustainable in the long term. It is now realized that sustainable agriculture involves a food-producing sector that over the long term can maintain or enhance environmental quality, provide adequate economic and social rewards, and provide a sufficient and accessible food supply (Smyth and Dumanski 1993; IBSRAM 1996). Fiji collaborators at this juncture are deeply grateful to PacificLand for generating data that has convinced the government that soil erosion in ginger cultivation is serious. For the first time ever, MAFF through its Commodity Development Framework programme is providing funds to promote conservation farming throughout Fiji, using vetiver hedgerows with cash crop combinations in the alleys. This paper will discuss the different issues that prompted the Fiji government to revitalize the use of vegetative barriers as a sustainable land management tool in Fiji. Also, it will try to relate the different experiences that accrued from working closely with farmers on technology transfers.

## Country Background

The Fiji group is situated in the SW Pacific Ocean between latitudes 15-22°S and longitudes 174-178° W. Fiji lies in a strategic location among other Pacific islands and is 3 155 km from Sydney, Australia, and 2 120 km from Auckland, New Zealand. The Fiji group consists of approximately 300 islands with a total land area of about 18 378 km<sup>2</sup> scattered over 230 000 km<sup>2</sup> of ocean. Approximately 100 of these islands are permanently inhabited. The two main islands of Viti Levu (10 544 km<sup>2</sup>) and Vanua Levu (5 535 km<sup>2</sup>) comprise some 88% of the total land area. The soils of Fiji are well described elsewhere (Twyford and Wright 1965; Leslie 1997). MAFF has tabulated the land area, and described the agricultural capability of the eight slope classes on Viti Levu (Table 1). With the exception of recent soils derived from alluvium, Fiji soils are rated as moderately to severely erodible, especially on the slopes.

Fiji enjoys a mild tropical climate with plentiful rain under prevailing conditions, although there are definite “hot, wet” (October-April) and “cool, dry” (May-September) seasons. Climate also differs between the windward (wet zone) and leeward (dry zone) coasts of the larger islands. Average annual rainfall for the wet zone ranges from 2 800 to 3 600 mm and for the dry zone from 1 300 to 1 600 mm. On all main islands, dense tropical forest covers the wet zone whereas the drier zones have only savannah cover. Repeated burning of the grass cover has reduced some areas to bare ground (*talasiga* areas) where sub-soils are often exposed. Economic planting of exotic pine and tropical hardwood species is now proceeding in such areas.

The Fiji Bureau of Statistics report of the 1986 population census indicated a population of 737 200 at a density of 39.1 persons/km<sup>2</sup>. While this can be considered modest, the average conceals accentuated densities in excess of 170 per km<sup>2</sup> of arable land. While more than 60 percent of the total population is in rural areas, migration to urban areas is significant and increasing. With almost complete utilization of first-class arable land, the current expansion of agriculture into marginal hill areas and steep land will continue to increase. Fiji's most comprehensive land use capability survey (IUCN 1992) revealed the following:

- 19.4% or 355 750 ha is first-class land suitable for sustained arable agriculture.
- 10.5% or 193 195 ha is second-class land requiring minor improvements for sustained agricultural use.

- 31.9% or 586 752 ha requires a great deal of land management if it is to be used sustainably.
- 38.2% or 702 092 ha is unsuitable for agricultural development, but may be of limited use for production forestry.

### **Land Use as Livelihood in Fiji**

According to Otanez and Tubuna (1992) and Seru (1994), the following changes in the 1956-91 period have influenced land use in Fiji (Tables 2 and 3):

- The population increased by about 100% from 345 737 to approximately 800 000;
- The number of farms increased by 280% from 33 500 to 95 400;
- Land used for agriculture increased by 240% from 242 500 to 591 407 ha; and
- The average size of farms decreased by 14% from 7.2 to 6.2 ha.

From these figures, it is apparent that more and more people have turned to the land for a living. This is an alarming situation for Fiji, given its smallness, geographical harshness and land ownership realities. Land use in Fiji, as elsewhere, is dynamic and responds rapidly to changing market demand, land productivity, policies, social pressure, pests and diseases and other natural calamities such as floods, droughts and cyclones (Table 4). Land, and more specifically soil, is a vital economic factor in Fiji whose usage and management is of paramount importance for future generations.

### **Agriculture**

About 60% of the total land area is suited to some form of agriculture activity, but only 16% is suitable for sustained arable farming. Along with the 240-percent increase in area used for agriculture in the last 35 years, there has been a considerable expansion into marginal and steep grass and forest lands. As reported in the 1991 Agricultural Census, 95 400 farms existed in Fiji covering 591 407 ha (Otanez and Tubuna 1992), an increase of 54% from 1978 (Table 2). In 1991, about 93% of farms were in rural areas and the remainder in rural-urban fringe areas.

Actual land use at the national level in 1991 (Table 3) was classified as follows:

- 39% or 230 881 ha as cultivated land (under temporary or permanent crops with fallow of less than one year). The main agricultural commodities include sugar, copra and coconut oil, cocoa, ginger and rice (MAFF 1996).
- 29% or 173 406 ha as pastures and grazing areas.
- The remaining 32% or 187 120 ha included fallow of less than one year over 20 398 ha, natural forest over 104 338 ha, planted forest over 8 359 ha and a non-agricultural area of 54 025 ha.

Much arable land has been alienated to housing and industry due to increases in population, especially the urban population. As a result much farming has shifted into marginal lands, especially sloping marginal lands, as is evident in the sugarcane growing areas. This has led to increasing levels of public awareness and concern in Fiji regarding land use and the need for a national land use plan and policy (Leslie and Ratukalou 1999).

### **Forestry**

The forestry sector contributes 1.5% of GDP and forest exports are now the fifth most important export commodity (IUCN 1992). The sector is expected to earn about US\$100 million in foreign exchange by the year 2000 and employs more than 1 000 workers in rural areas. Deforestation in the country is moderate but continuing. Since 1967 an estimated 90 000 to 140 000 ha of the national forest has been converted to non-forest land uses, in particular to:

- Large-scale commercial agriculture/rural development projects;
- Smaller holder mixed commercial and subsistence farming activities;
- Spreading small settlements and urban growth with service infrastructure (e.g. roads, dams, etc); and
- Fire.

Fiji has embarked on some highly successful plantation establishment programmes with softwood (pine) plantations covering some 43 000 ha in the primarily dry zones to reforest degraded lands. In contrast, hardwood plantations of introduced mahogany have been established within the existing native forest and now cover some 42 000 ha. Forestry programmes have returned some 50 000 ha of long-deforested land to production. With a total area of 1.83 million ha, some 47% of Fiji is now under forest cover.

## **Issues Affecting Conservation and Sustainable Land Management**

The effort to promote conservation work in Fiji, particularly the use of vetiver, does need careful analysis of issues, such as the expiring of leases under the current land tenure arrangement, which acts as a buffer strip to the efforts of the Ministry of Agriculture to promote long-term conservation of Fiji's soil resources. Such issues, if not carefully considered, may work against sustainable land management in the long term. Highlighted below are some of the issues that Fiji needs to carefully consider.

### **Demographic Changes**

Fiji has a modest population growth rate of two percent. It is predicted that the population will reach one million by the year 2000. This raises the question of where will farming occur due to the increased population pressure. Increases in Fiji's population over recent decades have placed pressure on the land, particularly marginal sloping land, and this has and continues to result in significant land degradation and soil erosion. The small size of farm holdings (60% are of less than 3 ha) further forces farmers to undertake intensive cultivation, often mono-cropping, activities for high-output, short-term production without or with minimal fallow periods (Leslie and Ratukalou 1999).

### **Pressure on the Production Base**

Multiple uses for the land have increased the competition on and the pressure for its use. Low input subsistence farming operations are increasingly being forced onto steeper slopes with the expansion of cash cropping and grazing operations onto flatter more fertile arable lands (Craswell et al. 1998). The alienation of agricultural lands to non-agriculture activities such as housing, industry, urban infrastructure, etc, also continues. Soil loss measurements clearly demonstrate that the agricultural productive base in many sugarcane areas and with ginger on slopes is increasing at a rate that is well above what would be regarded as economically acceptable (Leslie and Ratukalou 1999).

### **Overdependence on the Sugar Industry**

The country's dependence on the sugar industry with its internal quota and incentive system further encourages farmers to move onto slopes greater than 11°. Soil conservation measures are rarely applied. Over a short period of time the soil resources in many of these areas have been completely exhausted with severe problems relating to low fertility, low organic matter levels, poor water holding capacity and declining productivity. Where land degradation has become extreme, farmers are forced into growing non-cane crops or foregoing their leases. Current estimates suggest that some 15 000 ha of cane land on Viti Levu is in urgent need of soil conservation works and a further 6 500 ha should not be planted to sugarcane (IUCN 1992).

### **Use of Appropriate Technologies**

While land pressure indicates a need to increase production per unit area, there is a poor understanding throughout Fiji's agricultural sector of technologies to sustainably match land use, crop type and land capability in order to meet productivity goals (Leslie and Ratukalou 1999). For example:

- The use of vetiver grass along the contour in cane lands was a widespread practice until 30 years ago; this is no longer the case: only a fraction of vetiver grass planted then remains now.

It is a proven technique to control soil movement and loss on sloping land. Also the burning of cane trash is a widespread practice and over the years can result in seriously low levels of soil organic matter, limited soil fertility and substantial soil losses through water and wind erosion (Grimshaw and Helfer 1995).

- In the 1960s up to 140 000 ha of Fiji's forests was converted to non-forest land uses, leading to serious soil degradation. Also, the unplanned alignment of logging roads has both onsite and offsite consequences to the environment, with siltation of creeks and runoff surges during storm events (Burns et al. 1960).

Overall there is very low farmer participation in technology generation, resulting in poor adoption and application of land husbandry practices (IBSRAM 1996). This accelerates rates of land and water degradation. The impact of and vulnerability to natural disasters (e.g. floods, cyclones, droughts, etc) are also increasingly acute.

### **Weak Institutional Infrastructure**

Fiji ministries with responsibilities for agriculture, forestry and land use management under the Land Conservation and Improvement Act in general are under-resourced. They commonly lack funding, resources and trained technical staff to undertake effective environmental planning, management and enforcement activities. The primary responsibility of the Land Conservation Board in Fiji is supervision of land and water resources, yet activities have focused on downstream effects, such as coastal zone/floodplain drainage, rather than on the factors responsible for these effects. There is a reluctance to exercise legal rights with respect to bad land husbandry practices. There is a poor awareness of the interdependence of conservation and development, and conservation and environmental management in some cases are seen as obstacles to development or at best irrelevant to it (Leslie and Ratukalou 1999).

### **Inappropriate Land Use in Watersheds**

Erosion resulting from inappropriate land use and land management practices, and their lack of control, has led to progressive siltation of rivers resulting in drainage problems on floodplains, frequent inundation and the formation of shallow bars across the river mouths (Leslie and Ratukalou 1999). Dredging of rivers has become a very costly necessity with severe downstream impact on settlements, domestic water supplies, rural and urban infrastructure (roads, bridges) and crops (IBSRAM 1995). The potential impact on Fiji's tourist industry through loss of fish-spawning areas and damage to coral reefs may be industry threatening.

### **Inadequate Knowledge Systems**

There is poor understanding in the rural sector of existing legislation relating to land, land use practices and soil conservation (Leslie and Ratukalou 1999). This situation has resulted in part from a lack of awareness among ministry personnel of these laws. Also there are few programmes aimed at increasing public awareness of land husbandry provisions under law as written into rural leases, or of enforcing these provisions.

### **Land Tenure**

Over the period 1997 to 2026 approximately 11 800 leases issued under the Agriculture Landlord and Tenant Act will expire (Leslie and Ratukalou 1999). While many leases will be renewed, there will still be a number of farmers to be resettled. Given the shortage of good land in suitable locations, the question arises as to where the displaced farmers will be settled. While the close relationship between Fijians and their land is continually emphasized, there appears to be scant regard by Fijian landowners (who own 85% of the total land area of Fiji) to ensure the soil resources are husbanded and fertility retained by tenants who have leased traditionally owned land.

The intensification of land use will be constrained by the land ownership system, the rigidities of which will need to be modified if optimum use of existing arable land is to be achieved.

## Poverty

Social problems leading to rural poverty typically reflect inappropriate use of natural resources resulting in land degradation leading to social instability, decreased productivity and investment, and further environmental degradation (Leslie and Ratukalou 1999). Fiji is no exception to the global trend of increasing population pressure leading to land degradation and soil erosion. Rural poverty is greatest among those farming degrading and/or marginal land, especially where land tenure cannot be guaranteed.

The centralization of planning activities and the current legislation do not allow for the effective segregation of national, divisional and local issues as these relate to land management (Leslie and Ratukalou 1999). In Fiji, the previous national development plans have placed little emphasis on sustainable land management. A major limitation is the lack of a national land-use plan and an institutional responsibility for land-use planning. Fiji's land resources are limited. If the demographic trends continue, there is an increasing need to effectively match land systems, soil types and land uses to maximize production and sustainably meet the current and future needs of society. Land-use planning is fundamental to this process.

## Research Trial

The Fiji soil erosion trial has now completed phase one, which is purely research. However, as it moves into the second phase, that is the transferring of conservation technology to farmers, collection of data at the core site does continue. The results presented here therefore are part of an ongoing collection of data from the core site.

Measurements of soil loss and runoff from Fiji site are shown in Table 1.

Table 1. Annual soil loss (t/ha) and runoff (mm) (all treatments cropped with ginger)

Treatment	1992	1995	1996	1997	1998	1999
Farmers' practice	0.53	22.60	50.02	25.82	1.73	4.29
Pineapple barrier	0.11	0.64	0.33	19.22	0.89	0.04
Vetiver barrier	0.27	0.42	0.21	0.80	0.04	0.03

Table 1 suggests that ginger crops planted under farmers' practice (no conservation barrier) produce the most soil loss and runoff. In 1996, during heavy rainfall, soil loss amounted to more than 50t/ha in a cropping cycle. Results point out that vetiver and pineapple are successful in minimizing soil loss.

Table 2. Annual soil loss (t/ha) and runoff (mm) (all treatments cropped with cassava)

Treatment	1993	1994	1997	1998	1999
Farmers' practice	0.28	1.17	1.57	6.05	2.33
Pineapple barrier	0.09	0.18	0.33	0.90	0.03
Vetiver barrier	0.13	0.11	0.21	-	0.0005

Although minimal soil loss is reported in Table 2 from the three treatments, farmers' practice still yields more soil loss than vetiver and pineapple.

Table 3. Annual soil loss (t/ha) and runoff (mm) (all treatments cropped with taro)

Treatment	1992	1993	1996	1997
Farmers' practice	0.04	2.60	15.46	1.67
Pineapple barrier	0.04	0.21	0.12	5.05
Vetiver barrier	0.08	0.13	0.14	0.09

Farmers practice – crops planted up and down the slope-led to extensive soil loss and high rates of runoff (Table 3). The results suggest that vetiver and pineapple barriers do reduce the amount of soil loss and water runoff. The data suggest that between vetiver and pineapple treatments, pineapple barriers are less effective than vetiver strips in reducing soil loss, but pineapple does meet the short-term economic requirement of farmers.

### Transfer of Technology

Vetiver grass and pineapple technologies have been transferred to the three main agricultural divisions, North, West and Central. Farmers have also adopted leguminous and N-fixing tree species such as *Calliandra*, *Erythrina* and *Gliricidia* on contours to act as living barriers as well as hedgerows. Fruit trees such as citrus, coconut and mango are also incorporated into the hedges for economical benefit.

To date a total of 204 farmers have adopted the technology, 79 in Central, 52 in the West and 73 in the North, and many more have requested assistance for adoption.

## Optimization of Conservation and Cash Benefits

### Conservation and Technology Transfer

The Agriculture Department of MAFF, with the assistance of programmes such as the IBSRAM/PACIFICLAND and PRAP (Pacific Regional Agriculture Programme), do continue to research ways and means of working with farmers on their varied farming systems, even though there are issues limiting progress, as mentioned above. Contour hedges of pineapple (mid-slope areas) and vetiver grass (lower-slope areas) were established on sloping degraded lands managed by traditional landowners and tenant farmers in six areas of Fiji. Participatory approaches were followed to identify sites and to establish hedgerows. Planting materials were provided as required. The farming systems being studied include ginger-taro-cassava (in high-rainfall areas) and off-season vegetables (in seasonally dry areas). In one case, off-season tomatoes provided a US\$1 500 cash return to a single farmer. Equally appreciated and unexpected benefits have been increased food security, family and community collective action, and village wealth, with greater economic development and diversity of production observed.

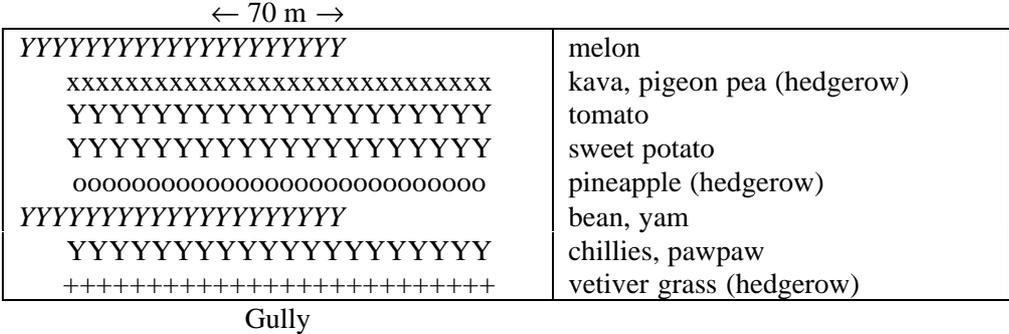
Hedgerow-based conservation cropping technologies at the village level on marginal sloping lands are being increasingly used for food production. The sustainability of production on these lands had declined due to land degradation. The initiative monitors biophysical, social and economic impact of this technology, mainly through observation and interviews, and transfers technology to farmers through field and on-farm demonstration. Technology is transferred by NGOs and government agencies in Fiji and other Pacific island countries through staff and information exchanges in other places. Men and women farmers have participated in design and implementation activities with a high level of ownership in on-farm activities. External support is provided by government to overcome barriers identified by farmers (for example, through the provision of unavailable planting material and knapsack sprayers); and finally, impact is optimized by balancing economic and conservation benefits.

### SLM Fiji Model

After three years of working with farmers on SLM, the Land Use Section of the Ministry of Agriculture has developed a model that will be promoted among the people who have no other option

but to farm on marginally steep slopes. In this model, three hedgerows (kava, pigeon pea, pineapple, vetiver grass) are placed 20 m apart. The vetiver grass hedge is preferred at the bottom of the slope and can act as a riparian strip to protect the gully. Cash crops (melon, tomato, sweet potato, bean, yam, chillies, papaya) are grown in the alleys. The farmer may space hedgerows closer together if he wishes. Crop diversification, intensification and relay give maximum ground cover and profit.

Fig. 1. The conservation farming model currently being used in Fiji



The generation of cash is regarded in Fiji as very important because it empowers people to deal with both poverty alleviation and food security. A useful guide in choosing plants for hedgerows and alleys is through a harvest calendar of marketable plants (Table 1). This can ensure continuity in on-farm cash flow. Farmers like this approach very much.

**Guiding Principles**

- The chosen hedgerow species must control erosion effectively and have other positive effects, e.g. short and medium-term cash flows, firewood, soil fertility improvement, fodder.
- The farmer must accept, like and gain from the adoption of conservation farming systems. He should not be burdened with additional costs and problems due to this adoption, e.g. additional labour costs, weeds.
- The conservation farming systems must address real on-farm needs such as bridging a cash-flow gap or improving the health of the farming community through sustained production of nutritious crop varieties.
- The conservation farming system should encourage biodiversity within the farming environment.

**Lessons from Fiji**

The MAFF land use approach to transferring technology to farmers involves a combined effort and an interdisciplinary approach. Experience shows that no one practice can solve all problems. Thus, MAFF is promoting a blend of technologies, to better address on-farm conservation needs and farmers’ needs for short to medium-term cash flows. Currently, the technology has been successfully transferred to 200 or so farmers in Fiji. The process has enriched us and provided lessons that will assist us in future transfers of sustainable land management technologies. Lessons learnt are mentioned below:

1. Technology transfer without a proper farming system appraisal and awareness programme will amount to zero in the long term. Materials handouts have a place but cannot be used to replace awareness and training. In the longer term, technologies will only be successfully transferred if they fit the farmer’s system of farming, have demonstrable benefits in both the short and longer term, and are well understood by farmers and the farming community.
2. Farmers become confused if they receive conflicting advice on a particular technology. This can limit the success of its transfer in the longer term. Good, effective communication is essential between all parties to ensure the desired messages are not only sent but also received by all parties involved in the information exchange. Farmers, researchers and extension agents need to work together.

3. Farmers need to be aware of the need for a particular conservation technology and to accept this need. A collaborative approach to identify on-farm issues and farmers' needs is a starting point to this. Experiences have shown that during PRA sessions, an exchange of information occurs. This can positively influence farmers to adopt a new technology. It also teaches facilitators to recognize and deal with problems that are outside their areas of expertise. For example, problems with water supplies, health, etc, can be passed on to the relevant authority. When farmers feel that their real problems are being addressed, they better respond to suggestions on lesser issues such as those relating to soil erosion and land management. We feel that such a process promotes trust and bridges the gap between farmers and MAFF officers.
4. Sloping land technologies need to blend long-term conservation with shorter-term cash benefits if they are to best serve the different expectations of the various stakeholders. In certain situations, ginger/taro farmers may not accept vetiver because they believe vetiver hedges will hold water and encourage tuber or root rot. In such circumstances, MAFF must be able to provide appropriate alternatives that will help the farmer maintain a viable cash income. The challenge as I see it is to balance the peculiar needs of individual farmers and groups of farmers with the national objective of reducing offsite costs of land degradation, such as river dredging, which is costing the Fiji government some F\$4 million per year.

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