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DISASTERS AND AGRICULTURE IN THE PACIFIC ISLANDS

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Prepared by Andrew M McGregor with Ian K L McGregor for the South Pacific Disaster Reduction Prograrrune (RAS/92/360) under consultancy arrangements with the UN Department for Economic and Social Affairs, New York

September 1999

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PREFACE

The Pacific island region is highly prone to natural disasters, especially cyclones, droughts and volcanic eruptions. These impose a heavy economic toll, diverting resources away from all forms of development. In a region so dependent on agriculture as the Pacific Islands, reducing exposure to and mitigating against the effects of natural disasters offers immediate and substantial benefits to the sustainable development of the region.

This report provides a detailed account of the inter-relationships between disasters and agricultural systems in four Pacific island countries: Fiji, Samoa< Tuvalu and Vanuatu. The authors note that traditional agricultural systems provided a high degree of food security. Although they have significantly changed over recent decades, many components of these systems remain in place, to varying degrees around the region. This continues to be an important mitigating force against the impact of disasters, as recent events in Samoa and Vanuatu have shown. The report argues that the impact of natural disasters on agriculture can be considerably reduced, first by better environmental management and, second, by finding ways to use traditional farming methods and adapt them to new uses, rather than the whole scale change to farming methods that has often been attempted in recent decades.

This report is one in the series of reports commissioned by the South Pacific Disaster Reduction Programme. The purpose behind these reports has been to increase awareness of the importance of disaster reduction for sustainable development in the Pacific region, and to demonstrate that there are practical ways to reduce the exposure of island economies and communities to natural hazards. The 1990s were designated by the United Nations General Assembly to be the International Decade for Natural Disaster Reduction. Reduction of disaster risks remains a priority for the United Nations system and for the South Pacific Applied Geoscience Commission (SOPAC), the regional organization which is now implementing the South Pacific Disaster Reduction Programme.

EXECUTIVE SUMMARY

The Pacific island region is a region of great diversity, in the size of the countries, their populations, resource endowments, the importance of agriculture, and environmental conditions. In almost all Pacific island countries, agriculture is an important, if not the most important, sector. The region's generally benign climate is punctuated by climatic extremes in the form of cyclones, floods and, more insidiously, droughts. These extremes of climate have far-reaching effects on land-use patterns and serious environmental consequences that require proper land use planning and watershed management.

This report comprises case studies of the impacts of disaster on agriculture, from four countries that are broadly representative of the range of physical and economic conditions in the region. Two case studies were selected from the large countries of Melanesia: Vanuatu and the Province of Kadavu in Fiji. The archipelago that comprises Vanuatu is one of the most cyclone prone areas in the Pacific yet, of all the island countries, Vanuatu is the most dependent on agriculture. Traditional disaster mitigation practices, together with the concerted national programme to encourage self-sufficiency, offer important lessons for the whole region. Kadavu, Fiji's southern-most province is relatively typical of Fiji's outer islands in that in recent years its population has declined and its agriculture has been considerably diversified and commercialised. As well as its high vulnerability to cyclones, Kadavu faces an environmental disaster, brought about by a combination of uncontrolled pigs, indiscriminate burning, and unsustainable cropping. Samoa, a typical Polynesian economy, was selected as a case study because apart from two severe cyclones this decade, Samoa provides a striking example of the incursion of a plant-borne disaster-taro blight, which destroyed the country's principal export and staple food. Samoa's economy has nevertheless performed better than any other in the region. Samoa thereby illustrates both the vulnerability of Pacific island economies to natural disasters and their resiliency to them. Atolls provide one of the harshest and most vulnerable environments on earth for agriculture. Tuvalu, an atoll state, provides the fourth case study for several reasons. This tiny independent country has experienced several severe cyclones over the last decade or so and has been at the forefront of the international campaign to highlight the plight of small island states in the face of sea level rise.

Pacific island societies evolved crops and developed cropping systems and other means to cope quite effectively with natural disasters. Although they have significantly changed over recent decades, many components of these systems remain in place, to varying degrees around the region. This continues to be an important mitigating force against the impact of disasters, as the Vanuatu and Samoa case studies show. The food security system in Samoan villages has proved remarkably robust, even though Samoan villages have a steady inflow of remittances at times of need. Samoa's capacity to quickly readjust after a series of catastrophic disasters in the early 1990s is testimony to the hidden strength that lies with the traditional food production system. In Vanuatu, as well, there is much to learn from traditional farming methods, such as planting timetables in determining strategic schedules for cash crops, and sequential harvesting techniques. Food preservation, which was central to traditional disaster mitigation in Vanuatu, offers modern income opportunities. There is good scope for adopting 'non-traditional' food preservation methods not only to provide for times of disaster but also to add dietary variety, create household income opportunities, and save household income.

In theory, economic development should reduce vulnerability to natural disasters. But if increased household income is accompanied by decreased food security, then vulnerability to disaster increases, as the Kadavu study demonstrates. An agriculturally affluent community, Kadavu maintains a strong subsistence base and can produce highly remunerative cash crops. The core of the island's traditional food security was yam, a disaster-resistant crop especially when planted in the traditional manner. Now people depend heavily on a single non-food crop, yaqona, which is susceptible to cyclone damage. Crops that provided food security at times of disaster are now rarely planted.

Agricultural development in Pacific island countries has brought with it some degree of environmental degradation, and thereby increased vulnerability to disasters. This is evident in Fiji where cash cropping of ginger and sugar has extended to steep sloping land without any soil conservation efforts. In recent decades, communities throughout the region have become increasingly dependent on government for food relief after cyclones. They have become more vulnerable to disasters because of their increasing

dependence on cash to obtain food, the decline in importance of traditional food crops, the virtual disappearance of traditional food preservation; and the virtual disappearance of village-owned sea-going transport. In some places, the growing dependence on government has coincided with a decline in the government's ability to deliver services to rural areas.

Food and crop losses to natural disasters are often over-estimated. While there is no doubt that cyclones, droughts or floods can inflict enormous damage on the agricultural sector, production often recovers quickly. Cyclones have also had surprisingly little effect on cropping patterns. Biological disasters are even more threatening to Pacific island countries, for their impact remains on-going and open-ended. In Samoa, for example, taro production may never be restored to its pre-blight levels. Other forms of biological disaster include coffee-rust in Papua New Guinea and fruit fly incursions throughout the region. Environmental disasters also pose a very serious threat to Pacific island agriculture, for these disasters tend to be longer-term and more insidious. Furthermore, the impact of environmental disasters is often correlated with and accentuates other natural disasters. Far too little has been done to quantify the economic impact of environmental disasters and identify ways in which they contribute to natural disasters.

1. DISASTERS AND PACIFIC ISLAND AGRICULTURE

THE PACIFIC ISLAND REGION

The Pacific island region encompasses a vast area of the world's globe, stretching from the Commonwealth of Northern Mariana Islands (20"N) in the north; to Irian Jaya and Palau (135^0 E) in the west; Easter Island (110^0 W) in the east; and New Caledonia and Tonga (25^0 S) in the south. Excluding Easter Island, Irian Jaya and Hawai'i, which are incorporated provinces or states of nations outside the Pacific island region, there are 22 discreet political entities in the Pacific island region, among them some of the world's smallest countries (Map 1). There is great diversity in the size of these countries, their populations, resource endowments, the importance of agriculture, and environmental conditions (Table 1). For the outside analyst, the category of the Pacific islands sub-region may be useful for purposes of classification. It is, however, of little use in explaining vulnerability to, or ability to cope with disasters. Countries like Tuvalu and Papua New Guinea have little in common other than their approximate location on the globe. Tuvalu is a small atoll country with a population of 10,000 people and a land area of a mere 26 sq. km. Papua New Guinea has a population of 4.5 million, a land area of some 460,000 sq. km, and vast endowments of arable land, forests, and minerals. The other Pacific island countries run the range between these extremes. Because of the disparities within the region it is often necessary to discuss Pacific island countries individually. They can however be categorised into four groups, based on their size, resource endowments, and the importance of the agricultural sector.

1. The relatively large countries of Melanesia: Papua New Guinea, Fiji, Solomon Islands, New Caledonia, and Vanuatu.

These countries have the best natural resources, including over 90 per cent of the region's land and around 85 per cent of the population. The western Melanesian countries--Papua New Guinea, Solomon Islands, and Vanuatu-are agrarian societies in which agriculture provides by far the largest source of employment and household income. Almost three quarters of Papua New Guinea's work force is engaged in subsistence agriculture. In Vanuatu and Solomon Islands, some 80 per cent of the population live in rural areas. Despite their rich resource endowments, these three countries rank low on the UN Human Development Index (HDI): Solomon Islands (122); Vanuatu (124); and Papua New Guinea (128). The Fiji economy is more diversified and a larger proportion of the population lives in urban areas. Even so, the sugar industry remains the largest net foreign exchange earner and biggest employer of labour, and subsistence agriculture contributes an equivalent amount to GDP as sugar. The level of human development is higher in Fiji than in the countries of western Melanesia, with higher per capita incomes, life expectancy, and literacy levels, and a HDI ranking of 46. Fiji might therefore be better able to cope with disasters than other countries in this group. The main environmental problems faced by the Melanesian countries are those of land degradation, deforestation, pollution from mining, and, apart from Fiji, rapid population growth; problems which increase vulnerability to natural disasters.

2. The middle-level countries of Polynesia: Tonga and Samoa.

Although these countries have more modest land resources, they are amongst the best performing economies in the region and have high levels of human development. Tonga's economic growth has been led by agricultural diversification, with the development of export crops of vanilla, squash and, most recently, kava. In Samoa, taro was the lead export sector until the industry was decimated in 1993 by taro leaf blight. Samoa nevertheless continues to enjoy a high level of domestic food security. These countries have slow population growth but high levels of remittances from expatriate communities in Pacific rim countries. Their main environmental problems are the loss of their limited native forest resources and pollution of ground water.

3. Resource poor, predominately atoll states: Cook Islands, Kiribati, Tuvalu, Federated States of Micronesia, Marshall Islands, Niue, Palau, and Tokelau.

These are amongst the tiniest nations on earth, yet some are spread over vast areas of ocean. Kiribati covers an area equivalent to the continental United

States. These countries have very limited terrestrial resources but vast marine resources. Some earn meagre, but important, cash income from copra. Others earn valuable foreign exchange from diversified agricultural exports, notably Cook Islands from papaya, Niue from taro, and Kiribati from seaweed. Overall, agriculture contributes most to subsistence and thus the survival of these countries. The level of human development varies from very high in Palau, Niue, Cook Islands and Tuvalu, to moderate in the other countries. Environmental problems facing these countries include sea level rise, coastal erosion and, in some, rapid population growth, factors that make these tiny states highly vulnerable to disasters.

4. Countries where agriculture is of little importance: Nauru, American Samoa, Guam, and the Commonwealth of Northern Marianas

Because of the insignificance of the agricultural sector in these countries, they are not included in this study.

THE VULNERABILITY OF AGRICULTURE TO NATURAL DISASTERS

A number of studies have indicated the relatively high level of vulnerability of Pacific island countries to natural disasters. Factors contributing to this vulnerability are:

- the high impact of disasters proportionate to the size of the country;
- fragile island environments;
- scattered and isolated communities;
- urbanisation and population concentrations; and
- the degradation of traditional coping measures [1].

To this list could be added

- Increasing environmental degradation.

Evidence of the impact of natural disasters on these economies can be gleaned from macro-economic indicators such as GDP growth following major cyclones. For example, for several years after Cyclone Uma in 1987, Vanuatu experienced a real growth rate of -9 per cent. In Samoa, the twin cyclones of Ofa and Val led to real growth rates of -7.5 per cent, 27.9 per cent, and -4.3 per cent in 1990, 1991, and 1992 respectively. In Fiji, Benson (1997:59) concluded that severe natural disasters have caused substantial declines in GDP growth.

Yet there remains a surprising resiliency in these small economies to natural disasters, particularly cyclones. Nowhere is this more evident than in Samoa. In the space of five years, Samoa experienced two '100 year' cyclones and the loss, through disease, of the country's most important staple food and main export earner. For most countries this would be a disaster of catastrophic proportions. The equivalent, perhaps, of a disease that eliminated most of Thailand's rice crop, or the potato blight in Ireland last century. Yet Samoa experienced no famine, export levels have been restored and economic activity is now buoyant, with real GDP growing 6.7 percent in 1996, being by far the best performance of any Pacific island country. The Samoan experience is testimony to the 'hidden strength' of the seemingly weak Pacific island economies that lies with their traditional food production systems.

In examining the vulnerability of agriculture, this study considers three broad categories of natural disasters:

1. volcanic eruptions;
2. Biological disasters; especially the incursion of agricultural pests and diseases; and
3. Environmental disasters.

Physical natural disasters

The Pacific region's generally benign climate is punctuated by climatic extremes in the form of cyclones, floods and, more insidiously, drought. These extremes of climate have far-reaching effects on land-use patterns, and serious environmental consequences that require proper land use planning and watershed management. Chung (1996) summarised the physical hazards affecting the region's agricultural sector (Table 2). Those with widest impact are cyclones, floods, and droughts. In some locations, tsunami, landslides, volcanic eruptions, and frosts are significant hazards

[1] *UNDHA, 1994:8*

Table 1: *A summary of Pacific island countries and territories*

Country! Territory	**Political status**	Land area **(sq.km)**	**Population (1997 est.)**	**Geographic type**	**Importance of agricultural sector**	**Main environmental issues**
American Samoa	Unincorporated US territory	240	61,100	High islands with a few atolls	Limited. Some subsistence and a little market gardening.	Little subsistence base and environmental problems associated with urbanisation
Cook Islands	Self-governing in free association with New Zealand	180	19,000	High islands and atolls "	Considerable. Main export earner. Subsistence is a significant component of GDP.	Sea level rise and coastal erosion.
Federated States of Micronesia	Self-governing in free association with US	702	111,800	High islands with a few atolls	Some. Small export earnings, some domestic cash income and some subsistence.	Deforestation, land degradation, sea level rise, and coastal erosion.
Fiji Islands	Independent state	18,376	779,200	High islands and atolls	Fundamental. Main employer and net foreign earner. Subsistence provides a significant proportion of GDP.	Land degradation, over-exploitation of resources, urban pollution and associated problems with urbanisation.
French Polynesia	Overseas territory of France	3,521	222,300	High island	Some. Small export earnings, domestic cash income and subsistence.	Marine pollution, sea level rise, and coastal erosion.
Guam	Unincorporated US territory	549	145,400	Predominately atolls	Limited. Some market gardening and a little subsistence.	Little subsistence base and environmental problems associated with urbanisation.
Kiribati	Independent state	726	83,400	Atolls	Considerable, especially for subsistence. Copra important for outer island cash income and some foreign	Sea level rise, high population density and growth. On main atolls, coastal erosion and lagoon pollution.
Marshall Islands	Self-governing republic in free association with the US	720	60,000	Raised coral island	Limited. Some subsistence and cash earned from copra.	Sea level rise, coastal erosion and lagoon pollution; problems associated with , population density and growth; and effects of nuclear testing.
Nauru	Independent state	21	11,200	High island	Insignificant.	Complete loss of arable land and subsistence base.
New Caledonia	Overseas territory of France	19,103	201,300	**Geographic type**	Important, particularly in the south.	Land degradation, pollution from mining and problems associated with urbanisation.

Table 1 ... *cont'd*

Country! Territory	**Political status**	**Land area (sq.km)**	**Population (1997 est.**	Raised coral island	**Importance of agricultural sector**	**Main environmental issues**
Niue	Self-governing in free association with New Zealand	258	2,100	High islands and atolls	Significant subsistence and some root crop exports.	Loss of forests.
Palau	Self-governing republic in free association with the US	475	18,100	High islands with a few atolls	Some subsistence.	Sea level rise and coastal erosion.
Papua New Guinea	Independent state	461,690	4,311,500	High islands with a few atolls	Fundamental. Main source of employment, provides a large part of net export earnings, and subsistence provides most of GDP.	Unsustainable forestry development, land and water pollution from mining, fast growth and problems associated with urbanisation.
Solomon Islands	Independent state	29,785	401,100	Atolls	Fundamental. Main source of employment, provides most net export earnings, and subsistence is a significant part of GDP.	Unsustainable forestry development and fast population growth .
Tokelau	Dependency of New Zealand	12	1,500	High islands with a few atolls	Some subsistence.	Sea level rise and coastal erosion.
Tonga	Independent kingdom	696	97,800	Atolls	Fundamental. Economic growth led by agriculture.	Agricultural and lagoon pollution, over-exploitation of marine resources.
Tuvalu	Independent state	26	10,900	High islands and atolls	Subsistence with some cash income from copra.	Sea level rise and coastal erosion, and high population density and growth on Funafuti.
Wallis and Futuna	Overseas territory of France	255	14,200	High islands with a few atolls	Some subsistence.	Marine pollution, sea level rise, and coastal erosion.
Vanuatu	Independent state	12,189	177,200	High islands	Fundamental. Main source of employment, provides most net export earnings, and subsistence is a significant part of GDP.	Deforestation, population growth, and problems associated with rapid urbanisation.
Samoa	Independent state	2,934	170,700		Fundamental. Subsistence is the strength of the economy.	Deforestation, pollution of water supply, over-exploitation of limited marine resources.
		960,436	6,684,300			

Map 1: The Pacific region.

Table 2: The vulnerability of Pacific island countries to natural disasters.

Country	Cyclones	River flooding	Tsunami	Earth-quakes	Land-slides	Drought	Frost	Volcanic eruption	Coastal flooding
Cook Is.	M	M	M	L	L	H	-	-	M
FSM	M	L	H	L	H	H	-	-	H
Fiji Islands	H	H	H	M	H	H	-	-	H
Kiribati	L	-	L	L	-	H	-	-	H
Marshall Islands	M	-	L	L	L	M	-	-	H
Niue	M	-	L	M	L	H	-	-	L
Palau	M	-	H	L	-	M	-	-	H
PNG	L	H	H	H	H	M	H	H	H
Solomon Islands	M	H	H	H	H	L	-	H	H
Tokelau	M	-	L	L	L	H	-	-	H
Tonga	H	M	H	M	L	H	-	M	M
Tuvalu	M	-	-	L	-	H	-	-	H
Vanuatu	H	H	H	H	H	M	-	H	H
Samoa	M	H	H	M	H	L	-	L	H

Risk Ranking: L = Low; M = Medium; H = High; non-existent

Derived from Chung 1996

Cyclones

Cyclones are the most prominent and widespread form of natural disaster, affecting all parts of the region except the highlands of Papua New Guinea. The main hurricane season is from November to March but major cyclones have occurred as early as October (Cyclone Oscar in Fiji 1982) and as late as June (Cyclone Keli in Tuvalu, 1997). Data for the last 150 years indicate that cyclones are more frequent in the island groups to the west--Fiji and Vanuatu- than they are for island groups to the east--Samoa and Tonga.

In the Fiji group, 136 cyclones were recorded between 1880 and 1997, and a similar number in the Vanuatu archipelago. The magnitude of the damage depends on the storm's intensity and path. Damage to crops and vegetation tends to increase exponentially with wind speed; for example, 180km/hr winds are four times stronger than 90km/hr winds. The rapid upward spiralling air in a cyclone can cause extremely heavy rain, particularly when the system is forced to rise over mountains. Low atmospheric pressure during tropical storms can raise the sea as much as 2 metres, causing engulfment of low-lying areas and considerable foreshore damage. Cyclones can also cause substantial loss of soil and vegetation with particular damage to foreshores and coral reefs, and less direct, more insidious, losses through pests and diseases that sometimes follow major cyclones.

There is a perception that in recent times there has been increasing and unprecedented cyclone activity. This is likely to continue as global warming increasingly affects weather patterns. But there have been periods of intense cyclone activity before, such as in the 1870s in several parts of the region. What appears to have increased is vulnerability to cyclones. Losses of soil and vegetation have been accentuated in recent decades by the expansion of non - sustainable agricultural and logging practices. Human settlements have relocated from being predominantly inland to the coasts, where they are more exposed to storm surges. Traditional cropping patterns that mitigated against the impact of cyclones are often no longer maintained. Traditional food preservation, once a disaster mitigation strategy, has all but disappeared.

Volcanic eruptions

Melanesia is a part of the 'Pacific Rim of Fire,' and is therefore subjected to volcanic eruptions, earthquakes, and tsunami. The most recent eruption to devastate agriculture was in East New Britain where volcanic ash, followed by flooding and landslides, badly damaged a large part of Papua New Guinea's coconut and cocoa industry. In Vanuatu, periodic volcanic eruptions cause big losses to subsistence and cash crops, but they are also beneficial in that Vanuatu has the richest soil and highest percentage of arable land of any Pacific island country, from millennia of volcanic ash-falls.

River flooding

This is common on the larger islands of Papua New Guinea, Fiji, and Solomon Islands. Severe river floods usually occur with cyclones, as occurred in Fiji with Cyclones Wally (1980) and Kina (1993). On average more than 60 per cent of the rain that falls on Viti Levu is discharged into the river systems, most ending up in the four main river systems and being discharged into the sea[2]. The correlation between rainfall and discharge would be higher during extreme rainfall events. High run-off can cause significant erosion if the soil is even slightly destabilised.

Flooding causes heavy and immediate crop losses as well as more insidious problems of erosion, siltation and soil nutrient loss causing damage to coastal ecosystems. Land-use practices adopted by commercial agriculture and logging have accentuated these problems. Flooding has considerable consequences as most river valleys and flat coastal areas are intensively cultivated and populated. An estimated 21,700 ha was flooded after Cyclone Kina, coming from four watersheds[3]. Around five per cent of Fiji's population, or 38,900 people, were directly affected. Fortunately the human disease problems associated with prolonged flooding of large delta systems, such as happens in south-east Asia, does not occur in the larger Pacific islands. Here the river systems rise and fall equally quickly. For example, in Fiji during Cyclone Kina in 1992, some 900mm. of rainfall fell in the interior of Viti Levu in 24 hours. The Sigatoka River, Fiji's largest, rose above 40 feet within 24 hours, sufficient to wash away a major bridge, but within another 24 hours was almost back to its normal wet season level.

Landslides

Landslides associated with river flooding land have

[2] *Mudgway, 1997:6.*
[3] *JICA 1997:8-9.*

Serious and direct local impact on food crops, while siltation and debris cause wider damage to agriculture. This happened after Cyclone Wally in 1980, when landslides caused large-scale sedimentation of the Rewa and Navua Rivers. Landslides are often natural phenomena but they can be induced or accentuated by poor land use practices. Widespread landslides in the interior of Viti Levu after Cyclone Wally can be partly attributed to poor logging practices in the Nadi, Ba, and Sigatoka catchment areas. The greatest incidence of landslides in Viti Levu occurs on the margins of farmland.[4] Pohnpei, in the Federated States of Micronesia, provides a further recent example of the interrelation between poor agricultural land use; the large scale clearing of upland forest to plant *sakau* (kava) resulted in massive landslides after a severe cyclone in 1997, causing the loss of some dozen lives.

Drought

Agricultural drought is defined as a reduction in moisture availability below the optimum level required by a crop during different stages of its growth cycle resulting in impaired growth and reduced yield[5]. Droughts occur throughout the region, but particularly on atolls and the leeward side of larger, volcanic islands. Most parts of the region have a normal dry season drought (May to October) which cropping patterns have adjusted to and depend on. In some years, the dry season can be pronounced and extended, putting agricultural activities under severe pressure. This occurred in 1978 and 1983 in Vanuatu; 1971 and 1989 in Samoa; 1987, 1992, and 1997-8 in Fiji; and 1941, 1972, 1987, and 1997 in Papua New Guinea. The 1986-87, and particularly the 1997-98, droughts in Fiji were amongst the worst in this century. The former began in the dry season and extended through the dry season, and the latter began in the wet season and continued in the dry season. The current Papua New Guinea drought is comparable to the catastrophic one in 1941. A compounding and increasing problem is uncontrolled fires. In the Papua New Guinea highlands, severe drought is also associated with damaging frost.

There is an evident correlation between severe drought in the Pacific and the EI Nino Southern Oscillation (ENSO). From his study of historical evidence for past ENSO events, Brookfield (1989) found that Indonesia had records of major and catastrophic droughts dating back to the 1600s which were likely to have been ENSO induced events. Benson reports that the 1987 and 1992 droughts in Fiji were associated with ENSO episodes[6]. From Papua New Guinea data dating from 1888, Allen reported that drought or frost and forest fires occurred in 1902, 1914, 1941, 1972, 1987, and 1997[7]. He concluded that, "the statistical association between measures of ENSO severity and the physical impact of these in terms of drought and frost is reasonable, but by no means perfect."

The whole of western Melanesia was in the grip of an extreme ENSO induced drought throughout most of 1997-98, with Papua New Guinea and Fiji especially affected. This drought was the worst, most widespread natural disaster that Papua New Guinea had experienced. Rainfall was below average in April 1997, and well below average for the rest of the year. The drought was compounded in the highlands by unusually cold frosts. Assessments by the Australian Government and NGOs in October and December 1997 identified the Gulf, Western Highlands, Chimbu, and Milne Bay Provinces as worst affected, with some 500,000 people at risk[8]. The assessment team reported:

- Severe food shortages: In the highland provinces above 2,200 metres, the staple food--sweet potato *(kaukau)--had* been completely eliminated by frosts that began in early June. These areas had no food remaining in the ground. Fires had substantially reduced the remaining bush food. There were also heavy losses to coffee, the main cash crop. Many people had, in traditional fashion, migrated to lower frost-free areas. But these places could not accommodate the migrants to the extent they had in the past because they, too, were affected by drought and the population in these receiving areas had doubled in the past 30 years.
- Critical water shortages: At the end of December 1997 an estimated 260,000 people lacked access to fresh water. Key institutions such as hospitals, health centres, aid posts and schools had therefore closed.
- Health problems: There was a marked increase in diarrhoea, skin and eye infections, malaria and other diseases. Some deaths had been attributed

[4] *JICA 1997:5-15.*
[5] *Glantz, 1987*
[6] *Benson, 1997*
[7] *Allen, 1997:25.*
[8] *Braumann, 1998*

to the drought but exact numbers were not determined.

The severity of the recent Fiji drought was reflected in the introduction to Fiji's current Strategic Plan, to quote:

Another key challenge facing the nation in the short to medium term is the recovery from the 1997/98 El Nino induced drought. This "100 year" event is probably the worst natural disaster the country has ever experienced. Sugar production in 1998 will be more than halved, but is expected to improve in 1999. The drought has also impacted on food production to an unprecedented extent. As a primary consequence of this drought, real GDP is estimated to contract by 3.9 percent in 1998. This drought will continue to adversely affect the economy for several years. It will not be until 2000, at the earliest, that sugar production could return to normal levels. Likewise copra production, which was gradually beginning to show some encouraging signs of reversing the downward trend of the last few decades will take several years to improve. Some specialty export crops will also be severely set back. The production of kava, emerging as a major export earner, will take at least three years to recover. The rehabilitation of food crops will be quicker once there is adequate rainfall, although serious shortages of planting material can be expected. The long-term economic impact of this disaster will be substantial. A guide to the order of magnitude of this impact is shown from a statistical model that estimated that real growth in the economy over the period 19821994 was halved due to the impact of natural disasters (cyclones and droughts). The severity of the 1997-98 drought is far beyond any event that occurred over the period of this analysis.[9]

Biological disasters

The introduction of a pest or disease can cause a far greater long-term disaster than a cyclone or a volcanic eruption. A cyclone may last anywhere from several hours to several days but has a discrete end, after which relief and rehabilitation begin. A drought can last much longer, but is eventually broken. The impact of an incursion of a major pest or disease, by comparison, is open-ended and may never end. There are also social costs resulting from lost livelihoods and environmental costs associated with control programs. Recent examples of devastating biological disasters in the Pacific region are:

- Introduction of taro leaf blight in Samoa, causing the loss of the main staple and export earner;
- Incursion of coffee rust in Papua New Guinea in the mid-1980s, the control of which required a large investment of industry, government, and aid funds;
- Entry of melon fly into the Solomon Islands, making it difficult to grow any member of the *cucurbit* family;
- Incursion of yellow zucchini mosaic virus and watermelon one virus into Samoa and western Viti Levu in Fiji, making it difficult to commercially grow *cucurbits* such as watermelon;
- Establishment of the papuana beetle on Viti Levu in Fiji and Efate in Vanuatu, thereby excluding growers from lucrative export markets; and,
- Arrival of spiralling white fly in the Cook Islands. Recent examples from the periphery of the South Pacific are:
- the near collapse of the $US20 million Hawaiian papaya industry due to papaya ring spot virus; and,
- Incursions in 1995 of papaya fruit fly *(Bactrocera papayae)* into Queensland through the Torres Straits Islands, causing losses of markets in Japan, New Zealand, and southern Australia costing an estimated $A115 million in the first year. An eradication program now mounted will cost $A55 million over 5 years (Drew 1997:205).

The impacts of these disasters on agriculture and on Pacific island economies, have been, on balance, far worse than any physical disasters, such as cyclones, as the case studies here demonstrate. There is also an inter-relationship between physical and biological disasters. Cyclones can disrupt delicate ecological balances and lead to the proliferation of pests or disease. The rapid establishment of taro leaf blight in Samoa in 1993 may have been partly caused by the cyclones that struck there in 1990 and 1991.

Environmental disasters

Environmental disasters also have significant effects on agriculture in the Pacific islands. These may be externally induced, such as sea-level rise, or internally induced, such as indiscriminate burning, deforestation, unsustainable cropping patterns and

[9] *Fiji Ministry of Economic Planning, 1999*

the incursion of feral animals. These environmental disasters can greatly accentuate the impact of physical disasters such as cyclones or droughts. Pacific island countries contribute infinitesimally to the climate change to which sea-level rise is attributed. Atoll countries, in particular, being only a few metres above sea level, will bear a vastly disproportional share of the consequences. In Tuvalu where no island rises above five metres, a sea-level rise of the highest predicted range could cause the complete disappearance of most islands. Even the lowest predicted level would cause some land loss and turn much of the agricultural land into brackish swamps.

Traditional Pacific island agricultural systems were highly sustainable. In Vanuatu, except on Aneityum, agricultural activities have contributed little to soil erosion and degradation, despite the cultivation of steep land on some islands. This is because of the generally discontinuous nature of cultivation, the small population relative to arable land, the small size of gardens, and the minimum tillage practices adopted. Forests were an integral part of the food security systems and protected gardens from drought and cyclones. Crops were grown in rotation with a long fallow period and without chemicals. In most places domestic pigs were an important part of the system, but social controls meant they were always fenced. The break-down throughout the Pacific region of such traditional systems and controls have had repercussions on sustainable food security and the ability of island communities to cope with disasters. This breakdown is associated with environmental degradation.

In Fiji, for example, land degradation is serious and increasing, despite greater environmental awareness. Widespread and indiscriminate burning itself constitutes a national disaster. In the 1950s, a Soil Conservation Officer described the damage done to soil by indiscriminate burning, and how this accentuated the impact of cyclones and drought:

The destruction by fire of the vegetable cover, which is the grass with its attendant dead litter, exposes the soil to strong winds, scorching sun, and pelting rains. The wind more often than not blows the residue of light ash away, and, if very strong, the fine soil particles as well. The scorching sun creates terrific soil temperatures, which rapidly oxidise out the organic content of the vital few inches of topsoil. Such soil bared and deprived of its humic content, cannot absorb and hold pelting rain which soon seals off the soil pores (air spaces between particles) at the surface, and with a velocity proportionate to the slope of the land, runs towards the first creek or gully, carrying with it all those fine soil particles which were formerly held in a sponge-like structure of a once healthy soil[10].

No effective legal sanctions have replaced traditional or colonial controls. For some villages in western Viti Levu this has meant the loss of food gardens within reasonable proximity. On some smaller islands, fire combined with over-grazing by goats is a devastating combination. Farming on steep slopes causes serious soil erosion in ginger and root crop areas and on marginal sugar-growing land, making these areas ever more vulnerable to cyclones and drought. Increasing areas of Fiji's land are becoming obsolete for agriculture. Land degradation is not a new problem. The eminent geographer, Professor Oscar Spate, reporting in 1959 to the Legislative Council, noted, "I have seen some classical areas of erosion in India, Australia and New Caledonia, but I do not think I have seen sheet erosion of such intensity as in parts of the hinterland of Nadi and Lautoka." Drysdale, in a paper presented to the Land Conservation Board entitled 'Soil Conservation the Hidden Disaster,' reported that 15,000 ha of cane land on Viti Levu was officially identified as needing urgent soil conservation work; of it some 6,500 ha was now obsolete for cane or any other arable agriculture[11]. The cost of this land degradation in terms of lost sugar production and increased fertiliser input has been conservatively estimated at $F16 million a year.[12]

In the 1950s, Whitehead described the causes of perennial fires in Fiji which "can be seen each dry season sweeping from range to range like a maddened *tevoro* (devil)" to be:

- The carelessly handeled firestick;
- The uncontrolled burning of dry pastures just prior to expected storms for the production of green shoots for goats and stock;
- The clearing of areas for wild yams
- The willful abandonment of small fires started to smoke out wild pigs from reeds;
- The careless clearing of *teitei* areas by fire;
- The lack of control exercised on large

holdings in the “renovation” of pastures by fire;

[10] *Whitehead, 1952*
[11] *Drysdale, 1994:3*
[12] *Nisha 1997:15*

- the natural agents of lightning and light rays in focus through quartz crystals or even glass bottles; or
- arson--intentional or otherwise.

All the above causes apply today, with the situation made worse by the decay of traditional and regulatory controls that prevailed in the past.

The increasing incidence of unsustainable cropping practices is increasing vulnerability to disasters, as the case studies here demonstrate. In Kadavu, larger planting of kava has involved forest clear-felling, reducing the habitat for yams and other wild 'food bank' crops. The cutting of trees with chain saws, instead of the traditional way of girdling them so they decay slowly, leads to much higher rates of soil loss and erosion. In Samoa, in the years prior to the arrival of taro blight, 2,400 ha of forest were being cleared each year to plant taro. Vanuatu has retained a viable resource base of wild yams, critical to food security in times of natural disaster, but even here this resource is under threat from loss of habitat, poaching, burning and animal damage. In the outer islands of Fiji and Tonga, pigs--particularly in combination with burning--are an ecological disaster for which urgent mitigation measures are needed. The activities of wild and domestic pigs are a greater threat to food security than cyclones.

THE SELECTION OF CASE STUDIES

In almost all Pacific island countries, agriculture is an important, if not the most important, sector. All, too, in varying degrees, are adversely affected by disasters. As it was not possible here to cover each country in detail, this report centres on four detailed case studies to guide policy development for the region. Two case studies were selected from the large countries of Melanesia: Vanuatu and the Province of Kadavu in Fiji. In 1998, Papua New Guinea was still experiencing a catastrophic drought and it could be considered a serious omission that this was not included as a case study. However the extent of neither the Papua New Guinea nor the Fiji drought was apparent when this study was being undertaken and later there were not sufficient resources to add them to this report. Some reference is nevertheless made to recent published reports on these droughts. A follow-up study of the drought in Papua New Guinea and other parts of Melanesia is recommended. One on the Fiji drought is underway and will be published separately.

Vanuatu was selected as a case study from western Melanesia for several reasons. The archipelago that comprises Vanuatu is one of the most cyclone prone areas in the Pacific and some islands are also subject to volcanic activity. Of all the island countries, Vanuatu is most dependent on agriculture. People on some islands also continue traditional disaster mitigation practices, including food preservation. These and the concerted national program to encourage self-sufficiency in disaster mitigation, offer important lessons for the whole region

More has been written about the impacts of natural disasters--specifically cyclones--in Fiji than in any other Pacific country, including recent comprehensive studies by Benson (1996) and Fairbairn (1997). It has been 20 years, however, since there was an investigation of the impact of natural disasters on rural Fiji, the last being Brookfield's 1977 study of eastern Fiji. Kadavu, Fiji's southern-most province was selected as a location for a rural Fiji case study for various reasons. It is relatively typical of Fiji's outer islands in that over the past decade or so, its population has declined and its agriculture has been considerably diversified and commercialised. Kadavu is one of the islands most prone to cyclones. As well, as in most of Fiji's outer islands, an insidious environmental disaster involving a combination of uncontrolled pigs, indiscriminate burning and unsustainable cropping patterns is at play there.

Samoa was selected as a case study because it is a typical Polynesian economy, reliant on migration, remittances, aid, and bureaucracy-supported employment, and with imports far exceeding exports. Apart from its recent cyclones, Samoa provides the most striking example of the incursion of a plant-borne disaster. Even so, Samoa's economy has performed better than any other in the region, and thereby illustrates both the vulnerability of Pacific island economies to natural disasters and their resiliency to them.

For agriculture, atolls provide one of the harshest and most vulnerable environments on earth. Tuvalu was selected for the atoll country case study for several reasons. This tiny independent country has experienced several severe cyclones over the last decade or so and has been at the forefront of the international campaign to highlight the plight of small island states in the face of sea level rise. Despite its size, Tuvalu stresses self-reliance in its economic development.

2. DISASTERS AND AGRICULTURE IN POLYNESIA: THE CASE STUDY OF SAMOA

THE GEOGRAPHY AND ECONOMY OF SAMOA: A BRIEF SKETCH

Samoa is about 3,700 km south-east of Hawaii and 2,900 km north-west of Auckland. The resident population numbers around 165,000 while another 100,000 or so Samoans reside in New Zealand, Australia, and the United States. Unlike most other Pacific island countries, Samoa is geographically concentrated. It consists of two large islands, Upolu and Savai'i, and several smaller ones, which total an area of little less than 3,000 sq. km (Map 2).

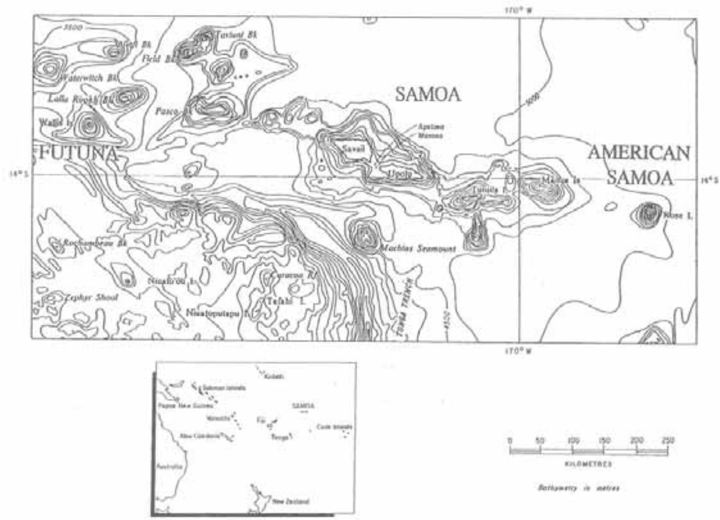
The islands are distinctive in that they were formed from relatively recent lava flows, the most recent occurring on Savai'i early this century. Both Upolu and Savai'i have central cores of volcanic peaks at elevations over 1,000 metres; on Upolu they form an east-west chain, surrounded by lower hills and coastal plains. Both islands slope relatively easily down from these central ridges but about 51 per cent of the land is of little use for agriculture because it is on steep slopes or poorly drained. In places the surface is quite rocky, particularly on the more recent lava flows, but weathered volcanic soils tend to be fertile, if low in phosphorus, and very suitable for root crop production. Rainfall varies from 2,300 mm to 5,000 mm, but north-western parts of both islands have a long dry season between May to October in which soil moisture deficits occur.

Samoa's location between 10° and 15° north and 170° and 175° west put it on the border of the cyclone belt, and cyclones are relatively infrequent. The few that have struck in recent years, however, have been particularly severe. Cyclone Of a, which struck in February 1990, was a slow moving cyclone, with wind speeds reaching 200 km. per hour on the north and east coasts of both islands. At that time, it was reputed to be comparable to the "great" cyclone of 1889, and caused damage to crops and infrastructure estimated at $US140 million[13]. In December 1992, 22 months later, Cyclone Val struck an even more severe cyclone and the most destructive to strike Samoa in the last 100 years[14]. As well as having winds of up to 240 km., the system moved slowly and erratically, lingering around Samoa for four days which greatly magnified its impact. It changed direction several times, moving northward after nearing Savai'i, passing over Upolu in a south-east direction, then remaining virtually stationary over Upolu for at least six hours.

GDP per capita in Samoa is around $WS2, 700 (US$l, l00), which places the country in the upper range of the low-income group of developing countries. Economic life is dominated by agriculture which contributes around 40 per cent to GDP, with government administration and tourism next in importance. A feature of Samoa's economy is the large contribution from subsistence production, which mainly takes place within the extensive rural village sector. This contributes greatly to the resiliency of the Samoan economy and its food security. Until recently, exports were dominated by taro sold to expatriate Samoans. In 1993, however, a fungal disease, taro leaf blight *(Phytophthora colocasiae)* decimated the industry. Leading exports are now coconut oil, coconut cream and automotive car components. Remittance transfers from extended family members overseas-estimated at $450 (US$180) per capita-are a major source of personal income and foreign exchange. Samoa, like other Pacific island countries, is a major aid recipient, annual grant aid alone equaling around $360 (US$150) per capita.

Samoa is an appropriate case study for, on one hand, it is a typical Polynesian economy, reliant on migration, remittances, aid, and bureaucracy supported employment. On the other hand, it has a strong subsistence base that has stood up to two major cyclones and a devastating disease to taro. Samoa provides a striking example of the incursion of a plant disease as a disaster. Furthermore, over the last few years the Samoan economy has performed better than any other Pacific island country even though it arguably has been the one most affected by disasters. Samoa thus illustrates both the vulnerability of Pacific island economies to natural disasters and their resiliency to these events.

[13] ADB, 1991: 270; ADB, 1992
[14] National Disaster Council 1992: 1



SAMOA
AMERICAN SAMOA
FUTUNA
Waterwitch Bk
Wallis Is
Pasco
Savaii
Upolu
Apolima
Manono
Tutuila I.
Rose I.
Machias Seamount
Rochambeau Bk
Zephyr Shoal
Tafahi I.
170° W
14° S
0 50 100 150 200 250
KILOMETRES
Bathymetry in metres
Solomon Islands
Papua New Guinea
SAMOA
Fiji
Tonga
Cook Islands
Australia
New Zealand

Map 2: Samoa.

Table 3: Household crop production by purpose of production.

Crop	Entirely for home consumption (%)	For home consumption and sale (%)	Predominately for sale (%)
Coconuts	52	43	5
Taro	62	35	3
Cocoa	71	25	4
Banana	87	12	1
Giant taro (*ta'amu*)	79	19	2
Yam	88	11	1
Kava	59	22	19

Source: GOWS/FAO 1990

THE AGRICULTURAL ENVIRONMENT

Samoa is a highly agricultural society and economy. According to the last population census (1989), more than 70 per cent of the economically active populations of 55,967 were employed in agriculture, fishing, and forestry. Around 72 per cent of 15,474 rural households are active to some degree in agriculture, mainly producing for home consumption (Table 3). Commercial agricultural production, including coconut products, cocoa and taro accounted for 14 per cent of GDP in 1994.

Samoa has slowly transformed its agricultural production base to various forms of market integration without losing the integrity of its subsistence base. A crucial aspect of food security in Samoa has been the maintenance of its customary land tenure system and the closely linked "mataiaiga" socio-cultural tradition, through which about 81 per cent of the land is held under customary tenure. This is central to the economic and cultural structure of Samoa. More progressive changes in the land tenure system have occurred through the informal assignment of tenure and inheritance rights to individuals. Overall, Samoa's land tenure system has provided relatively equitable access to land for food production. A recent FAO report concluded that that the most challenging food security issues facing the country are:

- sustaining domestic food production levels in line with food demands and market potential;
- increasing the productivity and returns to subsistence and commercial agriculture;
- the rising volume and prices of poor quality and nutritionally inferior food imports, and
- the narrow base of (predominantly) agricultural exports, and the existence of environmental degradation increasingly associated with poor resource management practices[15].

Foods produced for domestic consumption are mostly banana, coconut, breadfruit, taro and other root crops. There has been a rapid change from a diet based on traditional staple foods to one in which imported food features prominently. Fish capture is declining, and this loss of inshore marine resources has a negative impact on subsistence security in protein procurement. The threat to food security imposed by Samoa's marked trade imbalance has been mitigated against by the high level of remittances that flow from Samoan migrants abroad. This heavy reliance on remittances has also benefited domestic food security by reducing pressure to transform village agriculture systems and to use their resources for cash crops.

In the period 1988-1990, food crops comprised 82 per cent of the total food supply; livestock and fisheries contributing 16 and 2 per cent, respectively. Soon after, however, the composition, stability and reliability of food supply were affected by natural calamities, namely the disastrous cyclones Ofa (1990) and Val (1992) and taro leaf blight (1993). The supply of taro on the domestic market in June 1994 was 1 per cent of that available in June 1993. Yet FAO reports that by early 1995, rural households were producing adequate food crops for household subsistence, and the price of alternative food crops (bananas, giant taro, breadfruit, yams) on the domestic market had declined, as rural households began producing marketable surpluses. Responses to and recovery from the series of disasters suggest

[15]*FAO 1997*

that Samoans maintained subsistence security through rapid transformations in their cropping systems and diversification to other crops.

Samoa's generally rocky and steep landscape limits mechanisation, and the concomitant pressure for land consolidation. The distribution of village settlements along the coast exceeds the productive capacity of soils in these areas, particularly in more heavily populated parts of Upolu. Samoa has little left of its once large forest area mainly because it has been cleared for agriculture. The remaining forest is poor, degraded and mostly non-commercial. Much of land planted in taro during the export boom of the early 1990s was abandoned after the arrival of taro leaf blight. Some is now being used to grow kava.

Samoan agriculture is almost entirely small-holder based. Only 1 per cent of holdings are more than 40 ha., and 90 per cent are less than 8 ha., usually divided amongst several parcels.[16] Present land use is a blend of two farming systems where subsistence village cropping (taro, bananas, other root crops, mixed vegetable gardens and various minor crops) has had a plantation cropping system (coconuts, cocoa) imposed upon it since European contact. Intercropping is often practised, using various cultivars. Farrell and Ward (1962) described three zones of village land use; the structure of which remains essentially intact today:

- a zone of coconut, much of which is old and little managed, located immediately behind the coastal villages and extending inland;
- a mixed crop zone of cocoa, banana, taro, and minor crops and a variety of fallow land, inland from the coconut zone; and
- a zone of taro of plots and fallow extending from the mixed crop zone to the forest boundary.

Principal crops

Table 4 shows single crop equivalent areas for Samoa's major crops, derived from the last agricultural census (1989). There have been, however, quite dramatic changes in cropping patterns due to the cyclones of 1990 and 1991 and the arrival of taro leaf blight.

Taro *(Colocasia esculenta)* is Samoa's traditional subsistence staple. Samoa's soil and climate offer favourable conditions for taro, allowing it to be harvested in 7 months or less. The 1989 Agricultural Census indicated that nearly 15,000 hectares was planted in taro, of which 76 per cent was pure stand, 23 percent mixed stand (mainly with *ta'amu* and banana) and 1 per cent scattered plants. In the early 1990s, it was estimated that taro accounted for 39 per cent of Samoans' diet in Upolu and 43 per cent in Savai'i. It was also Samoa's major export earner and was being exported in ever-increasing quantities. Following cyclones Ofa and Val, planting of taro significantly increased to compensate for income lost from coconuts and cocoa. Deregulation of marketing also allowed farmers to take advantage of good market conditions. But the heavy dependence on one crop brought with it its own risk. By the end of 1994, the rapid spread of taro leaf blight had brought Samoa's subsistence and commercial taro industry to an abrupt halt. In the absence of effective controls, taro production had declined to almost negligible levels. While there has been some recovery in subsistence supplies, taro may never resume its position as Samoa's staple food crop.

Giant taro *(Alocasia macrorrhiza)* or *ta'amu* is traditionally the fourth most important staple, after taro, bananas, and breadfruit. It is often intercropped with taro or, in the drier areas, grown as a stand-alone crop. Ta'amu is both drought and cyclone resistant and is the most important reserve food. While it normally takes 18 to 24 months to reach maturity, an important food security attribute of *ta'amu* is that the tubers can be held in the ground up to four years. A long drought in 1989 led to a substantial depletion of *ta'amu* reserves and thus reserve stocks were low at the time cyclone Ofa struck in 1990.

Yams *(Dioscorea spp.)* and ***tapioca*** *(manihot esculentus)* are minor crops in Samoa. Traditionally, yams are consumed as a food supplement when available. Tapioca is regarded as a distinctly inferior food that is eaten at times of shortages but otherwise fed to pigs. There has, however, been a distinct increase in cassava consumption following the taro leaf blight.

Bananas *(Musa spp.)* have now replaced taro as Samoa's main subsistence crop. They are usually cooked green and eaten as a starch. In the early 1990s, they normally accounted for 23 per cent of food requirements in Upolu and 16 per cent in Savai'i, with families consuming one bunch per day on average[17]. Bananas is now very much a subsistence

[17] *Survey cited in Clarke, 1992:69*

[16] *Fairbairn, 1993*

crop; according to the 1989 Agricultural Census 87 per cent of households growing bananas did so only for household consumption. This was not always the case, for during the 1960s and 1970s a significant banana export industry to New Zealand existed. A combination of cyclone damage, disease and, most importantly, competition from Ecuador and Philippines led to the demise of this industry.

Breadfruit *(Ariocarpus altilis)* planted around villages is Samoa's third most important food crop. During the season, families on average consume 9 breadfruit per day on Upolu and 10.5 per day on Savai'i.[18] Most breadfruit varieties have two fruit seasons a year but several Samoan cultivars have three or even four seasons per year.

Coconuts, which have long dominated agriculture in Samoa, have a central place in subsistence as a food and as a building and weaving material, and also offer villagers a low-risk source of cash income. According to the 1989 agricultural census, 96 per cent of all households were involved in coconut production, mostly in small-holdings averaging around 6 ha. The importance of coconuts in subsistence is evident in that 52 per cent of households produced coconuts only for home consumption. Only 5 per cent produced coconuts predominately for sale. Based on this census, the World Bank (1991) estimated household coconut consumption to be 8,900 tonnes copra equivalent, approximately equivalent to commercial copra, coconut oil, and coconut cream production. After years of decline, accelerated by recent cyclone damage, the non-subsistence coconut industry is now experiencing a significant resurgence. In 1996, coconut products-copra, coconut oil, coconut cream, and fresh coconuts-were Samoa's main export by value, earning $16.4 million, or 66 per cent of the total. This recovery can be explained by a combination of factors

- The recovery of the productive base of the industry since the 1990 and 1992 hurricanes. The palms that survived the cyclones have now fully recovered with yields approaching their normal level. While accurate estimates of permanent tree loss are not available, WESTEC put their losses at around 10 to 15 per cent[19]. There was some replanting through a bonus-planting scheme.
- The recovery of world market prices in the last few years.
- The sustainability of the coconut cream industry. Coconut cream production and export earnings have remained remarkably consistent over the last decade, despite adversity. The two private coconut cream factories continued to operate in spite of the cyclones by importing nuts from Tokelau, Tonga, and Fiji.
- The privatisation of coconut oil processing industry.
- The loss of taro as a profitable crop for small holders.

Making copra and selling husked nuts has become a profitable activity for Samoan small-holders, compared with alternative uses for their labour and land resources. At the end of 1995, farmers received $715 per tonne of copra, at which price collecting and making copra generated a gross margin of $10-15 a day,[20] comparable to non-skilled wage rates. But while Samoan small-holders are prepared to produce

[18] *Clarke, 1992*

[19] *ADB 1995*
[20] *ADB, 1995*

Table 4: *Single crop equivalent area of major crops*

Crop	Household sector (ha)	Plantation sector (ha)	Total area (ha)
Coconut	23,300	4,400	27,700
Cocoa	6,600	1,900	8,400
Taro	51,300	–	18,200
Giant Taro (Ta'amu)	3,300	–	3,300
Banana	3,600	–	2,300
Yam	300	–	200
Other vegetables	600	–	600

Source: GOWS/FAO 1990

copra and husked nuts at this price, it remains to be seen if is sufficient to encourage significant replanting, especially in a country where such activities are associated with subsidies. Replanting is required as pre-cyclone data indicated that 15 per cent of trees were senile, over 60 years old, (a low figure by Pacific standards) and another 19 per cent were between 40 and 60 years old. Coconut production is not expected to ever again reach its previous height of production, of above 25,000 tonnes a year.

The Samoan cocoa industry dates back 150 years, being by far the oldest in the region and for many years provided Samoa's second most important export. Based on traditional Trinitario varieties, Samoa developed an international reputation for fine flavoured cocoa. In its heyday in the 1950s, 5,000 tonnes were exported annually. Cocoa also became integrated into traditional subsistence consumption, with beans pounded into a paste known as Koko Samoa, large amounts of which are consumed in Samoan estimated prior to the hurricanes at 2,000 tonnes dried bean equivalent[21]. According to the 1989 agricultural census, 64 per cent of all households had cocoa plantings, of which 71 per cent grew for home consumption only. With many Samoans now living outside Samoa, a significant niche market exists for this traditional product. Since the 1950s, however, the industry has been in decline, the hurricanes of 1991 and 1993 being almost its death-knell. The decline of this industry can be explained by a combination of factors:

- Low world market prices. But even though prices were exceptionally high during the early 1970s, production continued to decline.
- Monopoly parastatal marketing. The Cocoa Board was a high-cost operation that survived on high marketing margins. By affording monopoly status to the Board, Samoa also missed the opportunity for private exporters to develop premium niche markets for fine flavoured cocoa.
- The promotion of non-fine flavour cocoa. Traditional Trinitario cocoa was relatively low yielding and susceptible to fungal diseases, particularly black pod. A number of aid-funded cocoa planting projects over last 20 years therefore have been based on amelonado, a bulk variety cocoa. In hindsight this was a mistake, for the comparative advantage of a small producer like Samoa lies with speciality fine flavour cocoa.

[21] *World Bank, 1991*

- The 1990 and 1992 cyclones were particularly damaging to cocoa. Cocoa, with its strong deep root structure, is normally reasonably tolerant to cyclones. The 1990 and 1992 hurricanes were particularly damaging because of their duration and the large amount of salt spray, and many trees died. Farmers have been reluctant to replant, perceiving cocoa to be a high-risk crop.
- Competition from taro for farmers' labour.

Only in the last few years has the industry shown some recovery. A Samoan entrepreneur recognised the opportunities for Samoa cocoa and invested in processing facility to produce large volumes of Koko Samoa for export as well as other chocolate products. He has been working with farmers and is reported to be generating a supply response. Around 60 tonnes were produced in 1995. In the meantime he is importing dried beans from Fiji, Vanuatu, and Solomon Islands.

As in Fiji, Tonga, and Vanuatu, kava is an important traditional crop. Over recent decades it has grown into a significant commercial industry, with export markets in Fiji and Europe, now being the most important crop grown by small-holders (Table 1). Since the taro blight, kava has tended to replace taro in traditional cropping zone that stretched from the mixed crop zone to the forest boundary.

Livestock production has also grown, especially cattle. The cattle population now stands at around 24,000 head due to considerable demand from farmers who wish to integrate cattle into their mixed farming and to use land previously employed for commercial taro production.

DISASTERS IN SAMOA

From 1960 to 1989, Samoa experienced 10 cyclones, compared with 34 for Fiji and 32 for Vanuatu. The greater incidence for these two countries can partly be explained by their archipelago nature, but even taking 5° latitude longitude squares, the incidence remains much lower for Samoa[22]. But while the incidence has been relatively low, the severity of recent cyclones has been particularly high. The country is also exposed to natural disasters in the form of droughts, earthquakes, tsunamis, landslides, fires and volcanoes[23] although these potential hazards are even less frequent events. The most

[22] *ADB, 1995*
[23] *National Disaster Council 1986: 6.*

recent serious bushfires occurred in Savai'i in 1983, and then again in 1998. Several volcanoes are still considered active but there has not been an eruption since early this century. Samoa has frequent earthquake tremors, being located on the South Pacific collision zone, but no severe earthquake has occurred since 1917. Drought, however, can have an insidious impact. The north-western parts of both islands have prolonged dry seasons from May to October in which the porous volcanic soil experience moisture deficits and occasional severe droughts occur. A drought can be particularly damaging when it follows a cyclone, as often happens.

To the conventional list of natural disasters that affect agriculture, however, needs be added environmental and biological disasters that can have major impacts. A growing environmental threat is posed by the rapid spread of cultivation to elevations and soils that are not suitable for sustainable agriculture, thereby exposing the land to serious degradation, including landslides. The most devastating recent disasters for Samoa have been biological, in form of pest and diseases--in particular, taro leaf blight and the giant African snail.

Cyclones

The severity of Cyclone Ofa in 1990 can be gleaned from the following tree fall estimates provided by Clarke 1992:

- mature banana trees: 100 per cent;
- coconut trees: 5 per cent;

and, depending on location:

- large mature breadfruit trees: 50-90 per cent;
- pawpaws: 30-80 per cent;
- citrus trees: 10-50 per cent;
- mango trees: 30-80 per cent;
- avocado trees: 30-80 per cent; and
- mature cocoa trees: 10-50 per cent.

Damage to agriculture caused by Cyclone Ofa was compounded by a subsequent drought. In some areas, only 100 mm of rain fell in the next three months. Despite the severity of the cyclone and the drought, however, food production recovered remarkably fast.

The destruction caused by Cyclone Val in 1992 was associated principally with high winds, heavy rains and high wave action. Wind damage was all the more severe because of the duration of the cyclone and the shifting wind direction as the cyclone passed through the islands. Destructive winds and windborne debris wreaked heavy damage to crops, natural vegetation, buildings and related structures. Heavy rains caused flooding that damaged the environment and infrastructure, including roads and dams. High waves considerably damaged coastal areas and structures. The final official estimate of the cost of damage was almost $US300 million, equal to more than twice the GDP[24]. Table 5 provides a sectoral summary of official estimated losses, losses dominated by buildings and dwellings ($135 million) and primary industry ($82.4 million). The high figure for buildings and dwellings is partly *explained* by the lack of enforced urban building codes. (Fiji experienced similar building losses for cyclones in the 1980s but with the enforcement of building codes these losses fell dramatically for equivalent cyclones in the 1990s.) Of losses to primary industry, the $38 million to agriculture, however, seems to be a considerable over-estimate. There is an inevitable upward bias in such estimates to obtain a maximum response from donors, but the regenerating ability of the agricultural sector also appears to have been under-estimated, as explained below. On the other hand, given the long-term effects of deforestation, the impact on forestry may have been underestimated.

Two comprehensive studies of the impact of cyclones on agriculture in Samoa have been Clarke (1993) on cyclone impacts and Paulson and Rogers (1997) on the ability of Samoa's traditional farming systems to maintain food security in the face of the cyclones and the taro leaf blight. The analysis presented here draws heavily on these studies. The striking feature of Clarke's report was how surprising well taro *(Calacasia),* the main staple, stood up to what was a very severe cyclone. This finding contrasts markedly to the Vanuatu and Kadavu case studies, which found taro to be highly susceptible to cyclones. To quote:

Taro generally survived the cyclone reasonably well with little apparent effect on leaf growth and health of plants. Plants recovered quickly from leaf damage. The biggest effect was probably the *"tala susu"* or watery, poor quality corns, mainly found in taro where tubers were already formed and senescence or reduction in leaf dry matter had already taken

[24] *Government of Western Samoa, 1992*

place, i.e. taro at about 6-7 months of age. When leaves were damaged at the time of the cyclone, the plant stage started putting out more suckers or new leaf growth to counter the loss of leaf area. The starch in the corn starts breaking down to support this new growth resulting in watery corns with a poor starch quality.

Samoan farmers responded quickly after the cyclone, greatly increasing the area planted to taro, including on previously forested areas that the cyclone helped clear. The recovery was quite dramatic. A survey conducted by the Department of Agriculture found 100 plants were ready for harvesting per household per month from March to May. The number of mature plants per household increased to 210 between June and August, and to 650 between September and November. Three months after the cyclone, a physical inspection of twenty of the largest growers' plots found the following (Table 6):

Significant losses to taro, however, occurred six months after the cyclone with the outbreak of taro cluster caterpillar *(Spodoptera litura).* It often happens that a severe cyclone upsets the balance of natural predators. Disruption to the ecological balance by Cyclone Val may also have contributed to the rapid spread of taro leaf blight.

Ta'amu lived up to its reputation of being cyclone resistant. Most of the plants recovered quickly, with the set-back in yields being as low as 10 to 20 per cent. There was, however, a post-cyclone shortage of *ta'amu,* especially on Savai'i, as most mature corms had been harvested during the long drought of 1989. For yams, Clarke reports, 'the damage was more a set-back to growth than something causing major loss of crop. The yams recovered about seven months after the cyclone[25]. Damage to cassava was more severe, with supplies still scarce seven months after the cyclone.

As expected, kava was badly affected by Cyclone Ofa. Uprooting caused 25 to 75 per cent of plants to die, depending on whether the area was protected from or exposed to the winds[26]. The age of the trees undoubtedly contributed to whether the plants survived, yet some apparently destroyed mature plants reportedly produced new young stalks to replace some damaged by the cyclone [27]. The value of kava exports fell from $WS459, 000 in 1990 to only $WS43, 000 in 1991, and it took until 1995 for kava production to fully recover. In 1995 kava exports were valued at $WS1.4 million and kava was the second most important export after coconut products.

Almost 100 per cent of mature bananas were lost; only a few bunches nearing maturity were salvaged. Smaller suckers fared better. Clarke described a rapid recovery of the banana crop:

Bananas that were bent over and had to be slashed had vigorous re-growth. Many were flowering by April, only 2.5 months after the cyclone, and there was a small crop in August and more in September 7 months after the cyclone. These bunches were relatively small compared to bunches from trees growing from suckers.

There was also considerable banana replanting partly in response to a government subsidy of WS$600 / acre. The Department of Agriculture provided free fertiliser at the rate of five bags per acre, and subsidised spraying for bunchy top and leaf streak, lowering the cost to WS$10 per acre.

Almost no breadfruit were salvaged, for Ofa struck at the peak of the breadfruit season. Some 50 to 90 per cent of the mature trees were blown over, although most were not destroyed. As with other crops, recovery of breadfruit was quite rapid. To quote Clarke:

> *Observations three months after the cyclone were that trees still standing and even many blown over had refoliated. Many trees in villages had dead or damaged limbs pruned off and had a new flush of leaves up to the trunk and remaining branches. Shoots coming from the roots of fallen trees took a few months to come up to a size ready to replant. There was an abundance of these to replace fallen trees. Most trees flowered later and were bearing a heavy crop of immature fruit by October.*[28]

Damage to coconuts is harder to assess, for there were considerable differences in tree loss estimates. The Ministry of Agriculture, Forests and Meteorology reported tree losses for the two cyclones at 40 per cent,29 This figure appears to be exaggerated, for the Samoa Trust Estates Corporation (WESTEC) indicated their tree losses were about 10 to 15 percent for both cyclones,3o a figure more consistent with Clarke's estimate of 5 per cent of trees lost in Cyclone Ofa--although he did observe this went as high as 80

[25]*Clarke, 1993:69.*
[26] *Ibid*
[27] *Ibid*

[28]*Clarke, 1993:71*
[29]*MAFFM 1993*
[30] *ADB 1995, Appendix 11: 1.*

Table 5: Cyclone Val: damage cost estimates by sector, 1992.

Sector	$USequiv.
Roads	12.7
Major bridges	1.2
Water supply	2
Apia surface drainage project	minor
Coastal protection works	2.5
Buildings and dwellings	135
Airports	1.2
Ports	7.4
Sea transport	.4
Power supply	4.5
Postal and telecommunications	1.6
Primary industry:	82.4
• agriculture ($38)	
• fisheries ($.5)	
• forests ($43.9)	
Education	5.3
Health	8.2
Fire services	. 8
Environment, parks and reserves	26.6
Total	291.8

Source: GOWS 1992

per cent in some areas, especially in the hybrid blocks.[31] Self-seeded palms, on account of their shallower root system, also showed a greater propensity to be blown over than planted trees-which may explain some of the disparity between the MAFFM and WESTEC loss estimates. Varieties with large crowns were also more prone to being blown over. An estimated one-third of the nuts and one-third of the fronds were blown off, decreasing coconut production for the year by 50 per cent[32]. Nut and leaf loss tended to happen more on the northeast side of trees, the prevailing direction of the wind.

Mature dry nuts started to become available five months after the cyclone, but full production was not restored on trees that had lost their crown or most of their leaves until mid-1991. These nuts were either consumed locally or supplied to the two coconut cream factories that had hitherto maintained production by importing nuts. It took until 1995 for exports of coconut products to be restored to their 1990 level (Table 5).

All the trees that survived the cyclones have now recovered; 'the ability to achieve good recovery is a

[31] *Clarke, 1993: 73.*
[32] *Ibid*

major advantage of coconuts in cyclone sensitive areas[33]. The non-subsistence coconut industry is now experiencing a significant resurgence. In 1996 coconut products (copra, coconut oil, coconut cream, fresh coconuts) were Samoa's main export earner contributing 66 per cent of the total value of $WS24.8 million. This recovery can be explained by several factors:

- The productive base of the industry has largely recovered from the cyclones;
- The recovery of world market prices over the last few years;
- The sustainability of the coconut cream industry;
- The privatisation of coconut oil processing industry;
- The loss of taro as a profitable crop for small holders.

Losses to cocoa were unexpectedly high, possibly because of the long duration of the cyclone and long exposure to salt spray. Between 10 to 50 per cent of mature cocoa trees were blown over, the average loss being between 20-30 per cent.[34] Trees established by seed at stake were less susceptible to being blown over than those planted as cuttings. Most surviving mature trees were defoliated and there was considerable structural damage. Those pods and flowers not ripped off the trees by the wind soon succumbed to the fungal disease, black pod *(Phytophthora palmivora).* There was a complete loss of the small crop on the trees at the time, as well as 95 per cent loss of the main crop that was to start in March. Only about 10 per cent of young cocoa trees were immediately lost, but their subsequent development was impaired by the loss of shade. Many defoliated trees later recovered with a small new leaf flush, but trees that were physiologically weak were not able to support the new flush and died. Survival of these trees was made more difficult by the drought that followed Ofa. A variety difference in recovery rates was observed with the traditional trinitario cultivars doing better than the more recently introduced amelonado cultivars. In order to achieve optimal recovery, cocoa trees need to be pruned back and the black pod removed. Few farmers did this after Ofa for many gave up the maintenance of seedlings in favour of developing food gardens and repairing houses, fences etc., which had a detrimental impact on the survival of

[33] *ADB 1995, Appendix 11:2.*
[34] *Clarke, 1993:76.*

cocoa[35]. Only 2 tonnes of dried cocoa beans were exported in 1991, compared to 220 tonnes in 1990, and cocoa beans had to be imported from Fiji and Solomon Islands for processing into Koko Samoa. Since then, there have been no exports of cocoa beans.

Cyclone *Val* was an even more severe cyclone. There was no systematic study of its impact on crops but some information can be gleaned from Epila-Otara's 1993 report. This also reported a rapid recovery of crops from this devastating cyclone, and confirmed that human intervention can significantly speed the process. To quote:

> *Several physiotherapeutic treatments were given to a number of domesticated or semi-domesticated tree crops. For example, breadfruit were lopped, pollarded, pruned or limbed and uprighted soon after the cyclone. Similarly, broken sterns of nonfruiting banana trees were also cut to stimulate re-growth. Such banana trees responded in the week following the storm. Similarly woody plants which were not given any form of post-cyclone treatment also initiated new growth in just about the same time. In the second week following the cyclone, practically every plant species in study area had flushed with new leaves.*[36]

Epila-Otara's tree fall statistics, except for coconuts and bananas, were lower than those reported by Clarke after Cyclone *Of a,* perhaps reflecting the weeding out of weaker trees by the earlier cyclone.

What was remarkable after cyclones *Ofa* and *Val* was not so much the extent of the damage but the rate at which food production recovered. The resiliency of

[35] *Clarke, 1993:76.*
[36] *Epila-Otara, 1993:11*

Table 6: *Taro production recovery after Cyclone Val*

Age after planting	Upolu (% of crop)	Savai'i (% of crop)
0-1 month	33.9	42.2
2-3 month	25.7	20.2
4·6 months	27.7	24.9
7-9 months	12.7	12.7

Source: Clarke, 1993: 68.

Samoa's small-holder cropping system to these disasters was summarised by Paulson and Rogers:

> *Village households, spurred by quotas set by the village fono, expanded their taro plantations, and food supplies were restored within* 6-8 *months with limited assistance from overseas. By September 1990, seven months after the hurricane, the domestic market price of taro was at pre-hurricane levels, and in* 1991 *the export volume of taro was near pre-hurricane levels. Most other food crops had also recovered by the end of1990 ... In December* 1991, *an even more powerful hurricane hit the islands. Little data are available on the impact of this hurricane; reports were that the damage was considerably greater than in 1990. Again, taro exports recovered within a year, although export of coconut products and cocoa had not yet approached pre-1990 levels by* 1995. *Prices of three major staples (taro, banana, breadfruit) on the domestic market had returned to pre-hurricane levels by 1993*[37].

Fairbairn, in his recent study of the economic impact of Cyclone *Val,* concluded:

> *The damage to agriculture, fisheries and forestry was extremely severe, Savai'i in particular suffering heavy losses. Damage to the main food staples--taro, bananas, breadfruit, yarns and vegetables--was of the order of 90 per cent. Of the commercial crops, cocoa was most severely affected, with most trees completely defoliated, their crop destroyed, and many trees blown over. Well over* 60 *per cent of coconuts were similarly affected, with many old trees blown over. Damage to food and tree crops accounted for a large component of the total cost of $WS201 million (US$80 m.) estimated for agriculture.*[38]

The official assessment of the financial cost to the primary industry sector arising from Cyclone *Val* is presented in Table 7.

There can be no doubt of the severity of damage inflicted by Cyclones *Ofa* and *Val* on the agricultural sector, yet the money value of losses to food and tree crops seem to be over-estimated. For 1989, the year before the first of the two cyclones struck, subsistence contributed only $62.5 million to GDP in current value terms. A year after each cyclone, taro production had more than recovered. Coconut tree losses proved to be far less than the 40 percent estimated by the Department of Agriculture-as borne

[37] *Paulson and Rogers, 1997:4.*
[38] *Fairbairn, 1997: 53*

Table 7: Official assessment of the financial cost of Cyclone Val to the primary industry sector.

Sub-sector	$WS	$US
Food crops	44.2	17.6
Tree crops	29.0	11.5
Livestock	12.5	5.0
Fisheries	1.2	.5
Forestry	107.0	42.6
Other (incl. departmental structures &	7.1	2.8
Total	**201.0**	**80**

Source: National Disaster Council 1992

out by the almost full recovery of the copra industry once appropriate price incentives were in place. The loss of the capital stock of cocoa trees was large, but would have been far less had the trees been later pruned. Growers deemed that the returns from cocoa were insufficient to justify the effort required and decided instead to allocate their time to planting taro. A significant part of the cocoa income losses should thus be attributed to low cocoa returns, not just to the cyclones. Fairbairn concluded that the economic impact of Cyclone *Val* on the agricultural sector was as follows:

The cyclone dealt a serious blow to the country's attempts to develop agriculture, and significantly affected short-term performance and longer-term prospects. An immediate consequence was a severe shortage of fresh foodstuffs, including taro, bananas, yams and vegetables, and a heavy reliance on imported substitutes. This situation persisted for about 6-8 months - by which time the supply of locally grown foods had substantially recovered. The damage to coconuts and cocoa had a dramatic effect on exports, processing activity and, ultimately, employment and rural incomes. As opposed to the staple root crops, both coconut and cocoa are slow recovery crops, normally requiring 3-4 years. The heavy damage to agriculture highlighted the importance of factoring in cyclonic risk when designing agricultural development strategies. Recent policy initiatives in agricultural development suggest that this requirement is being given increasing attention. Thus in relation to crops, increased efforts are being made to diversify away from highly vulnerable tree crops such as cocoa, to foster continued cultivation of hardy, quick-growing root crops, and to promote appropriate food storage systems at the household level. The combined effects of cyclones *Ofa* and *Val* had a dramatic impact on agriculture (with fisheries and forestry). Agricultural production dropped sharply, remained depressed for a prolonged period of time, and contributed significantly to a decline in real GDP[39].

These conclusions reflect conventional wisdom and to a large extent are correct. What they do not reflect, however, is the ability of agriculture to recover from disasters of such severity. It is difficult to see how Samoa's cropping mix could be much improved in terms of the trade-off between food security, financial returns, and resistance to cyclones, which are relatively rare events. Fairbairn's recommendation for diversification away from 'highly vulnerable tree crops' appears not to be supported by the facts. His call 'to foster continued cultivation of hardy, quick growing root crops, and to promote appropriate food storage systems at the household level,' however, is sound advice that applies to all Pacific island countries.

Given the narrow economic base, the market decline in the macro-economic aggregates relating to the agricultural sector is not surprising. The decline in agriculture's contribution to aggregate real GDP was quite marked, falling from a level of $68 million (US$31 million) in 1989 to $50 million (US$20 million) in 1992, implying an average decline of 8 per cent per annum.[40] This compares with a decline in total GDP of $WS180 million (US$78 million) to $WS167 million (US$65 million) during the same period, equal to -2.3 per cent per annum. The sizeable decline in GDP from agriculture significantly reduced the relative importance of this sector in overall GDP' from 38 per cent to 30 per cent. The impact of the cyclones was sharply reflected in the level of export earnings, which at the time was dominated by taro and coconut product exports (Table 6). The value of exports fell from $30 million (US$ 14 million) in the 1988-89 period to a low point of $14 million (US$5.4 million) in 1992, a decline of 53 per cent.

By 1993, a recovery from the cyclones, led by taro, was well underway. In the first 6 months of 1993 approximately 126,000 cases of taro were exported at a value of $WS5.8m., accounting for 66 per cent of total exports. Agricultural production for the year grew by 7.4 per cent and the value of exports increased by 10.5 per cent [41]. Overall for 1993, real GDP for the year grew 9.5 per cent[42]. In July 1993, however, Samoa was hit by taro leaf b light, a disaster worse than the severest cyclone. Virtually overnight

[39] *Fairbairn, 1997: 53*
[40] *Fairbairn 1997, 63*
[41] *ADB, 1996*
[42] *ADB 1996: 380.*

the country lost its main food and a product that accounted for over 60 per cent of its export earnings. Worse still, had equivalent loses been inflicted by a cyclone, the industry and its capital stock could have been rehabilitated within a year, essentially through the input of labour. Such rehabilitation proved not possible for taro leaf blight, and it remains to be seen if production can ever be fully restored.

The effect of cyclones on agriculture and the choice of alternative crops tend to be in the forefront in the mind of planners immediately after disasters of the magnitude of cyclones *Ofa* and *Val.* Fairbairn, for example, stressed "the importance of factoring in cyclonic risk when designing agricultural development strategies." Yet it would seem that this consideration has already been factored into the decisions of farmers. It was no coincidence that coconuts and taro were Samoa's most important agricultural crops, even though they would be ill considered choices in terms of susceptibility to cyclones. Kava, now of high priority among commercial farmers, is also highly susceptible to cyclones-but its returns are sufficiently high to sustain the loss of a crop every five years or so, a much higher incidence than Samoa's historical frequency of cyclones. On the other hand, cocoa could not have been regarded as a poor crop choice, even given its perceived vulnerability to cyclones, for it was a major export earner for over a century. In all, it is doubtful that Samoa's cropping and agricultural patterns would have been greatly different had there not been the risk of cyclones. Samoa, as with other Pacific island countries, faces far more binding constraints to commercial agricultural development than cyclones, such as quarantine restrictions, high production and marketing costs, and inconsistent supply and quality.

The impact of droughts

Samoa is a high rainfall country that is not normally associated with drought. Yet occasionally serious droughts do occur and have a marked impact on agricultural production. Curry reports that northwest parts of both main islands experience high drought probabilities, with rainfall being less than the potential evapo-transpiration in more than 50 per cent of the months of May to September[43].The worst recent drought occurred in the early 1970s and lasted up to five months on Upolu, causing heavy damage to crops[44]. Cyclone Ofa was preceded by a prolonged dry period, which led to a run-down in the stocks of *ta'amu,* causing a post-cyclone shortage of this traditional emergency food. As often happens with a late season cyclone, Cyclone *Ofa* was followed by a three-month-long dry period, which slowed recovery especially for the cocoa crop.

The impact of environmental disasters

Since the 1950s, Samoa's forests have been largely cleared, a clearance that accelerated to around 4,000 ha. a year in the late 1980s and early 1990s. Paulson found the amount of land cleared in three representative villages over the period 1954 to 1988 more than doubled, with a significant per capita increase in in the area cleared. The motivation for the clearing was to plant cash crops, principally taro, and to stake land claims[45]. Despite this rapid clearing, there was no discernible increase in agriculture production, indicating the productivity of previously farmed land had declined. This expansion has pushed cultivation to elevations and slopes not suitable to sustainable agriculture. The rate of clearing slowed markedly after the establishment of taro leaf blight, but considerable damage has already been done in terms of lost biodiversity and soil degradation. High elevation areas that have been cleared are now especially vulnerable to leaching of soil nutrients and severe erosion during intense rainfall, as occurs during cyclones, so increasing the risk of landslides.

Biological disasters

Over the years, incursions of pests and diseases have had major impacts on agriculture, including the rhinoceros beetle (coconuts), the fruit sucking moth (fruit), and the giant African snail (leafy vegetables). Nothing, however, matches the devastation caused by taro leaf blight, a fungal disease that destroys most of the functional leaves and thereby substantially reduces corm production. The infection can also invade the corm, causing rapid rot after harvest. Taro leaf blight is thought to have originated in south-east Asia and is endemic in Papua New Guinea, Solomon Islands, and Hawaii.[46] It can now,

[43] *Curry, 1962:57.*

[44] *Fairbairn, 1997: 2.*
[45] *Bryant, 1967*
[46] *Jackson, 1995*

unfortunately, be regarded as endemic to Samoa, even though it was first reported there in mid-1993. Under the right environmental conditions, the fungus has a potentially explosive epiphytotic effect, as described by Pone[47]

P. colocasiae spread by means of tiny, oval shaded spores called sporangia. Under dry conditions disease development is very slow because the fungal spores need water to spread and to germinate. However, when conditions are favourable spores are produced quickly and are spread to nearby plants by rain splash, or wind driven rain. Depending on the prevailing climatic conditions one of two events may occur. The sporangium, upon contacting a moist leaf surface:

- germinates a gives rise to a single lesion; and
- breaks at the lid (called a papillae) and releases 20 zoospores each of which can cause a lesion. Thus more lesions are produced on one leaf ("cluster bomb" effect).

Estimates of spore production from work done in Papua New Guinea suggest that as many as 100,000 sporangia are produced from 1 cm^2 of lesion. If all these zoospores give rise to a lesion the total number sporangia produced in a few days will be 2, 000, 0000 x 100,000. Consider therefore the case that zoospore conductive weather prevails over two weeks. This capacity to multiply rapidly makes *P.Colocasiae* a formidable enemy indeed.

August and September 1993, which was an unseasonably wet period with cool nights, provided ideal conditions for the explosive spread of the fungus. Within eight weeks the fungus had invaded all districts of Upolu and 60 per cent of Savai'i[48]. An extensive government-subsidised spraying program using the fungicide Ridimol proved ineffective. For the first month, the chemicals were provided free to farmers at a cost of over $US500,000. The later use of phosphorus acid as a fungicide achieved better results.

It is likely that the blight came from American Samoa where it was identified in 1989. It is transmitted on leaves and suckers, and possibly even corms. There is considerable movement of people and produce between the two Samoas and quarantine safe-guards are regarded as the weakest in the region[49]. There is one school of thought that the blight may have been present in Samoa for some time before its explosive outbreak. After the balance was upset by the two cyclones and the large-scale monoculture planting of taro that followed them, the outbreak was then triggered by optimal rainfall and temperature conditions.

A control package for the disease developed involving a combination of chemical treatments and field sanitation. Systemic and contact fungicides (phosphoric acid) needed to be applied on a weekly basis. Infected leaves had to be removed daily. These practices were effective but required vastly increased labour input and continuous discipline. For example, a seven acre farm that was previously managed by a single family had to hire three fulltime workers just to manage the blight.[50]

Some taro continues to be produced; the index of agricultural production for taro was 63.5 in 1996 compared with 190.2 in 1993[51].This production is virtually all for local consumption. In 1996 only 1,000 cases of taro were exported, compared with 202,000 cases in 1993[52]. Most farmers no longer see growing taro to be a commercially viable enterprise, for the cost of production is now too high, the labour requirements and discipline too demanding, and the level of chemical input needed discouraging to both producers and consumers. The restoration of the taro industry to anywhere near its former level now awaits the long-term solution of the development of resistant varieties that are acceptable to consumers.

The 1995 ADB's Agricultural Strategy Study concluded that taro leaf blight was a major disaster comparable to that of the *Ofa* and *Val* cyclones[53]. But the blight actually had an even greater economic impact. After the cyclones, successful rehabilitation commenced almost immediately, with the main input being labour to plant taro. In the case of the blight, rehabilitation of the crop failed. The impact on the economy remains ongoing and open-ended. The two principal losses are:

[47] *Pone, 1993:3*
[48] *Pone, 1993*

[49] *The author observed first-hand the weakness of Samoan quarantine in 1994 when returning via Apia from a quarantine treatment workshop in Cook Islands. A number of Samoan participants, including Agricultural Department officials, brought with them bags of oranges from the Cook Islands. These oranges passed straight through airport quarantine. The Cook Islands has the economically important fruit fly B-rnelanatus for which citrus is a host. This fruit fly is 110t found ill Samoa.*
[50] *USAID, 1993*
[51] *CBS, 1997*
[52] *CBS, 1997*
[53] *ADB, 1995, Appendix 12: 2.*

Table 8: Samoa agricultural commodity exports: 1973-96.

	Taro		Copra		Coconut oil		Coconut cream		Cocoa	
	,000 cases	$WS million	,000 tonnes	$WS million	,000 tonnes	$WS million	,000 tonnes	$WS million	,000 tonnes	$WS million
1973			14.9						2.3	
1978		1.1	14.9						1.6	
1983		2.3	2.9		17.9				1.3	
1988	246	5.2	3.2	2.0	10.3	11.7	1.2	3.9	.47	
1990	128	3.5	2.4	1.1	5.2	4.2	1.6	5.6	.22	
1991	212	6.8	–	–	.03	.002	1.6	5.3	–	–
1992	107	4.7	–	–	.8	.697	1.3	4.9	–	–
1993	202	9.9	–				1.0	3.5	–	–
1994	2	.158	.06	.06			1.2	4.5	–	–
1995	2	.162	2.5	2.2	6.9	8.0	1.4	4.8	–	–
1996	1	.098	4.7	4.1	6.5	6.5	1.4	4.9	–	–

Source: Central Bank of Samoa Bulletin (various issues)

- A major export industry that was generating an annual export income of $WS9.5 million. This industry was expanding at a rate of 7 percent per annum; and

- The preferred staple food valued at $WS27.5 million (derived by the ADB 1995 from a market price of $WS.36/lb in 1993 prior to the blight and consumption at the time of O.5kg/person/ day).

Without any adjustments for resource allocations, this represents a total loss almost $WS40 million, equivalent to about 11 per cent of GDP in 1995. Of course there have been resource adjustments, with land and labour moved into production of other subsistence and commercial crops. The annual net impact of taro blight has thus progressively declined since 1993. It is not possible to precisely estimate what this decline might amount to, but assuming it is around 20 per cent per year, the total cost of taro leaf blight up to the end of 1997 would have been almost $W150 million. Additional costs identified by the ADB Sector Review include:

- loss of revenue from the suspension in 1993 of exports of green banana to ensure adequate local food supply;
- increased expenditure on imported rice and flour in 1994 and part of 1995 until other local food substitutes came on stream. The estimated increase in imports was $WS3.1 million;
- initial government expenditure of $WS645,000 to control the disease;
- a government subsidy of $WS82,000 for fungicides;
- higher cost to consumers of substitute staple foods (banana, ta'amu, and bread fruit); and
- research cost in developing resistant varieties acceptable to consumers.

When all things are considered, the cost of taro leaf blight is of a similar magnitude to the official estimate cost of Cyclone Val to Samoa's productive sectors (Table 7).

For most countries the loss of its main food and export earner would be a disaster of catastrophic proportions. Yet Samoa quickly adjusted to this disaster. There was no famine. Export levels have now been restored. This is testimony to the "hidden strength" of seemingly weak Pacific island economies, and of Samoa in particular, that lies with the traditional food production system. By January 1995, people were producing adequate food to meet their needs. The prices of alternative crops (bananas, ta'amu, breadfruit, yams) on the domestic markets had also dropped to low levels, as village households began producing marketable surpluses. Paulson and

Table 9: Real growth rates of Pacific island economies, 1995.

	Real GDP growth rate (%)
Papua New Guinea (1994)	.08
Fiji (1994)	4.4
Tonga	1.8
Vanuatu	3.2
Samoa	6.7

Source: ADB 1996

Rogers concluded that the apparent normalcy of village life suggested that many rural households had recovered to the point that they were able to meet much more than the base of their "hierarchy of needs."[54]

This adjustment involved a significant shift in cropping patterns and land use. Paulson and Rogers describe the adaptations to the blight that were made for the two villages they surveyed. In the cropping zone near the village where there were mixed food gardens, secondary forest growth, and old coconuts and cocoa, management levels and productivity were low. Inland and uphill from the village much of the broad zone of lightly covered coconuts and cocoa was old and unproductive. Above this was a broad and expanding zone where most of the commercial of commercial taro was grown. Most households had land in each of these zones, but the main labour effort was focused on taro in the taro zone. With the loss of taro, effort was again refocused on the zone nearest the village. To quote:

> *Old gardens, secondary growth and senile coconuts had been transformed into well-tended mixed gardens producing a variety of food and tree crops. Some households had also begun to clear or intercrop their nearer coconut and cocoa land, transforming them into mixed gardens. All gardens had several varieties of banana and at least two varieties of ta'amu. Most also had yams, cassava, and several varieties of breadfruit, and a variety of minor crops and useful piants*[55]

The cropping system and sufficient land availability enabled taro to be quickly replaced as a food by crops such as bananas, *ta'amu,* and bread fruit. As a source of cash income, taro was replaced by resurgence in the non-subsistence coconut industry. Making copra and selling husked nuts again became a profitable activity for Samoan small-holders compared with the alternative uses for their labour and land resources. By 1995, the macro-economic aggregates had more than recovered. Economic activity was buoyant with real CDP growing by 6.7 percent (Table 9). Vaai attributes this growth to a doubling of exports (principally coconut products), a substantial increase in domestic food production, manufacturing output, and increased earnings from tourism[56].

DISASTER MITIGATION IN SAMOA

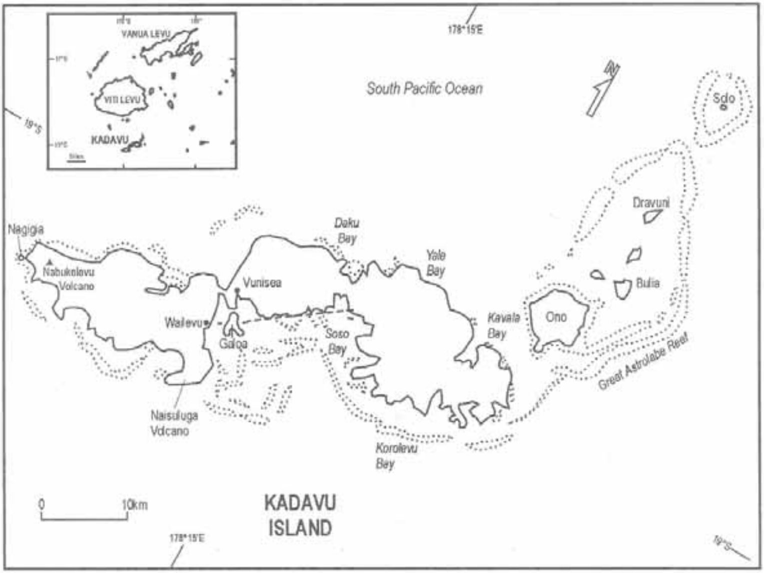
Traditional food security had as its basis a system of integrated multiple cropping which involved inter- cropping and the utilisation of a wide variety of cultivars, including famine crops. The cropping system was flexible in the face of changing circumstances and provided some resilience to natural disasters. This system essentially remains intact in Samoa, even though severely tested in the last decade by the cyclones and taro blight. Most rural Samoans maintain a food security base that is resilient to major disasters.

The traditional adjunct to cropping systems was food preservation. In Samoa, the main traditional form of food preservation, as a famine prevention strategy, was pit fermentation of bread-fruit and bananas, known as *masi* [57]. This anaerobic lactic fermentation allowed for staple carbohydrate food to be stored for months, or even years, without deterioration. Pit preservation, which was widely practised in Samoa and throughout Polynesia, allowed for surplus breadfruit and bananas to be converted into a food reserve in times of famine[58].This surplus food had important social and economic implications. It was traded for other goods and services. It was made into "puddings" that added variety to the diet and were used as treats for special occasions. This pit preservation is, however, no longer practised because of its high labour requirements.

It may now be an opportune time to rekindle pit preservation of breadfruit and bananas in Samoa. There remains a residual knowledge of the technology and a consumer preference for the highly nutritious *masi* with its distinctive cheesy acidic taste. The impact that the cyclones and taro leaf blight had on food availability remains fresh in people's minds. It would, however, be difficult to promote traditional food preservation on the basis of disaster mitigation alone. Of more immediate benefit is its ability to generate income for households or to save them money in buying food. Overseas Samoans, who can no longer buy taro from Samoa, long for products that link them with home. Fresh breadfruit is out of the question because it is a major fruit fly host. Whether breadfruit in the form of *masi* could be a viable export would require market research. A spin - off benefit would be greater food security after disasters. Less labour intensive processing techniques as described by Aalbersberg et.al. have been developed, and there may be scope for developing a traditional food-processing project for Samoa along the lines described for Vanuatu in this report.

[54] *Paulson and Rogers,*
[55] *Paulson and Rogers 1997:6.*
[56] *Vaai, 1996:14.*
[57] *Cox, 1980.*
[58] *Aalbersberg et.al, 1987*

4.



Map 3: Kadavu, Fiji Islands.

3. DISASTERS AND AGRICULTURE IN FIJI'S OUTER ISLANDS: THE CASE OF KADAVU

AGRICULTURE AND FOOD PRODUCTION IN KADAVU

Kadavu, Fiji's southernmost province was selected as a case study for several reasons. First, it is relatively typical of Fiji's outer islands, its population almost entirely comprising indigenous Fijians and its semi-subsistence economy being based on root crops. The population of Kadavu, in common with all of Fiji's outer islands, has declined over the last decade. Agriculture there, as on Fiji's other large outer islands, has experienced considerable diversification and commercialisation over the last decade or so. The province is also particularly prone to cyclones; the 1980s was a period of intense cyclone activity, followed, in the 1990s, by a period of relative calm. During this latter period, a high cyclone risk crop, kava, has become the main economic crop. In common too with most of Fiji's outer islands, an insidious environmental disaster is at play on Kadavu, involving a combination of uncontrolled pigs, indiscriminate burning, and unsustainable cropping. Compared with the attention given to cyclones, little notice is taken of this environmental disaster. Yet is likely to have a much more significant and long-term impact on the agricultural sector of islands such as Kadavu.

The island group of Kadavu is composed of one large island, Kadavu, which covers 90 per cent of the land area, and several smaller surrounding islands (Map 3). The total land area is 6125 ha., which represents one percent of Fiji's total land area. Some 85 per cent of the island's land area has slopes over 18° and only around 47 per cent of the land is suitable for agriculture or pasture[59]. Most of the soils are steepland clay types, soils of good structure with reasonable fertility, although often low in phosphorus and highly erodible. Kadavu has less rainfall varia tion than the larger islands of Viti Levu and Vanua Levu and usually sufficient rain to produce root crops and kava, apart from on the drier, smaller islands such as Dravuni. The northern side of Kadavu is relatively drier, normally having between 2,800 and 3,500 mm of rain a year and a moderate dry season of about three months, of which one month might be very dry. The windward side of the main island has annual rainfall as high as 4,600 mm, with one to two dry months, neither of them very dry[60].

The population of Kadavu in 1996 was 9,539, about 1.2 per cent of Fiji's total. Population density is low, at 1.6 persons per hectare, or approximately 3.3 persons per hectare of arable land. Kadavu's population has declined slightly over the last decade because of accelerating urban drift. Just over half (56 per cent) of the land is owned by native land holding units or mataqali, and another 28 per cent is freehold, in both cases relatively larger proportions than elsewhere in Fiji (Table 10). The rest comprises various forms of crown or native owned land. The most common form of land tenure in Fiji, namely NLTB lease, is insignificant in Kadavu (accounting for only 3 per cent of the land) because without a large immigrant population there are not many people to lease to. The main lease-holders are resort owners and the Government, that is, nonagricultural users.

Fiji's eastern and southern islands have been populated for more than 2,000 years. The people who built fortified villages in Taveuni in 1200 AD were agriculturists and so, too, probably were the people of Kadavu[61]. The agriculture of Fiji's maritime islands was based on two main crops: yams and taro, yams being the main staple in areas in well-drained and well-tilled areas and taro grown in wetter areas, often on irrigated terraces[62]. There were scattered coconuts in the coastal bush and among the food gardens, and breadfruit was an important crop. Sugar-cane and bananas were also grown. Kava or *yaqona (Piper methysticum),* now such an important cash crop, had only a limited role, for its consumption was limited to chiefs. Other staple root crops were introduced more recently. *Kumala* (sweet potato), cassava, and *Xanthosoma taro* (known as *dalo-ni-tana)* were introduced sometime before the middle of the nineteenth century. According to Brookfield, their establishment was gradual, with the old food

[59] Tyford and Wright 1961; National Agricultural Census, 1991

[60] Tyford and Wright 196
[61] Frost, 1969
[62] Brookfield, 1977: 148

Table 10: Kadavu land-use and farm structure, 1991.

Characteristic		
Number of farms	2,518	
Percent of farms in Fiji	2.6%	
	Ha	*% of total area*
Total land area	6,125	
Percentage of Fiji's total land Fiji	1%	
Area under temporary crops and	1,347	21.9
Fallow one year or less	41	0.7
Fallow more than one year	68	1.1
Permanent crops (no pasture)	426	7.0
Coconuts with pastures	289	4.7
Pastures	729	19
Natural forest	2,183	35.6
Planted forest	1,67	2.7
Non agricultural land	875	14.3

Source: Agricultural Census, 1991.

cropping pattern persisting through to the end of the nineteenth century[63]. In the twentieth century, however, change was quite rapid, with cassava and dry-land taro becoming the main food crops throughout most of Fiji. The most fundamental change has been the disappearance of yams as a major agricultural product-a contrast to Tonga and Vanuatu where yams continue to playa central role in custom and subsistence. The demise of the yam in Fiji, particularly wild yams, has had adverse implications for disaster mitigation and agricultural sustainability.

Kadavu today has a vibrant subsistence and commercial agriculture system. Root crops still meet most of the energy requirements of the population, as they do for most of Fiji's indigenous rural population. A range of nutritious traditional fruits, nuts, and leaves are harvested. Imported rice, while an important part of the diet of Fijian villagers, is not yet as dominant as it is in rural western Melanesia. Table 11 shows the distribution of the crops grown on Kadavu, as reported in the 1978 and 1991 agricultural censuses. The most obvious changes are the substantial increase in kava, taro *'(dalo),* and cassava planting, the decline in the coconut area, and the much reduced importance of yams. Until the mid-1970s, copra was the main income earner for Kadavu; it has now been more than replaced by kava or *yaqona.* Kava is a traditional beverage that has central place in custom throughout Fiji. Once only consumed by chiefs, it is now widely

[63] *Brookfield, 1977: 148*

consumed by all communities of Fiji as a social drink. There is also a large export market. This crop has had rapid commercial growth over the last decade or so and Kadavu is one of the main supply areas, being renown for the quality of its kava.

Kava is usually harvested at between three to five years but the quality and yield continues to increase further with age, the premium quality being achieved at around seven years. Most of Kadavu's arable land is very suitable for kava, for the crop needs fertile, free-draining soil, and cannot tolerate long dry periods. Under stress, it is susceptible to 'kava die back,' a viral disease that can rapidly kill mature plants. This disease has not yet become a serious problem on Kadavu. The basic cropping system on Kadavu is now taro inter-cropped with kava, but in recent years large areas of forest reportedly have been cleared for stand-alone kava.

Kava yields the highest return for any legal crop grown on any scale in Fiji (Table 12). The gross margin for a hectare of kava is around F$30,000, or F$7,500 per annum (Annex 1). This is based on a farm gate price of F$10 kg dried (which is significantly below current prices) and a yield of 3 tonnes dried product per ha. The return per person day is between F$80 to F$85 (Annex 1), the total labour requirements for a hectare of kava harvested at 4 years being around 370 person days. Kadavu's 685 ha planted to kava in 1991 could be expected to produce around 2,000 tonnes of dried kava, or an average of 500 tonnes per year. At a conservative estimate, this would contributed a net return to the Kadavu economy of F$20 million, or around F$5 million a year.

There is, however, a high risk associated with Kadavu's dependency on kava. Once a plant reaches 12 to 18 months of age it is very susceptible to wind damage. If the tops break and the roots are shaken, the plant will die. Cutting of the tops prior to a cyclone, as is done for cassava, is not an option. A damaged two-year-old crop will likely be a complete loss. The roots of older trees can be salvaged if they are pulled and dried immediately. This is the most labour intensive stage of kava production-yet immediately after a hurricane, demands on labour are at a premium. Thus a lot of kava can be lost, particularly in larger plantings where the area has been clear cut. These plantations lack the natural windbreaks of small traditional forest gardens.

The decision when to pull kava is normally based on a combination of factors: household income needs (payment of school fees, the meeting of social obligations); expected peak market demand (during the cane harvest, especially at the time of cane

Table 11: *Cropping patterns in Kadavu* 1991 *and 1978.*

Crop	Year	Temporary "pure stand" (ha planted)	Mixed & inter-planted stand (ha planted)	Permanent "pure stand" (ha planted)	Permanent mixed crop (ha planted)	Scattered plants and trees (no. of plants)
Taro *(Colocasia esculenta)*	1991	78	687			
	1978	32	296			
Cassava *(Manihot esculenta)*	1991	760	145			
	1978	151	39			
Kumala *(Ipomoea batatas)*	1991	91				
	1978	3	24			
Kava *(piper methysticum)*	1991	143	683		4	
	1978	139	301			
Yam *(Dioscorea spp.)*	1991	22	4			
	1978	48	54			
Coconuts	1991			710	4	25,304
	1978			2,399	12	
Pineapple	1991			1		
Banana/vudi	1991					11,205
Breadfruit	1991					6,095
Citrus trees	1991					4,117
Mango	1991					2,659
Pawpaw	1991					1,980

payments and during festival periods such as Christmas); and maximising production. The forced pulling of kava due to a cyclone can therefore substantially reduce the benefits that growers receive. If the cyclone is widespread, the market can be flooded by low-grade poorly dried kava, further driving down prices-yet within a month or so there are usually kava shortages and prices rise sharply to above pre-cyclone levels. Kadavu farmers were the beneficiaries of this phenomenon in 1993 following Cyclone Kina, a large system that affected kava growing areas throughout eastern and southern Fiji but largely spared Kadavu. Immediately after cyclone Kina, the kava price fell some 50 per cent, but by the end of the month it had risen sharply above the pre-Kina level. The windfall gain that Kadavu farmers reaped gave them further incentive to plant more kava.

Most of Kadavu's arable land is also suitable for growing taro, apart from drier parts of the north coast and the smaller islands. Culturally, taro is the most important staple in Kadavu, as it is for most of the rest of Fiji. Taro is still primarily grown for subsistence on Kadavu, although an increasing amount is sold. At the time of the 1991 Agricultural Census, 765 ha were planted to taro and 87 percent of it inter-planted with kava, a substantial increase since 1978. It appears that the kava area has increased significantly since 1991, but there has been little increase in the taro area. An area of 765 ha of taro, assuming a yield around 7 tonnes per hectare when inter-planted with kava, would produce around 5,000 tonnes of taro. The imputed gross value of this taro is F$10 million, based on the current farm gate price of taro of F$1 /kg. The estimated gross margin for taro in 1995 was estimated to be around F$3,600/ ha or F$15 person day-compared with F$80 to F$85 for kava (Table 12).

Table 12: Kadavu Copra Production: 1972 - 96.

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Kadavu production (tonnes)	1069	1048	384	309	383	895	912	484	96	92	161
% of national production	3.6	3.8	1.3	1.2	1.4	2.8	3.4	2.2	.4	.4	.7
	83	84	85	86	87	88	89	90	91	92	93
Kadavu production (tonnes)	126	44	61	–	49	49	56	79	6	–	1
% of national production	.5	.2	.3	–	.4	.5	.4	.4	.04	–	.01
	94	95	96								
Kadavu production (tonnes)	2	2	10								
% of national production	.02	.02	.09								

Source: The Coconut Board

Since 1994, taro prices have risen sharply, particularly for the *tausala* variety, as Fiji took over markets in New Zealand, United States, and Australia after the Samoan industry was decimated by disease. Kadavu's close proximity to Suva, good shipping links, excellent growing conditions, and freedom from the papuana beetle (which constrains commercial taro production on Viti Levu) have enabled its farmers to take advantage of this opportunity. Even so, surprisingly little taro from Kadavu has been exported[64] - apparently because of the much higher returns to increasingly scarce labour provided by kava. Taro, as a relatively short -term crop, (nine to ten months) is less risky than kava, but another risk factor is that taro is often dug up by pigs foraging for food.

Cassava, an undemanding crop, can grow on the poorest soils with much less labour input than either taro or yams. Its tolerance to poor soils means that it is often found in close proximity to villages. In most parts of Fiji it has become the most important subsistence staple, although not quite yet in Kadavu. The 1991 Census reports 760 ha planted to "pure stand" cassava, and a further 145 ha inter-cropped with taro and kava, compared to only 190 ha. reported in the 1978 Agricultural Census. Around 10,000 tonnes of cassava are now produced annually, at an estimated value of F$2.5 million, based on an imputed value of 25c per kg. at the farm gate.[65]

Cassava's tolerance to cyclones (if its tops are cut) and resistance to drought means it can play an important role in food security. The rapidity of the expansion of this crop has, however, had a down-side in that it has reduced fallow periods and pushed back bush regeneration, so adversely affecting on food store crops such as wild yams and indigenous nuts. The combination of cassava in short fallow, and on steep slopes in high rainfall areas has probably accelerated soil erosion and land degradation, although no soil loss estimates have yet been made for Kadavu or any other outer islands.

Other root crops are grown on Kadavu mainly for subsistence. These include yams, kumala (sweet potato), and dalo-ni-tana (Xanthosoma sagittifolium). The most common domestic yam in Fiji is uvi (D. alata). Despite its traditional value, over the last 20 to 30 years the area planted to yams has declined, largely because:

- The crop’s high labour requirement relative to other root crops, particularly cassava;
- Declining labour availability in the face of falling populations in the outer islands and a perceived reduction in the work ethic of those remaining;
- A general decline in chiefly authority in Fijian villages: in many areas yams were the principal

[64] Personal communication Mr Alf Hazelman Mnaging Director of Produce Processing, Fiji's longest standing taro exporter.

[65] A yield of around 20 tonnes ha can expected for pure stand cassava and 14 tonnes per hectare for mixed stand (1978 Agricultural Census, p 19)

- good involved in presentations to chiefs; and,

- for wild yams, the decline in habitat due to clearing to plant kava and other cash crops, as well as logging and indiscriminate burning.

The demise of the yam on Kadavu has probably been less marked than in other parts of Fiji, but it is nevertheless significant, the planted area declining r from 102 ha. in 1978 to 26 ha. in 1991[66]. It is too labour intensive a crop to challenge the popularity of kava, taro or cassava, the unavailability of planting material is a constraint, and monetary returns are lower. A major wholesaler sells yams at F$1.60 per kg, compared to F$1.80 per kg for taro.

Wild yams encompass any member of the genus *Dioscorea* that survive without cultivation and untended in both undisturbed and disturbed wild areas. Increased land clearing to plant kava and cassava, together with burning and wild pigs, has put considerable pressure on wild yam populations. A number of species have reportedly disappeared. Some, such as *tivoli (D. nummularia)*, are still common. Others often found are *yabia (D. pentaphylla)* and *kaile (D. bulbifera)*. *Tivoli* occurs throughout all lower forests, and when harvested it was usually replanted. Wild yams use trees and undergrowth for support and, unlike their domestic counterparts, are therefore resistant to cyclones. Thus wild yams served as a "food bank" and played a central role in traditional cyclone mitigation.

Dalo-ni-tana (xanthosoma) is the hardiest of the root crops to both cyclones and droughts. It is grown extensively elsewhere in Fiji, but very little was observed on Kadavu and went unreported in both the 1978 and 1991 agricultural censuses. While some is said to be grown in the drier areas along the north coast, the absence of *dalo-ni-tana* on this cycloneprone island is surprising. The cash economy has shifted the focus away from slow growing, non money-spinners such as dalo-ni-tana. *Dalo-ni-tana* also faces a lot of consumer resistance both locally and from expatriate Samoans, Fiji's largest traditional export market for tubers, being perceived as 'itchy' and dry- although the "red" variety is less so. Large potential markets however exist amongst Asian communities in Pacific Rim countries, particularly in the United States, a much larger market than for taro.

Kumala (Ipomoea batatas) (sweet potato) favours well drained soil and can be grown along the coastline and at elevation.

The crop's low and spreading growing habit is quite tolerant to high winds, provided it is not subject to flooding and sea surge. Kumala, once established, can tolerate dry conditions, thus it normally needs to be planted during the wet season. If so, it can mature in three months, making it the quickest maturing of all root crops.

Along with the growth in kava and the demise of yams, a notable feature of Kadavu's cropping patterns over the last 20 years has been the virtual disappearance of coconuts as a commercial crop. Once Kadavu's commercial mainstay, they are now nothing more than an important subsistence crop. This change can be explained by the following combination of factors:

- Very low returns for copra compared with other cash crops - particularly yaqona and taro.

- The logistics and cost of shipping copra to the oil mill in Savusavu, after the closure of the Suva mill in 1992.
- Damage caused to old trees by the intense hurricane activity in the 1970s.

A survey on Taveuni in 1977 found that almost 60 per cent of the trees were over 40 years old, probably a similar age profile as Kadavu. Many senile trees were reportedly broken by Hurricanes Lottie and Val in the mid-1970s. This was doubly unfortunate for Kadavu farmers as prices had then just recovered from a major slump in 1972. By 1977 there was some recovery in copra production, but by then the copra market had again collapsed, to the point where a price support scheme had to be introduced. The death-knell for Kadavu's copra industry came with Cyclone Meli in 1979 and Oscar in 1982. The period since has been remarkably free of cyclones for Kadavu and the remaining trees have fully recovered, but most nuts remain unharvested in face of an increasing labour shortage, low copra prices, and the high returns from other crops. There has been no incentive to replant coconuts in order to replace senile or broken palms. In most areas, it has been twenty years since copra was last dried for export; the dryers are now either dismantled or used instead for kava, beche-de-mer, or local oil production. It could rightly be said that cyclones led to the eventual destruction Kadavu copra industry, but the industry would probably have been rehabilitated had:

- returns from copra been higher;

- much more profitable alternative crops not been available, and

[66] *Agricultural censuses, 1978 and 1991*

- there had been a more adequate and willing supply of labour.

Fijian subsistence agriculture includes a wide variety of fruit, nut, and leafy vegetable crops. These crops may be planted but they are usually not formally cultivated. Among the most common are seasonal tree crops-- breadfruit, mango, and *vutu kana* or cut nut *(Barringtonia edulis)* - and bananas, plantains, and papaya which bear fruit year round (Table 13). Other than taro leaves, the most important green leaf crop is *bele (Hibiscus manihot).*

There are also many important wild foods and medicinal product crops. Other than wild yams, these include various fruits, nuts, leaves, and ferns. These wild foods provide day-to-day delicacies and important reserves against cyclones and other natural disasters. They have, however, become less important with increasing cash income, increasing dependency on external assistance after disasters, and the declining natural habitat.

A significant, extra-legal, component of Kadavu's cash economy is the growing of Indian Hemp or marijuana. As with all illegal activities, it is difficult to estimate the value of production. Police estimates suggest between F$50,000 to F$500,000 of Kadavu marijuana is seized annually[67]. An economic investigation of Fiji's marijuana industry is long overdue. However it would be reasonable to assume the farm gate value of marijuana on Kadavu would exceed several million dollars. A notable feature of marijuana as a crop is its resistance to cyclones and drought.

The 1991 Agricultural Census identified four types of livestock in Kadavu: cattle, goats, poultry, and pigs. Cattle are relatively insignificant, the census counting only 610 heads. There are surprisingly few horses. Despite the goat being the provincial mascot there are not many in Kadavu, at least not relative to the human population and land area; the 1659 goats counted in the 1991 census represented 0.9 per cent of Fiji's total goat population, about what one might expect from a province with both one percent of Fiji's land and human population. There is a large amount of poultry, around 2.3 per cent of Fiji's chicken population. Proportionally, the most significant animal is the pig. The 1991 agricultural census counted 7,441 domestic pigs on the island (a ten per cent increase from 1978) which represented 8.2 per

[67] *This is based on the Fiji Police rule of thumb that six 6-foot plants produce a kilogram of dried leaves and that a kilogram has a $50000 street value.*

Table 13: Fruit tree numbers on Kadavu, 1991

Fruit	Banana	Breadfruit	Citrus	Mango	Papaya
Number bearing	9,052	5,962	3,279	2,251	1,929

Source: Agricultural census, 1991

cent of Fiji's total herd, a relatively large number. There are approximately three pigs for every four people - and this does not include wild pigs. This may be more pigs than the province can support, a point returned to later.

THE IMPACT OF NATURAL DISASTERS ON KADAVU

Overall vulnerability

Some communities are more vulnerable than others to natural disasters. The most vulnerable are impoverished populations, those that occupy an ecologically marginal environment and those that are dependent on a single source of sustenance. This is not the situation faced by Kadavu or other parts of Fiji where land resources are abundant. The population of Kadavu is not impoverished. Blessed with abundant high quality land and marine resources, this is an agriculturally affluent community with a strong subsistence base and "opportunities to produce highly remunerative cash crops (see Table 14). The imputed annual income generated by kava and taro alone is F$15 million, equivalent to F$1,600 per capita and there are land resources and market opportunities sufficient to considerably raise this level of income. A target income approach to rural decision making is, however, evident - a target that may increase over time, but increasing agricultural activity does not necessarily mean increased production.

With its abundant natural resources and low population, density Kadavu is far from a marginal ecological environment. However recent decades have seen the adoption of non-sustainable practices and other negative developments that have increased the community's vulnerability to natural disasters. These include:

- the increase in the uncontrolled pig population;
- unsustainable land clearing of forest for kava planting;

- increasing incidence of indiscriminate burning;
- shorter crop rotation with increasing importance of cassava and declining importance of yams; and
- the decrease in the wild yam population.

Kadavu is heavily dependent on kava as an income earner, a crop which is vulnerable to cyclones, drought and disease and which offers nothing in terms of food security. This reflects a shift of Kadavu's limited labour resources from the production of copra to kava. Yet Kadavu could adjust relatively easily to the loss of kava from a major disaster, for a range of root crops, particularly taro, can also provide good returns to labour and land within a relatively short period.

Cyclones are the most conspicuous natural disaster that affects agriculture on Kadavu and other outer islands. Drought is another occasional hazard. There are also ecological disasters that are in varying degrees controllable. The most evident is the disastrous interrelationship between pigs, burning, and unsustainable cropping practices. In the longer term, these ongoing and insidious processes are more damaging than physical disasters. Kadavu agriculture is also at risk from an introduction of a pest or disease, such as the rhinoceros beetle which damaged coconut production. The arrival of the papuana beetle from the main island of Viti Levu would have an equally devastating impact on taro production today.

Cyclones

The main hurricane season is from November to March but major cyclones have occurred as early as October and as late as May. On islands such as Kadavu widespread flooding is not a significant problem due to the sloping terrain and absence of any river system. Sea-surges can contribute significantly to the damage caused by cyclones on small islands. Most of Kadavu is protected somewhat by an extensive reef network but there have been catastrophic sea surges in the past. Brookfield, discussing the cyclone of 1886, the worst storm in Fiji's recorded history, states:

On Gau (an island in Lomaiviti group), a sea surge 5.5 metres high is reported to have penetrated 650 metres inland, and on Nairai and Batiki (also islands in Lomaiviti) wave borne debris was found and measured ten metres above sea level after the storm. The worst damage was on coasts undefended by reefs, or with broken fringing reef [68].

Severe earthquakes are not perceived to be a hazard to outer islands such as Kadavu, even though a fault line runs through the Beqa channel, across the Suva peninsula and the Koro Sea to Taveuni. The last major shock, registering 6.75 on the Richter scale, was in 1953 and generated a tsunami that reached a height of 15metres on the outer Kadavu reef, causing considerable damage and killing two people [69]. For Fiji's outer islands, however, these are rare events with limited implications for agriculture. From an agricultural perspective, the main concern is damage to infrastructure (roads, storage houses) and landslides and tsunamis that can destroy crops.

Drought

Drought is a rare occurrence on the main island of Kadavu, apart from the northern leeward side of the island where the long dry season (May through September) can damage crops. The smaller islands of the Kadavu group are distinctly drier than the main island.

Environmental disasters

Traditional Fijian agricultural systems were highly sustainable even when planting was done on steep slopes. Crops were grown in rotation with long fallows and without chemicals. Forest areas were an integral part of the food security system of the village. Domestic pigs were an important part of the system but social controls meant that they were always fenced. The breakdown in traditional agricultural systems has been an environmental disaster with major implications for sustainable food production.

Burning of land, as elsewhere in Fiji, is increasing in Kadavu. The reasons given for this are typically to clear land for planting, to ease hunting for wild pigs, and to expose wild yams. The consequences in terms of land degradation and damage to pine plantations and natural forests are well documented and obvious. Continual burning can irreparably damage

[68] *Brookfield, 1977: 170.*
[69] *Brookfield, 1977: 167.*

the soil and vegetation complex, creating large bands of infertile soil which can be seen above the hills of many villages. Strict laws with substantial penalties exist for indiscriminate burning but they are never enforced by the national police force with whom responsibility now lies. This was not the case with the old Fijian Regulations, which vested some of the enforcement of burning laws in the local Fijian administration. Before this was dismantled in the 1960s, local magistrates known as buli would enforce these laws and could either punish offenders or refer them to the colonial courts.

Pigs are another hazard. Approximately eight per cent of Fiji's reported pig population is in Kadavu; only Lau and Rotuma have more pigs per person. Discussions with villagers suggested there are at least as many wild pigs, which of course were not counted in the census. Many villagers and officials who were interviewed considered the activities of pigs, both wild and domestic, to be a greater threat to agriculture than cyclones. It is difficult to define exactly the cost to agriculture, although government and aid agencies consider this to be a nuisance rather than as a disaster in the traditional sense. As with burning, the impact of pigs is insidious, cumulative, and long-term ecological disasters for which mitigation measures need to be urgently taken. Pigs foraging for food dig up and destroy root crops; domestic pigs in gardens close to the village, and wild pigs in gardens in the bush. Domestic pigs may cause more damage than their wild cousins for while wild pigs are a common good that can be hunted and killed with impunity; this is not the case with domestic pigs which all have identified owners within the village community. Farmers who once had only a wild pig problem now have a domestic pig problem too. The general consensus is that that there has been a decline in village discipline and leadership over the last decade or so since the dismantling of the old Fijian Regulations. Law enforcement responsibility was transferred to the central government and away from communities.

The effect on food production has been noticeable. Village elders say it gets worse every year. Particularly badly affected are wild yams, the traditional food store after disasters, but also taro, the main commercial root crop. This in part explains farmers' preference for kava - which, being inedible, is less likely to be destroyed by pigs - as a cash crop despite the higher cyclone risk. Cash earned from kava allows villagers to buy food to supplement lost subsistence which, however, has food security and nutrition implications. Rice and wheat flour are less nutritious than root crops such as yams and taro.

The problems of pigs, burning, and loss of food security compound each other. Fossicking by domestic pigs contributes to gardens being distant from settlements, therefore many farmers do not bother to travel the long distance to cut their cassava stems before a coming cyclone, knowing that government relief will come, or being aware that there are now more false alarms as hurricane identification and tracking technology that allows for 48 hour warnings compared with the 24 hour warnings that were the norm a decade ago. The wild pig problem increases the incidence of bush fires as frustrated villagers try to control or hunt the pig population by burning them out but, in the process destroying wild yams and their habitat.

The rapid expansion of kava and cassava have also brought unsustainable cropping practices. Larger new plantings of kava have usually involved the clear felling of forest. The trees are cut down with chain saws, whereas traditionally they were girdled and decayed slowly, now causing higher rates of soil loss and erosion. Increasing preference for cassava has meant land is often not allowed to go back into fallow and is planted again with cassava, pushing back the bush-line.

Biological disasters: pests and diseases

The introduction of a pest or disease can be more of a hazard than a physical disaster. Fiji has long history of exotic pest and disease introductions that could be considered disasters with profound impacts on the agricultural sector. These date back to the nineteenth century with the introduction of the coconut moth *(Levu ana iridescens),* a pest which prevented commercial coconut plantations from being established on Viti Levu last century. Fiji's infant coffee industry was destroyed in the 1880s by the introduction of *Hemilaia vastatrix.*[70] Sometime later, the coconut industry was afflicted by the Rhinoceros beetle *(Oryctes rhinocerous),* a pest which reduced coconut yields in all the main growing areas, including Kadavu, during the 1950s and 1960s and required considerable public resources to be invested in its control. Through the successful introduction of a viral control agents and natural ecological adjustments this is no longer a serious pest. In the 1950s and early 1960s bananas for export was the main cash crop from Fiji's Central Division but with the arrival of the interrelated fungal diseases

[70] *Brookfield, 1977: 166*

Sigatoka Disease *(Mycosphaerella muscola)* and black leaf streak *(Mycosphaerella Fijiensis)* this major industry disappeared in three years. More recently, the arrival of papuana beetle has meant that large areas of the Central Division can no longer grow commercial taro.

The relative isolation of islands such as Kadavu has spared them from most major biological disasters. The rhinoceros beetle did affect Kadavu's coconut industry, although it was not a major factor in the industry's demise. Kava die-back is present on Kadavu but it is limited to areas with poorer growing conditions - although larger monocultured plan tings may aid its spread. Kadavu does not have papuana beetle. Publicity campaigns against the movement of taro planting material from Viti Levu to the outer islands have successfully contained the pest to Viti Levu. The arrival of this pest would limit taro to being a subsistence crop until a biological control could be found. Even worse would be the arrival of the taro leaf blight that decimated the Samoan industry for this would cause the virtual disappearance of taro, even as a subsistence crop. Despite strict quarantine restrictions, the chance that taro leaf blight will eventually reach islands such as Kadavu is quite high, given that the disease has moved from the north into Solomon Islands and from the east into Samoa. In Kadavu's favour, however, is that taro is not grown in large monoculture areas involving a large use of chemicals.

Kadavu's two most important cash crops, taro and kava, are not especially tolerant to cyclones but high returns to producers more than offset the risk involved. Cassava, the most important food staple, can resist a major cyclone provided it is first pruned. The less popular root crops such as wild yams, *kuma la, via, via gaga,* and *dalo-ni-tana* stand up quite well to cyclones, but are little grown due to market preferences or the greater labour inputs involved. Table 14 summarises the vulnerability of Kadavu's crops to natural, biological, and environmental disasters.

TRADITIONAL DISASTER MITIGATION ON KADAVU

In pre-colonial times there was less coastal settlement in the outer islands than today and therefore devastation caused by sea surge and salt spray was less of problem. Brookfield describes the support system that existed between islands, or parts of islands, in the Eastern island group after a cyclone:

> *Where damage was restricted to a particular islands it was possible for the inter-island trading system* (which has now broken down) *to be activated to supply needy islands, especially as the main period of shortage is not immediately after the storm when there are crops to be salvaged, but in the subsequent months before plantings came to maturity. Planting material as well might have also been transferred in this way*[71].

This parallels the situation observed in other parts of the region where traditional links exist between different areas-rarely both affected in the same way by a particular event-that enabled people to cope in past times. These traditional relationships have often been ignored by disaster bureaucrats in the capitals not only to the detriment of those directly affected by a disaster and their self reliance, but also to the detriment of their traditional trading partners. The situation when the devastation is widespread was described for the Eastern islands in a 1948 report of the District Officer:

> *Lakeba is one of the most fertile islands in the Lau group. Its usual role* is *to provide less favoured islands food in exchange for other commodities (posts for houses,* tanoa *(kava bowls),* magimagi *(coconut rope) etc.) The hurricane would reduce the standard of living in Lakeba to a level which is strange in that island, but is by no means uncommon in other parts of Lau. For about six to seven months before new crops of taro and cassava would become available diet would depend on fish, dried fish, coconuts, leafy vegetables, pigs, poultry, and wild foods. The inhabitants of Lakeba would not be threatened by with starvation but inhabitants of adjoining islands, who traditionally been dependent for a supplementary food supply will be more seriously affected*[72].

In Kadavu the situation was somewhat different. The traditional political alignment was multi-polar, with a number of districts, none of which recognise the authority of another *(manu dui tagi),* whereas in Lau the whole province recognises the leadership of Lakeba. There were also no significant wealth differences between parts of Kadavu, perhaps with the exception of the outer islands of Ono and Dravuni, and there was therefore no central authority or breadbasket to co-ordinate disaster relief. Kadavu's small size also meant that there would be little difference in damage between different areas.

[71] *Brookfield, 1977: 171*
[72] *Reported by Brookfield; Ibid.*

Table 14: The vulnerability of Kadavu's crops to natural disasters: 1973-97.

Crop	Importance	Cyclones	Drought	Biological disaster	Ecological disaster
Taro (*C esculenta*)	The most important cultural and food crop. Most important economic crop after kava.	Highly susceptible to cyclone damage. Heavy winds shake the roots and rot sets in within days, but young plants up to about 3 or 4 months may endure such winds. It has poor keeping properties and is only edible for a few weeks after harvesting. Offsetting this susceptibility, taro is a relatively short-term crop (9 to 10 months) that can be planted any time of the year.	Will not survive a prolonged period of drought, but this is rarely a hazard in areas where taro is grown in Kadavu.	Taro is highly susceptible, as the experience of taro leaf blight in Samoa and papuana beetle on Viti Levu has shown. Isolation and traditional cropping practices have spared Kadavu from such disasters, but the island's vulnerability to such disasters is increasing.	The greatest threat to the industry is the damage caused by pigs, yet this disaster has the greatest scope to control.
Dalo-ni-tana: (*Xanthosoma*)	Not particularly popular with Kadavu people. In the past when people grew a variety of root crops, it was valued for its own sake and its keeping qualities, and was more common.	A much stronger plant than *C. esculenta*, it is less susceptible to high winds and has superior keeping properties, being edible for up to 4 weeks after harvesting.	Can be planted in areas too dry for *C. esculenta* and grown in all parts of Kadavu.	Tolerant to pests and diseases. *Dalo-ni-tana* is not afflicted by taro leaf blight or attacked by papuana beetle.	As with taro, damage caused by pigs is the major disaster threat to *dalo-ni-tana*.
Yams (cultivated domestic)	Popular amongst consumers but high and skilled labour inputs and shortage of planting materials have made cultivated yams less popular amongst producers.	The most susceptible of root crops to cyclones. During growth phase yams have long aerial vines which die off on maturity. For domestic yams, the vines are trained to grow over temporary trellises and supports. Cultivated yams on their weak supports are very vulnerable to wind. If the vines are broken or damaged before the tuber is mature, it will quickly rot. The peak growing period for yams coincides with cyclone season - most yam varieties are planted August through September and are harvested in June-July. A major consequence of a cyclone on yams is the loss of planting material - it takes 2 to 3 years to get back to full production. Offsetting this susceptibility is the storability of mature tubers. Stored yams can be kept up to 6 months, although the next hurricane is usually well beyond their storability limit.	Yams are quite tolerant to an extended dry period. The normal planting time is during the dry season.	Yams are subject to a range of fungal, bacterial, and nematode attacks. The pests and diseases of greatest concern are those that attack the tubers after harvesting and thus adversely effect storage life. However a pest or disease in Kadavu is never enough to wide out a significant proportion of the crop in a particular year. Under traditional cropping systems pests and diseases are unlikely to be major problem - particularly if disease free planting material is used.	The greatest threat to yams is pigs and human poachers.

Yams (wild)	Wild yams such as *tivoli* are particularly popular amongst consumers.	In contrast to domestic yams, these are the most tolerant of all root crops to both wind and drought. They are supported and protect by permanent tree cover to which they are anchored by very strong and fibrous vines. Thus they can survive the most severe of cyclone. These yams are not seasonal and don't need to be harvested, they just regenerate. Thus they can be left in the forest as a food bank and has a key role to play in traditional disaster mitigation.	Protected by the forest, wild yams are unaffected by drought.	Same as domestic yams but the random distribution of planting makes the spread of any particular pest or disease difficult.	Wild yams are most threatened by ecological disasters, in the form of unsustainable foraging practices that involve burning and loss of habitat; unsustainable clearing to plant kava; repeated planting of cassava in shorter fallow periods gives the bush has less opportunity to regenerate; and uprooting by wild pigs.
Cassava	Increasingly popular due to ease of planting, lack of skill required, tolerance to poor soil, and cyclone resistance if the tops are cut.	Good tolerance if the tops are cut prior to the arrival of the cyclone. If left in ground, and with tops cut, can be stored for extended periods - several months for most Fiji varieties. But if the tops are not cut cassava is particularly vulnerable to cyclones. The violent agitation of the stem and grown causes the tubers to crack and to rot quickly. Once harvested cassava has a very short shelf life unless processed. With cassava increasingly planted a long way from the village to avoid damage from wild pigs, many farmers do not bother to travel the long distance to cut their cassava stems before a coming cyclone, knowing it might be a false alarm and that, if not, government relief will come. The ability to be able to plant cassava at any time of the year make it well suited as a rehabilitation crop.	Cassava's ability to produce in harsh conditions makes it quite tolerant of drought.	Cassava in Fiji has few serious pest and disease problems, apart from white fly.	Cassava cropping patterns can contribute to ecological disasters. It dose have adverse impact on soil fertility when it is accompanied with repeated planting and shorter fallow periods. Bush has less opportunity to regenerate with adverse impact on traditional food store crops such as wild yams and forest fruits and nuts.
Kumala	A significant second level root crop staple after taro and cassava.	Its low and spreading growing habit makes kumala quite tolerant to high winds, provided it is not subject to flooding and sea surge. Once harvested the storability of kumala is about same as taro, better than cassava and not as good as dalo-ni-tana and yams. Quickest growing of the root crops – thus the distribution of kumala tops tends to be a central part of most cyclone rehabilitation programmes.	Does not tolerate extended dry periods, thus usually planted during the wet season.		Pigs again are the largest threat.

Table 14....continued

Crop	Importance	Cyclones	Drought	Biological disaster	Ecological disaster
Kava	Kadavu's most important cash crop	Mature kava plants are very susceptible to wind damage. Kava is a high-risk crop, particularly as it takes three years to reach maturity and several more years to reach optimum production. However for Kadavu's farmers the returns from the crop more than offset the risk. Furthermore the risks have been substantially discounted by decision-makers in that Kadavu has not been directly hit by a cyclone since 1983, with hurricane Bola.	Young kava is not tolerant to extended drought periods. Planting must be undertaken in the wet season. Provided this practice is followed, most of Kadavu's kava areas face little risk from drought.	'Kava die back' poses a threat to kava production through Fiji, particularly if the plants are under stress. Has not been a major problem on Kadavu because of the good conditions under which the crop is grown.	Clear felling of forests to plant kava can be a contributing to the environmental disaster facing food production in the outer islands.
Coconuts	Now of no importance as a cash crop - but remains a significant subsistence food crop.	Only in the most violent of winds are palms uprooted or broken. The most vulnerable are young trees that can be uprooted or senile trees that can snap. The main damage to coconut palms come from the striping of the fronds causing premature nut fall. Coconut production can be halted for several months to up to four years depending on the severity of the damage, the age of the trees, and soil fertility. It took 2 years after Cyclone Val in February 1995 for coconuts on Kadavu to show significant signs of recovery, and they had not fully recovered when Meli struck in March 1979.	Coconuts are particularly drought resistant. A prolonged dry period can retard nut production.	Due to isolation, and in more recent times strict quarantine, Fiji has been spared the entry of any major disease. Pest problems, notably coconut moth and Rhinoceros beetle, have been brought under control.	There have been no environmental disasters that have threatened coconuts or been caused by coconuts.
Marijuana	An illegal crop that plays an important role in the Kadavu cash economy.	Perhaps the most cyclone tolerant of Kadavu's cash crops. It is a six to seven month crop that can be planted at any time of the year. Thus it can be planted to avoid the cyclone season. A plant blown over by strong winds, provided it is not uprooted completely, can be propped up to start growing again.	Marijuana is reported to be highly resistant to drought.	As a illegal crop, little is known about its pests and diseases.	
Other food crops (fruit, nut, and leafy vegetable crops)	An important part of subsistence, adding an important nutritional component.	Fruit from seasonal tree crops such as mango, nuts, and breadfruit will be lost in a cyclone but the trees themselves are relatively cyclone resistant, and are usually back in production by the next season. Perennial fruits such as bananas and papaya are likely to be destroyed by cyclones but will be back in production within a year.	Within traditional cropping systems these crops tend to be relatively drought resistant.	Pests and diseases tend not be a problem with scattered plantings.	

Together, this has limited the scope for traditional trading relationships to develop for disaster relief as they have elsewhere in Fiji and the Pacific region. Traditional disaster mitigation arrangements in Kadavu were more localised.

Traditional cropping patterns

The most important traditional disaster mitigation practice was to grow a variety of foods that were resistant to high winds or stored well. Staples such as wild yams, *dalo-ni-tana, via,* and *via gaga* displayed both favourable characteristics. *Kumala* is resistant to high winds but does not store well. Domestic yams store well but do not tolerate strong winds. The people of Kadavu were well placed to avoid famine with a wider food base incorporating these *kakana ni cagilaba* (hurricane foods). At the core of traditional disaster mitigation and food security was the yam, particularly the wild yam. In times past, Kadavu people were expected to maintain a store of yams both as planting material and as a food store, a custom that has all but disappeared. One of the most regrettable changes in the cropping pattern of Fiji's outer islands is that yams are now rarely planted as the focus of food production has shifted to taro and cassava. Also, since the mid-1970s, the government began providing disaster relief food supplies thereby reducing the importance of disaster mitigation considerations in peoples' decisions to plant particular crops.

Food preservation

Kadavu has the same food preservation traditions as other Fijian communities. The most popular method was pit fermentation. Any staple could be placed in these pits, known as *davuke,* and a four to six week process resulted in *madrai,* the Fijian name for fermented staples. These pits were dug in welldrained land and lined with leaves. Cleanliness and a sterile environment were considered important while preparing the food for the pits. The result would be a paste-like substance with a distinctive smell and a shelf life of a few months to a few years.

Parkinson (1984) points out that people in high islands such as Kadavu might appear to have little need for such a complicated food preservation process. The soils are rich and the climate is mild. Traditional agriculture systems were in place to absorb any damage from drought or cyclones. These methods were used, however, because they were more than just a bulwark against famine. Preserved food was a status symbol, a means of exchange, a material of war, and a provision for long voyages. Parkinson also points out that the food of old was rather bland, and fermented food provided a relief from this blandness. It is little surprise, therefore, that food preservation has declined, for all of these roles of preserved food are no longer important or have been replaced by something else.

The state of traditional knowledge

The use of traditional food preservation methods and disaster mitigation cropping systems has declined but traditional disaster mitigation knowledge is far from dead, just rarely applied. These methods have been documented to some extent by researchers such as Parkinson, Aalbersberg, Gerahty, and Brookfield. The knowledge base is there; the challenge is to revitalise it before it is too late.

Youth programmes are one key to increasing the use of traditional resource conservation, food security, and disaster mitigation knowledge. Provincially sponsored youth training camps could be a venue where a variety of things would be taught, including modern agricultural methods, Kadavu's traditional arts and customs, food preservation techniques, and sustainable cropping practices of old. Such community-based initiatives warrant support in their design and implementation as do the production for traditional and appropriate food preservation posters as resource material for these programmes.

The Ministry of Agriculture Forests and Fisheries (MAFF) could help promote sustainable agriculture, including traditional disaster mitigation. At present, however, MAFF's efforts are almost entirely focused on a few commodity cash crops, including kava and taro. Regrettably they consider subsistence and food security activities to be unimportant and provide them few of the resources at the Ministry's disposal. Working in conjunction with the Provincial Administration, MAFF could try to encourage a return to the wide food base of old, including staples that are cyclone resistant or storable. This need was recognised in the recent Asian Development Bank review of Fiji's agricultural sector; to quote:

> *Farmers have little or nothing to learn from frontline extension officers in the production of traditional crops. To the contrary, experienced farmers should be used as resource persons in youth training*

programmes promoting sophisticated traditional crops such as yams.[73]

The ADB Sector Review also highlighted the need for the status of traditional food and farming systems to be enhanced through "school curricula, youth training programmes, and via the media.[74]

There is room for scientific research into traditional food preservation. Studies by Aalbersberg et al suggest that *madrai* ni *Viti* prepared in *davuke* lined with plastic and using other modern materials produces a superior product, both in terms of flavour and storability. Further research, perhaps by the Institute of Applied Science (I AS) at USP, could help meld traditional knowledge with modern science perhaps coming up with a product that overcomes many younger Fijians' antipathy to traditionally preserved food. There is also considerable scope to promote modern appropriate food preservation methods at the village level, but not primarily for disaster mitigation purposes. The people of Kadavu have not had a major cyclone in more than a decade and thus disaster mitigation will provide little incentive. The focus should be on generating (or more likely saving) household cash income with food security and disaster preparedness as 'spin-off' benefits.

AN ASSESSMENT OF THE IMPACT OF THE FIJI GOVERNMENT'S CYCLONE RELIEF PROGRAMMES ON KADAVU'S AGRICULTURE

Greater vulnerability leads to greater dependency on government

There is now substantial dependency on Government for food relief following a major cyclone. Government cyclone relief dates back to the 1880s, a period of intense hurricane activity. Yet the high current dependency on government cannot be seen as an immediate consequence of colonialism. In those early years, only small amounts of relief food supplies were provided and only in the direst of circumstances. The main reliance was on local food resources. Brookfield reports that in 1936, after villages in Kabara in the Lau group were destroyed by a severe cyclone, an appeal was made for rice, a request that was turned down by the then District Commissioner, the Fijian statesman Ratu Sukuna. After a storm only a month later, however, he relented and dispatched £419 worth of food.[75] Reports up to the immediate post-Second World War period indicate a prevailing strong level of selfreliance. The Fiji *Times* (5/1/49), reporting on the severe cyclone of December 1948, noted "offers of relief food to be paid for in cash, or even delayed payment, were only accepted with reluctance and often refused." In 1941, relief was supplied to victims of a severe cyclone that struck Suva, on the basis that it had to be repaid after two years.

Greater dependency of Fiji's outer islands on the central government was preceded by greater vulnerability. This came about through the increasing use of cash to obtain food (initially by producing copra and, later, kava in Kadavu and other islands), the emergence of cassava as the pre-eminent subsistence crop, and the demise of wild yams. With the virtual disappearance of village owned sea-going canoes and cutters, the possibility of seeking help from other islands was lost - thus putting the onus on the central government to assist. The late-colonial and early post-independence period saw a move to toward strong centralism and a new situation with respect to dependency which is reflected in cyclone relief.

The nature of government's hurricane relief programmes

Cyclone relief from abroad dates from 1948 when a Catalina from New Zealand distributed relief supplies and 85 tonnes of rice was donated from Australia. The same year, a government disaster coordinating committee was formed the precursor of the formalised Emergency Services Committee (EMSEC), which later became the Disaster Management Committee (DISMAC). Thus began the institutionalised system of providing relief supplies as a matter of course for any cyclone regarded as severe. The system that prevails today is for an inspection of needs to be conducted, on the basis of which relief supplies are provided. There was recognition from the outset - although often not followed - that the crucial period for relief supplies is between the exhaustion of salvaged food and the maturity of newly planted crops. The Government typically provides a food aid package to each

[73] *ADB 1996: 31.*
[74] *Ibid*

[75] *Brookfield, 1977: 172.*

household, calculated to be one month's rations, and composed of tinned meats and bags of rice and flour. There is often some discrepancy between reported or assessed needs and actual food needs, and allegations of waste or misallocation of supplies.

MAFF extension staff are heavily involved in cyclone relief and rehabilitation programmes, being responsible for the assessment of crop damage and for recommending the distribution of rations. The general consensus is that crop losses are often exaggerated and the need for food rations overestimated. MAFF staff are also involved in agricultural rehabilitation, which mainly involves distributing planting material, usually kumala cuttings or, for longer-term rehabilitation, taro suckers. These programmes have tended to prove counter-productive as they bid up planting material prices and undermine private sector initiatives in this area. It is recommended elsewhere in this report that appropriate varieties of corn seed would be better relief for distribution immediately after a cyclone.

After major cyclones, relief operations tend to massive operations, tying up a major part of government's human resources. As a result of these programmes, actual food shortages have never been severe, even after the most devastating cyclone, even though this has come at considerable cost both in direct financial terms and in terms of long-term food security and self-reliance.

The impact of government programs on food self reliance

While there is strong anecdotal evidence that these programmes have affected people's traditional methods of disaster mitigation and reduced their self-reliance, there is little evidence that they have affected agriculture greatly as a whole. A hurricane relief package is but a one-month ration and even during that one period most people endeavor to feed themselves, as they soon tire of the staples provided. There is no question, however, that the people of outer islands such as Kadavu are now less self reliant than in the past. But whether declining self-reliance/I in the face of natural disasters is more a result of government's hurricane relief, or whether hurricane relief is a response to the people generally being less ı self-reliant, is not clear. There are conflicting views | on this. Discussions with elders in Kadavu would suggest the former to be the case. Civil servants in Suva responsible for cyclone relief tend to suggest that it is more the latter. The true situation is likely to be a combination of both.

It nevertheless seems there is much scope to increase food self-reliance and reduce the need for food aid for islands such as Kadavu. Proposals as to how this might be done are discussed elsewhere in this report. This would provide substantial benefits, both private and social, including lower costs to government, allowing them to instead focus on repairing infrastructure after a cyclone, and better nutrition, as traditional disaster foods are almost always superior to those supplied by relief programmes.

THE COST OF CYCLONES TO KADAVU'S AGRICULTURE

The cyclones that have affected Kadavu over the last 25 years are listed in Table 15, together with an evaluation of each one's impact on Kadavu, based on official assessment reports of damage and the author's evaluation of what the costs to the agricultural sector were likely to have been. Over this period Kadavu has suffered three severe cyclones: *Val* (1975), *Meli* (1979), and *Oscar (1983).* The imputed damage to the agricultural sector in current value terms of each of these disasters is estimated to be around F$2 million. In the foreseeable future, Kadavu can expect a cyclone of similar severity. It is anticipated that its impact on the agricultural sector will be considerably more than a similar cyclone would have caused twenty years ago. There are two reasons for this:

- Kadavu has become heavily dependent on a single non-food crop, kava, that is susceptible to cyclone damage; and,
- Crops that once provided food security after natural disasters - notably wild yams and *dalo-ni-tana* - have declined in importance.

The expected kava losses from a severe cyclone are modelled in Table 16. Extrapolating from the 1991 Agriculture Census, it is assumed that there are 800 ha. of kava planted on Kadavu. As the census does not provide the age profile of these plantings, the age distribution shown in Table 16 is based on casual field observation and discussions with farmers and traders. The results of this simulation are summarised in Table 17. It is predicted that the loss of kava revenue in the year of the cyclone would be around F$4.5 million, with further future foregone loss of revenue estimated at F$6 million.

Table 15: *The cost of cyclones to Kadavu agriculture:* 1973 - 97.

Cyclone	Date	Reported intensity and proximity to Kadavu	Evaluation of the cost to sector
Kina	Dec 26-5 Jan 1992	Severe and wide-spread system, caused extensive damage to most of Fiji, with its path lying between Viti Levu and Vanua Levu. Kadavu was one of the few areas to not be severely affected, other than for heavy rain. The centre of the system passed approx. 150 km north- east.	**Cost**: Wind damage to food crops was minimal and confined to the north-east coast. Some cassava was lost where tops were not cut. Not sufficient wind to significant damage other root crops including kava. Some seasonal fruit and bananas lost. **Benefit**: With the Kadavu's kava crop essentially unaffected, and most other growing areas badly affected, Kadavu growers were able to reap a windfall gain when kava prices rose sharply a month after the cyclone. Root crop prices rose 50 to 100 per cent in the months following Kina. Kadavu's taro was largely unaffected. Thus growers had the opportunity to reap windfall gains on the Suva market. The heavy rains associated with Kina, followed by an extended period of sunny weather facilitated growth and allowed for planting. On balance, Kadavu was one of the few beneficiaries from Cyclone Kina.
Joni	Dec 6 -13,1992	A cyclone of moderate intensity that passed close to the western tip of Kadavu, the first to pass close to the island since Oscar in 1983. Most damage on Viti Levu was caused by flooding. The quk:k·moving system was weakening by the time it reached Kadavu.	Similar situation to Cyclone Kina in terms of costs.
Oscar	Feb 26 - March 2 1983	The centre of this severe cyclone passed direct~ over Kadavu.	The impact on subsistence and cash crops was substantial. Kava: Extrapolating from the 1978 Census, there would have been about 80 hectares of one and two year-old kava. It would be reasonable to assume at least 40 ha of this kava would have not survived, representing a future loss of kava production of about 120 tonnes (valued at F$1.2 m at conservative current prices. From census extrapolation, there was a further 50 ha old enough to harvest. Some of this kava would have been salvaged (say 50 per cent) . albeit at a considerably discounted value, a small percentage (say 20 per cent) will have survived Oscar, of which the balance would have been lost. Say around another 80 tonnes of kava would have been lost at a value of F$lm. The replanting of kava would have been seriously constrained given that this was a relative~ late hurricane striking Kadavu in early March. Thus the total Kadavu kava loss attributable to Oscar is estimated to be around 250 tonnes (current farm gate value F$2.5million). Taro: Using the 1978 Census as a basis it is estimated that there was around 270 ha of taro planted at the time. The peak harvest period is October through February (the 1978 Census estimated that 71 per cent of taro is harvested during this 5 month period.) Thus the bulk of the taro in the ground at the time of Oscar would have been young plants, thereby ameliorating the damage. It estimated that around 100 ha (500 tonnes) of taro might have been lost. The imputed value of this taro at current price would have been about F$400,000. Coconuts: By 1982, coconut production had returned to 162 tonnes - the highest level since 1979. Oscar was the last of a succession of severe cyclones to hit Kadavu starting with cyclone Lottie in December 1973. In 1973, Kadavu's copra was 1,042 tonnes. Kadavu has produced virtually no copra since Oscar- in part the cumulative impact of a decade of intense cyclone activity but also because returns from kava are much higher and labour is scarce. Thus loss of copra due to Oscar is estimated at 400 tonnes (the additional production in 1983 and 1984 had Oscar not struck). The value of this copra in current value terms would be around F$120,000.
Wally	April 3-5, 1980	Winds only gale force but severe flooding and landslides in southern Viti Levu.	Winds on Kadavu were not sufficient to significantly damage crops and only minor localised damage occurred. Late rainfall probably had some useful effect on crop production.

Table 15 ... continued

Cyclone	Date	Reported intensity and proximity Kadavu	Evaluation of the cost to sector
Meli	26-28 March 1979	A severe cyclone that passed over Kadavu (52 lives lost in Fiji).	Reported~ an even a more damaging cyclone to agriculture than Oscar. The loss to copra was significant~ greater, with production falling from 912 tonnes in 1978 to only 48 tonnes in 1979, and 96 tonnes in 1980. The immediate loss in copra production is estimated to be around 1,800 tonnes valued at around F$600,000 in current terms. It is assumed that the immediate losses to crops such as kava and taro were about the same as for Oscar. Rehabilitation of these crops would have been slower as the cyclone came at the end of the season.
Val	Jan. 31-Feb. 1975	A severe cyclone that passed south of Kadavu.	Food crop losses were probably similar to those after Oscar and Meli, but corning earlier in the season, food crop rehabilitation was probab~ faster. At this time, copra was by far the most important cash crop. Copra production Kadavu would have returned to above 1,000 tonnes in 1975 (its level prior to cyclone Lottie.) The forgone loss of production is put at 1,500 tonnes over 2 years. The opportunity cost of the lost production from cyclone Lottie and Val was very high, as this was a period of unprecedented high copra prices. The loss of this foregone production in current value terms would have exceeded several millions dollars.

Table 16: *Simulation of the kava losses from a major cyclone striking Kadavu.*

	< 1 year	**1 to 2 years**	**3 year**	**>4 years**
Estimated area planted (ha.)	230	190	180	200
Estimated area pulled after the cyclone	Nil	Nil	50	100
Estimated area surviving the cyclone	200	80	50	10
Estimated current year production and revenue loss	Nil	Nil	• 40 ha. lost that would have been harvested that year, the estimated loss of production being 100 at an est. value of F$l mill. • 25 ha. harvested that would have been harvested assumed to have F$21kg in value at a total estimated loss of F$125,000.	• 80 ha. lost that would have been harvested that year, the estimated loss production being 250 tonnes at an est. value of F$2.8 mill . • 80 ha. Harvested that would have been harvested assumed to have lost at a total estimated loss of F$500,000.

Source: Author's calculations.

The Kadavu community would lose most of its current cash income for a period of about two years, but should be well-placed to withstand and recover from this loss of kava income. Taro offers a remunerative substitute within a year and also provides food self-sufficiency. At a current farm gate prices of F$1.60 per kg., it is difficult to understand the almost exclusive preference to grow kava as a cash crop. Other root crops offer other income generating opportunities, and more extension work

Table 17: Predicted kava losses from a major severe cyclone striking Kadavu.

	Tonnes	value (F$F m)
Current year loss	350	4.40
Future loss	555	6.00

Source: Author's calculations.

Table 18: A simulation of the taro losses from a major cyclone striking Kadavu

		Comments
Total estimated area under taro (ha.)	780 ha	
Estimated current annual taro production	5,320 tonnes	Assumed yield 7 tonnes per ha.
Estimated monthly production (consumption)	455	
Plantings under 2 *months*	150 ha.	
Estimated area after cyclone	120 ha.	Assumes 80 per cent of plants under 2 months survive
Estimated monthly production commencing after 8 months	420 tonnes	Assumed yield 7 tonnes per ha.
Plantings between 3 and 5 months	220ha.	
Estimated area after cyclone	66 ha.	Assumes 30 per cent of plants between 3 and 5 months survive.
Estimated monthly production commencing after 5 months	143 tonnes	Assumed yield 6.5 tonnes per ha. (reduction in yield due to cyclone damage)
Plantings between 6 to 8 months	220 ha.	
Estimated area after cyclone	33 ha.	Assumes 15 per cent of plants between 6 and 8 months survive.
Estimated monthly production after 2 month	55 tonnes	Assumed yield 5 tonnes per ha. (reduction in yield due to cyclone damage)
Plantings 9 months and greater	190ha.	
Estimated area that could be pulled immediately after the cyclone	9.5 ha.	Assumes 5 per cent of the mature plants can be salvaged immediately after the cyclone.
Estimated production available in month following the cyclone	48 tonnes	Assumes yield of 5 tonnes per ha (allowing for post [illegible] losses).

Source: Author's calculations.

should now be put into promoting them as such. **In** the aftermath of a severe cyclone, even more effort will be put into producing the important illegal crop of marijuana, which only takes 6 to 7 months to come into full production. Using 1991 data as a base, a simulation of food crop losses from a major cyclone is shown in Tables 18 and 19.

Derived from these simulations, short-falls in taro consumption are shown in Table 19. It is assumed that virtually all taro currently produced on Kadavu is consumed on Kadavu, given that taro exports from Kadavu are negligible.

Table 19: *Projected short-fall* in *taro consumption after from a major cyclone.*

Month following cyclone	1	2	3	4	5	6	7	8	9	10'	11	12
Estimated current consumption (tonnes)	455	455	455	455	455	455	455	455	455	455	455	455
Consumption following cyclone (tonnes)	48		55	55	198	143	143	420	420	300	455	455
Short-fall (tonnes)	407	455	400	400	257	312	312	35	35	155	–	–

• An increase in the shortfall is expected in year 10. It assumed that almost a month after the cyclone, replanting will be completed. The surviving plantings under two montl1s old will have been harvested by the end of month 9.

Source: Author's calculations

Annex 1 to Chapter 3

Gross margins for Kadavu's main crops

Gross Margin for the Production of Kava from 1.0 hectare

Year	1	2	3	4
Planting density	4,450 plants/hectare			
Yield (kg per ha)				3,000
% Post-harvest loss		0		
Sales (F$10/kg)				**30,000**
Operating Inputs				
Planting materials		450 (4,450 stems @ F$0.3)		
Family labour	**person days**			
Clearing	40			
Planting	60			
Weeding	40	40	40	40
Harvesting				80
Washing				10
Drying				15
Sorting				2
Sub-total	**140**	**40**	**40**	**147**
				367
Average labour req. per annum				92
Total costs	-450			
Gross Margin	-450.0	0	0	30,000
				F$29,550
Average Gross Margin per annum				F$7,388
Return per family day of labour per annum				**F$81**

Gross Margin for the Production of Taro (Tausala ni Samoa) from 1.0 acre

	Quantity	Unit	Price(F$)	Value(F$)
Yield	5500	kg		
Post-harvest losses	F$0			
Sales	**5225**	**kg**	**0.65**	**3396**
Operating Inputs				
NPK 13:13:21	250	kg	0.69	173
Gramoxone (weed control)	12	litre	10.00	120
Planting material	5500	suckers	0.10	550
				843
Hired Labour				
Land preparation				
Clearing	3	person day	10.00	300
Digging and planting	40	"	10.00	400
Spraying	5	"	10.00	50
Harvesting and washing	20	"	10.00	200
	95			950
Transport to exporter's shed	5225	kg	0.03	157
Total cost				**$1,949**
Gross Margin				**$1,447**
Return per family day of labour				**$15**

4. DISASTERS AND AGRICULTURE IN WESTERN MELANESIA: THE CASE OF VANUATU

THE AGRICULTURE OF WESTERN MELANESIA

The countries of western Melanesia Papua New Guinea, Solomon Islands, and Vanuatu are agrarian societies with high rates of population growth.[76] Agriculture provides by far the main source of employment and household income. The current status of the agricultural sector in these countries is summarised in Table 20. The Papua New Guinea tree crop sector is by far the largest in the region, but the Solomon Island and Vanuatu industries are the most important in terms of their relative contributions to the national economies.

Western Melanesia is a region of frequent natural disasters. During the past thirty years, Vanuatu has experienced the most intense cyclone activity of this century. In Solomon Islands, hurricanes are less frequent but a major hurricane in 1986 severely affected copra, oil palm, and cocoa production. Papua New Guinea is outside the hurricane belt, but its tree crop sector has not been spared the impact of natural disasters.

In 1994, a volcanic eruption at Rabaul severely affected cocoa and coconut production in East New Britain, dropping national cocoa production by 10,000 tonnes. There has been some recovery in production, but the volcano undermined an already unfavourable investment environment. Development of Vanuatu's small coffee industry and food crop production on Tanna has been adversely affected by acid rain from volcanic eruptions, as has food production on Ambrym.

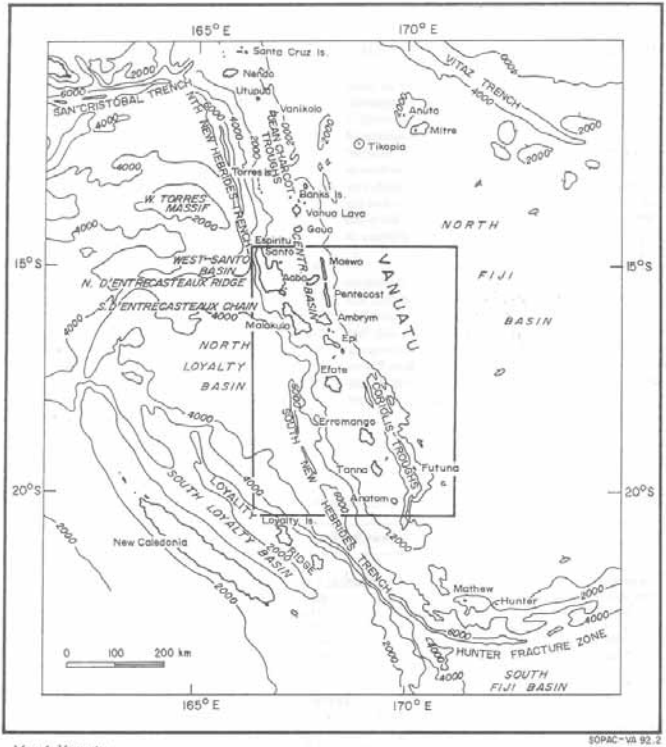
At the time of this study, all the countries of western Melanesia were in the grip of an EI Nino-induced drought. Especially affected were the highlands of Papua New Guinea, where the worst drought for fifty years was compounded by repeated frosts that killed kaukau (sweet potato) the staple of the highlands, and extensive fires that destroyed much of the bush food. Costs of emergency food and losses to commercial agriculture were enormous. In late 1997, the coffee industry, Papua New Guinea's largest agricultural export industry and the largest employer of labour, was projecting a drop in

Table 20: Contribution of agricultural sector to Melanesian economies.

	Papua New Guinea	Solomon Islands	Vanuatu
Year	1996	1996	1996
Exchange rate	Kina/$US= 1.32	$SI!$US3.55	Vatu!$US109
Total value of tree crop exports ($US mill)	353.6	31.7	11.4
Coconut products	44.6	7.8	10.1
Cocoa	36.0	5.0	1.2
Coffee	161.8	–	0.1
Oil palm	107.1	18.9	–
Tea	4.1	-	–
Per cent of total exports	13.9	17.1	58.1
Per cent of GDP	6.5 (1992)		5.2 (1995)
Per cent of population deriving income from tree	> 70	> 70	> 70
Per cent of population living in rural areas	> 80	> 80	>80
Contribution of subsistence to GDP[77]	13.9	16.7	16

Source: McGregor 1997

[76] Estimated in 1995 to be 1.9 per cent for Papua New Guinea; 2.4 per cent for Vanuatu and 3.3 per cent for Solomon Islands; South Pacific Commission, Population Data Sheet.
[77] Papua New Guinea and Solomon Islands: ANU, 1997; Vanuatu: ADB, 1997.



Map 4: Vanuatu.

production of 35 to 50 percent[78] and therefore a loss in export earnings of up to $US150 million, with catastrophic impacts on the national economy. Coffee export earnings are around 10 per cent of mineral earnings but its economic linkages are much higher. Coffee small-holders use very few purchased inputs and spend most of their income in the local economy, thus the coffee income multiplier is very high. Virtually all local businesses and employment in the highlands are dependent on the coffee industry. In total, around 1.3 million people are involved in coffee production, which is 35 per cent of Papua New Guinea's population--more people than the total combined populations of the other Pacific island countries[79].

THE VANUATU ENVIRONMENT

Vanuatu was selected as a case study for a more detailed investigation of the impact of disasters in western Melanesia for several reasons:

- The archipelago that comprises Vanuatu is one of the most cyclone-prone areas in the region. Several islands are also subject to volcanic activity.
- Of all the Pacific island countries, Vanuatu is the most dependent on agriculture.
- Vanuatu has embarked on a concerted program to encourage self-sufficiency in disaster mitigation.
- People in parts of Vanuatu continue to practice traditional food preservation to a significant degree.

A brief geography

Vanuatu comprises a chain of about eighty islands lying in a north-south direction in a rough Y shape over a distance of some 1,300 km., between latitudes 13° and 22° south (Map 4). Five active volcanoes lie along the central axis of the island chain. The country has a total land area of about 12,000 square km., and an exclusive economic zone covering a sea area sixty times as large. Vanuatu islands are geologically young and formed from volcanic eruptions or up-thrusts of seabed. They therefore have steep mountainous terrain, dissected plateaus and terraces, and narrow coastal plains. The only atolls are Reef Island to the north and Aniwa to the south. The two largest islands, Espiritu Santo and Malakula, measure 4,248 and 2,053 square kilometres, respectively, and together with the next six largest islands comprise 87 percent of the total land area. A summary of Vanuatu's topography and population distribution are provided by CSIRO 1992:28:

- 35 per cent of the country is high land (above 300 metres) and supports 10 per cent of the population;
- 8 per cent of the country has low slope (less than 2 degrees) and supports 32 per cent of the population; and,
- 55 per cent of the country is steep land (greater than 20 degree slope) and supports 16 per cent of the population.

Forty-one per cent of the total surface area has soils of good fertility located in climatic and topographical conditions which are favorable to agricultural and pastoral development a higher proportion of arable land than any other Pacific island country.80 An estimated 25 per cent of the land is used for village and other agriculture, 35 per cent is forested, and 40 per cent is covered by other vegetation.[81] Of the arable land, 24 per cent is on coastal plains and 73 per cent on plateaus. Vanuatu's good agricultural resources and mostly low population densities have meant that it has been better able to cope with natural disasters.

Vanuatu's climate ranges from hot tropical to the north to almost temperate in the south, but a wet tropical climate characterises most of the islands. Average seasonal temperatures range between 21° and 27°, and average humidity between 75 and 80 per cent. The hot rainy season, when most tropical cyclones occur, is from November to April. In some years, the dry season is pronounced and extended, with little rain between June and December. Severe droughts can occur. South-east trade winds create a more forested side to the windward of most islands and lighter vegetation to their leeward side. At low altitudes, the windward sides of the islands have a typical equatorial climate, with rainfall between 2,500 and 4,000 mm, while leeward slopes generally have rainfall less than 2,000 mm. Human activities

[78] *Islands Business, October 1997, p.2*
[79] *Overfield 1994*

[80] *Weightman, 1989: 8.*
[81] *CSIRO, 1992:28.*

have created exotic grasslands on the drier sides of the larger islands. The dominant vegetation type, covering about 34 percent of Vanuatu, is a disturbed low canopy thicket bush (Table 21).

Both human activities and natural events such as volcanic eruptions and frequent cyclones have disturbed the native forest cover. The forest inventory project showed much variation in the forest cover of the different islands, mainly related to population density and land use. Islands with the highest population densities Paama and the Shepherds no longer have any significant native forest cover. Those with more than 40 percent forest cover Tafea Province and Banks and Torres Islands have among the lowest population densities.

Of the national population of nearly 170,000 people, approximately 20 percent live in the two urban centres of Port Vila and Luganville. The population grew around 2.8 per cent per year over the decade 1979-89, growing slower (2.6 per cent) in the rural areas and faster (4.7 per cent) in the urban areas, because of urban migration[82]. Urbanisation increases vulnerability to natural disasters. For example, rural people supply their urban relatives with a significant amount of root crops, usually in exchange for past and future obligations, exchange flows that can be cut off by a cyclone on the home island. The last 100 years have also seen the movement of people from upland areas to the coast, which has increased their vulnerability to natural disasters such as cyclones.

The rural population is dispersed amongst the islands and has limited communications with the urban centres, necessitating a relatively high degree of self-reliance in times of disaster. Rural population densities are uneven, being high in some locations and sparse in others. Land ownership is a fundamental aspect of the indigenous culture, and 'custom' relationships restrict the use of land for economic development. Some more densely populated islands have a shortage of land and there has been substantial out-migration to urban centres and other islands. These crowded islands are most vulnerable to natural disasters. Given current land use practices and population growth rates, land shortages may become evident on a national scale within thirty to forty years, presenting a prospect of much greater national vulnerability to disasters.

[82] *ADB, 1997.*

Table 21: *Vegetation cover of Vanuatu.*

Vegetation type	Area (ha.)	Per cent of land area
Mid·height forest (20-30m)	205,300	16.7
Low forest (10-20m)	234,100	19.1
Woodland«10m)	400	0.1
Thickets (3-8m)	433,900	35.4
Scrub (3m)	45,000	3.7
Grassland	51,100	4.2
Swamps	2,300	0.2
Mangroves	2,500	0.2
Bareground/human made	252.300	20.6
Total land area	1,226,900	100

Source: Vanuatu National Resource Inventory System (VANRIS)

Agriculture in the Vanuatu economy

Agriculture is more important to the economy of Vanuatu than in any other Pacific island country. Vanuatu does not have the manufacturing base of Fiji, the mineral and forestry resources of Papua New Guinea, the forestry resources of the Solomon Islands, the marine resources of Micronesia, nor the access to remittances of the Polynesian countries. Over the last five years, the contribution of agricultural products (copra, cocoa, coffee, kava, and squash) to visible exports ranged from 69 to 75 per cent. According to Statistics Office and Reserve Bank estimates, agriculture accounts for 19 per cent of GDP at constant 1983 prices, and 15 per cent at current prices but this is probably an under-estimate given that subsistence was estimated to contribute a mere 9 per cent at 1983 constant prices and 7.5 per cent at current prices.

Agriculture dominates the Vanuatu economy, even more than official statistics might suggest. At least 80 per cent of the ni-Vanuatu population live in the rural areas and are involved in agriculture, mainly providing for their own subsistence. Much of the ni-Vanuatu population in urban and peri-urban areas supplement their household cash income through food gardening. While less than half of Vanuatu's arable land is under any form of cultivation, the agricultural population is skilled in traditional horticultural gardening and, in the commercial sector; there is a pool of agribusiness and entrepreneurial capability. Agriculture is expected to dominate the economy for the foreseeable future, providing, along with plantation forestry, the best opportunities for broad-based growth and employment even though terms of trade are likely to continue moving against the main export commodities of copra, and cocoa, coffee, and despite Vanuatu's susceptibility to natural disasters.

Subsistence crops in the form of coconuts, root crops, a wide variety of fruits, nuts, vegetables, and building and weaving materials are grown throughout Vanuatu. While the Department of Statistics estimates the GDP value of this subsistence to be more than twice that of copra, it could well be worth much more. Similar estimates of the value of subsistence for Papua New Guinea, Solomon Islands, Fiji, Samoa, and Tonga are 13.9, 16.7, 5.6, 28.0 and 14.6 per cent, respectively[83]. The ADB recently imputed a value of subsistence by taking the difference between the caloric needs of the population and what is supplied by imported rice and wheat flower, from which they derived an estimate of about 4 billion vatu at wholesale prices; that is, about double the official estimate.[84] Further allowance could have been made for the protein and vitamins that are also supplied by subsistence agriculture. Thus Vanuatu has a strong traditional food security base, making it well p laced to deal with the impact of natural disasters.

Even so, Vanuatu is a large importer of rice, importing around 7,000 tonnes annually, valued at some 400 million vatu, which represents a major foreign exchange leakage (4 per cent of imports and over 15 per cent of visible exports in 1995). The value of subsistence is nevertheless estimated to be some six times this amount. The bulk of rice is consumed in rural areas, where it represents the most important purchased item. There is high regional variation in rice consumption which is closely correlated to cash income earning capability, principally from copra and, increasingly, kava[85]. The popularity of rice explains the keenness of rural dwellers to obtain rice rations after a cyclone, even if they are not required.

Coconuts dominate the economy in terms of foreign exchange earnings, a situation that will continue for the foreseeable future, despite declining production and fluctuations caused by natural disasters and producer prices. While production and copra prices have fluctuated markedly over the last decade, copra has always contributed more than 30 per cent of export earnings and coconuts remain a sustainable industry. There has been substantial coconut replanting over the last decade, in contrast to the industries of Fiji and Tonga. Around 80 per cent of Vanuatu's copra is produced by small-holders; copra continues to offer them an assured, albeit low, cash income in return from their effort.

[83]ANU, 1996
[84]ADB. 1997
[85] Fay, 1990

During the 1980s, cocoa was promoted as a diversification crop for copra. Despite depressed prices in the 1990s, Vanuatu small-holders have found cocoa to be profitable and production levels have been maintained. Coffee, pepper and vanilla were also promoted during the 1980s. The centre of the coffee industry is a nucleus estate on Tanna. A small spice industry is now developing around a private sector processing and marketing nucleus. Vanuatu has also established an export beef industry. Its main markets are Japan, New Caledonia, Papua New Guinea, and Solomon Islands. The low labour requirements of beef cattle, and resistance to cyclones although not drought make it an attractive enterprise for plantation owners, particularly small-holders who own around 50 per cent of the national herd. A significant commercial squash industry was established on Efate in 1991 and exports to Japan. Kava has a central place in ni-Vanuatu custom. Its commercial production for export has grown rapidly in recent years with the proliferation of interest from the pharmaceutical and natural products markets. It has become an important mechanism for distributing income generated in urban areas to production areas in the outer islands. Trade in kava is also an important vehicle for ni-Vanuatu business participation. Vanuatu's rich subsistence base includes a range of indigenous nuts, especially nangai (Canarium) and navele (Barringtonia) which are now commercially exploited for the domestic market. There is also considerable and growing overseas demand for these forest products, but supply remains a constraint despite a significant resource base.

Weightman identifies four types of farming systems prevailing in Vanuatu today, namely:

- Continuous irrigated cultivation of taro (Colocasia esculenta), combined with a dry land, annual multi-crop food garden;
- Small-holder cash crop production, usually based on coconuts and often under-cropped with cocoa and under-grazed with cattle. Small-holder households also maintain separate multicropping food gardens;
- Plantation production of tree crops, dependent on wage labour.[86]

Subsistence multi-cropping food gardens are based on the annual clearing of forest or bush fallow for several areas of multi-crop family food gardens.

[86] Weightman, 1989:29.

These plots are rain fed and are intensively cultivated for one, sometimes two or three years. Some residual longer-term crops such as bananas remain in the garden for several more years before the plots are allowed to return to bush fallow. Yams *(Dioscoria spp.)* were traditionally the pivotal crop in the system but for everyday subsistence, taro *(Colocasia* and *Xanthosoma)* is the most important food crop. A leafy vegetable shrub known as island cabbage *(Hibiscus manihot)* is invariably part of a Vanuatu food garden. Pure subsistence gardening is now rarely found, except in remote upland custom villages on Malekula and Santo; today most gardening is semi-subsistence. Weightman describes a typical contemporary multi crop garden:

> *The gardens are planted to a variety of crops, often inter-planted as single plants, though sometimes planted with patches of one crop, such as sweet potato, taro, yam or cassava. The soft yams are planted first and take pride of place where the garden offers the best conditions for their cultivation. Other crops follow: sugarcane, island cabbage, naviso, pineapple, pawpaw, water melon, tomato, Chinese cabbage, sweet potato, cassava, bananas, taro, and kava. A single garden will generally contain many varieties of yam or taro and several other crops. The weeding* is *done by hand with the aid of a bush knife, and hoes are not used. The garden* is *generally kept clean weeded until harvesting of the yams nine months after planting.*[87]

While the main food crops grown are yams and taro, their pre-eminence generally is not as great as it once was, for introduced cassava, kumala, and Fiji taro have grown in importance. Even so, the continuing importance of cultivated yams in Vanuatu's village food production systems contrasts with the demise of the yam described in the Kadavu case study, Traditionally, Vanuatu's food gardens were fenced to exclude pigs and only included subsistence crops. While this is less common today, the incursion of pigs into food gardens in Vanuatu has not reached the disaster proportions it has in parts of Fiji. On the drier islands, yam is supreme. Taro predominates in the gardens of the wet northern or eastern central islands, particularly in upland areas and is, overall, Vanuatu's most important food crop, with *Xanthosoma* (Fiji taro) replacing *Colocasia* in drier areas. The root crop that has expanded most over the last twenty or thirty years is cassava, leading to some repeat cropping on the same land and shorter fallow periods.

The irrigated cultivation of taro, known colloquially as water taro *(Colocasia esculenta),* is restricted to areas with permanent running streams, being grown mostly in upland areas and often on steep slopes, but also in locations with high population density. Its area has diminished over the last century and it is now quite a minor agricultural activity, largely because people have moved from upland areas to the coast. Barrau, writing in the 1950s, described the system in south Pentecost:

> *There* is *a large irrigated garden on a very steep slope above Bunlap, which has been terraced by aligning tree trunks and branches along the contour. These form the face of the terraces against which earth* is *heaped on the upper side. Lines of tree trunks may also serve the incidental purpose of marking off the boundaries of the various plots of land belonging to the several members of the clan. Where the taro gardens are on the steep slope, stairways will have been built of logs* so *that the various garden plots can be reached easily and the cultivators can avoid the formation of ravines by treading down the soil.*[88]

Small-holder tree crops are now the most common farming system in Vanuatu. Households grow a cash tree crop, usually coconuts that are under-grazed with cattle or inter-cropped with cocoa. Around 70 per cent of rural households own coconut trees and most make copra at least intermittently [89]. Coconuts are a major source of subsistence. It is estimated, from 1993 census data, that almost 60 million coconuts are consumed each year by the households that produce them, either directly as food or indirectly through pigs. This is equivalent to about 9,000 tonnes of copra production, or about 30 per cent of annual production in 1995. Small-holder households almost invariably maintain a separate food garden. The proportion of cash cropping to food gardening depends on the land and labour available, altitude (which determines the extent to which coconuts can be grown), and the household's adherence to traditional systems. In some areas, such as west Ambae, the pressure of cash cropping has caused food production to fall below subsistence levels. In other places, such as Tanna, considerable food surpluses are produced but usually not sold, being used instead for custom purposes such as feasts. The 1995 agricultural census indicated that the average household had around two ha. of cash crops in around one third to one half hectare of productive

[87] *Weightman, 1989: 51.*

[88] *Weightman, 1989: 90.*
[89] *1993 Agricultural Census.*

food garden (in their first second or third year). More than three times that area would be fallow or contain residual crops such as kava. These food gardens provide most people with a high degree of food security.

Vanuatu's food production also includes an important wild food gathering component. 'Wild' foods have a place in everyday consumption, and include wild yams, nuts, and fruits. These are sometimes cultivated in the sense that they are often spared when clearing land for gardening and preserved around villages. Wild yams are perhaps the most important of these foods. Wild yams survive without cultivation and untended in both undisturbed and disturbed wild areas but human intervention in planting is usually required to perpetuate most wild yam species. To quote Siwatibau in her study of wild yam production in Lolihor on Ambrym:

> *This replanting of the top of the harvested yam* is *critical not only for the next harvest but also for the continual survival of the wild yam plant. The author was shown many areas where wild yams were claimed to have thrived* in *plenty, but where none now exist. The reason given for the disappearance was lack of care during harvesting.*[90]

Because they grow on trees in forested areas, wild yams are resistant to cyclones and drought. The forest floor is perhaps the location most protected from a cyclone Epila-Otara reports that bare ground wind speed increases rapidly and logarithmically with height. The severity of wind effects therefore tend to increase vertically so that vegetation in the lower stratum suffers less damage.[91] Wild yams are not seasonal, do not need to be harvested and can be left in the forest as a food bank. Vanuatu is in a more sustainable situation than Fiji in this regard, but even here this invaluable disaster mitigation resource is under threat from loss of habitat, poaching, burning and animal damage. To again quote Siwatibau:

> *The greatest threats to wild yams* in *Lolihor are claimed to be human poachers, wild pigs, wild cattle, and foraging megapods. The cultivators have yet to develop any defenses against any of these threats and seem to accept the inevitable high crop losses due to these agents.*[92]

15 Siwatibau, 1992:15.
16 Epi/a-Otara, 1993:16.
17 Siwatibau, 1992:17.

Breadfruit *(Artocarpus altitis)* is an important food crop in coastal areas of Vanuatu, particularly on the smaller islands where it is usually a companion crop to coconuts. It provides a good source of calories but is low in protein, fat and vitamin A, and needs to be supplemented in the diet with foods rich in these elements. It is a popular food, regularly delivered in quantity twice a year, entirely labour free. It was, and to some extent still is, the pivotal food preservation crop. The main breadfruit crop occurs between November and January, when food supplies are at their lowest before yams are harvested. In the small islands, preservation of surplus breadfruit was therefore a necessity, and on some islands this tradition remains quite strong today. The main breadfruit season also coincides with the cyclone season; folk wisdom throughout the Pacific islands correlates a heavy breadfruit crop with the likelihood of a cyclone. With greater food security today, breadfruit no longer has the essential role it once had. When breadfruit is preserved today, this is done more as a matter of food preference.

In the absence of any widely grown leguminous crop, several species of nut trees growing in the gardens, around the villages and wild in the bush, provide a useful source of vegetable protein. These include *namambe* or Tahitian chestnut *(Inocarpus fagifer), nangai (Canarium indicum), navele (Barringtonia edulis)* and *natapoa (Terminalia catappa).* Over the centuries there has been considerable genetic improvement in tha t the better trees have been selected for planting. The importance of forest nuts to Melanesian societies has been summarised as follows:

> *Indigenous nuts are an integral part of the complex arboricultural, agricultural and sociobiological systems that have evolved to suit the diverse biophysical conditions of the South Pacific islands. Selection, conservation, cultivation and exchange of superior cultivars over thousands of years by Pacific Islanders has produced a wide range of indigenous nut morphotype, a unique wealth of ethnobotanical knowledge, and strong cultural and spiritual affinities with the crops. Despite the introduction of exotics and a corresponding change* in *diets, indigenous nuts remain a seasonally important part of rural people's diet.*[93]

Plantation production dates from the 1880s and involves relatively large cash crop and livestock production units that use paid labour. Most Vanuatu plantations are not large in absolute terms, for few

93 Evans et.a/. 1996:5.

exceed several hundred acres of cleared land. Plantations are found on the central islands of Efate, Santo, and Malekula and mainly produce coconuts and cattle, with cocoa and coffee being of subsidiary importance. Recent years have seen capital intensive squash production on Efate. Some plantations grow food for their workers or allow their workers to maintain subsistence food gardens.

Urban food gardening is a more recent phenomenon; with rapid urban growth it has expanded to augment household income. Even the poorest squatter household on the outskirts of the capital Port Vila is likely to have found a small patch of land to plant cassava and island cabbage. These urban food gardens make a significant contribution to food security but are generally more vulnerable to cyclones than are the traditional tiered multi- cropping systems.

NATURAL DISASTERS IN VANUATU

Vanuatu is highly vulnerable to natural disasters. It lies in one of the most cyclone-prone parts of the south-west Pacific. Thirty-two tropical cyclones occurred in the country between 1960 and 1989 ¾ approximately the same number as Fiji (34), but many more than in Solomon Islands (14), Cook Islands (15), Tonga (15), or Samoa (10).94Vanuatu experienced severe damaging cyclones in 1951, 1959, 1972 (three that year), and 1985 (two that year), There are occasionally 'great' cyclones, such as occurred in 1879, 1959, and 1987 (Cyclone Uma). In general, the frequency of cyclones increases to the north-west, but by year there is considerable variability in frequency. The cyclone-free years of 1982 and 1983, for example, were followed by three cyclones in 1985. The impact of cyclones is generally localised, affecting only one or two islands. The frequency with which a particular location experiences a cyclone may therefore vary from around once every four to eight years.

Vanuatu also lies along the western Pacific trench, a line of high tectonic activity at the west edge of the Pacific Plate. It therefore experiences frequent earthquakes and volcanic activity. There are active volcanoes on Ambrym (Marum and Benbow), Gaua (Garet) and Tanna (Yasur). The volcano on Ambae, while currently not active, poses a major threat of eruption. Acid rain from volcanic eruptions has caused food shortages for communities close to active volcanoes, as is evident from the number of underweight babies and toddlers in West Ambrym at the beginning of the annual rainy season[95]. Both earthquakes and cyclones are sometimes accompanied by high seas and damaging waves that erode the coastline and destroy marine structures.

Although Vanuatu lies in a high rainfall belt, the distribution of rainfall and the porosity of some soils cause frequent, localised water shortages in many islands. Droughts may be either a drier than usual annual dry season or, occasionally, a severe drought. In some years, the dry season is pronounced and extended, with little rain between June and December or even until January. The prevailing winds at this time have a desiccating effect on crops, making site selection critical for crops such as cocoa, coffee, and vanilla. The worst droughts in recent years occurred in 1978, 1983 and 1997. In 1978, several thousand cattle died from thirst and starvation, notably in Santo and north Malekula; 1983 was the driest year in recorded history throughout Vanuatu [96]. The white grass area of west Tanna was particularly badly affected, and some food relief was distributed.

The impact of cyclones on agriculture

Many parts of Vanuatu's food production system are susceptible to cyclones, particularly yams planted .in the food garden, taro (Colocasia), and kava. Thus an integrated cropping and food production system has evolved over the centuries that provides a high degree of food security in the face of natural disasters. This system, although modified and somewhat weaker, remains essentially intact today, and there is still scope to build on the strength of traditional systems to mitigate the impact of natural disasters.

Seldom is a whole traditional food garden destroyed by a cyclone. The swirling nature of the gusts may mean that a particular garden may miss the full brunt of a cyclone. The bush surrounding most gardens acts as an effective windbreak. Certain crops in the garden, such as Xanthosoma (Fiji taro) are more tolerant to wind. Island cabbage, particularly if cut before the cyclone, will again bear within six weeks. Some crops such as bananas seldom survive, but the main rootstock is seldom destroyed and suckers will

[94] *ADB, 1991: 296.*

[95] *ADB, 1997*
[96] *Weightman, 1989*

reappear to fruit within six months. Post-cyclone pruning accelerates recovery. Food assistance from unaffected areas will usually be sufficient to bide the community over until quick maturing crops such as kumala and maize come on stream. Traditionally, as a back-up, there were disaster and hunger foods such as wild yams, arrowroot, elephant yam, and sago.

The impact of cyclones on the main Vanuatu food crops is as follows:

Cultivated yams. Paradoxically this pivotal crop is also the most susceptible to cyclones, because of risk of damage to the aerial vines which, if broken or damaged, will cause an immature tuber to rot. Furthermore, the growing season for yams coincides with the cyclone season. Offsetting yams' susceptibility to wind damage is the storability of mature tubers, which can be up to six months.

Wild yams. In drier parts of Vanuatu, wild yams are an important food. In contrast to domesticated yams, wild yams are the most resistant root crop to cyclone damage, for they have strong fibrous vines and use trees and the forest canopy for support. Unlike their domestic cousins, if left un-harvested they will regenerate. Wild yams are however threatened by deforestation, poaching, and the perdition of pigs, cattle, and megapods. The importance of wild yams as a survival food is borne out in an assessment report by the Vanuatu National Disaster Management Office for South Ambrym after Cyclone Beti in April 1996:

> *Yam* - this root crop is difficult to produce in sufficient quantity due to continual ash fall due to the volcano, their yam is not regarded as sufficient but would be consumed from now on. *Wild yam:* This root crop is popular in this region. It is harvested throughout the session and is planted anywhere in the bush or garden. It can last for the next 8 to 9 months.

Taro is susceptible to cyclone damage and rot can set in within days, although young plants may survive. Taro has poor keeping properties and is edible only for a few weeks after harvesting. Offsetting this susceptibility, taro is a relatively short-term crop and can be planted any time of the year. The more recently introduced Fiji taro is a hardier root crop, with respect to both cyclones and droughts, and is grown extensively in Vanuatu's drier areas. It also has better keeping properties, being edible for up to four weeks after harvest.

Cassava (manioc) has become the most important root crop in many areas, including urban food gardens. It is tolerant to strong winds if the tops are cut before the cyclone and if left in the ground, most varieties can last several months-Dne Vanuatu variety known as 'black sands' is reported to last much longer. Once harvested, cassava has a short shelf life unless processed. Good opportunities exist to dry cassava for flour, but these have seldom been taken up. Cassava's ability to grow at any time of year makes it a good rehabilitation crop.

Kumala. Its low and spreading growing habit make it quite tolerant to high winds but not flooding or sea surge. Once harvested, it stores about as well as taro, sometimes up to four weeks if free of damage and kept in a dark, cool, dry, airy place-better than cassava but not as good as taro or yams.[97] It is the quickest maturing root crop and can be planted any time of the year, thus the distribution of kumala tops are a central part of most cyclone rehabilitation programmes.

Kava an important traditional crop, is now the second most important cash crop after copra. Mature plants are very susceptible to wind damage, making kava a high-risk crop, especially as it takes three years to reach maturity and several more years to reach optimum production.

Coconuts. South Pacific tall coconuts varieties evolved in cyclone-prone environments and therefore have adapted to survive the strongest of winds. Other than very young or old trees, only the most violent winds can uproot or break them. Self seeded palms, which have shallower root systems, are more susceptible. The main damage to coconut palms comes from the stripping of the fronds which causes premature nut fall. In recent decades, the cyclones of 1959, 1972 (Carlotta, Wendy and Gail), and 1987 (Uma), caused major reductions in copra production. After the great 1959 cyclone, copra production fell some 10,000 tonnes, compared with the average for the preceding 10 years. In 1972, when there were four cyclones, production fell to its lowest level since the 1940s, an effect that continued into 1973.Cyclone Uma, which passed to the west of Santo, the main copra producing island, in February 1987, had a dramatic effect on production (Figure 1). By 1990, the industry had recovered to above previous production levels. But fluctuations in production over this period cannot entirely be attributed to cyclones; price and other nonsystematic factors also had an influence, as confirmed later in this case study. That Vanuatu small-holders discount damage caused by cyclones

[97] *Moengangongo,* 1983: *104.*

a)
to coconuts is evident from their willingness to replant. The 1993 Agricultural Census recorded over 400,000 coconuts were planted during the 1992-93 season, nearly all by small-holders, 1993 possibly being the peak planting year. Approximately 20 per cent were improved variety hybrid nuts. This is a quite different situation from Fiji, Tonga or Samoa where there has been virtually no replanting, despite cajoling by government.

Cocoa evolved in equatorial latitudes not subject to cyclones, yet it is reasonably cyclone tolerant, except to continual salt spray. The tree is elastic and has a deep taproot that anchors it and makes it quite drought tolerant. After a cyclone, damaged branches need to be removed and the tree pruned if it is to have a reasonable recovery. Cyclones cause the loss of the current crop or flowers, and may strip the leaves, but cocoa does not need leaves to induce flowering, and the stress of a hurricane can even accelerate flowering. The humidity brought by a cyclone can, however, increase the incidence of black pod disease *(Phytophthora palmivora)* as the wind spreads the fungal spores widely. Cherelles (small pods) tend to drop due to physiological wilt. Flower cushions, which are the points on the tree where the pods are formed, are damaged when mature pods are ripped off or twisted, making this area susceptible to fungal invasions. Branches falling from shade trees can damage cocoa trees, and the loss of shade trees can also impair the development of young cocoa trees, for they require 50 per cent shade for optimal growth.

Breadfruit an important seasonal subsistence crop, can tolerate poor saline soils but not sustained salt spray. The trees grow tall with relatively thin and weak trunks and often suffer much damage during cyclones. While most will survive, they will lose most of their fruit and take around 12 months to recover.

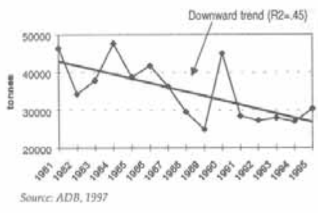


Figure 1: Vanuatu Copra production 1981-95.

Pruning of the branches before a cyclone can reduce damage and hasten recovery. Cutting off damaged branches after the cyclone will also accelerate re-growth.

Indigenous nuts. Vanuatu has a wide range of nutritious forest nuts, which contribute significantly to food security. The *navele,* which is an important food source with significant commercial prospects, are resistant to cyclones. The trees are deep rooted and strongly anchored.Their foliage will recover and thrive on the natural pruning caused by strong winds, and fruiting will return to normal within a year. This contrasts markedly to the macadamia nut, an introduced nut species with a shallow root system which will seldom survive its economic life in high risk hurricane areas such as Vanuatu. A macadamia project at Devils Point on Efate failed due to cyclone damage. The main flowering season for *navele* is towards the end of the cyclone season, although some varieties fruit most of the year. An early cyclone can see the trees recovering in time for the main production period. A la te cyclone can ca use the loss of the current year's production, but the trees will be back in production by the next season. *Navele* trees are evidently also quite tolerant to acid soil and acid rain caused by volcanic activity.

The *nangai,* another important food nut, is an even stronger tree which has characteristics similar to a mango in the face of a cyclone. The tree will lose leaves and branches will break, but the tree will seldom be blown down and may even benefit from the 'pruning.' *Nangai* re-growth is quick, although usually less so than the *navele.* An advantage of the *nangai* from a food security perspective is that it fruits in September and October, prior to the hurricane season.

Namambe, or the Tahitian chestnut, is found throughout the Pacific islands and, in season, is a supplementary staple just as kumala and plantain are. This large, deep-rooted tree is quite tolerant of a high water table and poorly drained soil. It can survive the severest cyclones and is drought tolerant. The cyclone may break the branches and blow some fruit off, but most will adhere to the branches. The kernel can be maintained for up to a week in the fruit, but it is perishable once removed and needs to be cooked (usually boiled) almost immediately. *Namambe* kernels are particularly nutritious, being low in fat, high in carbohydrates, and very filling, making it an ideal famine food, particularly as its fruiting season coincides with the peak of the cyclone season.

Cattle-rearing is perhaps the most cyclone resistant agricultural activity. Adult cattle will seek whatever shelter is available and can endure cyclone force winds and three to four days of rain. The main danger to them is from falling branches, and the main cost to the livestock industry is fencing. Most of Vanuatu's fencing in Vanuatu involves using living fence posts, such as *gliricidia,* which are usually pruned right back before the cyclone season in order to avoid substantial losses in terms of broken and unsalvageable fencing wire.

The impact of drought on agriculture

Around 10 per cent of the country has an annual average rainfall of less than 1800 mm. a year, with the dry season normally falling between July and October. Cropping patterns have adjusted to this seasonal pattern, but irrigation is necessary for exotic horticultural crops, as the experience of squash on Efate has shown. Every five to seven years or so, the dry season may be pronounced and extended. Most crops can endure these occasional droughts but occasional severe droughts can put agricultural activities under severe pressure, causing not only a shortage of food but also a shortage of planting material for rehabilitation. As Moengangongo noted in his paper on indigenous food storage in the Pacific islands, “People can overcome the food shortage problem through storage and preservation, while rehabilitation is more difficult.[98]

Traditional food gardens, which involve small plots surrounded by forest, are drought resistant, being able to conserve moisture and protect crops from desiccating winds. Yams are quite tolerant to an extended dry period, the normal planting time being in the dry season. This is especially so for wild yams
that are protected by forest. Forest nuts, namely *navele, nangai, namambe,* and *natapoa* are all drought tolerant; *nave Ie* and *namambe* fruit in January and February and can assist food security if the dry season is prolonged. Taro *Colocasia* will not survive prolonged moisture stress-seldom a problem in traditional food gardens-but Fiji taro *(Xanthosoma)* can be planted in drier areas and is more tolerant of water stress. Kumala is reasonably drought tolerant, provided there is adequate rain at the time of planting, but an optimal three-month crop requires good rainfall. In Vanuatu, under drier conditions, kumala can take six months to mature. Cassava can grow at any altitude where land is cultivated in Vanuatu. While it prefers abundant rain, it can withstand prolonged droughts, except at the time of planting. Commenting on cassava's introduction into Vanuatu Weightman noted, "As in Africa, the planting of cassava was soon appreciated as good insurance against food shortages, and considerable surpluses are grown for that reason today. Cassava also rapidly made obsolete traditional famine foods such as arrowroot, sago, Amorphopallus, wild taro, etc. that are more difficult to prepare, and growing wild as single plants took a long time to collect [99]. Young kava will not tolerate an extended period of drought, making the planting of kava outside the wet season highly risky. Coconut palms are particularly drought resistant, as evident from their ability to produce in harsh atoll environment, but prolonged dry periods retard nut production. Similarly, breadfruit survives, rather than thrives, in prolonged droughts. Cocoa, with its deep tap root is quite drought tolerant if not exposed to desiccating winds. A prolonged dry period can help induce flowering and pod set and minimise fungal diseases but, like any crop, cocoa will eventually suffer from an extreme, prolonged drought. One of the main threats to cocoa in a drought is from fire igniting the thick leaf litter that forms under the tree.

Impact of volcanic eruptions on agriculture

Yassur, on Tanna, has continuous small eruptions of ash and these ash deposits have reduced food production in the surrounding area, one of the most impoverished parts of Vanuatu. From time to time acid rain emanating from Yassur has a wider impact on crops, including the small coffee industry on the island. Recent on-going eruptions from the Ambrym volcanoes occur at longer time intervals and are often more violent, with large quantities of material being flung out. Acid rain from these eruptions can cause serious food shortages for nearby communities, an impact compounded in April 1996 by cyclone Beti. Indications are that acid rain has seriously upset the ecological balance on Ambrym. The extent of fruitfly damaged fruit in North Ambrym was the worst that the author had observed anywhere in Vanuatua surprising sight as Vanuatu, together with Fiji, is regarded as having the most favourable fruit fly status in the region. It could be that this is a result of the ecological imbalances caused by acid rain.

Some crops are more tolerant of ash deposits and acid rain, notably cassava, wild yams, bananas, and

[98] *Moengangongo, 1983:102.*

[99] *Weightman, 1989:106.*

nut trees. Siwatibau, in her study of wild yam cultivation on Ambrym, found that volcanic ash and acid rain were additional threats the cultivators had to live with. All the wild yam varieties found in Lolihor, although adversely affected by volcanic showers, do survive them[100]. Harvesting of wild food plays an important role in the survival of these communities during these difficult times[101]. On balance, however, volcanoes have been beneficial to agriculture in creating in Vanuatu the richest soil and highest percentage of arable land of any South Pacific country.

Biological disasters and Vanuatu's agriculture

As evident from the Samoa case study, the introduction of a pest or disease can cause a worse long-term disaster than a cyclone or a volcanic eruption. The impact over time can be devastating and there can also be an inter-relationship between physical and biological disasters, in that a cyclone can assist the rapid proliferation of a pest or disease. Research by ACIAR, for example, shows out-breaks of fruit-sucking moths in several Pacific island countries after major cyclones. Vanuatu has however been relatively free of major plant and animal pests and diseases. A recent New Zealand animal health survey enabled Vanuatu to apply to the Office International des Epizooties (OIE) for certified freedom from "type A" livestock diseases such as Foot and Mouth Disease-a critical step in obtaining USDA and EU certification for the beef industry and thereby the basis for a major export industry.

Fruit flies (family *Tephritidae)* are one of the world's major insect pests affecting fresh fruit and fleshy vegetables. Every Pacific island country has at least one, usually more, damaging endemic fruit fly. Vanuatu has only two of economic significance and their host list excludes the cucurbit family, such as squash, melons, and zucchini, or pineapples. Vanuatu is nevertheless in a vulnerable position, for to the north lies Solomon Islands, where melon fly *(B. cucurbitae)* is established on Guadalcanal, a pest that has quickly moved south. To the west lies New Caledonia, where Queensland fruit fly *(B. tryoni*) is now established. This aggressive, heat tolerant fruit fly has a wide host range or some 150 fruits and vegetables, and with weekly flights between Noumea and Port Vila, Vanuatu is vulnerable to this pest's incursion. While Vanuatu's isolation has spared the agricultural sector from a biological disaster of the magnitude of taro leaf blight in Samoa, the country has not been immune to costly pest incursions, two notable examples being the papuana beetle and the giant African snail.

Environmental disasters and agriculture

The Kadavu case study pointed to an environmental disaster in the form of a breakdown in traditional agricultural systems and with three interrelated 'elements: indiscriminate burning, a growing, uncontrolled pig population, and unsustainable cropping practices. To varying degrees, all of these elements are at play in Vanuatu but they generally have not reached disaster proportions. Overall, Vanuatu still maintains sustainable agricultural systems.

THE COST OF DISASTERS TO VANUATU'S AGRICULTURE AND ECONOMY

After a major natural disaster, estimates are made of the immediate financial cost but longer-term financial and economic costs are seldom measured. Cyclone *Uma,* Vanuatu's last major cyclone, was officially estimated to have cost $USI4.64 million (Table 22).of this, agricultural losses were imputed to be worth $3.13 million, or 21.4 per cent of total losses. It is, however, difficult to estimate accurately what these losses were. Commenting on the absence of a systematic reporting system at the time of Cyclone *Uma,* Mr Job Esau, Director of the National Disaster Management Office, noted, "We had some estimates of damage but none of costs. This is something we are working on with our new reporting system."

Food crop losses are particularly difficult to estimate. These figures are usually derived from assessment reports supplied by Department of Agriculture staff which mayor may not have involved field visits. There has tended to be an upward bias to maximise the inflow of food aid, an issue that the Director of the Vanuatu National Disaster Management Office (VNDMO) is trying to address in implementing the new policy of 'self reliance.' Unrealistic estimates of food losses are compounded by the lack of agricultural census data on crop production and yields. The recent ADB Pacific Economic Report on Vanuatu alludes to this problem: "Unfortunately neither the 1983 or 1993 Agricultural Census try to measure crop output or area, thus the value of

[100] *Siwatibau, 1992: 17.*
[101] *VNDMO. 1996.*

Table 22: *Damage Caused by Cyclone Uma ($US million).*

	$US
Agriculture	3.13
Communications	0.20
Education (School Reconstruction	2.53
Government Administrative and Office Equipment	2.75
Health Facilities	0.26
Marine Department (Replacement of Sea Defences, etc	0.69
Roads and Bridges	2.44
Housing	1.66
Government Technical Services	0.66
Water Supplies	1.32
Total	**14.64**

Source: ADB, 1991: 271

subsistence cannot be measured directly. Official GDP estimates are derived indirectly from the 1983 Agricultural Census estimates of time spent in gardening".

The VNDMO Director concluded in his assessment report on Cyclone *Beti* that, "The communities in the affected areas are already yelling for rice etc. but again this office is no longer encouraging the idea as there is no solution to the problem if rice is not distributed." The unprecedented step has been taken in recent years to refuse offers of disaster assistance from some foreign donors. People in affected areas made the necessary adjustments and met their food needs without any reported ill-effects. That they were able to do so indicates that Vanuatu's traditional cropping systems are essentially intact.

The value of subsistence food production has been estimated to be 4 billion vatu[102]. On average, approximately one quarter of the country is affected each year by a cyclone and a reasonable' guesstimate' is that around 50 per cent of food crops are lost.

A rough estimate of the average annual food lost to cyclones would therefore be around 500 million vatu (or $US4.5 million), quite a substantial figure given that Vanuatu's exports total just over $US20 million in value. This loss will, however, be recovered quite quickly starting with island cabbage in four weeks, maize in three months, and kumala in three to five months. After all but the most severe cyclone the loss would be fully replaced in twelve months, during which time the capital stock of wild food can also be drawn upon.

After recent cyclones *(Prema* in March 1993, *Beti* in April 1996, and Fergus in January 1997) the VNDMO instructed field assessment teams to provide accurate reports of the quantity of food lost. Cyclone *Beti* was a strong, localised cyclone that affected the central region islands of Maewo, Pentecost, north Ambrym, central Paama, and central and south Malekula. The agricultural assessment report is quite descriptive but it provides a useful insight into the food security situation following a typical cyclone, including in Ambryn the combined effects of the ongoing volcanic eruption. To quote:

North Ambrym

> *Crops: banana, cassava, island cabbage* - damaged but the population is consuming them at present. It is estimated that they will last 3-4 weeks. *Water and Fijian taro* - many not be completely damaged since the fruit are safe in the ground, which can be consumed at a later date. *Yam* - Volcano has also contributed to the damage, however it is believed that 80 per cent of the garden yam can still provide sufficient food consumption for the next 8 months. It is important to note that that harvesting season begins this month. And after the yams are dug, sweet potatoes are planted and are expected to be harvested in 3-4 months. *Fruits:* While overall reports indicated that fruit trees were damaged, there are some that could be consumed by the community. *Coconut* fruit can be eaten and satisfy thirst. Namambe *(Inocarpus edulis)* fruits can also feed the families since they grow wild in the plantations. We are now in harvest sessions. This can last for 5-6 months.

South Ambrym

> Prior to TC Betti was already affected by Volcano- *island Cabbage* completely destroyed. *Banana, cassava* - damaged but the population is relying on them at present. Estimated that they will last for 3 - 4 weeks only. *Water and Fijian taro* - Only some villages plant these crops. Although they may not be completely damaged, they won't last due to the volcano and TC Bettie. *Yam* - this root crop is difficult to produce in sufficient quantity due to continual ash fall due to the volcano, their yam is not regarded as sufficient but would be consumed from now on. *Wild yam:* This root crop is popular in this region.!t is harvested throughout the session

[102] *ADB, 1997:136.*

and is planted anywhere in the bush or garden. Although the vines may be blown down, the flesh can still be safe in soils. It can last for the next 8 to 9 months. *Fruits:* Although other fruits may be blown down as indicated it is important that people can still survive on coconut fruits and Namambe fruits for the next 4 - 6 months.

West Ambrym

Island cabbage - completely damaged, however it is estimated that they will be ready for consumption in 4 weeks or so. *Banana, cassava* - damaged but the community will be surviving on them for the next 3-4 weeks. These are the main source of food in the area as other root crops can't be planted in this part of the island due to volcanic ash fall. *Yams and water taro* these crops are very difficult to bear much in this area as volcanic ash and rainfall very easily affects them. *Fruits:* Fruits have all been damaged however; coconut fruits can be used in a number of ways to satisfy thirst, and hunger. Along with coconut is the Namambe fruit, which is now being harvested.

Paama Island

Cassava/banana were completely damaged but at the same time the families were still surviving on them for the last two weeks.

Kumala/yam/taro - May not be badly damaged since the root crop is in the ground and could still be eaten at a latter date.

North Malekula

Most damages were caused to banana/cassava and island cabbage. *Yam and taro* will still be usable for some time. Other resources such as seafood are always available, as Malekula is rich in marine resources.

One important consequence that these assessments did not account for was the build-up of rat populations that can sometimes follow a cyclone. This was a major problem for the Torres Islands in 1988 where rats caused large losses to crops in the ground and in storage.

The most important economic activity in Vanuatu after subsistence is copra production (Table 22). In 1984, when there was a fortunate coincidence of high production and high prices, the economy grew 6.9 per cent in real terms. Two years later, when copra export earnings were less than a quarter of the 1984 level, the economy had negative real growth of -0.2 per cent. From time to time, cyclones affect the copra industry and thus the whole national economy, as happened between January 1985 and February 1988, when the main copra producing areas experienced four major cyclones. The impact of these cyclones, together with low prices in all years except 1984 and 1985, saw production fall from 47,000 tonnes in 1981 to 24,902 tonnes in 1989 (Table 23). By 1990, production had almost recovered to 45,000 tonnes. Yet in 1991, a cyclone-free year in the copra producing areas, production fell away again to 28,500 tonnes as the grower price fell to 18,500 vatu per kg., the lowest price since 1983.

To try and separate the effects of cyclones and copra prices on short copra production, the following simple statistical model was estimated by ordinary least squares:

$$Q_t = \beta_0 + \beta_1 P_t + \beta_2 H_t + \beta_3 T_t + e_t$$

Where: Q_t = quantity of copra produced in the current year (tones)
P_t = average annual "beach price" for hot air copra (vatu/tonne)
H_t = hurricane incidence (1= a major hurricane producing areas in current year; 0= no major hurricane producing areas in current year)
T_t = a linear trend (1981=1)
e_t = random factors effecting copra production

The results obtained (with standard errors in parentheses) were:

$$Q_1 = 41{,}935 - 1738P_t - 9{,}250\ H_t + 334T_t + e_t \text{ adjusted}$$
$$R^2 = .27\ (5{,}655)\ (349)\ (3{,}523)\ (.236)$$

The results obtained were disappointing. The dummy variable used to measure the impact of the cyclones was not statistically significant, although a logical negative relationship was derived. Neither a statistically significant or logical relationship could be derived for the price variable. It is not that such relationship does not exist. The difficulty lies with separating out the distributed effect of the cyclones over time.

This statistical analysis nevertheless shows that cyclones have a significant impact on copra production, even if, over time, this is a lesser impact than price. Even so, cyclones and price instability have not discouraged investment in the copra industry. Vanuatu is the only country in the region

Table 23: Cyclones, copra, and economic performance: 1981-1990.

	1981	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Cyclones coconut areas				Ericl Nigel		Uma	Anne				Betsy			
Copra production (tonnes)	47,07	38,36	48,00	38,80	41,79	36,346	29,559	24,906	45,071	28,440	27,292	27,983	26,992	30,390
Grower copra (Vatu/tonne)	15,00	15,00	36,00	38,00	21,50	26,000	31,800	31,000	25,400	18,500	26,800	28,300	28,500	27,900
Copra export earnings (mill.		1,308	2,734	1,392	461	719	953	750	603	528	829	706	894	1,100
GDP growth (%)			6.9	1.8	-0.2	0.7	0.6	3.7	4.6	4.7	-0.7	4.5	2.5	3.2

Source: Statistics Office Copra and Cocoa Annual Report 1995, *Reserve Bank of Vanuatu Quarterly Economic Review Various Issues; ADB 1997*

where substantial coconut replanting has been undertaken in the last decade. The current rate of replanting equates to around 2,700 ha. per year, sufficient to replace the national stock of coconuts in 33 years and to offset the loss of production from senile palms. In Fiji and Tonga, by contrast, production has declined to below the level needed to be viable at least in the production of oil. Cyclones alone are not, therefore, sufficient to explain the general demise of copra industries in the Pacific region.

The effect of cyclones on agriculture and the choice of alternative crops has exercised the mind of agricultural planners since early colonial times. Preference for copra and cattle as the commercial enterprises can be explained in part by their resilience to cyclones. Vanuatu was able to successfully able to grow butternut squash for export to Japan. This short-term (105-120 day) crop is harvested in October and November, usually before the cyclone season, which no doubt was a prime consideration for the foreign investors. But it is doubtful if Vanuatu's cropping and agricultural patterns would have been much different had there not been so many cyclones. Kava is now the fastest expanding commercial crop and yams remain the pivotal food crop; both are susceptible to cyclones. Certain horticultural tree crops such as macadamia nuts would not be viable because of cyclones. Vanuatu's indigenous nuts, however, offer better opportunities for development. A recent ESCAP study on the feasibility of horticultural export development also showed that transportation links (both external and internal) and the high cost of power are more binding constraints to agricultural development than cyciones.[103]

TRADITIONAL DISASTER MITIGATION

Traditional disaster mitigation was based on food gardens protected by forest and this remains the basis of disaster mitigation today. Weightman reports that for centuries food crops and their relative importance remained unchanged[104]. The system was in an equilibrium adjusted to Vanuatu's resource endowments, the seasons, and the risk of natural disasters. The traditional Vanuatu food garden is small (1,000 to 2,000 sq. metres) and families often have several, which further reduces the risk of an entire food garden being lost. Methods of clearing bush for gardens remain essentially unchanged; large trees are ring-barked the previous year and later burned, with their branches piled around them. Fire played a central place in the traditional system, but was well controlled.

The first major change in traditional cropping patterns came with the introduction of sweet potato (kumala), probably in the seventeenth or eighteenth century. Three attributes of sweet potato enabled it to make a significant contribution to food security: its low lying habit makes it able to withstand cyclones; once established, it is reasonably tolerant

[103] *ESCAP, 1997:7.*
[104] *Weightman, 1989:42.*

of drought; and as a short-term crop it enables a rapid recovery of food supplies. Cassava was introduced around the middle of the nineteenth century. Where it became a supplementary crop, it contributed positively to food security. It can be planted any time of the year and some varieties can be stored in the ground for up to two years, providing total insurance against natural disasters. As cassava had no value in custom, it was less likely to be depleted in traditional feasting [105]. The traditional fallow period after two years of yam and taro was seven to ten years, with kava and bananas remaining in the garden another five years or so. In Vanuatu, as elsewhere in the South Pacific, the introduction of cassava has tended to reduce fallow periods, but this has been generally less pronounced in Vanuatu than in Fiji.

On some islands, such as Pentecost and Ambae, the cropping of steep slopes was necessary, which required terracing and other soil conservation methods, as described on Pentecost in Cook's Journal:

> *The shores of Whitsuntide Island are bold, without Inlets ... the Land high and Mountainous; but exhibits the most beautiful prospect I have ever seen, being cultivated up to the very summit, and divided into rectangular Fields by Fences which appear like Hedges from ye Ship ...*[106]

Such terracing is less evident today but Weightman concluded, "There is little evidence, except on Aneityum, that man's activities have contributed to soil erosion and degradation, despite the significant areas of steep land cultivated [107]. This is because of the generally discontinuous nature of cultivation, the small population relative to arable land, the small size of gardens, and the minimum tillage practices adopted.

Supplementing the food security of the multi-crop food garden were strategic planting timetables for crops that minimised the risk of disasters. Except for yams, there is no specific planting season in Vanuatu, other than that all crops require adequate rainfall at the time of planting. For yams, a variety of early and latter maturing cultivars are usually planted to reduce risk by prolonging the harvesting period. Baton Bisewei, Disaster Co-ordinator of the umbrella NGO organisation (VANGO), held a series or workshops on traditional disaster mitigation in which village participants presented planting tables from their localities. An example from the island of Epi is shown in Table 24 below.

There is much to learn from these traditional timetables in determining strategic schedules for cash crops. For example, papaya grown for export markets should be planted in October to November, just before the cyclone season. Then, if the crop is hit by a cyclone the trees will be small, enabling most to survive even a severe cyclone unless they are washed away and this too can be avoided by good site selection. Some cash crops are, however, intentionally planted at times when the risk of disaster is greatest in order to maximise market return, such as off-season vegetables sequential harvesting techniques also enhance food security, such as the partial harvesting of yams and kumala, where mature tubers are harvested first and immature ones later[108]. Some crops are also suited to storing in the field until they are required.

Traditional food preservation and storage

Food reservation was central to traditional disaster mitigation in Vanuatu. In some areas it still is relatively important, much more so than in Fiji or

Table 24: Epi planting timetable to maximise food security.

Crop	Planting time	Harvest time
Cassava	anytime	6 months
Kumala	March	June-July
Yam	June-July	March-April-May
Banana	full moon	1 year
Taro	end dry	Nov
Peanut	anytime	3 months
Watermelon	June-July	Nov-Dec
Pumpkin	anytime	1 year
Pineapple	December	1 year
Corn	anytime	3 months
Island cabbage	Oct-Nov	3 to 4 months
Chinese cabbage	Oct-March	3 months
Breadfruit	March-Oct	3-4 years
Kava	wet season	3-5 years

Source: Pers. comm.: Baton Bisewei

[105] *Weightman,* 1989:42.
[106] *Reported in Weightman* 1989: 49.
[107] *Weigthman, 1989:52.*

[109] *Moengangongo reports that the method of partial harvesting of sweet potatoes known as mutumutu is common practice in Papua New Guinea.*

b)

Samoa. Sufficient knowledge and practice remains to help revive food preservation to increase food security, by combining traditional and modern methods. Breadfruit, the most perishable of crops in its fresh form, is the main crop that is traditionally preserved when the crop is plentiful or blown down.

Traditional preservation techniques involve either some form of fermentation or drying. Different preservation techniques are associated with different parts of the country. Fermentation was more common in the central and some of the southern islands, while drying is more associated with the northern islands. Barrau (1956) described a fermentation technique used by a village on Pentecost:

> *There, the ripe breadfruit were wrapped in leaves and placed within heaps of stones on the sea shore, where they were regularly covered and uncovered by the rise and fall of the tide. This alternating submersion and exposure to the sun was an efficient means of promoting fermentation*[109].

Susan Parkinson (1984) described another method of fermentation still used on Futuna:

> *The breadfruit* is *picked to avoid bruising, cut into quarters, placed in a salt-water pool lined first with coconut then clean banana leaves. They are then covered with more banana leaves and then coconut leaves and finally the pit is sealed with rocks. Alternatively, the fruits are placed in banana-leaf lined woven coconut baskets and tied to the reef or to mangrove trees. After one week or until soft, the skins and core are removed and the pulp* is *placed in coconut baskets lined with banana leaves, These are placed in a* 'V' *shaped pit lined with coconut leaves and untorn banana leaves, Sea-water* is *sprinkled over the food, which* is *covered with more leaves and finally the pit* is *sealed with rocks. The pit* is *left for one year. When the baskets are removed, the pit* is *relined with leaves and at this time more food* is *added and once again it* is *sprinkled with sea water".*

Weightman described the fermentation method used on Tonga:

> *A circular first pit* is *dug about two meters in diameter and up to a meter deep, usually at the edge of the garden area, and line it with stones:* 'Naelu' *(philodendron) leaves are then laid at the bottom and an inner, basket-like lining* is *woven from the leaves of the* 'nakarie' *(veitchia spp?) palm. The hole* is *then filled with fully ripe but firm breadfruit, the basket lining drawn over them, upon which are then placed first a layer of* 'naelu' *leaves, and then banana leaves held down by stones, One month later the fruit by then very soft, are taken out and carefully peeled with bamboo knives, the stalk and seed removed and the pulp kneaded. The hole* is *relined with fresh leaves refilled with the fermented yellow pulp and covered up. This* 'navinang' *can be left for several years and taken out and eaten as required,*

In the Banks Islands, a strong tradition of drying breadfruit remains. Baton Bisewei, Disaster Coordinator for VANGO, described the system still widely used there. This first involves cooking the fruit in an earth oven, removing the stem and soft core and slowly drying the whole fruit over hot embers, which preserves the fruit. They are then hung in a well-ventilated location to cure before being placed in a large, specially prepared storage box. Some 300 to 400 breadfruits are held in these storage boxes. Dried in this matter, breadfruit can be held in a stable condition for years. Bisewei, who is from the Banks, reports that after Cyclone Wendy in 1972, the people survived on dried breadfruit and seafood. It is encouraging to note that dried breadfruit from the Banks was supplied to other areas of Vanuatu after cyclone Uma.

The production of sago starch from sago palm *(Metroxylon spp.)* was traditionally an important source of preserved food, but this very labour intensive process has virtually died out in Vanuatu even though it is still practised in parts of Solomon Islands and Papua New Guinea. Cassava starch is produced on some islands, such as Ambae, but this is not common despite its potential. More common throughout Vanuatu is the preservation of forest nuts through various smoking and drying techniques, but this is usually to add variation and delicacy to the diet, rather than specifically for disaster mitigation. There is considerable scope for expanding the preservation of nuts to promote food security. A national delicacy in Vanuatu is *laplap* which is made from grated yam or taro and coconut cream, filled into a green bamboo, sealed with banana leaves, and rotated over a hot fire. Cooked in this way, it will last four days but if it is smoked well above the cooking fire it will last for months.

An optimal storage environment can prolong storage. The yam culture has evolved the use of yam storage houses which can extend the storage life of certain cultivars for up to six months. The essential features of these houses are adequate shade, good ventilation, and security against pests. The storage life of planting

[109] *Reported in Weightman, 1989,*

materials can be prolonged by the application of ashes.

There is considerable scope in Vanuatu for adopting appropriate 'non-traditional' food preservation techniques. Vanuatu is already a leader in using basic food processing techniques to preserve nuts and fruits, particularly through the efforts of Mr. Charles Long Wah of the Kava Store in Port Vila. Using his revenues from kava wholesaling, the Kava Store has developed commercially viable processing and packaging for indigenous nuts and other fruit, vegetable, and spice products. Within the region, the Kava Store has become a showpiece for small-scale processing[110]. Long Wah's techniques are replicable at the village level as they are based on the principle of using only a 'pot and wooden spoon' and the products can be stored in sterilised glass bottles. Long Wah has run numerous training programmes to teach village people how to process products like tomatoes, but the uptake has been limited. To be effective, these training programmes need to be re-enforced by simple illustrative posters. The basis for promoting this type of food preservation should be to add dietary variety, create household income opportunities, and save household income. A spinoff benefit would be better food security and disaster mitigation.

DISASTER RELIEF AND REHABILITATION PROGRAMMES AND THEIR IMPACT ON AGRICULTURE

From colonial times, cyclone relief and rehabilitation programmes were mounted after major cyclones. Due to Vanuatu's unique Condominium status, (administered by both Britain and France) these efforts tended to be poorly co-ordinated, leaving the villages to their traditional disaster mitigation devices. In retrospect, this might have not been a bad thing, for it may explain the higher degree of self-reliance apparent in Vanuatu compared with most other Pacific island countries. After Independence in 1980, Vanuatu developed its own integrated disaster management institutional structure, which has mainly functioned as part of the Police Force. The emphasis has been almost exclusively on cyclones with relief programmes for agriculture and food security focusing on distributing food rations (principally rice) that have been supplied by aid donors. The ni-Vanuatu populations being substantial rice consumers, these donations have been gratefully received even if well in excess of survival requirements. Rehabilitation included the distribution of kumala tops and imported maize seed, with Department of Agriculture field staff providing crop loss assessments upon which rations were distributed.

A public service strike in 1993, and subsequent staff dismissals, had a crippling effect on the efficiency of government services. This particularly affected disaster relief and rehabilitation services to agriculture. The Agriculture Department lost most of its trained and experienced staff, including the officer now responsible for the VANGO Disaster Preparedness Project.

The present disaster management institutional structure originated from the Barr Report, prepared by AIDAB in 1990. NGOs play a key role in the structure recently developed by the National Disaster Management Committee (NDMC). A National Disaster Management Office (NDMO) serves as a standing secretariat for the NDMC. The NDMC is made up of the First Secretary of Home Affairs, the Commander of the Mobile Force of the Defence Force, the Deputy Commissioner of Police, nominated representatives of the provincial governments, and nominated NGO representatives. The NGO Co-ordinator is an experienced agriculturist whose main responsibility has been to implement a Disaster Preparedness Project funded by AusAid, a project which holds workshops in rural areas on traditional mitigation practices, including cropping systems and food preservation.

Self reliance, dependency, and back to self reliance

- To recognise the disaster problem as part of total government responsibility and to make the best possible arrangements to deal with it;
- To recognise the disaster management phases of prevention, preparedness, response, and recovery as essential ingredients for national development; and
- To develop an attitude of self help within the community through public education and awareness programmes.

The NDMO recognises that some food ration distribution programmes in the past have undermined self-reliance and the peoples' ability to deal with natural disasters. In the case of Cyclone

[110] *ADB, 1997:156*

Fergus, the NDMO made the unprecedented step of turning down offers of foreign aid assistance. The change of attitude is reflected in the NDMO assessment reports from Vanuatu's two most recent cyclones: Cyclone *Beti* in April 1996 and Cyclone *Fergus* in January 1997:

Recommendations for Cyclone Beti:

If the Government of the day's policy is to promote SELF-RELIANCE then this office can also help in educating our people through these types of situation to encourage;

- Island Chiefs to establish mutual cooperation in order to assist each community in resources and to find some traditional ways to sustain survival in times of disaster.

- Respective Provincial HQ to incorporate disaster preparedness programme and to assist in disseminating information to their region and not to over dependent on NDMO.

- Individuals to get up and work so as to utilise their skills to meet the needs of their community and to start using their common sense for their individual benefits as well.

With these few remarks I wish to make the following recommendations:

a) That there should always be cooperation between all community leaders to cope during such situations i.e. it is certainly our tradition and culture that we always share with other communities in need. Therefore as assessed there are some areas concern who are not directly affected by Cyclone so this Office if there should be some exchange of local food to those who are affected.

b) If in any means that the Government will decide to have some assistance provided with justification from the report then this Office recommends supplementary seeds as normally practised in the past.

The communities in the affected areas are already yelling for the supply of Rice etc. but again this Office is no longer encouraging the idea, as there is no solution to the problem if the rice is distributed[111].

Conclusions and recommendations for Cyclone Fergus

It is important that we continually develop self-help within community, Provincial level to maximally utilise existing resources before demands are sent to National Disaster Executive Committee for additional support. Promotion of cultural values and self-reliance is important in order to discourage dependency and to work hand in hand in achieving independence. However, National Disaster Executive Committee can only response when there is significant emergency demand affecting human life's and after the province has exhaustedly utilise its resources and that human life is in real hunger, then emergency relief supply can be considered urgently.

1. TAFEA Province and Agriculture Field Assistant to keep monitoring the situation and to play their part before demands are requested from the National Disaster Executive Committee for further support.

2. No emergency food relief food supply is require at present.

3. Seedlings may be considered for distribution.

4. TAFEA Agriculture Field Assistant to investigate fungal on taro effects (Futuna).

5. TAFEA Province to advice the people to re-plant crops and not to wait. (Follow-up be Agriculture Field Assistants) [112].

[111] *NDMO report on Cyclone Beti, 24 April, 1996*
[112] *National Disaster Management Office Assessment Report for TAFEA Province: Tropical Cyclone Fergus, Jan. 25, 1997*

PROJECTS TO ENHANCE SELF-RELIANCE AND FOOD SECURITY IN THE FACE OF DISASTERS

The policy shift toward promoting self-sufficiency and self-reliance in coping with disasters, the considerable scope to facilitate this process in the area of food security, and Vanuatu's major advantage of significant NGO involvement in disaster programmes and in the agricultural sector, together create an opportunity for Vanuatu to serve as a model for replication in other Pacific island countries. The following projects have been identified for consideration and are discussed at length in Chapter 7: Recommendations:

- The continuation and expansion of VANGO's Disaster Preparedness Project, together with a strengthening of the disaster mitigation capability of the Department of Agriculture;
- Preparation of a series of posters on traditional and appropriate food processing;
- Using the food processing expertise of the University of the South Pacific to enhance village and community food preservation;
- Developing yam seed banks; and
- Developing a reserve bank of proven domestic maize seed.

5. DISASTERS AND AGRICULTURE ON ATOLLS: THE CASE OF TUVALU

ATOLLS IN THE PACIFIC ISLAND REGION

Atolls are defined as low coral islands that lack volcanic or continental rock in their surface geology. From an agricultural point of view, they are one of the harshest and most vulnerable environments on earth. While the classical atoll has circular or semicircular reefs surrounding a lagoon, in some cases they are just low reef islands, rarely more than a few metres above sea-level that consist mainly of loose rubble and sand. Atolls have mostly formed in warm waters close to the equator. Pacific island atolls lie in clusters or chains that run in a south-eastern direction from the Marshall Islands through the Gilbert group in western Kiribati, to Tuvalu, then Tokelau, to the Northern Cook Islands, and to the Tuamotu Archipelago in French Polynesia.The atolls states Kiribati, Tuvalu, Marshall Islands, Tokelau and Niue, the last being a raised single coral island - are some of the world's tiniest nations (Table 25), yet some are spread over vast areas of ocean. Some other Pacific island micro-states, namely Cook Islands, Federated States of Micronesia, French Polynesia, and Palau, are a combination of atolls and high islands. Most other Pacific island countries have a few inhabited atolls, such as the northern islands of Tonga, the southern Lau group in Fiji, the eastern Solomon Islands, and parts of the Manus group in Papua New Guinea.

Soil development on atolls tends to be minimal due to the recent establishment of sand deposits on reef platforms. What soil does exist is shallow, alkaline, coarse-textured, and lacks most nutrients required for plant growth, such as organic carbon, nitrogen, potassium, iron, and magnesium. The water-holding capacity of these soils is very low, with plant nutrition dependent on the humus cycle and the retention of vegetation cover. The atolls have low annual rainfall (usually in the order of 1,500 to 2,000 mm) and are subject to considerable seasonal and annual variability. Low rainfall and poor water holding capacity means that fresh water resources are very limited, with the only permanent supplies being groundwater lenses that are often brackish. Compared with volcanic islands, the permanent moisture stress found on atolls requires highly intensive application of labour if there is to be any arable cropping.

Limited land and water resources puts binding constraints on any form of agricultural development. Thus the main basis of subsistence is marine products, with supplementary agriculture limited to a few tree species mainly coconuts and breadfruit that can survive in growing in virtual sand, high salinity, and water stress. Arable cropping is confined to root crops grown in compost pits dug below the fresh water lens that lies at the centre of most inhabited atolls. That agriculture in atoll countries like Kiribati and Tuvalu makes up a significant proportion of national income is in itself a reflection of their material impoverishment.

These small fragile island environments are susceptible to events that for larger islands might , be minor episodes, and are especially vulnerable to cyclones, drought, and the effects of sea-level rise. All the land area of an atoll and its entire population may be affected by a single event. Most atolls are located in warm waters close to the equator, the

Table 25: *Atoll states of the Pacific Islands.*

Pacific island states	**Population**	**Land area** (km^2)	**Population density**	**GDP** (A$'000)	**Population growth** (av. **ann.per cent**)
Kiribati	77,658	810.68	96/ km^2	46,260	1.4%
Marshall Islands	49,969	181	276/ km^2	131,549	4.2%
Tokelau	1507 (1996)	12.2	124/ km^2	na	-0.9%
Tuvalu	9764 (1995)	25.9	377 / km^2	17,385	1.7%

Sources: Pacific Islands Yearbook, Pacific Islands Population Fact Sheet 1997, *CDP figures from ADB 1996.*

Table 26: Atoll location and the incidence of cyclones: 1959-1975.

Longitude South	Atoll group	Number of cyclones
0' 10 5'	Kiribati	0
5'1010'	Tuvalu Tokelau	6 2
10'1015'	Northern Cooks	4
15'to 20'	Southern Cooks French Polynesia	7 4

Source: ADB 1991 p 307

region where most cyclones form. The incidence of cyclones increases away from the equator (Table 26). Tuvalu, which lies close to the South Pacific convergence zone (SPCZ), where the north-east and south-east trade winds meet in the southern summer, is a prime area for cyclones to form. By contrast, Kiribati, which straddles the equator, is seldom, if ever, affected by cyclones. During an El Nino episode, the SPCZ shifts eastwards, making cyclones more common around the northern Cook Islands and less common around Tuvalu although the cyclones that do affect Tuvalu during an El Nino episode appear to be more powerful.[113]

Atolls may be no more prone to cyclones than high islands of similar longitude, but they are more vulnerable to their effects. In some places they are only a few metres wide and every place is close to the sea; there is no higher ground to move to and any inundation affects most if not all of the island. The high waves and sea surges that accompany cyclones can cause the intrusion of salt water into compost pits, contamination of fresh water wells, and erosion of already limited land resources. On high islands, even in the most severe cyclones, pockets of land often escape relatively unscathed. Atolls are never so fortunate. Furthermore, a cyclone that hits a high island weakens as it loses contact with its power source-the sea-but this will not happen over an atoll. On the other hand, the small size of an atoll means there is rarely a direct hit.

Atolls are also susceptible to droughts, for they lack the natural rain catchments of high islands. Being low and small, rain-bearing clouds often pass right over. Nor are there other sources of water, except on some atolls that have a fresh groundwater lens. Most atolls have annual rainfall of around 1,500 to 2,000 mm. but there is considerable variability between atoll groups. The southern islands of Tuvalu average more than 3000 mm a year while the drier northern islands average around 2500 mm-considerably more than Tarawa in Kiribati (1500 mm), the Southern Gilberts (less than 1000 mm), Northern Gilberts (2,000 mm), Banaba (known to drop to 200 mm), Christmas Island (875 mm) and Ujelang in the Marshalls (2030 mm). There is also considerable seasonal and annual variability within particular atoll groups, a variability that is most pronounced on the margins of the dry belt. Much of Kiribati is affected in this way. Floyd (1978) reported that the annual minimum and maximum rainfall variability for Christmas Island ranged from 177 mm to 2,621 mm. On Kiribati's Phoenix Islands, settlements established in the 1930s had to be abandoned in the 1940s and 1960s due to serious prolonged droughts.

Because atolls are only a few metres above sea level, they are also vulnerable to sea-level rise. The highest point in the entire Marshall Islands is ten metres above sea level, in Tuvalu no island rises above five metres, and the atolls of Tokelau are all below 5 metres.[114] A sea-level rise at the high end of the range of predictions could mean the complete disappearance of most of these islands. Even low end predictions would mean that some land is lost and much of the available agricultural land is turned into brackish swamps.

Tuvalu was selected as a case study of the impact of disasters on atoll agriculture for several reasons:

- This country has experienced several severe cyclones over the last decade or so.
- Tuvalu has been at the forefront of the international campaign to highlight the plight of small island states in the face of sea-level rise.
- Despite its small size, Tuvalu has emphasized self-reliance in its economic development, in contrast to the atoll states of the north Pacific.
- Tuvalu has made an attempt, albeit unsuccessful, to export agricultural products, namely kumala to Marshall Islands.

[113] *cf. Keli 1997*

[114] *Douglas 1994*

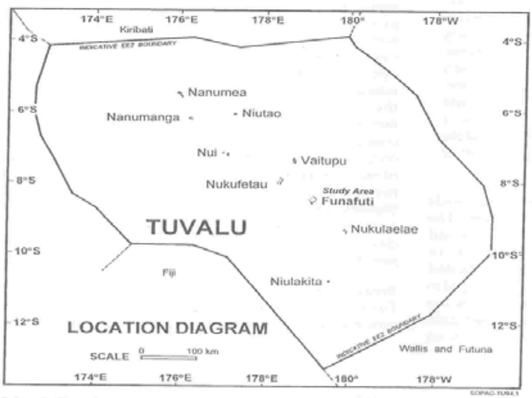
THE GEOGRAPHY OF TUVALU: A SUMMARY

c)
Tuvalu is a small independent dominion in the central Pacific (Map 5). It is composed of nine atolls of which eight are permanently inhabited. It is these eight islands that give the country its name, Tuvalu, as this means' eight standing together.' All the islands are small, the largest, Vaitupu, being only 5.6 km2 and the smallest, Niulakita, a mere 41 ha. The capital atoll, Funafuti, has 42.5 per cent of the total national population of 9,764 (1995). While Tuvalu's total land area is a meagre 25.9 sq. km, its exclusive economic zone extends a huge 900,000 sq. km. The atolls extend over 560 km from Nanumea in the north to Niulakita in the south. Funafuti, Nanumea, Nui, Nukufetau, and Nukulaelae are low-lying atolls with reefs enclosing a central lagoon. Nanumaga, Niulakita, and Niutao are reef islands, that is rock pinnacles rising from the ocean floor. Vaitupu is a combination of both.

From 1892 until 1975, the islands were governed by Britain as the Gilbert and Ellice Islands. As independence approached in the 1970s, the Ellice Islanders (now Tuvalu) made moves to separate themselves from the Gilbert Islands (now Kiribati) and in 1975 they became the Colony of Tuvalu with internal self-government, with full independence following in 1978. Since independence the nation has faced many challenges. The British were not disposed to separation and before the referendum warned that the separate state would receive very little of the Gilbert and Ellice colony's assets. This promise was kept and when the colony was split, all Tuvalu received was one ship. The expectation was that Tuvalu would soon clamour for reunification and that the new nation would fail from its outset. There was also a sudden influx of Tuvaluans returning from Tarawa, the colonial capital, and from Banaba, the site of a phosphate mine that had just been worked out, increasing the population of Tuvalu by almost 25 per cent between 1973 and 1979. Despite this, the small dominion stayed independent, displaying a spirit of self-reliance that is reflected in Tuvaluans' ability to cope with natural disasters[115].

The population has increased steadily, the average annual growth rate now being 2 per cent, at which rate the population could double in 35 years. As the Nauru phosphate operation winds down and Tuvaluan workers return, Tuvalu can expect another population increase, mostly to the capital atoll.

[115] *Personal communication with Sir Toaripi Lauti, Tuvalu's first Prime Minister*.



Map 5: Tuvalu.

Population density is high, at 377 persons per sq. km., and in some localities is even higher, rising up to 1,380 persons per sq. km on Funafuti, and even higher on the southern half of Fogafale islet, where most people live.

Tuvalu's agricultural and food production systems

Tuvalu's food production system is characterised by a reliance on seafood and a limited number of crops. Coconuts *(niu),* bread fruit *(mei),* and pandanus *(fala)* are the only tree crops that can survive the harsh agronomic conditions. Arable crops are restricted to what can be grown with compost, usually placed in pits. Giant swamp taro or *pulaka* (Cyrtosperma chamissonis), bananas, taro or *talo* (Colocasia esculenta) and, more recently, cabbage, are the most important. Yet agriculture accounted for a high 14.4 per cent of GDP in 1995, of which 93 per cent came from subsistence.[116] Copra is the only agricultural product that can be regarded in anyway commercial. *Kakeega O Tuvalu,* the National Development Strategy for 1995 to 1998, summarises the constraints to the agricultural sector:

> *About 37 per cent of the total domestic spending on foodstuffs, and two thirds of domestic cash expenditure, were supplied by imports. This emphasises the severe supply side constraints on food production in Tuvalu such as very poor soils, harsh climate, and very narrow product base. These problems are exacerbated by a land tenure system that ensures that agricultural production remains very labour intensive utilising extremely small plots. Beyond the limited natural resources other constraints facing the agricultural sector are the inadequate interisland transportation links, lack of agricultural data and research in the field of coral atoll cultivation, a dependency on imported agricultural inputs, and the lack of infrastructure to support the development of the sector.*

Coconuts can tolerate atoll conditions and provide the basis of subsistence of all atoll societies. The coconut is an important food source but has a myriad of other uses (Table 27). An estimated 2,100 ha., or 70 per cent of Tuvalu's cultivable land, are planted to coconuts. The tall varieties of coconut palm evolved in the South Pacific region and thus are tolerant of strong winds and drought, although gale force winds will bring down nuts. This means an eight-month wait in terms of copra production, but usually the fallen nuts can provide a month or two of food. Even a moderate hurricane will mean the loss of flowers and it will then be 12 months before new bunches are produced. If the storm has been strong enough to blow off leaves, then it will be three to four years before full production is restored as coconuts will not flower without leaves. The recovery of leaves is slower under harsh atoll conditions, and in drought conditions it can take several years, as happened on Funafuti after the devastating Cyclone Bebe in 1972[117]. If the tree breaks below the crown, it will die. This rarely happens as coconut trees are quite elastic, except those over sixty years or under ten years old. The government mounted a subsidised replanting program in the 1980s which was partly successful, but most of Tuvalu's coconut trees are now old and susceptible to cyclone damage.

Copra is Tuvalu's only agricultural export commodity. The value of these exports has fallen sharply over the last decade or so, although there have been considerable variations from year to year because of low but variable prices, declining productivity of old and often senile palms, and the impact of cyclones. The sole copra exporter, the Tuvalu Coconut Traders' Co-operative (TCTC), virtually ceased operations in the early 1990s, because of low prices and insufficient volume to warrant trading. In 1992, 1995, and 1996, there were no copra exports. While copra is unlikely to ever again be a major source of export earnings, the government recently decided to substantially subsidise copra prices, a decision which reflects the very limited employment and income generating opportunities for Tuvaluans, particularly in the outer islands. Cyclones have contributed to the demise of the Tuvalu copra industry but more fundamental factors have been the low returns to labour, the high cost of inter-island transportation, and insufficient critical mass to sustain viability. Irrespective of the bleak future for copra, the coconut will remain fundamental to people's sustenance. The Central Statistic Division estimates that households in the outer-islands consume an average of 18 coconuts per day, while those on Funafuti consume 10 coconuts per day.118

Breadfruit *(mei)* is the main traditional staple of Tuvaluan households. The fruit are available for around eight months a year, but not between October

[116] *ADB 1997: 85*

[117] *Clarke 1993*
[118] *ADB,* 1997: 87.

Table 27: *The coconut and its uses* in *Tuvalu.*

Coconut part	Tuvaluan Term	Description
Nuts	*mukomuko*	Only for drinking, without kernel
	uto	For drinking, kernel and husk eaten
	pi	The drinking nut with the soft kernel, favoured by young and old, also used for cooking, as well as for feeding to hens and pigs. Husk is used for making coconut fibre string and also for surrounding the earth oven. Hard shell used as a container in the earth oven.
	motomoto	With a harder shell and thicker kernel. This type is used for food and fodder for pigs. Hard shells are likewise used as food containers in the earth oven.
	Fuaniu	The ripe nut. Kernel eaten raw; used grated and pressed in cooking (coconut milk) and for body oil, copra (also for eating) and for pig fodder. Husk used as combustible material for or as "corks" or vessels, as flasks for oil, as markers during games (lafo), hooks and combustible material
	ufanu (pulapula)	The germinating nut. Contents eaten raw and used for cooking
	taume	For the production of fire-brands and fire tongs
Inflorescence		Cut to obtain toddy
Leaves	*kaumoe*	The young leaf before it unfolds, used for weaving fans and baskets and for tying skirts
	launiu	Green fronds, used for weaving floor mats, food plates, covering and balls for games; for tying skirts, for belts for those who climb palm trees, for magic, for "wind-mill" toys and for wrapping around fish being put in an earth oven
	kaulama	Old, brown fronds, used for blinds, food plates roofing, torches for fishing, containers for compost (plaited and wound round), skirts, garland of flowers, compost and combustible material
	kautuaniu	Midribs of the frond leaflets, used for brooms, fastening the pandanus leaves forming the segments of thatch, baskets, fans, "wind-mills" and toy canoes, for strengthening the sides of bonito hooks, as skewers for cooking fish and as "arrows" for shooting fish
	palalafa	Frond midrib, when green: used as a pole for carrying, for stirring food, as a weapon in mock fights, as an improvised coconut grater (with coconut shell), as an improvised tool for husking coconuts, as walls inside and outside the houses, pieces are used as toy clappers, and when split, used as a belt for carrying fish. When old and grey: used as roof patterns, as the support for the pandanus leaves used in the segments of thatch, for the platform in sleeping houses, for stirring food, for walls, covering, room partitions and as combustible material
	kaka	Natural fibre cloth from the base of the leaf stalk;
	(laufaka)	used as a filter bag for grated coconut meat/body oil, as herbal medicine, as a filter for toddy, as tinder when making a fire and as combustible material
Stem	*koganui (tafito)*	Used as supporting posts or beams for houses, for roof battens, house surrounds, spears, props, pigsty fences and fuel for lime-burning
Bark	*laukili c(pakili)*	Used as an ingredient for scenting body oil, for smoking skirts and as combustible material
Roots	*aka*	Used for fish traps, sand screens and medicine

Source: Koch, 1961:50.

and November Gust prior to the cyclone season) or April and May (usually just after the cyclone season). As with coconuts this crop survives, rather than thrives, in the harsh atoll conditions and compost and better soil is usually added to a seedling to give it a start in life. There are fewer breadfruit varieties in Tuvalu than in volcanic islands, but there are several Tuvaluan varieties of both species of breadfruit, *Artocarpus aItilis* and *Artocarpus mariannensis*[119]. Some, such as *aveloa* and *ma'afala* are relatively recent introductions from Samoa, but most are older Tuvaluan or Kiribati cultivars that evolved in atoll conditions and are thus well adapted to them. *A. mariannensis* cultivars and hybrids are particularly well adapted as this species is endemic to the North and Central Pacific, where most islands are atolls.

While breadfruit is tolerant of poor soils, it can not sustain salt spray, and this restricts the area where they can be grown. The trees are tall and have relatively weak trunks, and therefore often suffer cyclone damage, including having all its fruit blown off. Such a tree would take about 18 months to recover in Tuvalu. A tree that is pruned before a cyclone will recover more quickly but one that must be replanted will take two to three years to return to full production. Thus an atoll community can lose both its coconuts and breadfruit in a cyclone and therefore face a major food security crisis, unless it has sufficient preserved food in stock to supplement seafood.

Pandanus *(Pandanus odoratissimus)* or *fala* grows both wild and cultivated, and is used as raw material for handicrafts as well as a food source. Many things were once made with dried pandanus leaves, but less so today, other than mats, fans, tourist trinkets, and rolling material for tobacco. The leaves are also an important component of the pit compost system. The fruit was a more important food source in the past, but is still consumed today, in both raw and cooked states.

Outside of Kiribati and Tuvalu, *pulaka* (swamp taro) is a relatively unimportant tuber in the Pacific islands, being used largely as an emergency food or for animal feed. In Tuvalu, however, it is culturally the most important crop. It cannot tolerate sandy porous soil and therefore is planted in pits where the ground is damp and muddy, below the lens of percolated rainwater. *Pulaka* cultivation is very labour intensive and it takes at least five years to produce a reasonably sized root. A particularly large and prestigious *pulaka* can take up to ten years of

[119] *Ragone,* 1988

continuous attention. In Samoa (where it is known as *pula'a)* or Fiji (known as *via),* a similar sized root could be produced in three or four years with much less labour input. The cultivation of pulaka easily takes up most of a subsistence farmer's time. Smaller corms are used in everyday consumption but a large *pulaka* is valuable and reserved for special ceremonial events, such as weddings, important birthdays, or funerals. Regular *pulaka* growing contests are also held, with much prestige going to the group with the largest tuber. It is also an important medium of exchange between communities in the outer islands and in Funafuti. There is no export market for *pulaka.* Even if transport was available, it is too expensive to produce and not popular amongst expatriate Pacific island communities in New Zealand and Australia. The imputed value of a pulaka plant derived from the most recent cyclone assessment report is $A15[120]. It is also too slow-growing and labour demanding to be a regular part of a Tuvaluan diet. The introduction of imported food has further reduced its importance.

Because of the poor soil and moisture conditions, plant nutrition is highly dependent on the development and retention of a humus cycle and vegetative cover. That this requires an appropriate composting system has long been recognised by Tuvaluans, and applied in their traditional *pulaka* pits. A composting regime must increase water retention as well as improve the soil quality. Coconut husks and rotting coconut logs are grated up and added to the compost for this purpose, often comprising forty per cent of the compost mix, the rest being leaves and kitchen scraps. Compost will be used to give a start to seedlings or to plant a small patch of cabbage. Individual attention is often even given to coconut seed nuts, including the application of compost. Most compost, however, is used in the *pulaka* pits where *pulaka* and taro are grown and, around their edges, bananas all planted close together to make the best use of land. Water retention is much problem as the pits are moist areas in contact with the underground lens, enabling pit crops to survive occasional droughts. The nutrient level must nevertheless be kept up, and large amounts of leaves and kitchen scraps are painstakingly laid around the taro, *pulaka,* and bananas. There are quite literally centuries worth of compost in the pits, and some are quite large. Koch described a pit on Niutao about 400 metres long and 40 metres wide, surrounded by banks of earth that had been dug out[121]. The pit culture on three islands,

[120] *Tuvalu Government, 1997.*
[121] *Koch, 1961:52.*

Funafuti, Nukufetau and Nanumea, suffered a severe blow during the Second World War, for the occupying American forces built airstrips over many of them and removed some topsoil from other areas. Subsistence agriculture on these islands has never fully recovered from this. The war also bought Tuvalu into contact with imported foodstuffs, marking an important turning point in Tuvalu's food security.

Pulaka has adapted to swamps, a high water table, and brackish conditions and Tuvalu's isolation has meant that it has few pest problems. The crop is resistant to strong winds even when it is full-grown, enabling it to survive cyclones with a minimum of wind damage. The main problem it faces in cyclones is salt-water intrusion. The pits are usually in lowlying areas in contact with the water table. Peak tides in February coincide with the hurricane season and the *pulaka* pits are particularly vulnerable then. If salt water penetrates through the water table, most of the crop will be lost, as is evident from damage assessment reports of National Disaster Committee (NDC) for Cyclones Joni, Kina, and Nina that occurred between December 1991 and January 1993:

> **Nanumea:** The damage caused by strong winds to vegetation on the island seemed minimal compared to the damage caused by the action of big waves and flooding of low elevation areas on the coast (ocean side) and lagoon side ... Most of the local food crops especially breadfruit, banana, and pawpaw showed signs of yellowing and browning due to the intrusion of salt water during flooding ... At Lakena only two *pulaka* pits were damaged by the intrusion of seawater into the pits. The larger pit was completely damaged whereby the small pit was totally under sea-water.
>
> **Nanumaga:** The pulaka pit at Tekoko was completely under sea-water. Reports from local sources indicated that the height of sea-water in the *pulaka* pit was 7 to 8 ft. high. Most of the bigger *pulaka* crops were harvested the following day despite the fact that they were under water. All the *pulaka* plants at Tekoko *pulaka* pit, the leaves have turned brown and drying up and the same applied to banana and sugar cane plants around the *pulaka* pit.
>
> **Niutao:** Despite all the damage to local food crops, canoes and other resources on the island, the main source of food on the island were in total safety, i.e. the Te Talo and the Te Pela - *pulaka* food gardens.
>
> **Nui:** There were three low elevation areas around main pulaka pit in which sea-water managed to enter, two from the lagoon side and one from the ocean side. The intrusion of seawater into the pulaka pit was during the high seas and big waves causing flooding in the village area. The leaves of the pulaka plants around the above 3 areas have turned yellowish with young leaves still green. Pulaka further away from the entrance were not affected. In addition a separate pulaka garden was totally flooded with sea-water. All the leaves of the pulaka plants have turned yellowish brown to complete dry up of mature leaves. Also a lot of pulaka especially large pulaka plants from this garden had been removed for consumption before the corms get bitter and useless.
>
> **Nukulaelae:** There were two natural low depressions within the sand bank around the *pulaka* pit which caused the spill of sea-water into the *pulaka* pit. The pulaka growing in these particular areas have turned yellowish brown and therefore one of the council members advised owners of these pulaka pits to quickly pull out all *pulaka* if the situation did not improve.

Despite the great value placed on *pulaka* by Tuvalu society, it is difficult to quantify these losses in monetary terms because the crop is seldom traded. The government attempted to do so in its assessment of damaged caused by cyclones Gavin and Hina in 1997, estimating a total damage to vegetation of A$548,OOO, of which 65 per cent was attributed to *pulaka,* giving a value per plant of A$15. Compensation was also considered for the loss of *pulaka* pits, the rate recommended by the Lands and Survey Department in 1993 being $1 per square yard. On this basis, the Nanumaga Island Council made a claim for A$3,946 for a large *pulaka* plantation destroyed by cyclones Joni, Kina, and Nina.

Taro *(colocasia)* is also grown in the *pulaka* pits and suffers the same problems of salt-water intrusion. While it has the additional disadvantage of not being as tolerant to strong winds, it is faster growing (12 to 14 months under Tuvalu conditions) and thus able to recover from a cyclone faster than *pulaka.*

Kumala *(Ipomoea batatas)* is the only root crop that is not grown in the *pulaka* pits. It is of limited importance and grown only on the southern islands where there is usually sufficient rainfall. The relative drought tolerance of kumala and its ability to grow on sandy soil at the apron of the beach, make this possible. In early 1990, the crop on Funafuti was sufficient to attempt air freight exports to the Marshall Islands, an effort that however proved to be not viable. While kumala is quite tolerant to wind damage, being planted at the edge of the beach makes it susceptible to storm surge. Most is therefore destroyed in a cyclone. To quote the NDC damage assessment for cyclones Joni, Kina, and Nina on Vaitupu:

> *It is generally regarded that food tree crops near the shoreline and those growing in low elevation areas with will totally collapse due to flooding of the area with sea-water. An area of 1,000 square meters of sweet potato was completely buried in sand from the beach.*

Other common crops are bananas, sugar cane, papayas and cabbage. Bananas are regularly grown around the edges of *pulaka* pits and in other locations where soil can be found and compost added. Sugar cane is also grown around the edge of the pits. Papaya can be grown with the careful addition of soil and compost. Cabbage, a more recently introduced plant, can be moderately successful with a small amount of composting. All of these crops usually have to be replanted after a cyclone.

NATURAL DISASTERS IN TUVALU

Frequency and intensity of cyclones

According to Tuvalu Meteorological Department data, there was an increase in the number of cyclones between 1970 and 1990, compared with the period 1950 to 1970.[122] As well as a greater frequency of severe storms over the last twenty years, a notable phenomena has been the occurrence of a series of cyclones occurring in quick succession, as happened with cyclones Joni, Kina, and Nina in 1992-93 and Gavin and Hina in 1997. It is difficult to conclude that this reflects a structural change in the frequency of cyclones in the region, for there are occasional periods of more frequent and severe cyclone activity as happened in the decade of the 1870s.

Damage assessments for two sets of recent cyclones, Gavin and Hina in January 1997 and Keli in June 1997, show that damage from Gavin and Hina was widespread while Keli was concentrated on the southernmost and smallest atoll, Niulakita. These three cyclones-from the small and concentrated Keli to the large Gavin-represent a typical range of sizes and strength of storms and were also typical of the quick succession of these weather systems in recent years. Gavin and Hina were typical of 'normal' (that is, non EI Nino) systems in that they originated close to Tuvalu in the normal position of the SPCZ. They were therefore in the beginning stages of development and not at their peak strength when they hit. Keli, on the other hand, was a 'textbook' EI Nino cyclone-out of season, originating far to the north-east because of the position of the SPCZ, and at the peak of its strength when it reached Tuvalu.

The Lands and Surveys Department puts a dollar value on various crops, at A$20 for a breadfruit tree, A$15 for *pulaka* or taro, and A$25 for a coconut tree. These figures are used to impute estimates of damage to agriculture. Obviously these figures mask wide variations in individual damage and value, for a damaged coconut tree is valued at $25 regardless of its size or degree of damage. This allows the evaluators much opportunity to exaggerate damage and, since there is a definite incentive to do so, it is possible that the overall figures are rather high.

- Coconuts: In 1997, after cyclones Gavin and Hina, there was 950 damaged trees and, at the official rate of A$25, this represented A$23,750 worth of damage. In June 1997, cyclone Keli damaged 250 trees on Niulakita, damage estimated at A$3,750 worth of damage. (Interestingly, the number of trees damaged on Niulakita was exactly the same after cyclones Gavin and Hina.)
- Breadfruit: Cyclones Gavin and Hina caused A$2,440 worth of damage to breadfruit in Tuvalu, involving 144 trees valued at A$20 each. Given that the 1991 census recorded 1,483 households in Tuvalu, this equaled to one tree for every ten households. On the outer islands, where the custom is more or less maintained of planting one breadfruit tree at each corner of a household property, this damage caused less of a problem than on Funafuti, where many land-less outer islanders do not have the room (nor possibly the time or motivation) to plant the same quantity of breadfruit trees. On Niulakita, cyclone Keli damaged five trees, valued in total at A$100, or one tree for every three households. (No trees were evidently damaged there by cyclones Gavin or Hina).
- Pulaka and taro: Total estimated damage to *pulaka* was valued at A$360,000, a rather astoundingly high figure mainly due to the loss on Nukulaelae of 20,000 tops, an average of more

[122] *Seluka, 1996*

than 500 tops per person which undoubtedly would have had a devastating effect on the island. In relative terms, the estimated damage to Nukulaelae's crop represented more than half of the total national damage caused by cyclone *Keli* to vegetation, or almost one seventh of the total national damage caused by cyclones *Gavin* and *Hina.* Keli did no damage to *pulaka* on Niulakita as there are no pits there.

The National Disaster Committee (NDC)'s report on cyclones *Joni, Kina,* and *Nina* summed up the types of damage incurred by the meagre agricultural resources of atolls countries by major cyclones:

> *From a global view of the situation it can be estimated that 10-20 per cent of the natural resources were destroyed by this terrifying natural forces [Sic.] of nature. The figures would be much higher had the majority of the population been non-attentive. Overall, many took precautionary measures to save whatever resources they could at that time e.g. pruning of breadfruit trees, releasing pigs from pens etc. Besides it can also be considered that the situation in regards to agricultural and food resources will return to normal within* 2-3 *years.*

Tuvalu's cyclone relief programs are on an understandably much smaller scale than those of larger countries such as Fiji. Being more dependent on overseas assistance, Tuvalu tends to be more sensitive to donor generosity and priorities. There is thus much more variability in relief packages from cyclone to cyclone, depending on what the donors are able and willing to provide. As far as food relief is concerned, the usual relief package consists of the ubiquitous bags of rice and flour, tins of biscuit, and cartons of tinned meat and fish. The level and timing of this food assistance is often out of line with domestic food damage and availability and does little to encourage food security or self-reliance. Relief supply arrangements for cyclone Keli, the most recent cyclone to hit the Tuvalu group, reflect the distortions that occur. This small, out-of-season cyclone hit Niulakita, with its population of 78 people, in June 1997. Table 28 shows food crop losses as reported by the Damage Assessment Team of the NDC. On the basis of this assessment, the following food rations were supplied: 640 kg of rice, 650 kg of flour, 252 kg of biscuits, 26 cartons of corned beef, and 22 cartons of tinned fish. Relief supplies were donated by France and carried to Tuvalu by the New Zealand Air Force. The Republic of Korea also provided relief medical supplies. Additional food supplies were later given by the Adventist Disaster Relief Agency (ADRA) in Fiji, including 300 kg of flour, 150kg of sugar, 24 cartons of corned beef, cooking oil, cocoa, condensed milk, and spring wood. There is no doubt that these relief rations would have been greatly welcomed by this tiny, isolated community. They however seem to be well in excess of the actual food losses incurred, and would appear to encourage an unnecessary high level of dependency. Despite the island's susceptibility to cyclones, it has perhaps the best potential for arable cropping of any island in Tuvalu because of its phosphate deposits.

Incidence and severity of drought in Tuvalu

For an atoll nation, Tuvalu is relatively free of drought, quite unlike some islands in Kiribati that have had to be abandoned because of wa ter shortages. The southern islands average greater than 3000 mm a year while the drier northern islands average around 2500 mm. There is also less variability in rainfall than in Kiribati. There are often periodic dry spells that could be called droughts but, compared to similar nations, Tuvalu is in a fortuna te position. Water is nevertheless limited, and demand for it is growing. If tourism expands, there will be even higher demand, especially on Funafuti where tourism development is likely to be concentrated and where there is no drinkable underground water. Better infrastructure is needed; more and larger tanks are being built and the airstrip needs to be developed as a water catchment for non-drinking purposes in order to improve water security. A good system is already in place in Tuvalu, in that the government provides no subsidies for water use but instead subsidises the construction of water tanks and roof catchments for individual households. As a result, most households are self sufficient in water and only need government assistance at times of shortage. That government-supplied water is expensive provides another incentive for people to build large water tanks.

Pulaka and the other pit crops are protected against drought because water requirements come from the underground freshwater lens. On an atoll, the only source of recharge for this lens is rainfall. Without rain, the underground freshwater will steadily decrease as it leaks into the sea, eventually becoming completely sea-water, but fortunately this is a slow process. Depending on the geology of the island, the freshwater lens can remain in existence for several months (possibly beyond a year), if undisturbed by human activities. This is not a problem in Tuvalu as groundwater is not pumped for human use, and nor are droughts often lengthy. As a result, Tuvalu's pit agriculture is quite drought resistant.

Table 28: *Reported food crop losses on Niulakita after Cyclone* Keli, *1997.*

	Reported losses	Imputed value per tree by the Lands and Survey Department ($A)	Total estimated value of ($A)
Coconuts	150 (30 % of trees)	25	3,750
Breadfruit	5	20	100
Pandanus	20	15	300
Banana	1,000 (100% of trees)	10	10,000

Source: National Disaster Committee, 1997.

The effects of sea-level rise

Tuvalu has played a leading role on the international scene in discussions on climate change. In the recent South Pacific Forum meeting in Rarotonga, Cook Islands, Tuvalu's Prime Minister led the criticism by the small island states on Australia's position on binding greenhouse emission targets, and attempted to get the forum to agree to push for binding targets at the Kyoto Conference on Climate Change in December, 1997. Tuvalu also made a big contribution at the first United Nations Conference on Environment and Development in Rio de Janeiro in 1991, the Prime Minister chairing a meeting of small island states there, and emphasising the issues of climate change and sea level rise.

It is difficult to estimate the extent of any sea level rise in Tuvalu. In 1993, a team from Flinders University of South Australia installed a gauge in Tuvalu to measure sea level rise, but these gauges need at least five years to stabilise and, after that, another few years to detect any trend. An older gauge, considered less reliable than the Flinders gauge, was installed by the University of Hawai'i in 1976. Both have recorded rises in the sea level; the Hawai'i gauge recording a five-centimetre rise since 1976 and the Flinders gauge confirming the Hawai'i gauge results since 1993. Although the limitations of the measuring devices means that this is not firm proof, the fact that they have separately arrived at similar results increases the possibility that some sealevel rise is occurring. This is supported by much anecdotal evidence in Tuvalu. Many farmers and agriculturists feel that the problem of brackish water in the soil, especially in the *pulaka* pits, has become worse in recent years. Farmers find that they must place more leaves in the pits to reduce the impact of salty water. Many have also attempted to raise their pits above the water table. Unfortunately there are no scientific instruments installed to measure the salinity of the pits or any changes that have occurred over time.

The first victim of a significant sea level rise would be the pit agriculture system, for these are in low lying places and in contact with the underground water table. A rise of a few centimetres could increase salinity enough to make the pits unusable. Tuvalu's land elevations range from one to four metres, and the high water mark from 2.9 to 3.25 metres. As a result, every month during the highest tides some land is below sea level, often damaging the crops in the pits. Even at the low end of the range of predicted sea-level rises-that is, 0.5 m by the year 2100significant damage could therefore occur to the traditional cropping system. Given that these pits hold Tuvalu's richest soils and are of great cultural and agricultural importance, this would be a very serious development. The danger of Tuvalu and other small atoll states completely disappearing may have been overstated but, even so, often serious inundation occurs now, especially during the Christmas tides. February is the worst month when some areas are inundated with water one foot deep; the airport has sometimes been ankle deep. If this coincided with a cyclone, the consequences would be disastrous, for the winds would add large amounts of salt water to the flooding.

Coconuts, breadfruit, and pandanus would be perhaps the last victims of sea level rise. These are non-pit crops with relatively shallow root systems. If sea levels rose sufficient to affect these crops the country would probably be already uninhabitable.

TRADITIONAL CYCLONE MITIGATION METHODS

The focus of food preservation in Tuvalu is the drying of food.[123] Techniques common in volcanic islands, such as smoking and fermenting, are not done here in part perhaps because Tuvalu's drier climate favours drying, but also because fermentation in Pacific island societies is usually done in deep pits, which is not possible in Tuvalu

[123]*This section draws heavily on personal communication with various community figures resident in Funafuti, including Tomu Matifono Sione, former Governor General and Niutao elder*

because of the high, brackish water table A small amount of fermentation is nevertheless practiced, mainly by old women who went to school in Samoa.

There are drying methods for almost every traditional food in Tuvalu. All manner of fish are cooked in the *umu* (earth oven) until hard and then sun dried, enabling them to keep for up to one year. When needed, the fish are soaked overnight and cooked in coconut cream. Similarly, breadfruit, taro, and *pulaka* are sliced, cooked in the *umu,* dried, then soaked when needed for eating. In sterile conditions, these staples can last for two to three years. To ensure sterility, these foods are stored in airtight biscuit tins which are thoroughly boiled before use. Clean tongs, either modern or traditionally made, are used to remove each piece of food when needed; touching the food is discouraged. An additional method is used for *pulaka.* The root is grated raw then dried and stored according to the methods used above. When needed, it is cooked in coconut cream. This also has a lifetime of two to three years. Puddings are made from the taro, *pulaka* and breadfruit (known as *solotaro, solopulaka,* and *solomei,* respectively. These are made by pounding up the crop and mixing it with flour or arrowroot starch (known locally as vatia). These are heavily sweetened with either toddy or sugar, which prevents them from being attacked by bacteria, and then cooked in an umu or any form of oven. This food typically has a lifetime of six to eight months, but has been known to last for up to a year. *Pululeti* is another example of preservation by sweetening. This is grated coconut mixed with toddy, boiled till thick and rolled into balls. If packed in sealed, sterilised containers, it can last for up to five years.

The traditional place to store these foods was in the roof rafters, in woven baskets, which allows the food to be continuously sterilised by smoke and hot air from the hearths. The advent of biscuit tins and other modern containers has made this practice disappear, as they are more convenient and, if they are properly sterilised, can provide better storage capabilities. As well, *pulaka* can be buried for up to three months and then removed and cooked in the normal way when needed. This is not a fermentation method like the Fijian *davuke,* but rather a method of field preservation. *Fulaka* is kept alive while buried and does not start decaying as it would above ground.

These labour intensive foods are rarely made on Funafuti, for imported rice and tinned meats are relatively cheap and store well. Most households have at least one wage earner. Also two-thirds of households of Funafuti are people from other islands who have no access to land, nor, therefore, to the large surpluses of crops that usually spur people to preserve food. On the outer islands, however, these methods are more common. Preserved foods are often sent by outer islanders to their relatives on Funafuti in exchange for the imported goods that people on Funafuti have access to. Given the irregularity of the shipping services, these are popular as trade items, as they will not go bad waiting for the ship to turn up. These are also popular foods to send to Tuvaluans abroad, such as the Nauru workers and the seamen, for the same reason. Even so, the popularity of these foods has declined even on the outer islands. Imported foods have gained a foothold at the expense of all traditional foods, particularly those that take work to prepare. The preservation methods survive today primarily for the reasons named above. They are not seen as hurricane mitigation methods and food preservation is not mentioned in the government's disaster preparation manuals, although it is recommended that is should be. Even the various women's councils that are, with government support, trying to revive interest in food preservation are doing it from a nutrition and self-reliance perspective. Food preservation's importance as a disaster preparedness measure seems to have been ignored. Much of this is probably due to both government and the populace becoming so reliant on the common method of government led disaster relief, namely large amounts of food aid sent from Funafuti.

Traditional methods to counter the effects of a water shortage or drought include pruning the leaves of whatever can be pruned to restrict water lost through leaf pores. For some crops such as cabbage this is not possible and thus very little can be done. Pit crops have their own source of water. The other risk of increasing sea-water in the pits can only be countered by placing more compost in them in order to reduce salinity and raise the level of the pit beyond the reach of the saline groundwater.

6. THE VULNERABILITY OF PACIFIC ISLAND AGRICULTURE TO DISASTERS

THE VULNERABILITY OF ISLAND COMMUNITIES

Pacific island societies evolved crops and developed cropping systems and other means to cope quite effectively with natural disasters. Traditional agricultural systems evidently provided a high level of food security. Although they have significantly changed over recent decades, many components of these systems remain in place, to varying degrees around the region. This continues to be an important mitigating force against the impact of disasters, as the Vanuatu and Samoa case studies showed.

Overall, however, economic and social change has brought with it less food security and greater vulnerability to disasters. Traditional disaster mitigation was founded on multi-crop food gardens protected by forest. These systems were adjusted for resource endowments, the seasons, and occasional natural disasters. Traditional food gardens were small but families often had several, so utilising the best locations for particular crops and maintaining the use of land. This dispersion also reduced the risk of all crops being lost. The surrounding trees protected against desiccating winds in a drought and the swirling gusts of a cyclone. Strategic planting timetables and sequential harvesting techniques further enhanced food security. While these systems remain in some places, especially in Vanuatu, they have declined as cash crops have taken precedence. In Kadavu, the virtual disappearance of yams from the cropping system has left many people dependent for food on cash earned from *kava*-*a* crop that is vulnerable to cyclones, drought, and disease and offers nothing in terms of food security. Most rural people on the west side of Viti Levu in Fiji now depend on a single monocultured crop, sugar. There, too, is a marked decline in the subsistence rice and pulse crops that previously provided food security. Many farmers on Tongatapu, Tonga, similarly depend on income earned from squash-a crop susceptible to drought or biological disaster. Farmers in Samoa became highly dependent on taro for cash.

Few Pacific island rural communities are impoverished in that they lack access to resources. Most have access to good quality land and marine resources, maintain a strong subsistence base, and have opportunities to produce some cash crops. Although cash incomes tend to be quite low and a target income outlook still widely prevails, usually there are sufficient land and markets to increase this income. (The Kadavu case study estimated annual income from kava and taro alone to be F$15 million, equivalent to F$1,600 per capita.) But there are important exceptions to this subsistence-based affluence. Some communities are more vulnerable than others, the most vulnerable being those that are impoverished, occupy an ecological marginal environment, or depend on a single source of sustenance. The Vanuatu case study identified communities in areas of volcanic ash-fall which have barely enough resources to meet their subsistence needs. Land-less rural communities that depend on the sugar industry for employment are another particularly vulnerable group.

In some places, larger populations have increased vulnerability to disasters. Atoll countries have most impoverished agricul tural resources, a difficulty sometimes compounded by high population densities and growth rates. Marshall Islands, an extreme case, has over 330 people per sq. km on some islands and an annual population growth rate of 4.2 per cent (SPC 1997). Similar densities occur on the capital atolls of Tuvalu (Funafuti) and Kiribati (Tarawa). While average population densities on the high islands are low by world standards, some have fast growing populations. With its current population de,nsity of 14 persons per sq. km., Solomon Islands might possibly absorb a greater population without ill effect, but this growth has to be seen in the context of the rapid depletion of forests which are critical to peoples' livelihoods and ability to cope with disasters. In the Papua New Guinea highlands, people traditionally migrated to below the frost line during droughts and frosts, but the doubling of population over the last 30 years make these areas unable to accommodate immigrants as they once did (Allen, 1997:24).

Land tenure distortions have created inequities in land distribution and thereby increased disaster vulnerability. Fiji, with a low overall population density of 43 persons per sq. km, has the most marked disparities, with no rational relationship between the number of cultivators in any traditional land holding unit and the amount of land available to them. Tonga and Samoa have low population growth rates, of 0.5 and 0.3 per cent respectively, and land in these countries is fairly evenly distributed. This, and the large inflow of remittances, helps explain Samoa's remarkable recovery from its series of major disasters in the last decade.

Settlement patterns have changed, with increasing concentrations and quite rapid urbanisation in some places. In Fiji, there has been considerable migration from rural areas and outer islands to the cities of Suva, Nadi, and Lautoka. This has also been the case for the other Melanesian cities, especially Port Moresby and Lae in Papua New Guinea), Port Vila in Vanuatu, and Honiara in Solomon Islands. The population of Port Vila, for example, grew 5.8 per cent a year over the past decade, increasing from 19,311 in 1989 to around 32,000 today. These cities face problems of unemployment, poverty, and squatter housing. People living on the town margins are particularly ill equipped to handle disasters.

In short, while the environment for most rural populations is far from marginal-the atolls being important exception-various changes have increased the vulnerability of island communities to disasters. These include:

- unsustainable commercial logging which reduces the capability of forests to serve as a food store, especially in western Melanesia;
- unsustainable cropping practices on slopes;
- increases in uncontrolled pig populations, especially in Fiji and Tonga;
- unsustainable land clearing of forest for *kava* planting, especially in Fiji and Pohnpei;
- increased indiscriminate burning and soil erosion, especially in Fiji and Papua New Guinea;
- pollution of ground water;
- shorter crop rotation with the increasing importance of cassava, especially in Melanesia;
- declining importance of cultivated yams, especially in Fiji; and,
- the decrease in the wild yam population, throughout the region.

THE VULNERABILITY OF PACIFIC ISLAND CROPS AND CROPPING SYSTEMS

There is no longer any clear distinction between subsistence and commercial crops. Purely subsistence gardening is now rare and confined to remote custom villages in western Melanesia. Predominantly subsistence farming is, however, still common, particularly in Melanesia, for some traditional subsistence crops are also important commercial crops, such as *taro* and *kava.* There is no clear distinction between subsistence food crops and commercial tree crops, either. Coconuts, a cornerstone of subsistence in all island countries, have, in the form of copra, historically been the most important export product and remain an important cash crop in some countries. In Samoa, cocoa has a significant subsistence role. Vulnerability is therefore analysed here in three broad categories of crops: root crops, tree crops, and other important crops.

Root crops are the traditional staple for all Pacific island communities. These include *taro* (Colocasia esculenta) in Samoa and Fiji; yams (Dioscorea spp.) in Vanuatu and Tonga; sweet potato *(kumala* Ipomoea batatas) in the Papua New Guinea highlands; and giant swamp taro *(pulaka* or *babai*Cyrtosperma chamissonis) in Tuvalu and Kiribati. A recent, now almost universal, introduction is cassava (Manihot esculenta). Imported starchesrice, wheat flour and potatoes-are increasingly important in the diets of Pacific island households, both urban and rural, as they generally are cheaper than traditional root crops. **In** addition to root crop food staples, *kava* (piper methysticum), an important traditional beverage in Fiji, Vanuatu, Tonga and Samoa, is now a significant commercial crop. Table 29 summarises the susceptibility of these root crops to disasters.

Tree crops-coconuts, cocoa, and coffee-are the region's traditional export earners. While their overall importance has declined, they remain the dominant source of income for some countries or areas. Other than the universally important coconut, important sources of subsistence include breadfruit and various nut and fruit trees. Table 30 summarises the susceptibility of tree crops.

Field crops are generally not grown in the Pacific islands, major exceptions being sugar in Fiji and squash in Tonga. Attempts to establish large-scale irrigated rice industries in Fiji and Solomon Islands failed, although Fiji maintains a small-scale traditional rice industry. Unsuccessful attempts were also made to grow maize commercially in Fiji, but it now grows throughout the region as a small-holder subsistence crop. A variety of fruits and vegetables are grown throughout the region, mainly for subsistence but increasingly for export. Table 31 summarises the susceptibility of these crops.

Pacific island crops have varying degrees of tolerance to disasters. The traditional resilience of Pacific islands agriculture came through the integration of the whole cropping system, the system being more resilient than its component parts. Either yam or taro provided the main staple, complemented with bananas and breadfruit. Leafy vegetables, sugar cane, fruits, and nuts and fruits from the forest, were supplementary foods. Other foods, those especially cyclone or drought resistant, or preservable, were reserved for times of hunger, as they still are in some places. Some crops are more tolerant than others. Island cabbage, especially if cut before a cyclone, can bear again within six weeks. Bananas seldom survive strong winds but the main rootstock is rarely killed and suckers will reappear to fruit six months later. Immediate cutting and pruning accelerates their recovery. In the past, local food assistance from less affected areas was usually forthcoming, sufficient to bide the community over until quick maturing crops came into production.

Kumala and later *cassava* were introduced into these cropping systems. The low growing habit of kumala helps it better withstand cyclones. Once established, it is also reasonably tolerant of drought. In the highlands of Papua New Guinea, where it has become the dominant staple, it is however susceptible to the frost that tend to accompany ENSO induced droughts there. An advantage of kumala is the short time it takes to produce a crop - three months if planted in the wet season-allowing for rapid recovery of food supplies after a disaster. Comparing the impact of the extreme 1941 drought with that of 1997, Allen (1997:27) noted the dramatic change to a *kumala-dominated* cropping system. Many agricultural systems in 1941 did not include crops that are now important foods, in particular sweet potato, Xanthosoma taro, cassava, and triploid bananas. As well, in 1997 systems tended to be more intensified, usually by extending the cropping period with an extra planting, often of kumala. The long term ecological and economic implications of these changes are not yet known.

Cassava, introduced to the region in the mid-nineteenth century, became a supplementary crop in some places and so contributed to food security. It could be planted at any time of the year. Some varieties could be stored in the ground for two years, so providing insurance against natural disasters, especially as cassava had no value in custom and was therefore less likely to be depleted in traditional feasting. But cassava has also served to increase vulnerability by helping change agricultural patterns. Previously when land was exhausted it was left fallow and the bush would take over along with fruit and nut trees. Traditionally, fallow periods tended to be seven to ten years, until regrowth of the bush indicated the return of sufficient soil fertility to start cropping again. But cassava will grow on even the poorest land, tempting farmers to plant on land that should be allowed to regenerate. Thus the introduction of cassava into the cropping system has tended to reduce fallow periods and increase vulnerability. Continuous replanting of cassava degenerates soil to the point where it has little or no cropping value.

Food preservation complemented the cropping system. It usually involved some drying (especially in drier areas) or fermentation (more in wetter locations). Some crops, such as breadfruit, were particularly important. In a few places, such as the Banks Islands in Vanuatu, traditional food preservation retains some importance but it has declined almost everywhere else. Some remaining knowledge and practice could support its revival, especially by combining traditional and modern methods. While the promotion of this revival would be best based on enhancing or saving household income, rather than food security or disaster mitigation, these would be important spin-off benefits.

DEVELOPMENT AND VULNERABILITY OF THE REGION TO NATURAL DISASTERS

In theory, economic development should reduce vulnerability to natural disasters. Households with higher incomes should be better able to cope by having cash to buy food, repair or rebuild housing, and re-invest in productive activities. But this assumes a reasonably high rate of savings which in Pacific island communities is generally not the case. Domestic savings in all countries are low, in some cases negative, because of the high spending propensity of consumers and monetary policies that generally suppress nominal interest rates (McGregor et al., 19-:10). If increased household income is accompanied by decreased food self-sufficiency, then vulnerability to disaster increases.

The Kadavu case study demonstrates this. An agriculturally affluent community, Kadavu

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Table 29: The susceptibility of Pacific island root crops to disasters.

Root crop	**Current status**	**Cyclones**	**Rank**	**Drought**	**Rank**	**Volcanic eruption**	**Rank**	**Biological**	**Rank**	**Environmental**	**Rank**
Yams (Dioscorea spp.) - domestic cultivars	Remains the pivotal crop in Vanuatu, Papua New Guinea, Solomon Islands and Tonga. In Fiji, there has been a sharp decline in yam cultivation over the last decade or so.	Highly susceptible. The vines of domestic yams are trained to grow over trellises and supports and are very vulnerable to wind damage. If they are broken or damaged before the tuber matures, it will quickly rot. The peak growing period for yams coincides with the cyclone season. A major impact of cyclones on yams is the loss of planting material: it takes 2 to 3 years to get back to full production. Offsetting the susceptibility of yams is the storability of mature tubers.	1	Very drought tolerant. Planted during the dry season.	3	One of the more tolerant crops to some acid rain and volcanic ash.	3	No major pest and disease problems within traditional cropping systems.	3	No major problem for domestic yams.	3
Yams (Dioscorea spp.) - wild cultivars	Wild yams include any member of the genus Dioscorea that survives without cultivation and untended in bush areas, including native forests. In western Melanesia they are the most important 'wild" reserve food but they are disappearing rapidly in Fiji.	Unlike domesticated yams, wild yams are most resistant to cyclones. Their strong fibrous vines use trees and the forest canopy for support, protecting them from strong winds. Unlike their domestic cousins if left unharvested they will thus providing a food bank in times of disaster.	3	When protected by the forest canopy, wild yams are even less susceptible to drought than domestic yams.	3	One of the more tolerant crops to some acid rain and volcanic ash.	3	Less at risk than domesticated yams because of the wide distribution of individual plants.	-	The greatest threats are loss of habitat and destruction by pigs.	1
Taro (Colocasia esculenta)	The main root crop in Fiji, and important in Vanuatu, Tonga, and coastal areas of Papua New Guinea. Once important in Solomon Islands and Samoa.	Taro is susceptible to cyclone damage, especially plants less than 3 to 4 months old. Heavy winds shake the roots and rot sets in within days. Cutting the tops prior to the hurricane is not an option as it is for cassava. Taro has poor keeping and is only edible for a few after harvesting. Offsetting this susceptibility, dalo is a relatively short term crop (9 to 10 months) and can be planted any time of the year. In Samoa, taro stood well to two severe cyclones. Samoa's favourable soil and climate also allowed taro to be harvested in 7 months or less after planting.	2	Colocasia will not survive prolonged moisture stress, but this seldom poses a problem in a traditional food garden.	1	Not tolerant.	1	Highly susceptible to pest and diseases. Taro leaf blight eliminated production in Samoa and Solomon Islands. Papuana beetle has lowered production in Vanuatu and parts of Fiji.	1	Damage by pigs is a major threat. Widespread clearing of forest for monoculture taro production in Samoa increased the vulnerability of the crop to biological pests.	2

*1 = *very susceptible;* 2 = *susceptible;* 3 = *least susceptible*

Xanthsoma sagittifolium Known as Fiji taro Vanuatu; and dalo-ni-Tanna in Fiji; and taro palangi in Samoa	A popular root crop in Fiji, Vanuatu and, to some extent, Tonga	This is a stronger plant than C. esculenta and less susceptible to **high** winds. It has been known to survive hurricanes. Superior-keeping properties, edible for up to 4 weeks after harvesting. This crop can be harvested in 12 months, or left standing in the ground for up to 5 years.	3	More drought tolerant than Colocasia. Can be planted in areas too dry for Colocasia or stored in the ground for long periods.	3	More tolerant than Colocasia.	2	Resistant to pests and diseases. Dalo-ni-tana is not inflicted by taro leaf blight nor attacked by papuana beetle.	3	In some places damage caused by pigs is a major threat.	2
Cassava (Manihot esculenta)	Has become increasingly popular due to ease of planting, lack of skill required, and tolerance to poor soil. In many areas, especially urban food gardens, cassava has become the most important root crop.	Good tolerance if the tops are cut before a cyclone. It can be left in ground with tops cut, most varieties lasting several months. If the tops are not cut, cassava is vulnerable to cyclones. Violent agitation of the stem or crown causes the tubers to crack and rot quickly. Once harvested, cassava has a very short shelf life unless processed. Because it can grow at any time of year, cassava is a good rehabilitation crop.	1 or 3	Quite tolerant of drought.	3	The most tolerant root crop to ash-fall.	2	Tolerant of pests and diseases, but Spiralling white fly is a problem in some places.	3	Cassava cropping patterns contribute to ecological disasters by lowering soil fertility when it is repeatedly planted and encouraging shorter fallow periods.	1
Kumala (Ipomoea batatas)	The dominant staple in the highlands of Papua New Guinea and in most other countries a significant second level root crop staple after taro, cassava, and yams.	Its low, spreading growth makes kumala tolerant to high winds, but not to flooding or sea surge. Harvested kumala stores about same as taro, better than cassava but less well than Xanthsoma or yams. The quickest growing root crop, distribution of kumala cuttings is part of most cyclone rehabilitation programs.	3	Can tolerate normal dry conditions but not extended dry periods so well. Usually planted during the wet season. Drought and frosts in Papua New Guinea highlands can cause famine in kumala dependent communities.	2	Not tolerant to acid rain or volcanic	1	Subject to several serious pests and diseases. Region-wide quarantine restrictions preclude international trade in Kumala.	2	Pigs are the largest threat.	2
Pulaka Giant swamp taro (Cyrtosperma chamissonis	Pulaka is a tuber well adapted to swamps, a high water table, and brackish conditions. Also thrives in volcanic soils. Important only in atoll counties. Grown as a famine food in some other islands, but of declining importance.	Resistant to strong winds even when mature. Can therefore survive with little wind damage but susceptible to salt-water intrusion. The pits where is grown are usually in low-lying areas.	2	Pulaka grown in pit crops are protected against drought they take their water requirements from underground lens.	3	Not relevant.	–	No known serious pests or diseases.	3	Pulaka pits in the atoll countries are threatened by sea-levels.	1
Kava (piper methysticum)	An important traditional crop in Fiji, Tonga, Samoa, and Vanuatu. Main income earner for some islands in Fiji and Vanuatu. Considerable growth in domestic consumption over the last decade or so. Huge export potential being is far from fulfilled.	Mature kava plants are susceptible to wind damage. If the tops break and the roots get shaken, the plant will die. Takes three years to reach maturity and several more years to reach optimum production. Thus kava is a high-risk crop, but its high returns more than offset the risk.	1	Young kava is not tolerant to extended drought. Must be planted in the wet season.	1	Not tolerant to volcanic ash-fall.	1	Kava die-back is a threat throughout the region, particularly if plants are under stress.	2	Clear-felling of upland forests to plant kava is a problem in some areas.	1

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Table 30: *The susceptibility of Pacific island tree crops to disasters.*

Tree crop	Current status	Cyclones	Rank	Drought	Rank	Volcanic eruption	Rank	Biological	Rank	Environmental	Rank
Coconuts	Important cash crop in Vanuatu, Solomon Islands, Samoa and Papua New Guinea. Important food crop throughout the region.	South Pacific tall coconuts varieties evolved in a cyclone prone environ· ment, thus can survive strong winds. Only in the most violent winds are palms uprooted or broken. The most vulnerable are young trees (< 5 years) which can be uprooted or senile trees (> 60 years) that can snap. Coconut production can be halted for several months or up to four years, depending on the severity of the damage, the age of the trees, and soil fertility.	3	Coconuts are particularly drought resistant, hence their ability to grow on atolls. Prolonged dry periods retard nut production.	3	Can withstand acid rain and ash· fall better than most crops.	2	Most of the Pacific islands, due to their isolation and strict quarantine, have been spared the entry of diseases. Pest problems have included coconut moth and Rhinoceros beetle, but these have been brought under control.	2	No environmental disasters have threatened or been caused by coconuts. In common with all tree crops, not by pigs.	3
Breadfruit	An important companion food to coconuts throughout the island lowlands.	Breadfruit grows tall, has relatively and weak trunks, and thus often damage during cyclones. The main fruiting season coincides with cyclone season. Folk wisdom throughout the region links a heavy breadfruit crop to the likelihood of a cyclone. Cyclones cause a total crop loss but the tree usually survives and produces an off· season crop in June-August. On recovery takes longer. Traditionally, preserved breadfruit was the main disaster food.	3	As with coconuts the crop survives (rather than thrives) in harsh agronomic conditions but is drought tolerant.	3	Same as coconuts.	-	No major pest or diseases.	3	No environmental disasters have threatened or been caused by them.	3
Indigenous nuts: • T ahrtian chestnut (Inocarpus fagifer) • Canarium indicum • Cut nut Barringtonia edulis) • Sea almond • (Terminalia catappa)	Forest nuts are an important particularly in western Melanesia. These nut trees are cullivated in that they are otten spared when land is cleared for gardening and preserved around villages. Over the centuries there has been considerable genetic improvement as better trees have been selected for planting.	These trees have evolved in an environment with frequent cyclones and therefore have various survival mechanisms. All recover quickly, thriving on the natural "pruning" provided by cyclones. These nuts are traditional~ preserved for food	3	As deep rooted forest trees, they are very tolerant to drought.	3	Barringtonia trees are tolerant of acid soil. In Vanuatu they occur in areas with high levels acid rain and are being used in rehabilitation programmes.	3	These forest trees are not planted in a monocullure and are therefore resistant to pests and diseases.	3	These trees are threatened by deforestation, particularly in Solomon Islands , Papua New Guinea.	2

*1 = *very susceptible;* 2 = *susceptible;* 3 = *least susceptible*

Cocoa	The second most important tree crop after coconuts. Significant industries exist in western Melanesia. Was important in Samoa.	The evolution of cocoa occurred in equatorial latitudes not subjected to cyclones, but it is reasonably tolerant-although recent Samoan experience does not confirm this. tree is quite elastic:. Its deep anchors the tree and makes it quite drought tolerant. Cocoa trees will die from long exposure to salt spray. Damaged branches should be and the tree pruned to assure	2	The deep tap root makes cocoa drought tolerant if not subjected to desiccating winds. A prolonged dry period can induce flowering and pod set and minimise fungal diseases, but the tree can not survive water stress. A further threat is from fire igniting the thick leaf litter that forms under the tree.	3	The PNG cocoa industry was badly affected by volcanic eruptions. Plantations in the path were destroyed. Other trees lost leaves but new ones in 3 weeks. Trees took 6· 12 mths to recover, if they had been pruned.	2	Grown as a monocrop it is subject to some serious diseases, particularly in Papua New Guinea from vascular streak die back.	2	Pacific: island cocoa cropping systems environmentally benign.	3
Coffee	Papua New Guinea's most important cash crop industry. Largest employer of labour of any industry in the region. Vanuatu a small speciality coffee industry.	Located in Papua New Guinea highlands and therefore not to cyclones.	3	Reasonably tolerant to normal drought conditions.	3	Vanuatu's coffee industry located on Tanna has been adversely affected by acid rain.	2	The incursion of coffee rust in themid-1980s, a major disaster for the coffee industry and Papua New Guinea, was controlled through radical measures and the allocation of substantial resources.	1	As with cocoa.	3
Mango	**An** important fruit crop in the drier lowlands. Offers considerable export potential for Fiji.	The strong and deep-rooted mango tree will usual~ survive severe cyclones. Although branches will be broken and fruit and flowers lost, tree will be back in production the season, often benefiting from the natural 'pruning' it has received.		These deep-rooted trees adapted to the zone are highly drought resistant.	3	Can tolerate acid soils and, to some extent, rain.	2	Has serious pest and disease problems and high risk of incursion by exotic fruit flies.	1	Same as other crops.	3
Papaya	Has major export potential for Fiji, Tonga, and Vanuatu.	Mature papaya trees will be by a cyclone, yet papaya can be successfully grown in cyclone areas if well drained. The high rate return can sustain occasionally crop. Strategies to reduce risk the timing of planting and dispersion of production sites.	2	Papaya has very high water requirements and cannot withstand drought. The crop cannot successfully be commercially grown without irrigation.	1	No tolerance.	1	Same as mango.	1	Same as mango.	-

Table 31: The susceptibility of other major Pacific island crops to disasters

Crop	Current status	Cyclones	Rank'	Drought	Rank	Volcanic eruption	Rank	Biological	Rank	Environmental	Rank
Sugar	The crop, native to Papua New Guinea, has been part of Pacific island food gardens since ancient times. Fiji's most important commercial industry, largest employer and net generator of foreign exchange. Papua New Guinea has a protected import substitution industry.	Sugar cane, a grass, is tolerant to cyclones. Some losses occur to mature cane, mainly from flooding. Most cyclones occur after harvesting season. Late cyclones are often followed by drought, causing yield problems. More insidiously, cyclones accentuate soil erosion caused by poor land use practices. Cane is tolerant to cyclones in traditional food gardens, and an important energy food after a cyclone.	3	Quite tolerant of dry conditions but extended dry periods, especially after a cyclone, depress yields. Drought has a worse effect on soils degraded by poor land use practices. Very drought resistant in traditional food gardens.	3	One of the more tolerant crops in a traditional food garden.	3	No major pest or disease problems.	3	Fiji sugar industry risks a major environmental disaster from poor land use practices on sloping cane land, at an estimated cost in lost sugar of F$15million a year.	1
Squash	Buttercup for export to Japan is Tonga's major export industry. A significant industry was also established in Vanuatu but has since closed.	This short-term (105 - 120 day) crop is harvested in October and November, usually before the cyclone season. Tonga has not yet had a squash crop damaged by a cyclone.	3	Susceptible to an extended dry period. The crop could not be grown in Vanuatu without irrigation.	1	Not relevant.	-	The Tongan squash industry is vulnerable to incursions of pests and diseases. of exotic fruit flies or yellow zucchini mosaic virus would create huge management problems for the industry and undermine its viability.	1	Squash is grown with high fertiliser and other chemical inputs. Tonga-tapu's water supply comes from an under-ground water lens. Run-off of chemicals into the water lens threatens the viability of the industry.	1
Rice	Fiji retains a significant traditional rice industry, but attempts to establish capital intensive industries failed in Fiji and Islands.	Traditional rice production in Fiji is relatively cyclone resistance, but capital intensive irrigated rice schemes were badly damaged. Cyclone Uma provided the death knell to the Solomon island industry on Guadalcanal.	2	Dryland rice is planted in the wet season but is susceptible to long dry periods.	2	Not relevant.		Pests were a serious problem with the Fiji and Solomon Islands rice schemes.	2	Fiji's traditional rice crop is environmentally benign. Irrigated schemes involved some loss of mangrove habitat.	2

Maize	Fiji and Papua New Guinea have tried to grow commercial maize for their poultry industries with limited success. Vanuatu has a small sweet corn industry and exports to NZ. In Melanesia maize is now an important subsistence food crop.	Maize is not particularly cyclone resistant but an ideal cyclone rehabilitation crop. It is fast growing; can be planted any time of the year; requires almost no land preparation; and is easy to store and transport—in many respects superior to kumala, the main crop now used for cyclone rehabilitation programs.	3	Reasonably drought resistant.	2	Not relevant.	-	No major pest and disease problems for subsistence-grown maize.	3	No apparent environmental problems	3
Island cabbage (Hibiscus manihot) – bele in Fiji	The leaves are plucked and eaten like spinach. All food gardens in Melanesia include these plants, the most commonly eaten green vegetable.	If the branches are broken the leaves recover quickly and are ready for consumption in 4 weeks or so.	3	As a part of a multi - crop food garden, island cabbage is very drought tolerant.	3	Not particularly tolerant.	2	Resistant to pests and diseases.	3	As part of a traditional cropping system which is environmentally sustainable	3

*1 = very susceptible; 2 = susceptible; 3 = least susceptible

maintains a strong subsistence base and can produce highly remunerative cash crops. While it was not possible to collect data on household savings, there is no reason to believe that they would be different from estimated aggregate rates for Fiji. The core of Kadavu's traditional food security was the yam. People were once expected to maintain a store of yams, as planting material and a food store, but this custom has all but disappeared and yams are rarely planted now. The labour required is considered too high; the returns from the alternative crops of kava and taro are far greater; and planting material is scarce and expensive. The area planted to Xanthosoma, the most disaster-resistant tuber, has also declined. The focus of food production has shifted to dalo and cassava for they are easier to plant, faster to grow, and preferred locally and by the market. Kadavu can expect another cyclone of the severity of *Val, Meli,* or *Oscar.* The impact would probably be much more than for a similar sized cyclone 20 years ago, despite the large growth in income levels, because:

- people now depend heavily on a single non-food crop, kava, which is susceptible to cyclone damage; and,

- crops that provided food security at times of disaster are now rarely planted.

The situation described for Kadavu is typical but not universal. The food security system in Samoa's villages has proved remarkably robust. Samoan villages have a particular advantage in the steady inflow of remittances in times of need. This reduces the pressure to convert the traditional cropping system into one based on monocultured cash crops. In exchange for remittances, expatriate Samoans also expect traditional village culture to be maintained, including the systems of food production which are central to it.

Soon after independence in most countries, many governments set up development projects to promote agricultural growth, diversification, and indigenous participation in commercial agriculture. In Vanuatu, for example, during the first development plan period (1982-1986) there were 26 aid - assisted projects in the agricultural sector involving 13 donor or technical assistance agencies. Most resources were directed to producing commodities such as coconuts, cocoa, coffee, and livestock. In Fiji, the government instigated projects to develop irrigated rice, cocoa, citrus, and tropical fruit production. In Samoa, there were banana and cocoa planting projects. But despite the large investment of aid and government resources, most projects fell short of their targets, for several reasons:

- Planners' targets were unrealistically high;
- These aid-driven projects were beyond the absorptive capacity and sustainability of government extension and support services;
- The inefficiencies of government services meant that not all farmers received the planned assistance at the right time and some became dependent on it;
- There was an incorrect assumption that semisubsistence farmers would acquire the attitudes of commercial farmers during the project;
- Needs of project beneficiaries were not identified; and
- Marketing requirements for new crop development were not taken into account.

Despite the lack of success, this government-led commodity orientated approach continues to be the cornerstone of most governments' agricultural development programs. Most recently, the Fiji Government allocated F$69 million to the Commodity Development Framework (CDF) Project. This involves the selection of a few 'priority' commodities (taro, kava, ginger, copra, tropical fruit, and capital-intensive hydroponics) on which the Ministry of Agriculture's resources will focus most of its resources. How much this type of approach has undermined food security and the capacity of rural communities to cope with disasters is difficult to judge. On balance it probably has had limited direct impact, as most farmers operate independently of government extension services. Yet much more could have been done to promote the traditional strengths of Pacific island integrated cropping systems. In Fiji the demise of the yam has undermined food security, yet neither yams nor the cropping system in which they are grown feature in the Ministry's extension programs, nor in rural youth and farmer training programs.

Agricultural development in Pacific island countries has also brought some degree of environmental degradation, and thereby increased vulnerability to disasters. This is evident in Fiji where cash cropping of sugar and ginger has extended to steep sloping land without any soil conservation efforts. Erosion is at it worst during the intense rainfall that accompanies cyclones.[124] In many cases, land productivity has fallen so much that the land is now obsolete. Farmers, who eke out an existence from this marginal land are most vulnerable to disasters, rarely having savings to fall back upon nor any form of food security through subsistence crops. It is ironic that Fiji once led the way in soil conservation measures. The Colonial Sugar Refining Company that once operated the Fiji sugar mills enforced contour farming and pioneered the use of vetiver grass for soil conservation. Vetiver grass has been adopted worldwide as an effective soil conservation measure, but has been abandoned in Fiji. In the colonial period, the Department of Agriculture maintained a substantial soil conservation service. It now has none. The rapid degradation of land that has accompanied commercial agricultural development in Fiji can be explained by the combination of:

- the insecure and short term land tenure of many farmers;
- the unwillingness of government agencies to enforce existing good husbandry or soil conservation legislation;
- the lack of concern for sustainable agriculture in commodity orientated extension programs; and
- the unwillingness of the sugar milling company, the Fiji Sugar Corporation, to internalise the cost of lost sugar production resulting from soil erosion.

In recent decades, communities throughout the region have become increasingly dependent on government for food relief after cyclones. In Fiji, government involvement in cyclone relief dates back to the 1880s, but the high level of dependency now is not an immediate consequence of policies then. Brookfield (19-) reported that in the early years only small amounts of relief food supplies were provided and only in the direst of circumstances. Island communities have come to depend more on government assistance as they have become more vulnerable through:

- their increasing dependence on cash to obtain food;
- the decline in importance of traditional food crops;
- the virtual disappearance of traditional food preservation; and
- the virtual disappearance of village-owned seagoing canoes and cutters, and thereby the

124 Clarke and Morrison (1981), *estimated a loss of* 37 *tonnes of soil per hectare per year on sugar cane field with* 8 0 *slopes in western Viti Levu, using the Universal Soil Loss Equation (USLE). These losses were significantly higher during the torrential rain associated with cyclones.*

possibility of seeking assistance from other islands, thus turning the focus toward the central government for help.

In the late-colonial and post-independence period in Fiji, the move toward strengthening central government was reflected in the way cyclone relief programmes were managed. In Vanuatu, even in colonial times, relief and rehabilitation programmes were mounted after major cyclones but, due to Vanuatu's unique joint administration by Britain and France, these efforts were usually poorly coordinated, leaving the villages to their traditional devices. This may explain the higher degree of self-reliance in Vanuatu even today. The geographical compactness of Samoa simplified its government's role in managing relief programmes, but the many expatriate Samoans who maintain a close link with their villages lessen villagers' dependency on government assistance. Relief supplies after cyclones are also donor driven, particularly in the smallest countries that depend heavily on foreign aid. Relief packages vary greatly from cyclone to cyclone, depending on what the donors provide. The Tuvalu case study found that the level and timing of food assistance was often out of line with domestic food damage and availability and did little to encourage food security or self-reliance.

In some places the growing dependency on government has coincided with a break-down in the governments' ability to deliver services to rural areas, as became evident during the current drought in Papua New Guinea:

> In 1997 Papua New Guinea is a sovereign nation that has struggled since it gained independence in 1975, in striking a balance between central government and decentralised provincial and local forms of government of government. Yet another series of administrative and political reforms has just been completed. These have had the effect of removing almost all central financial control over the provinces, and has established more than one hundred small local government administrations which are financially and legally responsible for local areas, but which are critically short of the skills and capacity to discharge those responsibilities. The same thing has been said of administrations at the provincial level, and at the national level. This state of affairs has resulted in a serious decline in the capacity of the Papua New Guinea State to deliver education and health services in rural areas. This decline in capacity has been blamed for increases in infant and child mortality and the declining standards of education. The drought assessment teams found at least half of all primary schools were closed but many had been closed before the drought began. Health facilities were similarly affected by lack of staff, lack of funds and lack of medicines and equipment (Allen,1997: 27).

The system of food relief that prevails today usually starts with an inspection of the damaged area. There is some recognition-not always followed-that the real need for relief lies in the period between the exhaustion of salvaged food and the maturation of newly planted crops. Usually, each household receives a food aid package which is based on their food needs for one month and mostly comprises tinned meats and bags of rice or flour. There often are large discrepancies between reported and actual food needs, and much anecdotal evidence of wasteful misallocation of supplies. Relief efforts often become massive operations that tie up much of the government's resources, but through these programs, immediate food shortages are usually prevented, albeit at considerable cost. The greater costs, however, are in terms of longer food security and self-reliance. The Kadavu case study revealed the local confidence, based on recent experience, that government will provide food in emergencies and this, evidently, has contributed to the marked decline in the planting of *kakana* ni *cagilaba* (hurricane foods).

Whether declining self-reliance results from government relief programmes, or whether these programmes necessarily reflect that people are less self-reliant, are a moot point. Wha t is clear is that there are real benefits from increasing self-reliance and food security, including lower costs to governments and better nutrition, as traditional disaster foods are generally superior to relief supplies. The potentially adverse impact of food assistance on self reliance is recognised now by most national disaster management bodies. Vanuatu's National Disaster Management Office has turned down donor offers of food assistance after a cyclone, a policy of self sufficiency and self reliance they intend to pursue. Of course some dependency on the central government is probably inevitable, for sometimes the severity of damage makes food relief essential. Some people will always need special assistance, particularly those who depend on cash crops grown on degraded land and the growing numbers of people living on the margins of cities such as Suva, Port Moresby, Port Vila, and Honiara.

THE COST OF DISASTERS TO THE AGRICULTURAL SECTOR AND THE ECONOMY

Costs of disasters to the agricultural sector can be categorised as follows:

- the direct costs to subsistence and commercial agriculture;
- macro economic impacts;
- indirect costs in terms of opportunities foregone and alterations to land-use patterns; and
- the cost of relief and mitigation measures.

Cyclones

After major cyclones, governments estimate immediate financial costs, based on apparent losses to industry and replacement costs for infrastructure, housing etc. Estimates for the last three major cyclones in Fiji, Vanuatu and Samoa are shown in Table 32, and a breakdown of losses from Cyclones *Val* and *Kina* to primary industries and agriculture in Table 33. *Val,* the most damaging of these cyclones, cause damage estimated at $US285 million, around 30 per cent involving losses to primary industries. In Cyclone *Kina,* more losses occurred to primary industry, around 55 per cent of the estimated cost of US$76 million. In Cyclone *Uma,* about 22 per cent of total losses accrued to agriculture, valued at around $US3.13 million. Differences in measuring costs and losses however complicate comparisons between countries.

Food and crop losses are often over-estimated. There is no doubting the damage Cyclones *Ofa* and *Val* inflicted on Samoa's agricultural sector, but the estimated money value of losses to food and tree crops seemed excessive. In 1989, the year before the first cyclone, subsistence contributed only 62.5 million tala to GDP, in current value terms. After both cyclones, production of taro recovered within a year. That coconut palm losses were far less than the 40 percent estimated by the Department of Agriculture, was borne out by the almost full recovery of the copra industry once appropriate price incentives were in place. The loss of the capital stock of cocoa trees was large, but losses would have been less had the trees been pruned after the cyclone. This did not happen: growers considered that cocoa gave insufficient return to justify this effort and planted taro instead.

Table 32: *Official estimates of the cost of damage caused by Cyclone Uma (Vanuatu* 1987), *Val (Samoa* 1991), *and Kina (Fiji* 1993) - *$US millions.*

	Uma	Val	Kina
Primary industry (agriculture, fisheries, and forestry)	3.1	80.4	41.6
Communications	0.2	1.6	1.8
Education (school reconstruction	2.5	5.2	5.4
Government administrative reconstruction and office equipment	2.8		.4
Health facilities	0.3	8	1.0
Sea transport	0.7	.4	
Roads and bridges	2.4	13.6	19.2
Buildings and dwellings	1.7	132	3.5
Airports		.6	
Power supply		4.4	2.7
Ports and jetties		7.2	
Government services (fire etc.)	0.7	0.8	
Water and sewerage	1.3	2	.7
Environment, parks and reserves		26	
Coastal projection works		2.4	
Total	15.7	284.6	76.3

Sources: Vanuatu: ADB 1991:271; *Samoa: UNDP/UNDHA,* 1997:52-53; Fiji: *Department of Regional Development, 1993.*

Table 33: Official assessed damage to the primary industry sector from Cyclones Val and Kina.

	Value of damage ($US million)
Cyclone Val (Samoa)	
Food crops	18.2
Tree crops	11.9
Livestock	5.1
Fisheries	.5
Forestry	43.9
Other (incl. Departmental structures and nurseries)	2.9
Total	82.5
Cyclone Kina (Fiji)	
Sugar	15.6
Fisheries	2.0
Crops	11.1
Livestock	3.3
Forestry	5.2
Drainage and irrigation	3.3
Research facilities	.7
Total	41.2

Source: UNDP/UNDHA 1997

A large part of the losses to cocoa should therefore be attributed to low cocoa returns, not just the cyclones.

The way that crop losses are estimated makes it difficult to establish costs, particularly for subsistence production. Assessment reports mayor may not involve field visits. Mr Job Esau, Director of Vanuatu's National Disaster Management Office (VNDMO), commented on the lack of systematic reporting after Cyclone Uma: "We had some estimates of damage but none of costs - this is something we are working on with our new reporting system". He also noted that there has tended to be an bias towards maximising the flow of food aid, a problem the Director of VNDMO is now addressing in its policy of 'self reliance.'

The Kadavu case study estimated that the last three major cyclones caused crop losses of around $F3 million in 1997 value terms. (These estimates could not be compared with official crop loss and cost estimates made at the time, for this data has not survived.) Kadavu can expect more cyclones of similar severity. An extrapolation of possible costs of an equivalent cyclone today shows that the impact would be much greater than it was 20 years ago-as it would be on most outer islands that depend on kava for cash income.

Marked declines can occur in the macro economic aggregates of these small countries after a major cyclone-not surprising given their narrow economic base and the fundamental importance of agriculture. What is more surprising is how quickly these economies adjust and macro economic aggregates are restored, as the Samoa, Fiji, and Vanuatu case studies showed.

After Cyclone Ofa in Samoa, the contribution of agriculture to aggregate real GDP fell from US$31 million in 1989 to US$20 million in 1992. This compares with a decline in total GDP from US$78 million to $WS167 [US equiv??]over the same period, equalling a -2.3 per cent annual growth rate. The cyclone was also reflected in export earnings, of which, at that time, around 90 per cent came from taro and coconut products. The value of exports fell 53 per cent, from US$ 14 million in 1988-89 toa low point of US$5.4 million in 1992. Yet the economic recovery was equally dramatic. By 1993 it was well underway, led by taro exports. In the first 6 months of 1993,126,000 cases of taro were exported, valued at $WS5.8 m. and accounting for 66 per cent of total exports. Agricultural production that year grew 7.4 per cent, the value of exports increased 10.5 per cent [(CBS??)], and real GDP grew 9.5 per cent (ADB, 1996: 380). In July 1993, however, Samoa was hit by a biological disaster, taro leaf blight, which had far greater impact than the severest of cyclones.

In her study of the economic impact of disasters in Fiji, Benson (1997) used variable analysis to separate the impact of natural disasters and the 1987 military coups, as shown in Table 34. Benson concluded that a high vulnerability of overall GDP and agricultural output could be attributed to natural disasters. Even so, care needs to be taken to not overstate the impact of natural disasters on the Fiji economy based on this model. The statistical results are not as strong as they may first appear. The use of a geometric model to capture the lagged impact of disasters results in the use of a lagged dependent variable (GDP and agricultural output lagged one year) as an explanatory variable. Models containing lagged dependent variables inevitably result in a high "goodness of fit". The goodness of fit here (adjusted $R2$ of between .65 and .7) cannot, therefore, be regarded as particularly high. In none of the equations is the coup dummy variable statistically significant, yet the 1987 coup and subsequent structural adjustments had a huge impact on the Fiji economy (Sturton et aI., 1991). It would seem that some of the impact of the coup is being picked up by

Table 34: *Results of regressions to examine the relationship between disasters and GDP and agricultural growth* in Fiji *over the period 1982-94.*

Dependent variable	Constant	Cyclone drought dummy	Coup dummy	Dependent variable lagged 1 period	DW	F statistic	Adjusted R^2
GDP	6.753	-3.496 (-3.599)'	-2.155 (-1.283)	-0.342 (-1.986)	1.696	8.17	0.642
Agriculture	9.194	-6.697 (-3.239)	-1.293 (0.376)	-0.500 (-2.932)	2.003	10.29	0.699
Agriculture excl. sugar cane	7.368	-5.02 (-3.446)	1.538 (0.626)	-0.510 (-3.126)	2.067	10.83	0.711

* *t statistic* *Source: Benson* (1997) *Annex, Table 3.*

the natural disaster variable. Furthermore, the natural disaster dummy variable lumps cyclones and droughts together, but droughts evidently have a greater economic impact via their effects on the sugar industry, as occurred in 1983 and 1986-87. The 198687 drought was compounded by many fires brought about by the political instability at the time and these also lowered sugar and pine production.

According to Benson's model, if no natural disasters had occurred between 1982 and 1994, Fiji's real growth rate would have been 4.8 per cent, whereas actual growth was 2.4 per cent (Benson, 1997:7). That this probably overestimates the disaster impact was acknowledged by Benson herself: "these results exaggerate the rates of growth under a no-disaster scenario to the extent of other factors which influence inter-yearly fluctuations in GDP are excluded from the analysis"(ibid). This analysis nevertheless lends empirical support to the view Fiji's economic growth is depressed by intermittent natural disasters. Furthermore, the analysis showed that most of the linkages work through agriculture, principally the sugar sector.

In Vanuatu, copra is by far the most important economic activity after subsistence, dominating the rural cash economy and export earnings, as Table 35 shows. In 1984, when there was a fortunate coincidence of high production and high prices, the economy grew at 6.9 per cent in real terms. Two years later, when copra export earnings were less than a quarter of the 1984 level, the economy had negative real growth of -0.2 per cent. Cyclones have severely affected the copra industry and Vanuatu's economy especially between 1985 and 1988 when the main copra producing areas experienced four major cyclones: Eric and Nigel (January, 1985); Uma (February 1987); and Anne (January, 1988). These cyclones, together with low prices in all years except 1984-85, saw production fall from 47,000 tonnes in 1981 to 24,902 tonnes in 1989. In 1990 production almost recovered to 45,000 tonnes, but in 1991-a cyclone-free year for copra producers-production fell again to 28,500 tonnes, perhaps reflecting a drop in the grower price to the lowest point since 1983.

To separate the effects of cyclones and copra prices on short copra production the following simple statistical model was estimated by ordinary least squares:

$$Q_t = \beta_0 + \beta_1 P_t + \beta_2 H_t + \beta_3 T_t + e_t$$

Where: Q_t = quantity of copra produced in the current year (tones)
P_t = average annual "beach price" for hot air copra (vatu/tonne)
H_t = hurricane incidence (1= a major hurricane producing areas in current year; 0= no major hurricane producing areas in current year)
T_t = a linear trend (1981=1)
e_t = random factors effecting copra production

The results obtained (with standard errors in parentheses) were:

$$Q_1 = 41{,}935 - 1738P_t - 9{,}250\,H_t + 334T_t + e_t \quad \text{adjusted } R^2{=}.27$$
(5,655) (349) (3,523) (.236)

The results from these calculations were disappointing. The dummy variable used to measure the impact of the cyclones was not statistically significant, although a logical negative relationship was derived. Neither a statistically significant or logical relationship could be derived for the price variable. It is not that such relationship does not exist.

The difficulty lies with separating out the distributed effect of the cyclones over time. Benson, as explained above, overcame this problem to some extent by using a geometric distributed lag model.

It is often suggested that more profitable cropping patterns would exist if Pacific island countries were not so susceptible to cyclones. The effect of cyclones on agriculture and the choice of alternative crops have exercised the mind of agricultural planners since early colonial times. Fiji's Governor Thurston in 1889 outlined his plan for primary economic activities that would have minimal vulnerability to natural disasters:

> *The frequently recurring losses and constant annual risks incurred at present by agriculturists ... and the means of reducing and avoiding them have been long under consideration ... it would appear that planters should devote their attention to the culture of products that could be planted, gathered and dispersed of during the period of immunity from which three fourths of the year present to them (cited in Campbell,* 19-:179).

Unfortunately few crops fit Governor Thurston's ideal of being "planted, gathered and dispersed" within the months that are free of cyclone risk. Agricultural development generally involves growing crops that are exposed to the risk of cyclones. Much thought has gone into alternative crops. Fairbairn (19-:), for example, stressed "the importance of factoring in cyclonic risk when designing agricultural development strategies". However it would seem that this consideration has already been factored into the decision-making of farmers. It was no coincidence that coconuts and taro were by far Samoa's most important crops. Similarly in Vanuatu, it is not surprising that copra and cattle are the most important commercial agricultural activity, nor sugar cane in Fiji. Occasionally a commercial crop emerges that fits Governor Thurston's requirement, one being butternut squash, which is successfully exported to Japan by Tonga, Vanuatu and New Caledonia. That this short-term crop is harvested on October and November, usually before the cyclone season, was no doubt a consideration when New Zealand agribusiness companies decided to invest in squash growing in Tonga and Vanuatu.

Yet cyclones have probably had less influence on cropping patterns than expected. Pacific island agricultural patterns may have been little different even if cyclones did not occur regularly. In Fiji, Vanuatu, Tonga, and Samoa there has been a rapid expansion in kava plantings. It is difficult to identify

Table 35: Cyclones, copra, and economic performance in Vanuatu: 1981-1990.

	81	83	84	85	86	87	88	89	90	91	92	93	94	95
Cyclones effecting coconut areas				Eric/ Nigel		Uma	Anne				Betsy			
Copra production (tonnes)	47,070	38,365	48,000	38,806	41,798	36,346	29,559	24,906	45,071	28,440	27,292	27,983	26,992	30,390
grower copra price (vatu/tonne)	15,000	15,000	36,000	38,000	21,500	26,000	31,800	31,000	25,400	18,500	26,800	28,300	28,500	27,900
copra export earnings (million vatu)		1,308	2,734	1,392	461	719	953	750	603	528	829	706	894	1,100
GDP growth (percent)			6.9	1.8	-0.2	0.7	0.6	3.7	4.6	4.7	-0.7	4.5	2.5	3.2

Source: Statistics Office Copra and Cocoa Annual Report 1995, Reserve Bank of Vanuatu Quarterly Economic Review Various Issues; ADB 1997 a more ill-conceived crop choice based on kava's susceptibility to cyclones. Yet the returns to kava are sufficiently high to sustain the loss of a crop every five years or so-a much lower incidence than the frequency of cyclones in most countries. That Samoan farmers have essentially abandoned cocoa since cyclones *Ofa* and *Val* was attributed by Fairbairn (19-) to this crop's susceptibility to cyclones. But cocoa could not be regarded as a poor crop choice simply because of its vulnerability to cyclones, for it has been a major export earner for over a century. Instead, farmers perceived their returns from cocoa to be insufficiently high for them to spend their labour rehabilitating and re-planting their trees.

Some horticultural tree crops, such as macadamia nuts, are not viable because of cyclones, but there are several indigenous tree nuts *(Canarium, Barringtonia, Terminalia,* and *Inocarpus)* that offer better opportunities for development (McGregor and McGregor 1997). Because these trees evolved in the Pacific region, they developed a high tolerance to cyclones. Some horticultural export crops such as papaya can also be successfully grown in cycloneprone areas, as Fiji has shown. These crops have a sufficiently high rate of return to sustain losing a crop every three to four years. Other strategies that reduce risk involve the timing and dispersion of production sites. Overall, Pacific island countries face more binding constraints to commercial agricultural development than cyclones, namely quarantine restrictions, high production and marketing costs, and inconsistent supply and quality.

Relief and rehabilitation programs: The most immedia te public financial cost following cyclone is the purchase and distribution of rations, and this cost can be high. After Cyclone Kina, which affected most of Fiji, $F13.8 million was spent on food rations, equivalent to 2.1 per cent of the government's operating budget and 13.6 per cent of the capital budget in the preceding year, or around 10 per cent of the value of food imports in previous year. Other than the probability of some resource misallocation, the level and timing of food assistance is often out of line with domestic food damage and availability and does little to encourage food security self-reliance, as discussed above.

Agricultural rehabilitation is encouraged through the distribution of planting material, almost invariably involving the distribution of kumala tops. After Cyclone Kina, the Ministry of Agriculture spent almost $F700,000 on rehabilitation, most of it to buy and distribute kumala and vegetable seeds. The preference for kumala is based on its reputation for producing within 3 months-but this is rarely achieved in the dry conditions that often follow a cyclone. There also tends to be a high degree of wastage; much of this bulky vegetative material can be wasted waiting for shipping. Kumala also requires some land preparation which people may not have time for immediately after a cyclone. Distribution of appropriate varieties of maize seeds may be more cost effective.

Longer-term rehabilitation tends to focus on roads and bridges. After Cyclone *Val,* Samoa's rural road system cost approximately $US6.28 million to repair (ADB 1992:13). After Cyclone *Kina,* approximately F$4 million was spent repairing Fiji's rural roads (Departrnent of Regional Development, 19-:22). Fiji usually faces the additional cost of river dredging and river engineering improvements. After Cyclone *Kina* some $US2.2 was spent but the work was still curtailed by insufficient funds (Department of Regional Development, 19-:13). Another $F1.6 million has been spent annually on dredging the Rewa and Ba systems since Cyclone *Wally* in 1980.

Drought

The insidious nature of droughts, with the long lead up time before they are recognised as a disaster, makes their impact more difficult to measure. Certainly in Fiji droughts get far less attention than cyclones, even though their cost to the agricultural sector and the national economy are at least equivalent. The sugar industry is especially susceptible. Sugar cane is relatively tolerant to cyclones and droughts but can withstand a severe cyclone better than a severe drought. The worse case is where a late cyclone is followed by a drought, as happened in 1983. Average cane yields fell from 55 tonnes in 1982 to 37.3 tonnes per hectare in 1983, and total sugar production fell from 487,000 tonnes to 276,00 tonnes. Much of the crop that would have been rationed the following year had to be replanted. Had normal rains followed the cyclone, the losses would have been modest and mostly confined to low-lying areas where there was prolonged flooding. Another severe drought in 1986/ 87 similarly caused sugar production to fall sharply, a problem added to then by political instability. Another problem that compounds the impact of drought is the high incidence of fires during droughts, and these contribute to Fiji's land degradation problem.

The other case study countries similarly experience strong droughts and the financial and economic costs they bring but, unlike Fiji, these do not usually approach the costs of major cyclones. In Papua New Guinea, however, the 1997-98 drought may prove to be the most catastrophic disaster ever experienced in the South Pacific. Some 500,000 people in the worst affected areas have lost a high percentage of their subsistence. The area affected produces coffee, Papua New Guinea's most important export crop, and there have been substantial declines in coffee exports. Although coffee export earnings are tiny compared to mineral export earnings, the economic linkages are much higher. Coffee small holders purchase few inputs and spend most of their income in the local economy, making the coffee income multiplier very high. Virtually all local businesses and employment in the highlands depend on the coffee industry. In total, around 1.3 million people, or 35 per cent of Papua New Guinea's population, are involved in coffee production (Overfield 1994). This drought has also lowered mineral exports with the closure of Papua New Guinea's largest gold and copper mine, Ok Tedi, through lack of water.

Volcanic eruptions

Volcanic eruptions have had direct financial and economic costs on agriculture in Papua New Guinea (East New Britain) and Vanuatu (Tanna and Ambrym) in recent years. In 1994, a series of major volcanic eruptions occurred in East New Britain, Papua New Guinea's main cocoa growing province, affecting 4,000 to 6,000 cocoa growing households, including their food gardens, and 70 fermentary owners (Peter, 19- :2). The estimated cost to the Papua New Guinea cocoa industry was approximately K12 million, as shown in Table 36. Lost wages to the cocoa industry were estimated to cost another K7 million, and losses to copra production at perhaps K5 million. The total cost to East New Britain's cash crop sector alone was therefore over K20 million ($US17 million), a catastrophic impact on the regional economy and a major blow to the national economy.

Vanuatu's small coffee industry and food crop production on Tanna has also been affected by acid rain from volcanic eruptions on the island, but estimates of actual losses are not available. As a result of a steady fallout of ash, food production has been severely affected, and this area is now regarded as one of the most impoverished parts of Vanuatu. On the island of Ambrym, volcanic eruptions occur less frequently but tend to be more violent, with large amounts of material being flung out. Acid rain cause food shortages here too, but again the financial cost has not been quantified. On the other hand, East New Britain, Tanna, and Ambrym have very rich soils and a high percentage of arable land. On balance, volcanoes have been very beneficial to the agriculture of Melanesia, through the spread of volcanic ash from volcanoes, many of them now dormant, and the creation of high fertility soils.

Biological disasters

The major biological disaster in recent years was the incursion of taro leaf blight into Samoa. This disaster has been cited as comparable to Cyclones Ofa and Val (ADB, 1995:2), but this report cpncludes the blight had an even greater economic impact. Had equivalent losses been inflicted by a cyclone, the industry could have been rehabilitated within a year by investing labour. But rehabilitation after taro leaf blight failed, and production may never be restored to previous levels. The impact on the economy thus remains ongoing and open-ended. The two principal losses from the leaf blight have been:

- A major export industry that was generating an annual export income of $WS9.5 million and expanding at a rate of 7 percent per annum; and
- The preferred staple food of Samoans, valued at $WS27.5 million (ADB,1995).

Without any adjustment for resource allocations this would represent a loss of almost $WS40 million,

Table 36. *Total cost and damage to the Papua New Guinea cocoa industry from the* 1996 *volcanic eruptions.*

Sub-sector	Revenue loss (K,000)	Cost of rehabilitation (K,000)
Smallholder	2,485	450
Plantations	1,874	500
Exporters	4,024	200
Cocoa Coconut Research Institute	481	220
Cocoa Board	101	555
Total	8,965	1,925

Source: Peter. 1996:10.

equivalent to about 11 per cent of GDP in 1995. There have, of course, been resource adjustments, as land and labour have moved to produce other subsistence and commercial crops. The annual net impact of taro blight has therefore progressively declined, but it is not possible to estimate what this annual decline in impact might be. If one assumed it had been 20 per cent per year, then total cost of taro leaf blight to the end of 1997 would have been almost $WS150 million, approximately $US80 million. Other costs can however be added, including:

- loss of revenue from the suspension in 1993 of exports of green banana, to ensure adequa te local food supply;
- increased expenditure on imported rice and flour in 1994 and 19 95 until other local food substitutes came on-stream, this increase in imports estimated at $WS3.1 million;
- initial government expenditure of $WS645,000 to control the disease;
- a government subsidy of $WS82,000 for fungicides;
- higher cost to consumers of substitute staples, mainly banana, taamu, and breadfruit; and
- costs of research to develop resistant varieties that were acceptable to consumers.

Adding these puts the cost of taro leaf blight to be of a similar magnitude to Cyclone Val's impact on Samoa's productive sectors (table 7 above).

An equivalent biological disaster in the region was the incursion of coffee rust in Papua New Guinea in the mid-1980s. This threatened the existence of Papua New Guinea's most important industry and caused an immediate loss of K30million in export earnings. Some K15million were spent on eradication programs. As a smallholder eradica tion and rehabilitation program could not be implemented through extension services operated by the national and provincial governments, which were then nonfunctional, the industry had to establish its own extension service, at a cost of K8million, part of which was contributed by AusAid.

Various other Pacific island countries have experienced biological disasters in recent years, though not of this magnitude. These disasters include:

- the entry of melon fly into the Solomon Islands;
- the incursion of yellow zucchini mosaic virus and watermelon 1 virus into Samoa and Fiji;
- establishment of the papuana beetle on Viti Levu in Fiji, and,
- The arrival of spiralling white fly in the Cook Islands.

The greatest biological threat facing the region is the incursion of exotic fruit flies, which are one of the world's major insect pests for fresh fruit and fleshy vegetables. There is at least one damaging endemic fruit fly in every Pacific island country. But apart from Papua New Guinea, Solomon Islands, and New Caledonia, they are free of more economically devastating fruit fly species such as Mediterranean fruit fly *(Ceratitis capitata),* oriental fruit fly *(Bactrocera. dorsalis),* melon fly *(B. cucurbitae),* papaya fruit fly *(B. papaya e),* and Queensland fruit fly *(B.tryoni).* These pests make it almost impossible to grow fruit commercially or they are more difficult to kill with quarantine treatments, sometimes both. The incursion of any exotic fruit fly would have devastating economic and social costs in any country of the region.

Yet a recent report noted that "without adequate quarantine surveillance programs, the incursion and establishment of exotic fruit flies in the Pacific island countries can be expected with the next few years" (SPC, 19-:45). Some of the most damaging fruit flies are established in neighbouring countries, namely oriental fruit fly in Hawaii and French Polynesia; papaya fruit fly in Australia; melon fly in Papua New Guinea and Solomon Islands; Mediterranean fruit fly in Hawaii and Nauru; and Queensland fruit fly in Australia and New Caledonia. Incursions of any of these flies would have serious results:

Fiji

- Papaya, eggplant, and mango exports to New Zealand would cease for at least 2 years until a new quarantine treatment was approved, at an annual loss of $F2 million;
- Papaya and mango exports to Japan would cease, at a potential annual loss of $F3million;
- Potential markets in the US, Australia, and Korea will not be developed, at a potential annual loss of $F5 million.

Tonga

- Squash export to Japan will cease, (this being Tonga's most important export industry);
- Watermelon exports to New Zealand will cease, and potential markets in Japan will not be developed;
- Papaya exports to New Zealand will not be developed.

Cook Islands

- Papaya exports to New Zealand will cease (this being Cook Islands most important export industry) and no new papaya markets will be developed;
- Mango exports to New Zealand will not be developed.

Vanuatu

- Squash exports will cease;
- Papaya and mango exports will not be developed.

Environmental disasters

Environmental disasters pose a particularly serious risk for Pacific island countries, but the costs are most difficult to estimate or forecast. These disasters tend to be longer-term and more insidious, and the impact of environmental disasters is often correlated with, and accentuates other natural disasters, making it becomes difficult to separate the effects. For example, land degradation and deforestation will greatly accentuate the impact of a cyclone. The effect of drought will be made far worse if it accompanied by indiscriminate burning.

Far too little has been done to quantify the economic impact of these environmental disasters and identify ways in which they contribute to the cost of natural disasters. Some indicative figures have been presented as to the economic cost of land degradation to the Fiji sugar industry. The money that the Fiji government currently spends on dredging to remove silt from the Rewa and Ba rivers is a direct consequence of unsustainable land-use practices in these catchments-a cost, too, which in recent years has exceeded the value of root ginger exports, the ginger industry being a principal cause of soil loss. Much more needs to be done to quantify the economic cost of land degradation in order to establish correct policy priorities. This is beyond the scope of this study, but one of its main recommendations.

7. RECOMMENDATIONS ON COST-EFFECTIVE MEASURES TO REDUCE THE IMPACT OF DISASTERS ON THE AGRICULTURAL SECTOR IN THE SOUTH PACIFIC

d)

The recommendations that emerge from the four case studies and the overview report fall into four broad areas:

- Enhancing self reliance and food security in the face of disasters;
- Research requirements;
- Information dissemination; and
- Policies and measures to reduce risk.

From these four areas, eleven specific projects are identified (Table 37).

ENHANCING SELF RELIANCE AND FOOD SECURITY IN THE FACE OF DISASTERS

Recent years have seen a policy shift toward promoting self-sufficiency and self-reliance in coping with disasters. There is considerable scope for providing assistance in facilitating this process.

Promotion of traditional and sustainable cropping systems

Traditional food security had, as its basis, a system of integrated multiple cropping which involved inter-cropping and the use of a wide variety of cultivars, including famine crops. This system gave flexibility in face of changing circumstances and provided a degree of resiliency to natural disasters. Despite rapid economic and social change, many of the components of traditional cropping systems are in place, as was evident in the Vanuatu and Samoa case studies where traditional cropping systems were effective in mitigating against the impact of disaster.

More generally within the Pacific, however, economic and social change has decreased food security and increased vulnerability to disasters, as was evident in the Kadavu case study. Nowhere was this more apparent than in the 1997-98 drought in Papua New Guinea where Allen answered his own rhetorical question, "Are these the same societies and the same agricultural systems that survived events in the past?" with an emphatic, "No, they are not [125]. While it is unrealistic to expect a reversal to cropping systems that have changed significantly over the past fifty years, there are features of traditional sustainable agricultural systems that need to be promoted as part of government and NGO extension and training efforts, such as:

- the food security value of certain crops such as yams (particularly wild yams);
- the principle of traditional planting timetables to minimise risk;
- the value of maintaining multi-crop systems and rotations;
- the value of forests as a food bank; and
- the need to control pig populations.

The image of traditional food production and preservation techniques and systems needs to be improved. They need to be promoted as prestigious and desirable items, not products that are considered 'backward.' This has rarely been done as part of the commodity focused extension efforts that are practised in most Pacific island countries. There needs to be a change from the current top-down approach to agricultural extension to a more participatory approach. Extension officers have much to learn from traditional farmers in the promotion of sophisticated traditional crops such as yams. Such persons need to be drawn on as resource persons in community and youth training programmes.

[125] *Allen, 1997: 27.*

Table 37: Projects identified for mitigating the impact of disaster on Pacific island agriculture

Project	Location	Indicative cost ($US 000)
Project 1: Developing yam seed banks	Vanuatu	160
Project 2: Food security and disaster preparedness project	Vanuatu	219
Project 3: Posters on traditional and appropriate food processing	Initially Vanuatu and Tuvalu	110
Project 4: Utilising USP's food processing expertise to enhance village community food preservation	Fiji, Vanuatu, and Samoa	44
Project 5: Estimating the financial and economic cost of land degradation	Fiji	75
Project 6: Awareness posters on the damage caused by burning	Fiji	20
Project 7: Hazard mapping of the incidence of cyclones	Fiji and Vanuatu	70
Project 8: Establish a revolving fund to finance viable disaster mitigation measures	Fiji	250
Project 9: The preparation of extension manuals on mitigation measures	Fiji, Samoa, and Vanuatu	40
Project 10: A study on the viability of establishing disaster insurance for commercial agriculture	Fiji	20
Project 11: Assistance with the design of quarantine emergency response plans.	Region	600

There is a need to encourage non-government extension and training efforts to promote traditional crops. The Vanuatu case study reports the success of the Farm Support Association in bulking up and distributing wild yam planting material. There is considerable scope for replicating these efforts, and a project proposal to this effect is presented as part of this report.

Agricultural extension needs to take a much broader rural development approach. The disastrous combination of indiscriminate burning, deforestation, and uncontrolled pig populations should be central to the extension message.

The status of traditional foods and farming systems needs to be enhanced through school curricula, youth training programmes, and via the media. Radio, as the most extensive and important information source. has a critical role to play. All the Departments of Agriculture have Information units that can tap this resource.

Creating youth employment is a priority in most countries. To this end, there has been a proliferation of government and NGO-sponsored employment generating youth training schemes in recent years. Schemes directed at the agricultural sector should give priority to traditional food crop production. This is a high return and low risk activity which has a high capacity to generate employment and social and economic stability, and to mitigate against inevitable future natural disasters.

Traditional food production systems should not necessarily be promoted on the basis of the substantial disaster mitigation benefits that accrue. These activities make good financial sense to farmers and to the national economy in their own right. Recent ADB sector reviews for Fiji and Vanuatu concluded that both countries had a competitive advantage in traditional food crop production. To quote the Fiji review:

> *Fiji's farmers produce an impressive quantity and range of traditional food crops and handicraft raw materials. These include a wide range of root crops, coconuts, traditional rice varieties, leafy vegetables (both Fijian and Indian), other traditional Indian vegetables, fruits, and leaves for weaving. Some, notably root crops, offer export opportunities. However the great bulk of this production is for domestic consumption. In assessing the value of agriculture to the national economy sight should not be lost of the fact that the contribution of the subsistence component alone to CDP* is

> *approximately equivalent to that of sugar. A combination of ability to grow, consumer preference, and unavailability or high cost of imported substitutes provides a long-term competitive advantage in the production of these crops. If grown in the traditional manner, without chemicals and in rotation, these are highly sustainable activities.*[126]

The promotion of traditional food crops and production systems could prove to be a cost-effective means of disaster mitigation. The Fiji Agricultural Sector Review recommended an agricultural strategy based on promoting Fiji's two identified areas of competitive advantage:

- high value niche exports; and
- the production of traditional food crops.

The report argued that, "Re-allocating existing resources and focusing and co-ordinating efforts will be largely sufficient to achieve the necessary changes to secure the future of Fiji's agricultural secto"[127]. If a reasonable degree of success is achieved in promoting traditional crops and production systems, immense benefit will be achieved in terms of disaster mitigation. This recommendation holds for most other Pacific island countries.

Promotion of traditional and appropriate food preservation

Complementing the cropping system, food preservation played a central role in traditional disaster mitigation throughout the region. This usually involved some forms of drying in drier areas and fermentation in wetter locations. There has been a marked decline in traditional food preservation throughout the region, al though it remains important in some localities, as in parts of Vanuatu. A sufficient base of knowledge and practice remains in most areas and provides scope for substantially reviving these practices by combining traditional and modern methods. Breadfruit, the most perishable of crops but the one most amenable to preservation, is characterised by abundant harvests that are well in excess of fresh consumption capacity. Vanuatu is a leader in the use of basic food processing techniques to preserve nuts and fruits. The Kava Store in Port Vila has developed commercially viable processing and packaging methods, techniques that are replicable at the village level. The promotion should not be primarily for food security or disaster mitigation, although these would be important spinoff benefits. Rather it should be to add dietary variety, create household income opportunities, and save household income.

Under the leadership of Dr Richard Beyer, the University of the South Pacific (USP) Institute of Applied Sciences has become a centre of excellence in food technology and food preservation, and is at the forefront of developing minimal processing food preservation techniques. A particularly interesting development has been with "pouching." This involves placing hygienically peeled fresh fruit in a clear plastic "pouch" or "envelope," with specific permeability characteristics, followed by a series of blanching operations. This essentially fresh product then has a shelf life of several months. While the science is sophisticated, the application is quite straight-forward and the capital requirements quite modest. It is now starting to be applied to the Tahitian chestnut *(ivi* in Fiji or *namambe* in Vanuatu), which could make a major contribution to food security.

Traditional food preservation techniques of drying, pit storage, smoking, and baking are found in most Pacific island countries. Methods vary according to local custom, but the same scientific principles apply everywhere [128]. Many of these practices can be modernised or adapted, using food science principles, for use by villagers and communities wanting to generate cash income or reduce cash expenditure. Parkinson saw particular scope for researching storage in pits, where traditional methods of keeping staple crops in pits could be adapted by modern farmers to enable them to hold surpluses for marketing purposes 129. Fermentation processes could be important in countries of high rainfall for both human and animal food, but by using methods, fermentation could be made more simple, efficient, and more acceptable to consumers. Back in 1983, Parkinson highlighted the urgency of this research and the need for it to be of a participatory nature:

> *The process of many of the processes is dependent on the collection of accurate information from the people who are familiar with them. Unfortunately, much of this information is being lost because people no longer regard it as important. If the dying art of Pacific food preservation is to be kept in the region, information must be collected now from the older people who still have the knowledge.*[130]

[126] *AVB, 1996*
[127] *Ibid, p. 54*

[128] *Parkinson, 1983:108.*
[129] *Ibid*
[130] *Ibid: 109.*

Now at the end of the twentieth century, there is perhaps the last opportunity to retain and apply this traditional knowledge. Vanuatu is an appropriate country in which to focus this revival for there is still a residue of traditional practice in place, active NGO involvement in promoting traditional food processing, and active private business interest.

Projects to enhance self-reliance and food security

Project 1: Developing yam seed banks

Cultivated yams are the central crop in food gardens but they are most susceptible to cyclone damage. Major cyclones can cause a shortage of yam planting material for several years. The FAO Root-crop Development and Research Project identified yam varieties with superior food security characteristics, such as better keeping qualities or shorter maturity time, characteristics that are often also favorable to commercial development. Some of these yams are scarce and seed material is difficult to obtain, increasing the need to bulk up a "bank" of selected seed, both as planting material to distribute after cyclones and to improve the overall stock of yams in Vanuatu and other yam growing countries in the Pacific.

Wild yams, in contrast, are among the most disaster tolerant of crops, but are nevertheless at risk from loss of habitat and encroachment by poachers, pigs, and wild cattle. The capital stock of wild yams may be being eaten out. The superior varieties are known in traditional knowledge, but seldom documented. Following on from Siwatibau's work in the Lolihor region in North Ambrym, there, is an urgent need for a comprehensive wild yam survey to identify varieties with the best food security and disaster mitigation attributes - information that is important for the food security of the region as a whole.

There is an urgent need for countries to build up their capital stock of yams, both wild and domestic by creating a yam seed industry. For example, one goal should be to bulk Vanuatu material to replace some of the Fiji wild yam varieties that have been lost. An innovative step in this direction was made in 1992 with "yam bank" project established under USAID's Profitable Environmental Protection Project (PEP) which used the services of the Farm Support Association (FSA), a long-standing agricultural NGO, working in collaboration with a community group in North Ambrym. Rapid multiplication techniques were applied to selected cultivars. Initially yam seed was made available to yam growers in exhange for their supplying other cultivars to the bank. As the "yam bank" grew, cash sales of seed were also allowed. The FSA and the community group, continued the project after the closure of PEP in 1995. There is considerable scope to expand and replicate these efforts elsewhere at modest cost, by developing the yam seed distribution programme throughout Vanuatu and eventually other Pacific islands. As with the successful North Ambrym pilot programme, payment would either be in seed or cash.

Some working capital is required for the initial purchase of the planting material. Overhead and travel costs would be required for FSA supervision. A retainer would have to be paid to FSA members to build up, and hold, a reserve of yam seed to distribute after a cyclone or drought. Given FSA's network of members on Efate, Santo, Malo, Malekula, North Pentecost, and Ambrym, this organisation would also be best placed to conduct the yam survey. The estimated cost of FSA involvement would be around $160,000 over the three year project, as detailed in Table 38.

Project 2. NGO food security and disaster preparedness project: Vanuatu pilot project

VANGO's Disaster Preparedness Project has been in existence for the last two years under AusAid funding. The main focus of the project has been to

Table 38: An indicative budget for expanding FSA yam seed bank project.

	$US
Yam resource survey • FSA co-ordinator for 1 year ($25,000) • travel and communication costs	35,000
Working capital to purchase yam planting in year 1	25,000
FSA over head expenses for 3 years (@$10,000/year	30,000
FSA co-ordinator for 3 years • Salary (50 per cent of time for 3 years • Travel and communications (@	54,000
Contingency (10 per cent)	14,000
Total cost	158,000

Table 39: An indicative budget for NGO food security and disaster preparedness project ($US).

	Year 1	Year 1	Year 2
Co-ordinators salary	8,000	8,000	8,000
Co-ordinators per diem and salary	6,000	6,000	6,000
Workshop cost (6 per year at $3,200/workshop)	19,200	19,200	19,200
Fees for the participation of the Kava Store in workshops	15,000	10,000	5,000
Preparation of a manual on traditional and appropriate food processing		35,000	
Preparation of a manual on cropping system that maximise food security			35,000
Contingencies (10 per cent)	4,800	7,800	7,300
	53,000	**86,000**	**80,500**

hold community-based workshops on disaster preparedness. The Project Co-ordinator is also a key member of the NDMC. The emphasis has been on traditional food preservation and cropping systems and planting timetables to minimise the impact of natural disasters. The approach has been to encourage a two-way flow of information on traditional and appropriate food security techniques. Vanuatu has a distinct advantage over some other countries in that a strong base of traditional knowledge and practice is still in place, especially in the smaller islands and more isolated communities. Aid funding is expected to end in 1998 and indications are that this programme has been quite successful, particularly as it has been managed by an experienced agriculturist who has a sympathetic understanding of traditional agricultural systems. This project should be continued, and its coverage and scope widened.

Some activities for an extended project could include:

- wider community coverage of the existing workshop programme; and
- the preparation of a bislama manual on cropping systems that maximise food security.

An indicative budget for a three-year project is presented in Table 39 above, with a total estimated cost over three years of $US219, 500. This represents a small fraction of donor contributions to relief and rehabilitation after a major cyclone. It is difficult for a project of this nature to have a high level of self-funding but in keeping with the theme of self-reliance, as high as possible a contribution from the communities involved should be sought. For example, the communities who host the workshops could be required to provide food and accommodation for the participants. Communities not prepared to do so are unlikely to be receptive to the self-reliance principles that are being promoted.

Project 3: Utilising USP's food processing expertise to enhance village and community food preservation

The USP Institute of Applied Science, using UNIDO funding, has undertaken a village-based food processing project at Namara near Suva in Fiji. In order to give systematic attention to the food processing and preservation needs of the other Pacific island countries, IAS involvement in the food preservation component of the Vanuatu Association of Non-Government Organisations (VANGO)'s disaster preparedness project in Vanuatu, and collaboration in the efforts of the Kava Store, would be invaluable.

Some activities for an extended project could include:

- extending the food processing coverage to cover appropriate as well as traditional food processing (including the involvement of the Kava Store);
- broadening the emphasis of the food processing workshops to include household income generation and income saving; and
- the preparation of a *bislama* manual on traditional and appropriate food processing techniques.

It is recommended that Dr. Beyer visit Vanuatu on three occasions over an 18 month period, for around one week each time. A food technology technician would remain in Vanuatu for a longer period, say two periods of one month each. The implementing agencies for the project would be VANGO and the Kava Store. The estimated cost of the project is around $US4S, 000 as indicated in Table 40.

Table 40: An indicative budget for IAS involvement in *community food preservation.*

	$US
Supervising food scientist • 20 days @ *$300/day* • airfares for 3 visits ($2.000) • per diem @*150/day*	11,000
Food technology technician ·3 months @*$3,000/month* • airfares for 2 visits ($2.000) • living expenses for 2 months @$4,000/months	19,000
Equipment and materials	10,000
Contingencies (10 per cent)	4,000
Total cost	**44,000**

Project 4: *Posters on traditional and appropriate food processing*

Charles Long Wah from the Kava Store has over the years held numerous workshops for village and community groups on food preservation techniques. Despite considerable enthusiasm on the part of the participants, and their will to implement what they have learnt in their own households, the success rate has been disappointing. It is suspected that the same situation will exist for the traditional food processing workshops by VANGO's Disaster Preparedness Project. Long Wah believes what is missing is a simple illustrative poster (with simple Bislama captions) that participants can hang on their walls as a ready reference. Long Wah has taken many photographs over the years of the various steps in the processing of fruits and vegetables using his 'wooden spoon and pot approach.' These would be a valuable resource in the preparation of such posters. The Kava Store already has experience in producing high quality promotional posters with assistance from the Forum Secretariat. The existing photographs would need to be supplemented by photographs taken by a specialist in this area who is also a layout specialist. Complete sets of specialist photographs would be required for posters depicting traditional food processing techniques. It would take a whole year to obtain the necessary photographs for various crops because of the different seasons involved.

An initial project might involve ten posters. They could include, say, five selected traditional food preservation methods that are widely applicable, even outside Vanuatu. Another five posters might be prepared for non-traditional processing techniques. The first step of the project would be to select from a wide range of options the products and processing to be presented in the posters. Breadfruit, which would undoubtedly be included in the traditional poster series, could also be featured in a non-traditional processing poster--such as making breadfruit leather, as has been successfully produced by the Kava Store. Bottled tomatoes would probably be included in the non-traditional processing series, for not only are they abundant in season but they are an ideal product with which to teach preservation techniques for other fruits and vegetables. It is recommended that the co-ordinating agency for the implementation of the project be VANGO's disaster unit, in collaboration with the Kava Store. The estimated cost of producing these posters is around $USl10, 000, as detailed in Table 41.

A second phase of this project would be to produce appropriately modified posters for other Pacific island countries.

RESEARCH REQUIREMENTS

The various studies highlighted the immense economic consequences of environmental disasters for the region. Of all forms of disaster, however, these costs are the most difficult to estimate and forecast. An environmental disaster tends to be longer-term and more insidious in nature. Furthermore, their

Table 41: *An indicative budget for traditional and appropriate food preservation posters.*

	$US
Photographer and layout specialist weeks) • consultancyfee $15 000 • travel expenses $7,000	22.000
Consultancy fee to Kava Store of photographs)	10,000
Layout and printing cost ($7,000 500 posters)	70,000
Contingency (10 per cent)	10,000
Total cost	**$112,000**

impacts are often correlated with, and accentuate, those of natural disasters, making it difficult to separate the effects. Land degradation and deforestation, for example, can greatly accentuate the impact of a cyclone, as recent experience in Pohnpei has shown. The effects of a drought will be made far worse if it accompanied by indiscriminate burning.

Too little has been done to quantify the economic costs of environmental disasters and their contribution to the costs of natural disasters. Some indicative broad parameters were presented on the economic impact of land degradation on the Fiji sugar industry and the cost of dredging of Fiji's river systems. A lot more, however, needs to be done in Fiji in this regard in order that the necessary changes in policy and implementation occur. If the cost of land degradation induced by sugar production is conservatively estimated at $F16 million a year, for example, it would likely be much higher in the year of a major cyclone or prolonged drought. On this basis, several million dollars spent annually on effective soil conservation programmes in the sugar sector would be well justified. Well researched, authoritative cost estimates are a necessary first step in order to encourage the industry and government to design and implement such soil conservation projects and programmes. Obtaining these cost estimates is far beyond the scope of this study, but could be the basis of a separate project.

Project 5: Estimating the financial and economic cost of land degradation in Fiji

A major research project is recommended to estimate the financial and economic costs of land degradation in Fiji, as a matter of priority. The study team should comprise an experienced agricultural economist and a soil scientist. The coverage should include the four main river catchment areas on Viti Levu, the sugar growing areas of Vanua Levu, and taro and kava producing areas on Taveuni. Current IBSRAM and the JICA Watershed Management and Flood Control Projects are generating a considerable amount of data on soil erosion in Fiji. What is required is to translate these and other data, into financial and economic terms. The methodology for conducting this research is provided by Dixon, 1990. Approximately six months of consultancy time would be required to adequately undertake this work, at an estimated cost of $US75, 000.

INFORMATION DISSEMINATION

In recent years, a lot of effort has been put into community disaster preparedness programmes by various national disaster agencies, NGOs such as the Red Cross, international agencies such as DHASPPO, and regional agencies such as the South Pacific Regional Environment Programme (SPREP). There has been a good deal of bilateral donor support for these efforts. Many posters, information calendars, and pamphlets have been produced, which can often be seen displayed on houses in rural areas throughout the region. These have been supported by media campaigns, particularly on radio. The consensus is that these efforts have been quite successful in minimising loss of life and property during cyclones.

In the agricultural sector, similar efforts need to be directed at longer-term mitigation efforts and to disasters others than cyclones. With respect to biological disasters, posters prominently displayed at Fiji's international airport warning of the dangers of smuggling fruit and the severe penalties that apply have been successful, judging from the large increase in the quantity of fruit put in amnesty bins. Damage and economic costs incurred by indiscriminate fires in Fiji could be another target for such a poster campaign.

Project 6: Awareness posters on the damage caused by burning

The seriousness of burning is not well understood by the public but well-produced and distributed posters could have an impact on community attitudes, as has been evident in the province of Cakaudrove. The coast adjacent to the island of Taveuni is notorious for indiscriminate burning, particularly in the dry season. In November 1997, a concerned local leader took the issue up with the Tikina (local area) Council and the Provincial Council and village meetings were held on the effects of burning. While December and January, usually a period of severe fire activity, were particularly dry that year, no fires were reported in the areas where the meetings were held. Without the re-enforcing influence of posters hanging in peoples houses, however, the remarkable benefit achieved from these meetings may prove to be transitory.

It is recommended that the Pacific Community is the appropriate organisation to produce these posters. The cost of this project is estimated at $US15, 000 to $US20,OOO.

POLICIES AND MEASURES TO REDUCE RISK AND MINIMISE THE IMPACT OF DISASTERS ON AGRICULTURE

Land-use planning

The impact of a given natural disaster will be \ determined by how land is utilised: what crops are grown, where they grown, how they are grown, and when they are grown. It also depends on the state of the forest cover in the catchment area for this not only protects the soil but provide a food bank at times of disasters. Land-use planning therefore appears to offer a good opportunity to minimise the impact of natural disasters on agriculture. Yet there is very little scope for regulating Pacific island farmers in terms of what, where, how, and when they grow crops. The landowner, or the land owning group, determines how the land is used. In Fiji, there are strong laws governing the husbandry of leased native land and land governed by Conservation Boards. The Native Land Trust Board, which manages the leasing of native land, has wide powers to ensure sustainable land use, requiring tenants "to farm and manage the land in such a way as to preserve its fertility." A "certificate of bad husbandry" can be issued on the basis of which a lease can be terminated. These provisions include prohibitions on planting of crops on slopes exceeding 15°. Yet they are virtually never enforced, as is common in other Pacific island countries.

As the Kadavu case study indicated, the driving force behind the changing land-use pattern is economic change. Information, access to technology, the availability of planting material and access to credit, however, also influence what crops are grown and how they are grown. All these could be used as instruments to encourage agro-forestry on degraded sugar land and to encourage the planting of vetiver grass as a soil conservation measure.

One aim of sustainable development is to integrate social and environmental costs into economic activities. There is place for the use of judicious subsidies to encourage sustainable land-use where a large gap exists between social and private costs. Buresova and McGregor recommended a fiscal 'carrot' as part of an overall package to discourage land degradation in Fiji's ginger industry[131]. Their proposal was that farmers who meet the good husbandry provision of their lease qualify for a cash subsidy to be paid toward the farmer's own labour (75 per cent of costs) used in planting vegetative strips and leucaena hedge rows and in constructing drains. The rationale for such a subsidy is to offset the farmer's preference for immediate cash earnings, as opposed to investment in longer-term conservation measures. Similarly, the use of taxes can be used to internalise longer-term environmental costs that society pays into the private costs incurred by land users. For example, Tonga currently faces the prospect of polluted ground water as a result of excessive agrochemical use in the squash industry. Serious consideration needs to given to pricing agrochemicals to reflect the true cost to society of producing squash under the present package of practices.

There is some scope for influencing the location in which certain crops are grown. Ginger grown on steep slopes in Fiji is a major cause of siltation in the Rewa River, incurring substantial annual costs in dredging to reduce the risk of flooding during the torrential rain that accompanies cyclones. Government has been unable to enforce good husbandry regulations in these areas. However, withdrawing extension support for ginger in steep areas provides some scope for influencing land-use. A proactive approach can be taken in this respect by taking into account the disaster risk involved in promoting crops in certain areas.

In most countries around one hundred years' worth of data are now available on cyclone paths and intensities. They indicate that some areas have lower probabilities of cyclone damage-such as in Fiji the Cakaudrove Province, apart from Taveuni. The risk here for major horticultural development could therefore be considered significantly less than in other parts of Fiji. It would be worthwhile to systematically incorporate this information into agricultural hazard maps. These maps could be used to attract investors in agriculture, who may otherwise perceive the whole of Fiji (or any other country) to pose too high a cyclone risk. These maps could also be used to obtain reasonable disaster insurance cover for certain areas. In Fiji, the JICA Watershed Management Study would enable flood hazard information to also be incorporated in maps for Viti Levu. Information on the probability of droughts could also be included, although available data are less accurate.

[131] *Buresova and McGregor, 1990: 254.*

Hazard information needs to incorporated into resource information systems that are being developed in several Pacific island countries. Vanuatu's natural resources have been documented in the computer-based Vanuatu Resource Information System (VANRIS). The Vanuatu system, developed by Australia's CSIRO, is the most advanced in the region and provides the basis for land-use and environment management planning. The system has been set up in all the six provinces and this has enhanced the capacity for planning and sustainable development within the country. Papua New Guinea is developing a similar system, known as Papua New Guinea RIS. The system has been used to undertake rapid environmental appraisals for the Papua New Guinea Tropical Forestry Action Plan. Incorporating disaster hazard information will enhance the planning value of these systems.

There is greater scope for land use control is forested parts of water catchment areas. In these often fragile and critical environments forest reserves need to be declared in which no logging or arable agricultural activity is permitted. Fiji has introduced a National Code of Logging Practice designed to minimise the destructive impacts of logging but, as the National State of the Environment Report points out, "It is clearly only as good as its enforcing officers and the resources made available to them by Government [132]. Given the immense cost of natural disasters, it makes sound economic sense to substantially increase the resources devoted to enforcing Codes of Logging Practice. Furthermore, some of these costs need to be internalised into the cost of logging licences, thereby making logging a less attractive land use activity.

It is hoped that the Watershed Management Plan being developed by the IICA Study will identify areas where logging should be banned or curtailed. Policy and political support for such recommendations, however, are only likely to be forthcoming if the broader financial and economic costs of these activities can be quantified. It is proposed that these cost estimates would be derived as part of Project 4 above.

Project 7: Hazard mapping of the incidence of cyclones in Fiji and Vanuatu

The proposed project would prepare a cyclone probability map for the various areas of Fiji and Vanuatu, using historical data on the paths and intensities of cyclones. To the extent that available data will permit, these maps should include flood data for Viti Levu. A provisional estimate of the cost of this hazard mapping project is $US70, 000. This exercise is only feasible for Fiji and Vanuatu which are the only countries with sufficient historical data on cyclones to calculate probabilities, and the agricultural opportunities to justify the use of these data.

CAPITAL INVESTMENT OPTIONS

There are various private and public capital investment options available to mitigate against disasters in agriculture.

Private investment

There are a number of cost-effective investments farmers could make to mitigate against disasters. These include:

- investing in soil conservation measures such as planting vegetative strips and building contour drains;
- investing in the building of raised beds to improve drainage;
- planting windbreaks; and
- investing in small-scale appropriate irrigation systems.

Despite the apparent financial benefits derived from these investments, farmers seldom do so. This seemingly irrational behaviour can in part be explained by their preference for immediate cash earnings. Buresova and McGregor described the situation for Fiji ginger farmers, most of whom lease land:

> *Smaller settler farmers who cultivate land on relatively short leases can be expected to prefer immediate cash earnings. By ignoring future returns, these farmers give scant regard to the land-use requirements of future generations. The Chinese immigrant ginger farmers probably regard their position as even less secure and thus view intensive cash cropping as an interim step to more remunerative economic activities*[133].

[132] *Watling and Chape 1992*

[133] *Buresova and McGregor, 1990: 252.*

There is clearly a close link between investment in disaster mitigation measures, sustainable agriculture, and the security and length of land tenure. In Fiji's Sigatoka Valley, the centre of the fresh fruit export industry, many farmers cultivate freehold land. Yet even here there is a conspicuous absence of the use of windbreaks and an under utilisation of the available irrigation infrastructure-investments that have been shown to give high rates of return. The fact that these investments are not occurring points to weaknesses in the research and extension systems but, even more so, to the failure of Fiji's small-holder agricultural credit system. The recent ADB Sector Review concluded in respect of agricultural credit in Fiji:

> Investors, including financiers, see agriculture as a risky venture due to the nature of its susceptibility to large and sudden changes in weather and market prices. This, allied to the commercial banks' need to have 100 per cent security on lending has restricted the levels of investment in the sector. Thus even the Fiji Development Bank (FDB) has become increasing reluctant to lend to agribusinesses, even where financial and economic viability can be shown.[134]

Project 8: *Establish a small revolving fund to finance viable disaster mitigation measures*

In an attempt to break the credit log-jam to capital investment in disaster mitigation, it is recommended that a small pilot scheme be established in the Fiji Development Bank (FDB) to provide small loans (perhaps a maximum $F5,000 to $6,000) to viable mitigation projects, including irrigation, soil conservation, and wind-breaks. Where possible, participating farmers should be tied to exporters and processors to ensure loan recovery. To provide an incentive, and to internalise some of the social costs involved, interest rates should be subsidised. The scheme would operate as a revolving fund. It is recommended that seed capital of $F250,000 be applied to this fund. There are a number of precedents for such FDB operated schemes, including the New Zealand ODA-financed women's loan scheme.

[134] *ADB, 1996: 41.*

Public investment

Large-scale public investment can help mitigate the impact of floods and droughts on the agricultural sector. So far, Fiji has been the only country in the region to embark on such a public investment project. After devastating flooding in the Central Division that accompanied Cyclone *Wally* in 1980, a major flood control project was embarked upon in the Rewa Delta and Navua. It involved sea wall channel and out-flow construction, drainage and dredging works; the latter still continues today. The total cost of the project was around $US38 million, with funding coming from the World Bank, ADB, and the Fiji Government. This investment undoubtedly has had a major mitigating impact on the flooding that would otherwise have resulted from the fifteen cyclones that have occurred in the intervening years.

Cyclone *Kina* (1993) was accompanied by widespread and prolonged rain which caused Viti Levu's four major river systems to overflow, creating the worst floods in over sixty years.[135] This encouraged consideration of further large-scale public investment in flood control. JICA and MAFF are evaluating various options as part of a major study on watershed management and flood control. For each catchment area a flood control plan has been prepared for discussion. The main components

Rewa River	Sigatoka River	Nadi River	Ba River
• Diversion channel • Weir and retarding basin • Cut-off channel and retarding basin • Flood control dam • River improvement • River channel widening • River dike construction • River bed excavation	• Flood control dam • Dike construction surrounding the urban area • River improvement • River channel widening • River dike construction • River bed excavation	• Diversion channel • Improvement of confluence point • Flood control dam • River improvement • River channel widening • River dike construction • River bed excavation	• Flood control dam • River improvement • River channel widening • River dike construction • River bed excavation

of each plan are:

No estimates are available on what these developments might cost, but a large capital investment project is envisaged. A thorough benefit analysis will be required before a decision is made on part or the entire project. This analysis should also take into account possible alternative uses of. these funds for disaster mitigation. It may prove to be more

[135] *Rokovada and Vrolijks, 1993: 3.*

cost- effective to invest several million dollars in on-farm measures to reduce land degradation.

CROP SELECTION, TIMETABLES, AND DISTRIBUTION

This report has discussed the relative tolerance of various crops to disasters. Clearly some crops are more resistant to disasters than others. In some cases it was found that susceptible crops, such as kava, were planted because the returns justified the risk. On balance, crops that are endemic to the region, or have adapted over a long period of time, tend be more resilient to disasters than more recently introduced crops. This consideration is sometimes over-looked by agricultural planners. For example, tree nuts has been correctly identified as having outstanding commercial potential and export diversification potential.[136] Macadamia nuts, given the industry's success in Hawaii and Australia, have been recommended in a number of reports, [137] yet these evolved in a region of Australia that is not subject to cyclones and are highly susceptible to strong winds. Once the tree is broken it does not recover, in complete contrast to several indigenous Pacific island nuts. No doubt had the same resources been devoted to developing these industries, as have gone into macadamia nuts in Hawaii, they would now be significant industries. It is encouraging to note that in Vanuatu a serious effort is being made to develop a commercial indigenous nut industry.

The various case studies showed the important role that planting timetables for crops had in traditional disaster mitigation. This traditional knowledge needs to be preserved and promoted. It can also be applied to non-traditional crops in order that the plants and their crops are put at least risk. The example was cited earlier of minimising risks for commercial papaya production in Fiji by planting in October or November, at the beginning of the cyclone season.

The Vanuatu case study described the dispersion of traditional gardens as a cyclone mitigation strategy. The impact of most cyclones is generally localised, affecting only one or two islands--Cyclone *Kina* in Fiji and *Ofa* and *Val* in Samoa being notable exceptions. Even within the path of a major cyclone, some localised areas can be relatively undamaged by wind. Thus the geographic spreading of planting can be promoted as a mitigation measure even for commercial crops.

Project 9: *The preparation of extension manuals on mitigation measures*

There is a need to integrate the promotion of disaster mitigation and food security measures into agriculture extension programmes. These programmes need to highlight the correlation between the adoption of sustainable agricultural practices and disaster mitigation. To facilitate this process, it is recommended that an extension manual on disaster mitigation practices for the agricultural sector be prepared. This would incorporate traditional and non-traditional crops, and would cover types of crops, cropping systems, planting timetables etc. It is proposed that initially the manual be prepared for Fiji, Vanuatu, and Samoa. The estimated cost of these manuals is $US40, 000, as detailed in Table 42. It is recommended that the Pacific Community co-ordinate this project.

CROP INSURANCE

Investors, including financiers, consider agriculture to be a risky venture due to its susceptibility to large and sudden changes in weather and market prices. This in part explains the low level of investment in commercial agriculture in Pacific island countries. Insurance offers in principle a way of transferring some of the risk. It helps facilitate the recovery of individual producers and may encourage

Table 42; *Indicative cost estimates for an extension manual on disaster mitigation measures*

	$US
Consultant agriculturist • fee (28 days @ $350/day) • travel and perdiem $5,000	14,800
Design and graphics consultant • fee (21 days @ 350 day) • travel and per diem $3,000	10,350
Manual production and printing costs	15,000
Total cost	**40,150**

[136] *McGregor and McGregor, 1996*
[137] *ADB* 1991; *Carlos and Dawes, 1990*

investment in agricultural enterprises where risks may otherwise be perceived to be too great.

There is no disaster insurance available for agriculture in any of the case study countries, with the notable exception of the Fiji sugar industry. The Fiji Sugar Corporation (FSC) offers a cyclone insurance scheme to cane farmers, and the FSC carries the largest insurance risk in Fiji. There is a perception that the risks are too great, and potential loses too high, to warrant insurance to be available to farmers at realistic premiums. However, the fact that FSC can obtain substantial insurance cover indicates that such insurance might be possible. The establishment of disaster hazard probability maps as proposed in Project 7 may improve the viability of agricultural projects in lower risk locations. An important spin-off benefit for establishing insurance cover for commercial agriculture would be that insurance companies are likely to require investment in mitigation measures. It is conceivable that a code of standards could be established equivalent to those successfully developed by Fiji's building industry for insurance purposes. Since their implementation, damage to urban buildings during cyclones has been far less than it was a decade ago.

Project 10: A study on the viability of establishing disaster insurance cover for non-sugar commercial agriculture in Fiji

A comprehensive study is required into the viability of establishing insurance cover for Fiji non-sugar commercial agriculture. This study would need to detail how such a scheme would operate and be underwritten. The terms of reference of this study should include market risk and other agricultural risks that could be incorporated in the scheme. This study will require the services of an agricultural insurance expert for a period of about six weeks at a total estimated cost of $US20, 000.

IMPROVED QUARANTINE SURVEILLANCE AND QUARANTINE DISASTER RESPONSE CAPABILITY

The risk of biological disasters can be minimised by adequate quarantine surveillance and rapid disaster response capability. A comparison of the recent fruit fly incursions in New Zealand and Australia illustrate the immense benefits that can accrue from investment in these areas. In early 1996, Mediterranean fruit fly *(Ceratitis capitata)* was found in traps in the vicinity of Auckland international airport. The establishment of this devastating fruit fly would have meant the loss of multi-billion dollar horticultural exports. The New Zealand quarantine trapping system however meant that this fruit fly incursion was detected almost immediately. A rapid disaster response plan was activated and the outbreak was confined to the vicinity of the airport. Within six months, New Zealand MAF was able to declare that Mediterranean fruit fly was eradicated. This situation markedly with the incursion of Asian papaya fruitfly *(Bactrocera papayae)* into Australia. Asian papaya fruitfly is one of the most damaging fruit flies both in the damage it causes to fruit and its wide host range. It is now established through much of Queensland. When papaya fruitfly was first identified in October 1995, it was already well established in a continuous area covering 2500 sq. km[139]. An eradication programme that was then mounted proved to be too little, too late. Markets in Japan, New Zealand, and southern Australia were lost, at an estimated cost of $A115 million in the first year. The ongoing eradication programme will cost $A55 million over 5 years, with no assurance of success[140]. To this must be added the social costs resulting from lost livelihoods, as well as environmental costs associated with control programmes and their impact on rain-forest ecosystems.

This is an example of failed quarantine that Pacific island countries cannot afford to emulate. The Pacific Community's Regional Fruit Fly Project has put into place a quarantine surveillance network throughout the region that substantially reduces the risk of such a disaster occurring in the region. What is further required is for individual Pacific island countries to invest in maintaining and strengthening this surveillance network. A benefit cost analysis carried out for the Regional Fruit Fly Project estimated an internal rate of return of 33 per cent for investing in the maintenance of the quarantine surveillance system[141]. Each country in the region should be encouraged to make this investment to benefit not only themselves but the whole region. Weak quarantine surveillance in any country undermines the regional network. Each country needs to have an emergency quarantine response plan in place,

[138] *Benson, 1997: 43.*

[139] *Drew, 1997: 205.*
[140] *Ibid*
[141] *McGregor, 1997:217.*

with adequate resources for its rapid implementation, as well as a budgetary commitment for emergency funding. There is a requirement for further development of a regional capability in this area under the auspices of the Pacific Community, including the stockpiling of materials to allow an immediate response to an outbreak.

Project 11: Assistance with the design of quarantine emergency response plans.

The recent New Zealand Mediterranean fruit fly experience demonstrates the value of having quarantine emergency response plans in place. The Regional Fruit Fly Project has provided assistance in this area as part of its second and third phase, which ends in 2000. A concerted effort is still required in this area, particularly for biological disasters other than fruit flies. It is recommended, therefore, that a project be established under the auspices of the Pacific Community to develop quarantine emergency response plans for all member countries, plans that cover both crops and livestock. A regional response plan to be co-ordinated by the Pacific Community would also be prepared. It is recommended that this two-year project be designed and implemented in close collaboration with the Regional Fruit Fly Project. An experienced quarantine expert would be appointed as Project Coordinator. The estimated cost of the two-year project would be $US500, 000 to $US700, 000. This would include provision for the stock-piling of materials to allow for a rapid response to a pest or disease outbreak in the region. There would also need to be an ongoing commitment of emergency funding.

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