EU EDF 8 – SOPAC Project Report 122
Reducing Vulnerability of Pacific ACP States

FIJI TECHNICAL REPORT
An economic analysis of flood warning in Navua, Fiji

October 2008

Looking for safer spots

Navua bridge... with debris

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An economic analysis of flood warning in Navua, Fiji

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ACRONYMS

ACP	Africa Caribbean Pacific
EDF	European Development Fund
EDF8	countries participating in the 8th European Development Fund
EDF9	countries participating in the 9th European Development Fund
NDMO	National Disaster Management Office (Fiji)
NPV	Net Present Value
VC	Variable Costs

GLOSSARY

Alert	notice that a disaster (e.g. flood) might happen
Benefit cost analysis	technique to evaluate the benefits and costs of a project from a social perspective
Benefit-cost ratio	present value of benefits from a project divided by the present value of its costs – an indication of the return on an investment
Disaster	the occurrence of a sudden or major misfortune which disrupts the basic fabric and normal functioning of a society (or community); an event or series of events which gives rise to casualties and/or damage or loss of property, infrastructure, essential services or means of livelihood on a scale which is beyond the normal capacity of the affected communities to cope with unaided (Government of Fiji 1995)
Discounting	a calculation that transforms the gains and losses accruing in different time periods to a common unit of measurement, usually that of the present day
Discount rate	the rate at which future payments are transformed to a current day value
Net benefits	the difference between the present value of total benefits and the present value of total costs. This value measures the contribution of an investment to society
Net present value	difference between the value of total benefits from a project and the total costs of the project over time
Warning	notice that a disaster (e.g. flood) is about to happen

EXECUTIVE SUMMARY

Navua town and its surrounding area are subject to flooding approximately once every seven years. The most recent serious floods occurred in 2004 and imposed considerable financial and physical damage. Under the European Development Fund (EDF) project *Reducing Vulnerability in Pacific ACP States*, SOPAC worked with the Government of Fiji to establish a flood warning system for the town of Navua and nearby communities. The system will involve close monitoring of rainfall and river levels with the expectation that flood warnings can initially be issued up to three hours before a flood and subsequently up to six hours once the system has been operating for some time. Once established, the warning system will require on-going financial support to maintain its operation. To assist the Government of Fiji in its deliberations over supporting the scheme, an economic assessment of the Navua flood warning system was conducted to determine:

- the investment potential or 'economic return' of investing in the Navua flood warning system; and
- issues that affect the likelihood of economic returns eventuating.

Assessment of the economic return of investment in the Navua flood warning system was based on estimates of the cost of damage from the 2004 floods in Navua. It is estimated that the 2004 floods affecting Navua cost Fiji and international helpers a minimum of FJ$13 million. This value is likely to be an underestimate since it does not include values for the loss of irreplaceable records, human trauma, government coordination of assistance activities, certain humanitarian aid, loss of education opportunities or the cost of volunteer labour (especially the military) to assist in distributing aid.

Estimated economic losses from the 2004 Navua floods:

Item	Value of loss
Household losses	6 745 228
Business losses	2 980 837
Agricultural and fisheries losses	832 388
Government losses:	
▪ Replacement of destroyed lean tos	34 800
▪ Infrastructure rehabilitation	400 000
▪ Medical services	2 000 000
▪ Education	25 625
▪ Provision of water tanks	0
▪ Provision of emergency clothing	1 000
▪ Provision of food rations and disaster sundries	10 908
▪ Coordination by government	Not known
Humanitarian aid valued:	
▪ Australian High Commission	1 560
▪ French Embassy	208
Unvalued humanitarian aid:	
▪ Blankets	Not known
▪ 10000 oral dehydration salts	Not known
▪ 2400 litres bottled water	Not known
▪ 11 cartons Fiji water	Not known
▪ Red Cross provisions	Not known
Other losses	
▪ Early school break for Catholic primary School due to need for fresh water	Not known
▪ Volunteers to government and NGOs	Not known
▪ Trauma and irreplaceable items	Not known
ESTIMATED TOTAL (not including 'unknown' values)	13 032 554

The scale of losses from the 2004 floods highlight the economic dimension of the Navua disaster. Aside from the human trauma associated with the disaster, there were substantial losses to the national and local economy.

The economic returns of investing in the flood warning scheme was subsequently conducted using benefit cost analysis. First, the proportion of 2004 losses that could be avoided in different sectors were estimated if a flood warning system operates successfully in the future. Using these assumptions, the potential benefits (cost savings) of the system were estimated on the basis of losses from the 2004 floods. It was estimated that a successfully implemented warning system would be most likely to save Fiji (its government, Navua families and the Navua business community) and the international community organisations a combined total of at least FJ$2.1-4.2 million over 20 years. The range of values reflects that the major floods of the 2004 scale are likely to happen somewhere between once or twice during the life time of the system. It needs to be recognised that this estimate of savings from using the warning system is likely to be a significant underestimate since several smaller and larger floods are additionally likely to occur during the life time of the system and so cost savings would arise from these as well. Furthermore, the estimates presented do not include the value of benefits arising from savings to education, reduced need to bring in volunteer labour such as the military, reduced trauma, potential use of the warning system for other local warnings and/or the value of lessons to any other warning systems in Fiji and across the Pacific (current or future).

The costs of establishing and operating the system were estimated to sum less than FJ$0.6 million over the 20-year lifespan of the warning system. Given the expected benefits of the system, overall investment returns from the warning system would then most likely be a minimum of between 3.7 to 1 to as high as 7.3 to 1 (table). In other words, every dollar spent on the warning system would be most likely to save FJ$3.7 - 7.3 in return.

Not surprisingly, the biggest beneficiaries of the warning system are expected to be the Navua community who would benefit from the warning system by protecting possessions and their health. Navua families were estimated to most likely save between FJ$ 1.7 and FJ$2.4 million over the 20-year life of the warning system.

The Government of Fiji would also benefit substantially from the system, by having the hospital, infrastructure and schools better protected and because it would need to provide less emergency aid (food etc.) if people were better prepared. Government savings would most likely be between $0.4 and $0.8 million over 20 years. These are minimum estimates. To achieve these savings, the Government of Fiji would need to cover the costs of awareness raising and maintenance of the system over its life. Together with its in-kind contributions to establish the system, the Government would be expected to pay a total of just under FJ$0.4 million over the life of the warning system. Given the benefits to the Government of the system, the Government of Fiji would most likely gain an investment return of $1-2 per dollar invested in the system. In other words, every dollar invested by the Government of Fiji in the system would most likely come back to it in savings – or be doubled. This is an encouraging economic return. It suggests that it would be rational for the Government of Fiji to invest in maintaining the system. In fact, since the estimates of benefits from the system are highly conservative, investment returns overall and to the Government of Fiji specifically are likely to be higher in reality.

The returns estimated highlight the value to the national economy of investing in disaster mitigation measures. Investments in this area are likely to generate significant economic benefits over the life of the system.

Summary of most likely investment returns for different stakeholders (10 per cent discount rate):

Stakeholder	Net present value over 20 years FJ$	Benefit: cost ratio over 20 years
Navua community	1.6-3.3 million	∞
Government of Fiji	0.03-0.4 million	1.1-2.2
International stakeholders	1.5-3.6 million	3.7-7.3

The presented returns on investment from the warning system are 'most likely' case scenarios. However, the economic returns overall and to the Government of Fiji specifically actually cover a range of values including 'worst case' scenarios (minimum likely returns) and 'best case' scenarios (maximum likely returns). Worst case scenarios represent cases where the potential benefits of the warning system are limited because of poor warning dissemination or poor responses to warnings (e.g. people not acting in time to save possessions once they receive a warning). Best case scenarios suggest the reverse – that people receive the warnings and save all that is practical within the time given.

If the 'worst case' occurred, overall returns from the warning system could be between 1.8:1 and 3.7:1, still highly lucrative for the community. However, returns to the Government of Fiji specifically could fall to between 0.7:1 and 1.3:1. This means that the investment in the system might not pay for itself. Realistically, this is highly unlikely given that benefits from the warning system are already underestimated. Furthermore, the warning system is expected to improve in predictive capacity over time with the effect that long-term benefits from the system are likely to increase.

If the 'best case' eventuated, economic returns from the scheme overall could be between 5:1 and 10:1 with returns to the Government of Fiji between 1.4 and 2.8:1. These are significant returns which suggest that the Government would be unwise to not support the scheme.

While the Navua warning system offers substantial benefits to the local and national community, its benefits are not guaranteed. Whether the benefits of the scheme eventuate hinges substantially on getting the warnings to people and ensuring that they respond appropriately. This report identifies a number of issues that should be considered in designing a flood response plan for the community of Navua including the type of information that people need to know and options to disseminate warnings. The ability of the scheme to disseminate warnings and enable community response will itself rely to a large extent upon funding of ongoing awareness and education activities. The analysis presented here assumes that government investment in these activities over the 20-year life span of the system is generous. If the Government of Fiji chooses to assign lower priority to funding to awareness and maintenance activities, it could adversely affect the success of the system. The importance of these activities to the success of the system should not be underestimated. Provided that these investments are maintained and other issues noted in the analysis observed, it would appear that the Navua flood warning system should be a wise and beneficial investment.

A INTRODUCTION

The SOPAC/EU Project

The Pacific Islands Applied Geoscience Commission (SOPAC) currently executes the European Development Fund (EDF) project *Reducing Vulnerability in Pacific ACP States*. The goal of the project is to reduce the vulnerability of Pacific ACP states through the development of an integrated planning and management system which targets:

- Hazard mitigation and risk assessment;
- Sustainable mining of coastal and marine aggregates; and
- Water resources and sanitation.

The project seeks to address problems such as: the unavailability of accurate and timely data; weak human resource base; limited resources (both in terms of finance and infrastructure); and lack of appropriate management plans, policies and regulatory frameworks to deal with these focal areas.

The project aims to utilise geoscience outputs and information to underpin the development of planning and management tools in the context of island systems management[1] to reduce vulnerability to natural risks. Additionally, the project is intended to promote access to, and use of Geographic Information Systems for sustainable resource management via communications networks drawing on Map Servers provided by the project.

The project commenced in March 2002 via funding from the 8th European Development Fund (EDF8). Implementation of the project initially focused on those SOPAC Member Countries that were ACP States under EDF8, namely Fiji, Kiribati, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu. In February 2004, the Project was extended to another six Pacific Island Countries under the 9th European Development Fund (EDF9). The six (EDF9) countries are the Cook Islands, Federated States of Micronesia, Republic of the Marshall Islands, Nauru, Niue and Palau.

The EDF8 component of the project ended in December 2007 and the EDF9 component would end in December 2008.

Flood Risks in Fiji

The high rainfall, steep topography and relatively large catchments combined with intensive agricultural use of lowlands by village communities have made Fiji generally susceptible to flood disasters over the years.

On average, Fiji is estimated to suffer 10 fatalities and around FJ$20 million worth of flood damage per year to infrastructure, agriculture and homes (SOPAC 2006). These losses do not include social impacts such as trauma.

[1] Islands Systems Management – an approach endorsed at the First Ministerial Meeting on SIDS in the Caribbean and adopted by the SOPAC Governing Council at its 27th Session (1998) – is an adaptive management strategy which addresses issues of resource use conflicts, and which provides the necessary policy orientation to control the impacts of human intervention on the environment, coordinating the initiatives of all public and private sectors while ensuring through a unified approach that common goals are attained.

In many cases, the after effects of the flooding are as important as the immediate impacts. For example, several weeks after the floods of 2003 and 2004 (resulting in 29 fatalities combined)**,** over 10 000 people remained in need of food rations following the loss of subsistence crops (SOPAC 2006).

Many floods, such as those that occurred in 2003 and 2004, came with little or no warning and it was generally regarded as lucky that there were not more fatalities. Harm could have been significantly reduced if appropriate flood warning had been given.

The principal cause of major floods in Fiji is tropical cyclones. Rainfall begins while the centre of the cyclone is still some distance out at sea but intensifies as the cyclone approaches land. Rapid runoff in already saturated catchments results in the floods. Other severe weather events with high intensity rainfall can also cause floods. For instance, persistent and heavy rain further up the catchment can result in flooding down stream. Although such non-cyclone related flood incidents can be severe (such as the 2004 floods which occurred because of a tropical depression), they occur less frequently in Fiji. Slow moving cyclones and/or cyclones possessing large circulations are particularly efficient in creating long- lasting heavy rainfall conditions leading to floods in Fiji (Yeo et al. 2007).

Furthermore, storm surges (onshore gushes of water associated with a low pressure weather system like tropical cyclones) can exacerbate flood levels around the coastal zone can high tide levels coinciding with the flood peak.

According to Yeo et al. (2007) land use change and siltation of rivers do not – as commonly assumed – contribute significantly to the frequency or severity of floods in Fiji.

Flood Risks in Navua

Flooding of inland areas is a major hazard to communities in Fiji. Navua, situated to the south east of Viti Levu, is located next to Fiji's third largest river system and is subject to high and intense rainfall patterns. According to Parry (1981), flood records of Navua before 1972 are inconsistent and were poorly maintained. Nevertheless, he suggests that flooding in the period 1929-1980 occurred on average around once every seven years. Together with information from the Fiji Department of Public Works (Hydrology Section), flood occurrences around Navua are estimated to have occurred as indicated in Table 1.

Table 1. Flooding in the Navua catchment.

Year	Stage (in m)	Estimated Discharge (in m^3/s)	Source
1929	N/A	> 1150	Parry (1981)
1931	N/A	> 1150	Parry (1981)
1935	N/A	> 1150	Parry (1981)
1941	N/A	> 1150	Parry (1981)
1972	10.9	> 1150	Public Works records
1980	12.0	6050	Public Works records, Parry (1981)
1993	11.3	2700	Public Works records
2004	10.1	N/A	Public Works records

This certainly seems to support the suggestion that damaging flooding in Navua occurs approximately each seven years.

The most recent floods to have hit Navua occurred in 2004. The floods occurred as part of widespread flooding across Viti Levu which resulted from two consecutive tropical depressions.

Proposed Work

The Government of Fiji seeks to improve the management of flood risks and events. It conducts awareness raising and response activities and has, through the Division of Land and Water Resources Management, conducted flood and dredge work around Nadi and Navua in the past. In addition, it currently plans to upgrade provincial flood warning services as a way to mitigate flood impacts as far as possible in the future.

Currently, there are six major watersheds in Fiji where warning services could be technically provided and where population centres and/or facilities are significant enough to highly benefit from such services. The six potential watersheds are in:

- Ba (Viti Levu);
- Labasa River (Vanua Levu);
- Nadi River (Viti Levu);
- Navua (Viti Levu);
- Rewa (Viti Levu); and
- Sigatoka (Viti Levu) (see map 1).

The Government of Fiji has committed to install flood warning systems at Ba and Nadi river catchments with the assistance of the Government of France. The SOPAC-executed Pacific HYCOS Project is supporting the re-establishment of a flood warning system for Rewa.

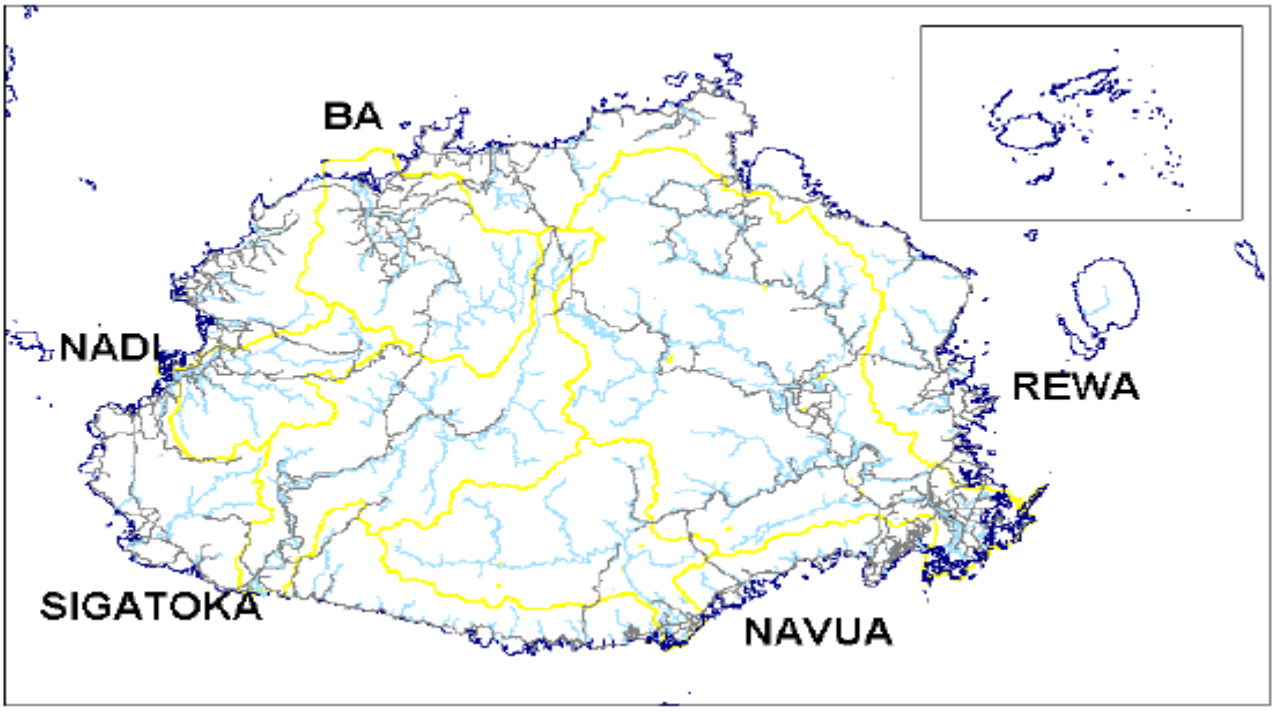

Figure 1. Location of potential flood warning systems on Viti Levu, Fiji.

The role of the SOPAC/EU Project

Early consultations were conducted with the Government of Fiji to determine the focus of EDF work in Fiji. The National Disaster Management Office (NDMO) and the Meteorological office expressed interest in reducing Fiji's vulnerability to flood disasters. The EDF would thus complement the work planned for Ba, Nadi and Rewa by establishing a fully automated flood warning system for the Navua River watershed. This warning system will be the first of all those planned to actually be installed. The intention with the Navua warning system is to be able to initially provide up to three hours prior warning of 'flash' floods following prolonged intensive rainfall. Once the system has been operating for some time, it is expected that the system could provide up to six hours warning time.

The key elements of the proposed Navua flood warning system under the SOPAC/EU Project are:

- rainfall monitoring and river monitoring to produce flood predictions; and
- dissemination of flood-level alerts and warnings to emergency agencies and the general public (Figure 2).

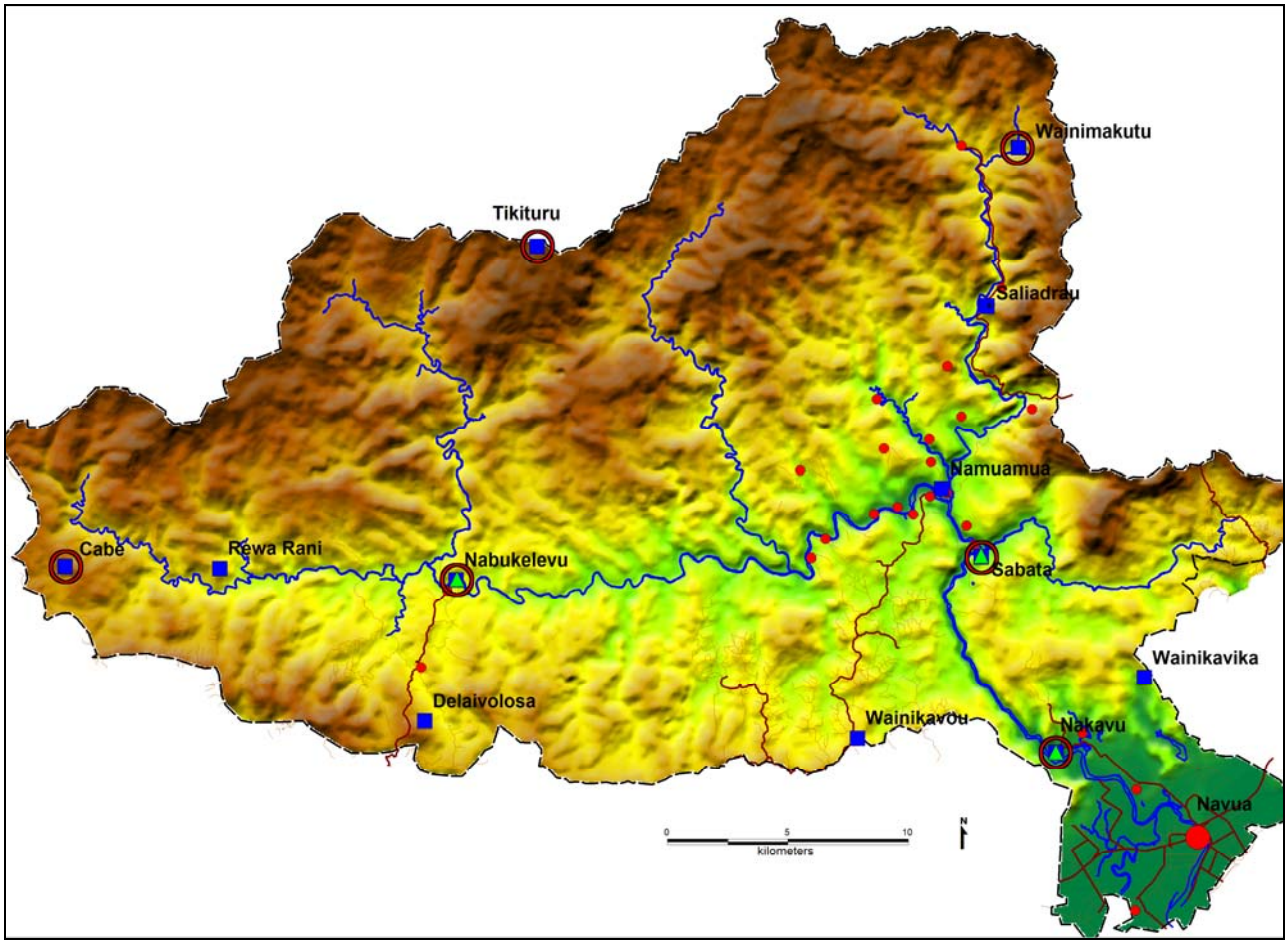

Figure 2. Hydrological network of the Navua catchment. Green triangles indicate water level gauges (all but the one at Tikitura already exist). Blue squares rain gauges (the Nakavu station already exists whereas the Sabata and Nabukelevu ones are yet to be established). Red circles indicate proposed telemetric sites and red spots indicate villages.

The physical infrastructure for the warning system for Navua is expected to cost the SOPAC/EU Project around FJ$145 000. (See section F for details.) This value does not include the value of operational costs, training, in-kind and/or financial contributions from the Government of Fiji or from SOPAC.

It is anticipated that the flood warning system would be fully operational during 2008. In anticipation of the flood warning system, staff of the SOPAC/EU project had, at the time of preparing this analysis, conducted a number of consultations with the NDMO and key stakeholders of Navua.

The installation of the Navua flood warning system will not only benefit the community of Navua but will also act as a national and regional case study for the design and implementation of other warning systems planned for Fiji. Lessons learned from the Navua case will also inform the future interest in flood warning systems as well as their design in other countries in the region. There is therefore a critical need to ensure that the design and implementation of the Navua system is efficient to maximise returns from the investment and thereby create the right environment for their wider adoption.

Accordingly, there is a need for information on the following:

- The likely net benefits of the system, including the identification of key components to include and beneficiaries to target in any communications element.
- Issues that affect the likelihood of those benefits being fulfilled (such as awareness raising, operational/viability, data needs, maintenance, monitoring needs and impediments to realising benefits).

Purpose of this Study

This study is an economic analysis of the expected net benefits of the planned Navua flood warning system. It is intended to:

- generate information on the economic return on investing in flood warning systems using the Navua system as a case study. This information can be used to support applications to fund the on-going operation of the system, should the analysis reveal a positive expected pay off.
- Identify issues that affect the likelihood of benefits being fulfilled. This information can then be used to improve the design and implementation of the Navua warning system and similar systems being planned elsewhere.

The broad terms of reference for the study are given in Annex 1.

Structure of this Report

The analysis commences in section B with a general introduction to Navua, its environment and population as well as the nature of the proposed flood warning system. Section C contains a description of the methodology to be used to estimate the benefits from establishing and using the system. Section D contains an explanation of what data was needed to conduct the estimations and how the data was collected. Section E estimates the value of losses arising from the last major flood of Navua, which occurred in 2004. This value forms the basis for estimating costs savings that might be achieved using a warning system in the future. Section F then describes how the warning system might reduce those losses in the future and estimates the value of benefits from the flood warning system. This section also describes the likely returns on

investing in the warning system from a number of different perspectives (that of the Navua community, Government of Fiji and international community). The benefits of a flood warning system are not guaranteed. They hinge on technical issues such as the ability to distribute warnings to different households as well as assumptions about what people need to know. These issues – and the impact they could have on potential investment returns from the system – are discussed in section G.

B BACKGROUND

Disaster risk reduction, Disaster Management and the SOPAC/EU Project

The SOPAC/EU Project *Reducing Vulnerability in Pacific ACP States* attempts to improve the life of Pacific islanders by reducing losses from natural disasters. Conventionally, and certainly in the Pacific, efforts to reduce losses related to natural disasters have focused on responding as quickly as possible to natural disasters while regarding their occurrence as largely inevitable or unavoidable. Such 'disaster management' involves various activities such as preparation for disasters ('preparedness'), response (emergency relief, rescue work, medical assistance etc.) and/or recovery/rehabilitation. More recently, and as emphasised in the Hyogo Framework for Disaster Reduction (UN 2005), there is often a role for countries to play in reducing the likelihood of disasters happening in the first place – or at least in reducing the scale of impacts, if they must occur. Such 'disaster risk reduction' can include hazard analysis and vulnerability assessment. Together, the disaster risk reduction and disaster management comprise the overarching goal of 'disaster risk management' (Figure 3).

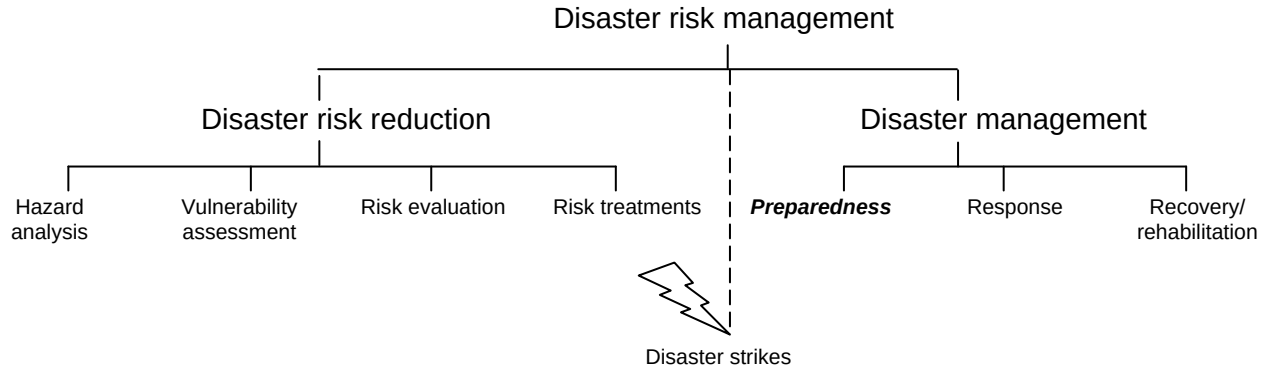

Figure 3. Disaster risk management and the SOPAC/EU Project in Navua.

The SOPAC/EU Project in Fiji addresses a variety of activities across the disaster risk management spectrum, from disaster risk reduction (hazard analysis and risk evaluation enabling prediction of flooding) through to disaster management (Figure 3). In the case of Navua, for instance, disaster risk reduction included assessment of flood risks increased by unsustainable land use upstream. Theoretically, other disaster risk reduction activities could also be done, such as risk treatment measures that reduce flood risks by controlling that behaviour (zoning, enforcement of legislation over land use etc.).

By comparison, the Navua flood warning system addresses the issue of disaster management. Specifically it addresses preparedness since it is designed to help the community and the government prepare to move or protect possessions once a flood is predicted. The establishment of early warning systems for flooding is a key recommendation in the Hyogo Framework for Disaster Reduction.

A benefit cost analysis of the Navua flood warning system is intended to provide information focussed on the value of flood warnings to the Government of Fiji and donors and to identify key issues that underpin the realisation of those benefits. By focusing on the issue of preparedness, a benefit cost analysis of the Navua flood warning system would not address issues that reduce the likelihood of flooding (disaster risk reduction). Consequently, there is no analysis in this document of the benefits and costs associated with managing activities that cause flooding (such as upstream logging management of irrigation channels).

Navua River Catchment

The Navua catchment is located in south eastern Viti Levu. The catchment is Fiji's third largest river system. Its drainage area covers 1070 km^2 with the river extending 91 km. At the highest point, the catchment is 1084 m above sea level (SOPAC 2006).

Town and Environs

The settlement of Navua is generally referred to as a town although it is not formally designated as such. Rather, it is an administrative and commercial centre serving the people of both Serua and Namosi provinces as well as the island of Beqa off shore (Sinclair Knight Mertz 2000). For the purposes of national government assessment (census etc.), Navua town falls under both Serua and Namosi provinces (rather than belonging to one province only) although the larger portion of the town falls within Serua. The administering authority is the Navua Rural Local Authority.

The administrative and commercial centre and their associated residential areas of Navua lie on the east bank floodplains of the Navua River (Sinclair Knight Mertz 2000). A section of Navua River measuring about 163 m wide and 5.81 km in length runs along the town of Navua. As a result, some homes, including the central business district of Navua are only a few metres from the river banks (Mataki et al. 2006). The greater Navua area is also crisscrossed by a network of irrigation channels and flood gates at the coast, previously used to distribute and control water needed for commercial rice farming (Mataki et al. 2006).

Key amenities in Navua include a district administration, a commercial centre including a market, a hospital, schools and residential areas. The central business distinct of the town is located at a bend of the Navua River with the market, jetty and bus depot forming its centre. The town stretches along the eastern bank of the Navua River with the hospital on the landward end and the district and provincial administration seaward (Sinclair Knight Mertz 2000).

Population

At the time of preparing this report, the last national census for Fiji had been conducted in 1996. The 2006 census – which would have updated figures relating to population size, access to amenities and activities – was postponed until 2007 because of the 2006 general elections (Government of Fiji 2006c). No interim census was conducted during this time. This means that data on the Navua (and the country generally) is now out of date. The 1996 census stated that the total population living across the two provinces that Navua serves was over 21 000 (Table 2) with a substantial proportion of the population estimated to be under the age of 15 (Table 3).

Table 2. Population of Namosi and Serua provinces (1996).

	Namosi	Serua	Total
TOTAL	5742	15 461	21 203

Source: Government of Fiji 2000.

Table 3. Demographics of Namosi and Serua provinces (1996).

	Namosi	% Namosi	Serua	% Serua	% overall under age 15
Less than 15 years	2424	42	5747	37	39
15 years or more	3318	58	9714	63	61
TOTAL	5742	100	15 461	100	100

Unfortunately these figures do not reveal specifics about the population size and structure of Navua itself. First, the sizes of the two provinces far exceed the size of Navua township. Second, the population of the township is known to have changed since the last census, as a result of increasing urbanisation as well as the resettlement of displaced sugar cane farmers following the expiry of their land leases. On the other hand, the 2000 coup in Fiji also led to the outward migration of many Indo-Fijians from Fiji and it is not clear to what extent this impacted the Navua population. In light of these changes since the last census, information on the size of the Navua population is unreliable. Mataki et al. (2006) estimated the current population of the main body of Navua town to be around 7000, a figure backed up by the following indicative breakdown of population for Navua (Table 4) provided by the Government of Fiji.

Table 4. Indicative population of Navua (based on 1996 census).

Serua urban area	5345
Deuba/Pacific Harbour	1607
TOTAL	6952

Source: (Vasemaca Lewai, Statistician, Bureau of Statistics, Fiji, personal communication, 7 February 2007).

While Navua serves both the Namosi and Serua provinces, the greater part of the township is located in Serua province. Census data for Serua (Government of Fiji 2000) indicates that the majority of the population in the area in 1996 was indigenous Fijian (55 per cent) with a consequent predominance of Christians in the area (63 per cent). Such information on ethnicity is likely to be important when considering the dissemination of warnings once the Navua flood warning system is operational. (See section G for more information).

Information on access to amenities is also be important since it would determine the medium by which warnings could be communicated (phone, TV, radio etc.). According to the census, only one quarter of Serua households had access to a phone in 1996 (Government of Fiji 2000) which might mean challenges in reaching households (especially at night) to advise warnings.

Education

The 1996 census revealed that education levels around Fiji are high with over three quarters of the population nationally attaining secondary education (SPC 1999). The percentage of the national population attending school through to the age of 13 was 93 per cent.

Incomes

No information was collected during the Fiji census on income levels. (This is a matter for the Inland Revenue and the information is confidential.) However, Mataki et al. (2006) conducted a socio-economic study of Navua in 2003-2004 as part of a larger internationally-funded project on Adaptations to Climate Change (AIACC). The study indicated that, on average, a Navua resident earned $US 35-46 per week, which was comparable to the average weekly earning recorded by a consulting firm in 2000 (Sinclair Knight Mertz, 2000). This indicated that the socio-economic status of average Navua residents had not improved within the past five years. Consequently, they also rely on subsistence farming and fishing for sustenance and to supplement their incomes (Mataki et al. 2006).

Human activities

Navua is only an hour's drive from Suva, the capital of Fiji. Lonergan (2005, p. 23-24) cites a personal communication from the Serua Provincial Authority that, based on the frequency of bus services between Navua and Suva, as many as 80 per cent of the workforce living in Navua has employment in Suva. This underlines the importance of access to roads which may become unavailable during flooding and therefore impact access to work. Pacific Harbour, a major tourist development is located close to Navua and uses the Navua river for cruises (Lonergan 2005). Again, this underlines the importance of access to roads which may become unavailable during flooding and therefore impact access to work.

Commercial rice farming was an important economic activity in the greater Navua area prior to 1990 (Mataki et al. 2006, Sinclair Knight Mertz 2000). However, commercial rice farming was subsequently abandoned because of competition from cheaper rice imports from Asia, floods and pest infestation. Consequently, small-scale commercial and subsistence farming of temporary root crops (cassava and dalo) and vegetables, as well as animal grazing (mainly cattle and goats) took its place as the main agricultural activities (Mataki et al. 2006). Agricultural activities other than for subsistence purposes (which is commonly undertaken) are conducted around Navua for the most part by resettled sugar cane farmers (Melchior Mataki, Programme Manager – Pacific Centre for Environment and Sustainable Development, University of the South Pacific, personal communication, 14 November 2006).

Logging in the upper catchment of the Navua River is a significant activity. Some of Fiji's largest mahogany forests are found around Navua and harvesting and planting are underway (Mataki et al. 2006). Aggregate mining in the Navua River is also an ongoing activity.

According to Sinclair Knight Mertz (2000), fishing along the Navua coast is dominated by net fishing (for the Navua market) and spear fishing (cod, coral trout, lobsters for sale at the Navua jetty). Sinclair Knight Mertz (2000) indicated that the total volume of fish caught is not known because fishing is not monitored at source and when it reaches land it is diffused to various outlets and mixed with catches from other areas.

Sinclair Knight Mertz (2000) also indicated that up to 22 fishing boats from Beqa Island operate as unlicensed ferries.

Flood Management at Present

National management arrangements for flooding

The principal guide for the management of disasters in Fiji in the Fiji National Disaster Management Plan (Government of Fiji 1995). According to the plan, a disaster is:

The occurrence of a sudden or major misfortune which disrupts the basic fabric and normal functioning of a society (or community). An event or series of events which gives rise to casualties and/or damage or loss of property, infrastructure, essential services or means of livelihood on a scale which is beyond the normal capacity of the affected communities to cope with unaided (Government of Fiji 1995, p. x).

The National Disaster Management Plan is intended to cover all disasters, including but not limited to flooding. The Plan outlines key government and non-government agencies involved in averting, planning for and responding to disasters such as flooding; and the responsibilities of all agencies.

The Plan outlines emergency operations for activities immediately before, during and after a disaster. According to the Plan, emergency operations can be initiated by either:

- The National Disaster Controller (the Permanent Secretary for Regional Development); or
- The Divisional Commissioner, provided they first notify the National Disaster Committee and the emergency is in their area of responsibility.

National processes for alerting people to the threat of floods start with the monitoring and notification of tropical cyclones (alerts as well as warnings to government agencies as well as the public). Naturally this is only relevant to Navua where a potential flood results from a tropical cyclone and not when flooding is the result of persistent and heavy rain higher up in the catchment.

The Fiji Meteorological Services Tropical Cyclone Warning Centre in Nadi is responsible for providing information and advice concerning tropical cyclones. It issues:

- routine weather bulletins;
- special weather bulletins (when there is a need to put the community on alert, provide progress reports or provide warnings); and
- ‘flash’ bulletins (to advise of substantial changes in a situation (Government of Fiji 1995).

A tropical cyclone alert is issued whenever there is a significant possibility of a tropical cyclone developing in or moving into Fiji, with the possibility of generating gales or stronger winds within the next 36-48 hours. A warning for tropical cyclones is issued when there is an imminent threat.

Additionally, the Public Works Department in Suva is responsible for notifying relevant agencies of floods in general.

According to the Plan, general operational activities to be conducted in the event of a disaster include:

- survey and assessment of the area (preliminary damage assessment, casualties, relief requirements);
- rescue;

- treatment and care of casualties;
- clearance and access (road, airfields, ports, bridges, jetties) to allow access to vehicles, aircraft and shipping;
- communications (reestablishment of phone and radio links);
- evacuation;
- shelter;
- food;
- water and power supplies (re-establishment of supplies or temporary arrangements);
- health and sanitation;
- security (maintenance of law and order and prevention of looting and unnecessary damage);
- basic clothing; and
- basic household utensils for food preparation.

Dredging

The key management tool to mitigate flooding around Navua has been the dredging of the river mouth. The most recent dredging activity was conducted in late 2006. The purpose of the dredge was to reduce the effects of flooding in the Navua Delta (Government of Fiji 2006a). Dredging also occurred in 1982 and 1992 (Lata undated).

According to the Government of Fiji (2006b), further dredging is to occur from the river mouth to Navua market which is upstream and it would be a new project for which tenders would be issued.

Unfortunately, dredging is very costly and a short-term solution with its efficiency and economic benefits only poorly understood. The dredging of the Navua River mouth in 2006 costed some FJ$2 million alone.

Specifications of the Proposed Warning System

The following description of the proposed flood warning system for Navua is taken from Bonte-Grapentin (2006; personal communications, February 2007). The general features of the flood warning system are:

- flood forecasting based on rainfall and river level monitoring; and
- dissemination of flood alerts and warnings to emergency agencies and the general public.

Flood forecasting

In order to predict and forecast flooding in Navua it is important to know how much rain is falling in the catchment and how high the river levels are and how fast they are rising. The Navua flood detection system involves a combination of 3 river levels and 6 rainfall gauges placed at strategic points of the catchment.

River level gauges. Information on river levels upstream is the primary source of data for flood forecasting. The Navua flood warning system involves three river level gauges (Map 2 re-printed below):

- Nakavu river gauge is located at the outlet of the Lower Navua Gorge, approximately 15 minutes[2] upstream of Navua town. Nakavu is an existing station with a 35-year hydrological record. Under the SOPAC/EU Project, it has been upgraded to act as a control site.
- Sabata river gauge is located at the upstream end of the Lower Navua Gorge, approximately 60-75 minutes upstream of Navua town. Sabata is a site newly established under the SOPAC/EU Project and is located to measure almost the entire discharge of the Navua catchment whilst being significantly upstream of the population centres on the delta (thereby providing advance indication of flooding).
- Nabukelevu river gauge is located upstream of the Upper Navua Gorge, approximately 2.75-3.25 hours upstream of Navua town. Nabukelevu is also a site newly established under the Project. It is located to measure about one third of the catchment's discharge whilst providing a good early indication of flooding.

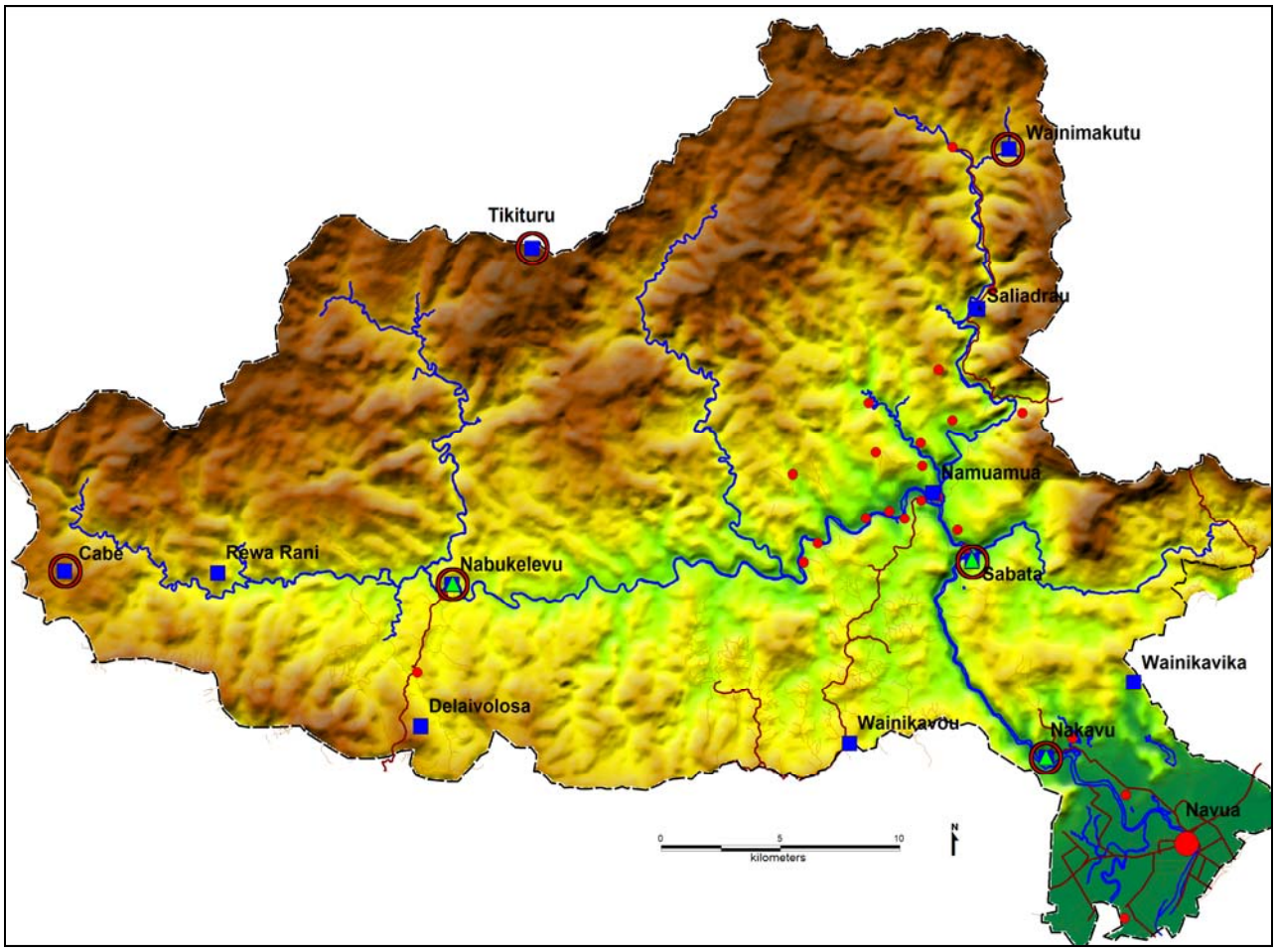

Figure 2. Hydrological network of the Navua catchment. Hydrological network of the Navua catchment. Green triangles indicate water level gauges (all but the one at Tikitura already exist). Blue squares rain gauges (the Nakavu station already exists whereas the Sabata and Nabukelevu ones are yet to be established). Red circles indicate proposed telemetric sites and red spots indicate villages.

[2] The time estimates indicate the approximate travel time of a flood wave. Note that the travel time depends on the height of the flood wave. Larger floods tend to travel faster.

Figure 4 shows river stages recorded at the three sites from 18 September to 22 November in the 2007. It is clear that the Navua River at Nabukelevu (red) peaks before Sabata (green) and Nakavu (blue) a relationship used to provide flood forecasts and warnings for Navua. Nevertheless, it should be noted that Nabukelevu represents only one third of the catchment and the timing and severity of flooding can be modified by whatever is happening in the remaining two thirds.

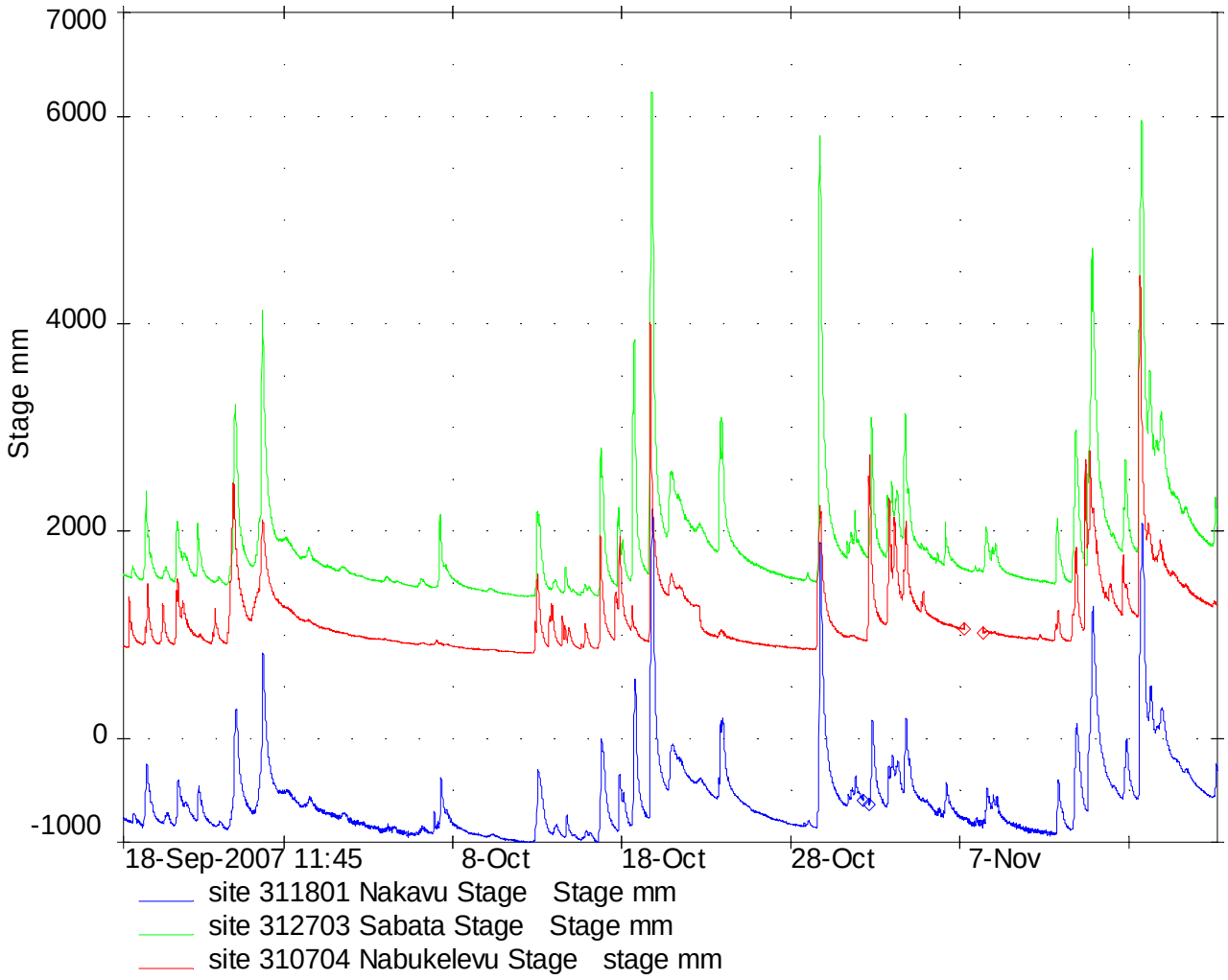

Figure 4. Indicative river heights along the Navua River.

Rainfall level gauges. Because of the risk that the timing and severity of flooding can be modified by whatever is happening in the rest of the Navua catchment, and in order to allow longer flood warning lead times, a number of rainfall recording stations are to be used in addition to the river level gauges to help predict floods. Before the levels in rivers rise, some time is required for rain to run off the land and concentrate in creeks and thence run into streams. Though this time is short in an environment like Fiji with steep slopes and high intensity rainfall, the inclusion of rainfall data is still expected to add 1-3 hours of warning time for a flood. In practice, many factors control how much rain enters the streams and how fast river levels rise – this includes factors such as pre-existing soil moisture levels, local topography, geology and land use. Consequently, a flood forecasting model including rainfall recordings will need some refinement over time.

Expected warning times from the Navua flood warning system would be in the region of 2-3 hours if only river gauge data was used. With rainfall data included as well, flood warnings from the Navua flood warning scheme should ultimately be as high as 3-6 hours. The flood forecast will initially be based solely on the river level recordings. However, it is expected that enough rainfall data will be available after the wet season 2007-2008 to refine the forecast model and increase flood prediction (Michael Bonte-Grapentin, SOPAC Risk Assessment Specialist, personal communication, 25 October 2007).

The Navua flood warning system will operate six rain gauges (see Figure 2): three in the Navua River valley combined with the river level gauges at Nakavu, Sabata and Nabukelevu; and another three located at the margin of the catchment at Cabe, Tikituru and Wainimakutu (Figure 2). An example of the type of gauge used is given in Figures 5 and 6.

Figure 5. Nabukelevu gauge.

Figure 6. Nabukelevu gauge.

Four of the rainfall stations already exist and have previous rainfall records. However, those at Nabukelevu and Wainimakutu were only manual in operation, meaning that an operator had to travel to the stations daily to collect data for analysis. Under the SOPAC/EU Project, those existing rainfall stations are to be replaced to enable data to be automatically recorded every 10 minutes.[3] This allows the analysis of rainfall intensities which is important for flood analysis and can not be done with mere daily rainfall data. The stations at Sabata and Tikituru will need to be established from scratch and start new records. Sabata could build on the records from nearby Namuamua. For hydrometeorological investigations and flood analysis in particular it is important to rely on relatively long monitoring records featuring several major flood events.

Communication of river and rainfall data. River levels and rainfall at each of the stations are to be monitored at 10-minute intervals with data telemetrically transmitted every 3 hours under 'normal' conditions and, in the case of a potential flood event, transmitted more frequently with transmission intervals of up to 10 minutes. The data is transmitted via a VHF radio system to a base computer at the Department of Public Works Hydrology Section in Wailoku/Suva, which is linked via broadband internet to a second base computer at the Nadi Meteorological Office. The Department of Public Works Hydrology Section is the lead agency in maintaining the system and

[3] Stations will still have to be inspected and serviced about every 3 months to ensure smooth operations.

responsible for all field operations, including discharge measurements of flood flows and flood field assessments.

During a flood event, field stations will transmit an alarm to the base stations as soon as predefined critical river level or rainfall intensities are reached. The operators at both operational centres (Suva and Nadi) will then manually examine the data of the gauging stations and graphically display the incoming data to obtain an overview of the situation. He or she will then interpret the data to determine whether flooding is likely to occur. An automatic flood forecast model will then estimate when flooding is likely to occur and to what degree of severity.

The relationship between the rainfall monitoring component of the system and the river level gauge component is summarised in Table 5 below.

Table 5. Rainfall monitoring and river water monitoring in the proposed Navua warning system.

Component	Strength	Weaknesses
Rainfall recording	▪ Relatively long warning times. ▪ Relatively low installation costs (half that of river gauges).	▪ Relatively high uncertainty in prediction. ▪ Relatively high number of units needed (representative of catchment rainfall), sometimes in very remote areas.
River Gauges	▪ Relatively high certainty in prediction (measured not calculated).	▪ Relatively short warning times. ▪ Relatively high installation costs (roughly twice that of river gauges). ▪ Relatively high maintenance costs. ▪ Only few sites suitable for installation.

Alerts and warnings

As outlined in the Navua Flood Response Plan (National Disaster Management Office (NDMO) undated), the Nadi office of the Fiji Meteorological Service (FMS) will act as the lead agency for issuing flood alerts and warnings. The Department of Public Works Hydrology Section will provide technical advice to the Meteorology Office during hours of operation. There are two key reasons for this. First, although the Suva Hydrology office is the lead agency to maintain the Navua flood prediction system under the SOPAC/EU Project, it only operates during normal working days from 8 am to 5 pm which means that it cannot interpret information or release alerts and warnings every day 24 hours a day. By comparison, the Nadi Meteorological Office operates 24 hours a day and 7 days a week, enabling warnings and alerts to be determined and issued at all times, including night time and weekends. In addition, the Nadi Meteorological Office already operates as a regional warning centre for cyclone and weather-related natural disasters. It therefore has much of the capacity and system in place to manage the Navua flood warnings and alerts.

Flood alerts and warnings have similar but nevertheless distinct purposes. An alert is used to indicate that a flood *might* happen; a warning indicate that it is *about* to happen. A special flood alert for Navua will be issued based on the general weather radar observations by the Nadi Meteorology Office as soon as a bad weather system (tropical cyclone, tropical depression or trough) is identified which could cause intense rainfall in Central and Southern Viti Levu (see figure XY). The alert will inform key agencies to be on stand by and make preparations to activate the local response arrangements, if necessary. A warning is issued as soon as (sub-) critical rainfall or river level conditions are reached and flooding is predicted by the flood warning system. A severe flood warning will be issued, if flood levels are expected to reach or exceed flood levels of the 2004 flood. Detailed dissemination of flood warnings are to be detailed in the Navua Flood Response Plan which is currently still being designed (see Navua Flood Early Warning System and Response Plan, currently being considered by the Government of Fiji for approval).

Figure 7. Possible alerts and warnings for flood warning systems.

FLOOD ALERT (YELLOW)	Flooding is possible. Be aware of this. Be prepared! Watch Out!	Issued at least 24hrs in advance by Fiji Meteorological Office to media & key agencies
FLOOD WARNING (RED)	Flooding of homes, business and main roads is expected. Act Now! Please Evacuate!	Issued by FMS 2-3 hrs prior to flooding event to media, all relevant agencies & txt alerts
	Severe Flooding expected. There is immediate danger to life and property. Evacuate Now!	Issued by FMS (as soon as practical) prior to event to all agencies and media.
ALL CLEAR (GREEN)	There are no Flood Alerts or Warnings currently in force.	Issued by FMS after consultation with Hydrology and sent to all agencies and media

Technical needs

To implement the system, funding and technical advice was provided through the SOPAC/EU Project as follows:

- Conduct reconnaissance surveys of selected water level/rainfall recording sites as well as work to upgrade and/or establish sites.
- Upgrade the hydrological network (e.g. establish telemetry systems, replace rain gauges, establish telemetric rain gauges etc).
- Develop a flow prediction model to enable prediction of potential flood impacts.
- Supply software and base station.
- Develop a flood alert/warning system based on predefined flood impact levels.
- Develop effective means for distribution of flood alerts/warnings, raise awareness of flood risks and develop appropriate response plans/mechanisms at the national and local level.

C ASSESSMENT METHODOLOGY

Assessment of the economic value of the proposed warning system involves a benefit cost analysis, which is a technique that evaluates the benefits and costs of a project from the perspective of society (as opposed to a single individual). It involves:

- measuring the gains and losses to the community, using money as the measuring rod for those gains and losses.
- aggregating the monetary valuations of the gains and losses and expressing them as net community gains or losses (Pearce 1983).

In this analysis, the losses sustained in the most recent serious flood to hit Navua – the 2004 flood – are calculated and used to estimate the potential benefits from a flood warning system.

With and without scenarios

The economic benefits of a flood warning system is the value of reduced losses arising because of it. In practice, a warning system is likely to reduce the scale of losses that the Navua community would incur in the future. However, it would be unable to prevent them experiencing all losses. This is because a sufficiently timed warning would only enable families and businesses to prepare for the flood (protect some possessions, protect themselves and families and livestock) but would not prevent the flood from taking place. Some residual damage would therefore be inevitable, such as the loss of buildings or the destruction of crops that could not be moved.

The economic benefit of the flood warning system is therefore the difference over a certain time period between the value of economic losses that are likely to occur *without* the flood warning system (e.g. the losses a repeat of the 2004 flood would impose today) and any reduced value of losses likely to occur *with* it. In economic terms, this involves a 'with and without' analysis of flooding in Navua.

Without scenario

Losses arising from floods (or disasters generally for that matter) are commonly categorised as direct, indirect and intangible effects (see McKenzie et al. 2005 for details). Direct costs reflect immediate tangible damage accruing to people and assets (houses destroyed, injuries sustained) and indirect costs reflect tangible costs arising following the flood (illnesses arising from loss of hygiene facilities, loss of future earnings from agriculture due to destroyed land). Intangible costs reflect non-physical damage from floods such as trauma from disasters or loss of records or community spirit.

Without the flood warning system, businesses and families around Navua will continue to have insufficient warning about oncoming floods with the likelihood that the types of losses sustained during the 2004 flood would also be sustained to various degrees (depending on the severity of the flood). Information on the types of losses sustained in the 2004 floods is given in NDMO records describing damage and assistance provided by the Government, charities and other agencies and individuals.

Accordingly, losses arising from the 2004 flood comprised losses to householders and businesses (as people lost homes, premises and possessions) as well as the value of assistance provided from national agencies, local charities and NGOs, international donors and other humanitarian agencies. (Such donations – although they are given for free – represent economic resources that could be used valuably in a range of other situations. There is therefore an

economic cost of Navua flooding, even if these were freely donated.) Additionally, the personal losses to families (injuries, loss of loved ones or pets, irreplaceable possessions etc.) are likely to be important.

To mitigate some of these losses, the Government of Fiji pays compensation to householders and businesses experiencing severe flood losses, provided that they can prove their need. For instance, the government may provide financial handouts to assist in establishing replacement shelters or may even construct shelters for families. Such compensation reduces the financial value of losses to households and businesses. However, they represent real costs to the Government which uses financial reserves to provide assistance. Consequently, payments made by the Government of Fiji to householders and businesses are also economic losses.

The total economic cost of the 2004 flood was estimated to comprise:	household losses + business losses + government losses + humanitarian aid + other (trauma etc) losses

With scenario

The economic benefits of the flood warning system for Navua would be any reduction in the direct, indirect or intangible costs of flooding that are achieved. A key challenge lies in estimating which reductions are likely to occur and the scale of those potential reductions.

With sufficient warning from the flood warning system and appropriate action from the community, certain damages from a flood could be either largely avoided or at least reduced. Likely changes could include those noted in Table 6.

Table 6. Potential benefits from a warning system.

Type of benefit of the warning system	Type of cost
People have time to evacuate the area and avoid injuries from flood exposure	Immediate medical costs
People have time to move more personal possessions and moveable business and/or government assets (e.g. computers, electricals, clothing, vehicles, livestock) to higher ground or protect them	Personal and commercial financial costs
People avoid later sickness by having the time to store clean water, medical provisions and tarpaulin etc. in readiness	Subsequent medical costs
People potentially able to reduce days lost resulting from injury by having time to flee floods (but unlikely to be able to get to work any faster as infrastructure damage unavoidable)	Lost income (due to business damage, inability to get to work because of infrastructure damage etc.)
People suffer reduced stress and trauma as they have time to protect more possessions and avoid injury	Trauma from flooding, loss of personal possessions, pets, records etc.
Reduced harm and losses to families means that the government and humanitarian agencies need to provide less medical, food or other assistance and/or have to spend less time coordinating efforts	Government and humanitarian assistance

Estimation of benefits from a flood warning system is based on the losses incurred in Navua in the 2004 floods. These are estimated using a combination of business and household surveys (see section E) and assumptions about the proportion and type of savings that could have been achieved had a flood warning system been in place at the time. For instance, consultations with Department of Health staff indicate that a flood warning of just a few hours in Navua might have been sufficient to save all key medical machinery and provisions. Assumptions about the proportion of cost savings that are expected to be achieved through the warning system are based on discussions with individual agencies/individuals as well as a participatory exercise with key agencies involved in the steering committee for the Navua warning system project (see Annex 3). Assumptions are given in section F.

Costs of flood warning systems

The costs of flood warning systems reflect establishment costs as well as operational costs (Table 7). These involve technological investments (operational software systems and hardware such as gauge VHF transmitters), technical advice from key agencies and a communications system to alert stakeholders of imminent floods. The majority of the investment for the system would be expected to take the form of establishment costs, that is, the establishment of the system and the education of users (including the community). Maintenance would also be needed throughout operations as well, presumably, as on-going awareness raising to ensure that the Navua community are advised what to do in the event of a warning. The value of these costs will need to be determined.

Table 7. Costs of flood warning systems.

Establishment costs	Operational costs
▪ Equipment (e.g. transmitters, river gauges, rainfall gauges)	▪ Maintenance
▪ Software (e.g. flood prediction models)	▪ Awareness raising
▪ Technical advice and training on how to use the system	
▪ Communications systems to alert people	

The appropriate time frame for evaluating costs is the life span of the technology involved. This is because it has already been determined under the SOPAC/EU Project that a warning system would be introduced and there are few options within this. The life span of the system being proposed is difficult to determine with certainty since it depends on ongoing maintenance. The warning system put in place for Rewa ran for 20 years before ceasing to function. (Michael Bonte-Grapentin, SOPAC Risk Assessment Specialist, personal communication, 17 January 2007). On the basis of the durability of the Rewa system, 20 years is the proxy benchmark used for the lifespan of the system for Navua.

Monetisation of benefits and costs

Once the benefits and costs of the flood warning system have been identified, they need to be converted to monetary values. There are a number of procedures for calculating the monetary value of benefits and costs. For details see Tietenberg (2000), Wills (1997) and for a summary relevant to this exercise, see Hajkowicz and Otakai. (2005).

The approach taken in this analysis will be to identify cost savings that could be achieved through the use of the flood warning system. In some cases, it would not be possible to convert the benefits of using a warning system to monetary values. For instance, an effective warning system may result in families experiencing reduced levels of trauma if they were able to avoid injury or save some irreplaceable possessions. However, it is unlikely that it will be possible or practical to monetise trauma in the first place. Where values cannot be monetised, the net value of the warning system is supplemented by a description of the values not included in the calculation. This limits the meaning of the benefits and costs calculated and requires that both qualitative and quantitative values are considered to assess the true contribution of the scheme to well being. It is critical to realise that although some benefits may not have a monetary equivalent attached to them at the end of this analysis, they remain valuable nevertheless.

Annualisation of benefits

Depending on whether the 2004 flood was a 1–in-20 year event or a 1-in-10 year event, it is likely that the Navua community would benefit from a flood warning system on average at least once and perhaps twice over the expected lifespan of the warning system (20 years). (Realistically, the community would benefit more than this since other floods may also occur in this period and the warning system would be used to assist the community with these, too.)

The total likely benefits from the warning system over the 20-year period will be determined and then averaged per year over the period ('annualised') to reveal the likely nominal value of benefits gained *each year*. Even though a flood is not in practice spread over 20 years[4], the figure generated enables average benefits over the life of the system to be calculated. This information is sufficient to plan for investing in flood warning since it enables the calculation of average returns from investing in flood warning.

Time preference

The benefits and costs of a project such as the proposed warning system for Navua occur over time, usually with costs occurring earlier in the piece (in preparing for a flood) and benefits not being felt until later when the flood happens. For Navua, the costs of the warning system (upwards of FJ$130 000) would be paid in the first year of its life but, as already noted, there would in all probability be only one or two major floods of the 2004 magnitude occurring on average during this period[5]; and it might be several years before the first one occurs. In that time, no tangible benefits would appear to be generated by the system (save, perhaps, peace of mind of knowing that the system is ready) and the value of the system would look poor. Understandably, these time lags between costs and benefits complicate assessing the value of the warning system.

The issue is further complicated by the fact that people generally have a preference for money sooner rather than later. In other words, they place more importance on money values (benefits or costs) incurred earlier than later. This 'positive time preference' is accommodated in benefit cost analysis by weighting earlier monetary values of costs and benefits more heavily than later monetary values of benefits and costs. The total value of benefits and costs over time are then presented as present-day values. The procedure to convert the values of gains and losses generated over time to present-day values is termed 'discounting'.

[4] For instance, a 1:10 year flood would on average occur twice over a 20-year period. However, the benefits of a warning system would be higher if the two floods occurred in years one and two, rather than being spread evenly over the entire period. In this case, the benefits of the system would be substantially higher.

[5] Depending on whether the 2004 flood was a 1-in-10 year event or a 1-in-20 year event.

The expected value of annualised benefits from the Navua warning system will therefore be discounted over time to generate an overall pay off to Fiji of the system in current-day values.

The rate at which later values should be discounted in comparison to earlier ones has been under debate for some time in economic circles and is unlikely to be resolved (see Pearce et al. 2003 for examples). Key themes in the debate are noted below.

Discounting and the Navua economic analysis. The standard approach to discounting money values in economic analysis has been to use interest rates on investments (say with the government or banks) as a proxy since this reveals how much more money people will demand before they can be induced to surrender their savings now before getting something back later. For example, if an investor demands a return of $1100 before he or she can be induced to surrender $1000 of savings for a year, this reveals that the discount rate he or she uses is 10 per cent.

Current commercial bank rates for investments in the Pacific are currently around five to seven per cent which indicates that the discount rate for this analysis should be around the same values. On the other hand, Woodruff (2006) observes the long held argument by many economists that communities as a whole have lower discount rates since they are willing to wait longer for benefits, compared with private or commercial individuals. This suggests that the discount rate should be lower than the commercial interest rate available to the Pacific. This is important where the proposed flood warning system only offers benefits every few years (when a flood actually occurs). Where the benefits of an investment are slow to eventuate, as in the case of a Navua flood warning system, the discount rate may need to be lower than the commercial interest rate. In fact, the UK Treasury, in its recently released Green Book, Appraisal and Evaluation in Central Government, recommends that public sector bodies use a discount rate of only 3.5 per cent for international development assistance projects. (See HM Treasury 2006, Annex 6.)

As a result of the debate on discount rates, the discount rates used throughout the Pacific for environment and development projects have varied widely in the past three years alone, from 3 to 12 per cent with 10 per cent being the most commonly used figure (see as examples Cesar et al. 2004; Jacobs 2004; Hajkowicz and Otakai, 2005; Mohd-Shahwahid 2001; Campbell 2006; Woodruff 2006; Greer Consulting Services 2006; McKenzie, et al. 2006; Lal et al. 2006; Lal and Takau, 2005; Pesce and Lal, 2004; McKenzie 2004; Greer 2005). The figure of 10 per cent is consistent with ADB (2006) guidelines that state that its practice is to apply a discount rate of 10-12 per cent on development projects.

Because there is uncertainty in the appropriate discount rate generally in the Pacific and specifically for Navua, this analysis will be conducted using discount rates of 3, 7 and 10 per cent.

Comparison of benefits and costs

Once benefits and costs are identified, monetised and discounted to present-day values, there is a need to compare the value of benefits and costs to consider the return from investing time, energy and resources in the warning system. Comparison of benefits and costs may take several forms. The two approaches used in this analysis are:

Net present value: this is the difference between the total value of discounted benefits and the total value of discounted costs. This 'net value' reveals the social return on the investment. This is similar to a financial return on an investment but is not limited to financial concerns. The benefit cost analysis is intended to represent broad societal and national interests such as the value to the community and government of using the system. If the resulting net present value is greater than zero, the scheme is economically viable.

Benefit-cost ratio: the value of total discounted benefits are compared with the value of total discounted costs. If the ratio of benefits to costs is greater than one, the scheme is economically viable.

Scope of analysis

As indicated in section B, this analysis is focused on the economic returns of investing in flood warning only. The analysis will not include any assessment of the value of disaster risk reduction activities (potential changes in land use, introduction of new laws etc.). That analysis falls outside the scope of this study, although the introduction of successful risk reduction strategies would certainly impact the Navua community.

The benefits gained from a flood warning system will vary across stakeholders. Investment in a flood warning system for Navua will have its greatest impact on the residents of Navua and nearby. The economic return to the community of Navua is almost certain to be positive, given that the benefits of the system will be felt most directly by businesses and residents there and the costs are to be funded externally through the SOPAC/EU Project, Government of Fiji and other stakeholders.

On the other hand, the investment occurs at the expense of the Government of Fiji and international agencies who devote their time, expertise and funds to it. This is an important issue as the return to donor investments of the Navua system is likely to influence future investments in flood warning systems in the region (both in terms of advocacy and design). Accordingly, this economic analysis will be conducted from the perspective of not only the community but also of agencies contributing to the establishment and operation of the system.

Sensitivity analysis

Estimation of the economic value of the warning system will involve making assumptions about the benefits or costs generated by the system, its success, operation or other parameters. Where the value of the items are uncertain, a sensitivity analysis will be conducted in which the different types of benefits arising from the warning system will be determined using different assumptions and thereby generating ranges of values. In this respect, estimations will be made according to a worst case, most likely case and best case scenario where scenarios are discussed with stakeholders.

Realising benefits

Calculating the expected benefits of the warning system through a benefit cost analysis involves predicting the impacts of the investment. The benefits estimated are therefore only potential and are not yet realised. The estimated benefits of a flood warning system hinge on the assumption that appropriate communications occur to alert the community of an oncoming flood and that the community responds appropriately. This study identifies such issues affecting the realisation of potential benefits and discusses them in detail in section F.

D DATA COLLECTION

Information on the costs to the Government of Fiji of addressing flooding in Navua and contributions from other agencies (charities, NGOs, international agencies) was collected from the government. (Detailed information is given in section E.)

However, there was limited data available on the impact of flooding on families in Navua specifically or on local businesses (other than agricultural impacts). In addition, information relating to whether the benefits of the warning system might actually materialise in practice (such as how warnings would be communicated to the community, for instance, whether people even own a phone in order to be reached); as information provided in the 1996 census was considerably out of date. Accordingly, an economic survey was conducted of key areas of the Navua township. The purpose in the survey was to get an idea of:

- the extent to which people suffered as a result of the last flood (2004), including how much they lost commercially and personally – this would inform the potential benefits of avoiding a flood through early warning should a repeat of the 2004 flood occur.
- Access to phones, media and power – this would inform how the authorities would need to communicate warnings to families and businesses to ensure that potential benefits of early warnings could be brought to fruition.
- Educational and race background and knowledge of escape routes and evacuation centres – this would inform the kind of information people would need to be given and how to get it to them.
- Attitudes to floods – this would inform how people are likely to react to a warning of a flood (such as whether they would pack up and escape if sufficient time existed or whether they were more likely to wait for help).

Survey design

Several questionnaires were used to cover:

- households;
- businesses; and
- market stalls.

All questionnaires used closed and open-ended questions. Questionnaires used for residents and businesses were highly detailed and investigated attitudes related to the 2004 floods as well as losses and access to communications. By comparison, the market questionnaire was kept to a strict minimum on the understanding that businesses could change frequently and that people had limited access to communications. Unfortunately, this also meant that some information opportunities were lost, but also meant that the demands on stall holders were limited. Questionnaires used are given in Annex 2.

Twenty-eight (28) staff from across SOPAC, NDMO and the University of the South Pacific conducted interviews with local residents during 7-13 March 2007. Interviewers were given a day's training in the conduct of the survey. SOPAC staff keyed in data and conducted the analysis.

Sampling for the household surveys was based on the districts employed by the Fiji Bureau of Statistics in conducting its census. The Fiji Bureau of Statics divides the country into a number of enumeration districts of between 80 and 120 households each for the purposes of census – 100 households per district on average. Fourteen (14) enumeration districts were used to cover downtown Navua and its hinterland – thirteen (13) districts from Serua and one (Nakavu Village) from Namosi. This covers outer Navua along the river and stretches as far as Nakavu to the west. Enumeration districts used for the survey are displayed in Figure 8.

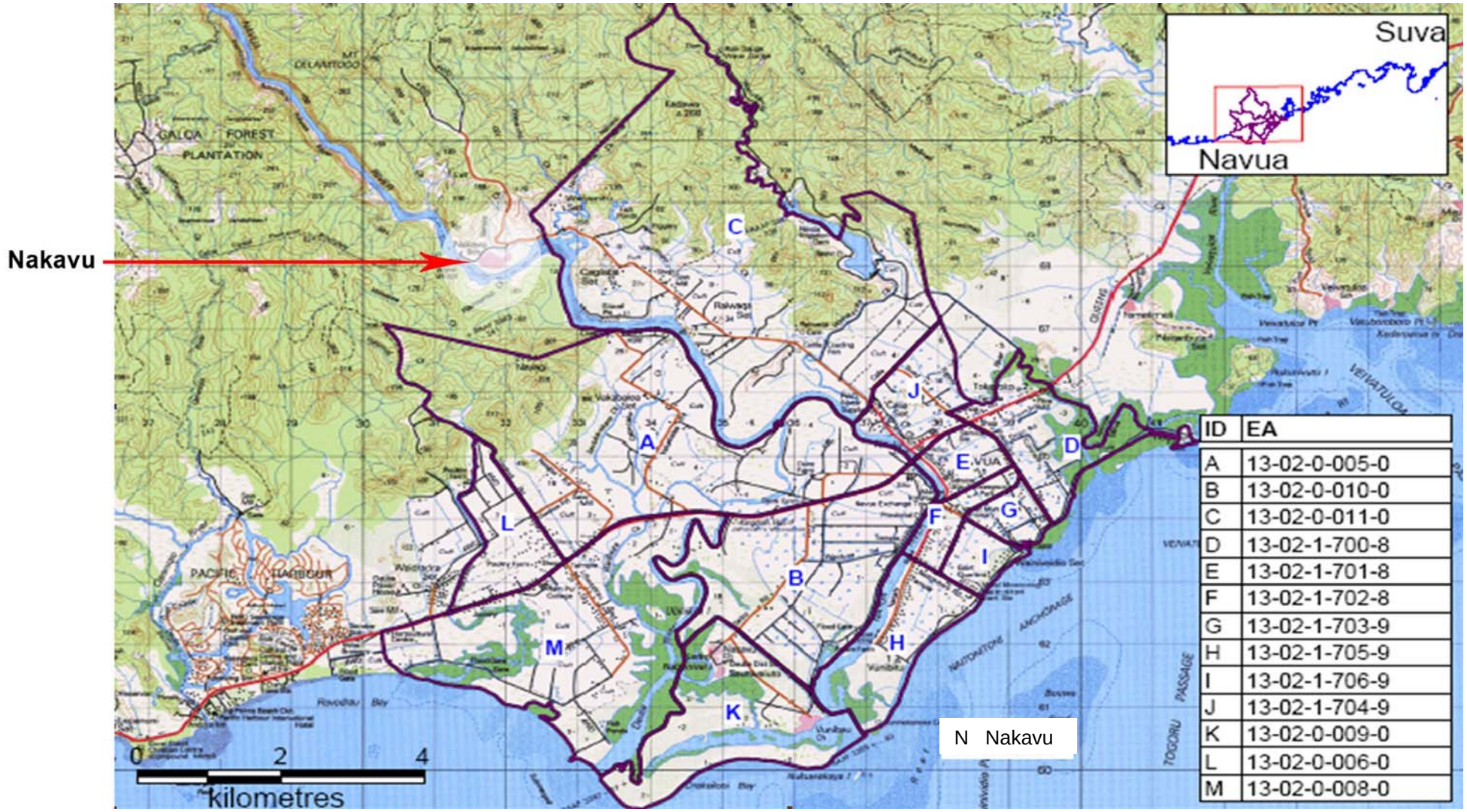

Figure 8. Navua economic town survey: enumeration areas. (Source: SOPAC Secretariat)

Population sizes

Household surveys

The definition of a household was taken from the 1996 census (Bureau of Statistics, 1998, p. 13):

> Those persons who usually ate together, food prepared for them in the same kitchen and who together shared the work and cost of providing the food.

The average number of occupants in a house in 1996 was estimated to be 5 (SPC 1999). According to the Bureau of Statistics, the population in Navua in 1996 was around 7000 (Vasemaca Lewai, Statistician, Bureau of Statistics, Fiji, personal communication, 7 February 2007). This is consistent with an average household size of five people per house as follows:

Total population size in Navua survey area	= 14 districts x 100 households x 5 people per household	= 7000

In reality, these figures are now likely to be outdated since they were 11 years old at the time of analysis and there has been inward migration of former lease holders to the region in the last decade and a national flight of many Indo-Fijians following the 2000 coup. However, since no census or population survey covering Navua had been conducted since the last census, the figure of 7000 inhabitants was used as the population estimate for the town.

Business surveys

Information on businesses licensed to operate around Navua was available from the Serua Provincial government office. Data was provided on all businesses licensed for the area and those businesses falling outside the survey area were omitted. There was some duplication remaining in those businesses left in the Navua area in that some businesses held more than one license but acted as a sole commercial enterprise (for instance, dairies and cafes). Some businesses were also recorded more than once in the provincial listing. Additionally, some of the businesses licensed by the provincial government operated outside of the survey area. The estimated number of total businesses actually operating in and around the survey area after accounting for these exceptions are given in Table 8.

Table 8. Total number of commercial enterprises around Navua survey area.

Businesses	Population size
Market stalls	55 **
Other operations *	167
TOTAL	222

* Businesses overall comprise market stalls and other operations. Market stalls are licensed separately from other commercial operations so there should be no overlap between the two groups. Other operations include: small retail, restaurants, hawkers (not stall holders), small retailers (including hairdressers and other services), canteens and dairy shops, video hire operators and taxi drivers) etc.

** According to the Department of Health which holds the data, there are supposed to be around 34 stalls operating at the Navua market but 55 were observed in total during the week of the survey so this was used as the population.

The breadth of businesses operating in Navua was wide, ranging from market vendors to large-scale retail and wholesale operations. Business operations were categorised according to their estimated size as indicated in Table 9.

Table 9. Business groupings for Navua area.

Size		Business	Population size
Larger ↓ Smaller	Category A	Large retail/wholesale operations *	30
	Category B	Video shops, restaurants, small retail, canteens, bakeries	88
	Category C	Taxis, hawkers, vendors	49
		Market stalls	55
TOTAL			222

* includes service stations

Sampling

Within the districts, sampling was random. The target in survey design was to achieve a household sample size of around 15 per cent. Accordingly, interviewers were directed to target every sixth house for interview in the survey.

For businesses and market stalls in the Navua central business district, interviewers were directed to target every second enterprise. For businesses and stalls outside the central business district, interviewers targeted whoever was available. Given the limited time available for the survey (one week), only one business from the smallest business category was interviewed. This meant that any calculations based on this single interview for the category would be statistically unreliable. Responses for taxis/ hawkers/vendors were therefore merged with the responses for market stalls which were of relatively the same scale of business. The final sample size used for survey calculations were as given in Table 10.

Table 10. Sample size for Navua EWS economic survey.

	Sample size (households or business)	Approx. pop size (households or business)	% representation (average district contains 100 households)
Households	225	1400	16
Business A	10	30	33
Business B	40	88	45
Business C (small businesses and market stalls combined)	18	104	17
Total businesses	68	222	31
Total responses	293	n.a.	n. a.

E ESTIMATED LOSSES FROM THE 2004 FLOOD

Estimates of the value of these losses are made in this section. As noted in section C, the total economic cost of the 2004 flood comprised:

household losses + business losses + government losses + humanitarian aid + other losses

Losses accruing to households and businesses are estimated on the basis of the survey described in the previous section. Estimates of loses sustained by the government and contributions made by agencies are based on government documentation.

Household losses

Information from households on losses sustained during the 2004 floods were averaged across districts and then used to generate average losses for the whole area. 16 per cent of households across the entire area were interviewed, of whom 96 per cent experienced the 2004 floods in Navua. Overall, the majority of those who experienced the floods stated that they suffered as a result (60 per cent), with some districts suffering more than others. Householders located in district B most frequently stated that they suffered (but not the most costly – see below). By comparison, householders in neighbouring district C stated least frequently that they suffered as a result of the flood (Figure 9).

The variation in frequency with which householders claimed to have suffered as a result of the flood is not clear. In the case of districts B and J, the high incidence of suffering is possibly due to the fact that flood waters are channelled into these districts by the bridge (B and J) and by the presence of poorly maintained irrigation channels (M. Bonte-Grapentin, Risk Assessment Specialist, SOPAC, personal communication, 11 April 2007). However, the reason for a lower incidence of flooding further along the river is unclear, although elevation may be important in some cases.

There was little apparent relationship between the number of times householders in a district said that they suffered as a result of the 2004 flood and the extent to which they prepared for it (Table 11). For instance, over 90 per cent of householders in district H said that they moved some of their possessions to higher ground in preparation for the flood, with only just over half then saying that they suffered as a result of the flood. On the other hand, over three quarters of householders in districts A and B did the same thing but still suffered. (72 and 88 per cent of householders in districts A and B claimed to suffer as a result of the flood.)

Table 11. Preparation for flooding and incidence of suffering.

District	% stating they suffered as a result of 2004 flood	% who moved possessions in preparation for the flood	% adopting other measures in preparation
A	72	78	0
B	88	88	31
C	46	38	15
D	65	71	59
E	53	42	26
F	53	41	12
G	67	56	33
H	53	93	27
I	47	65	12
J	74	53	11
K	50	86	21
L	50	43	21
M	54	69	8
Nakavu	60	73	27

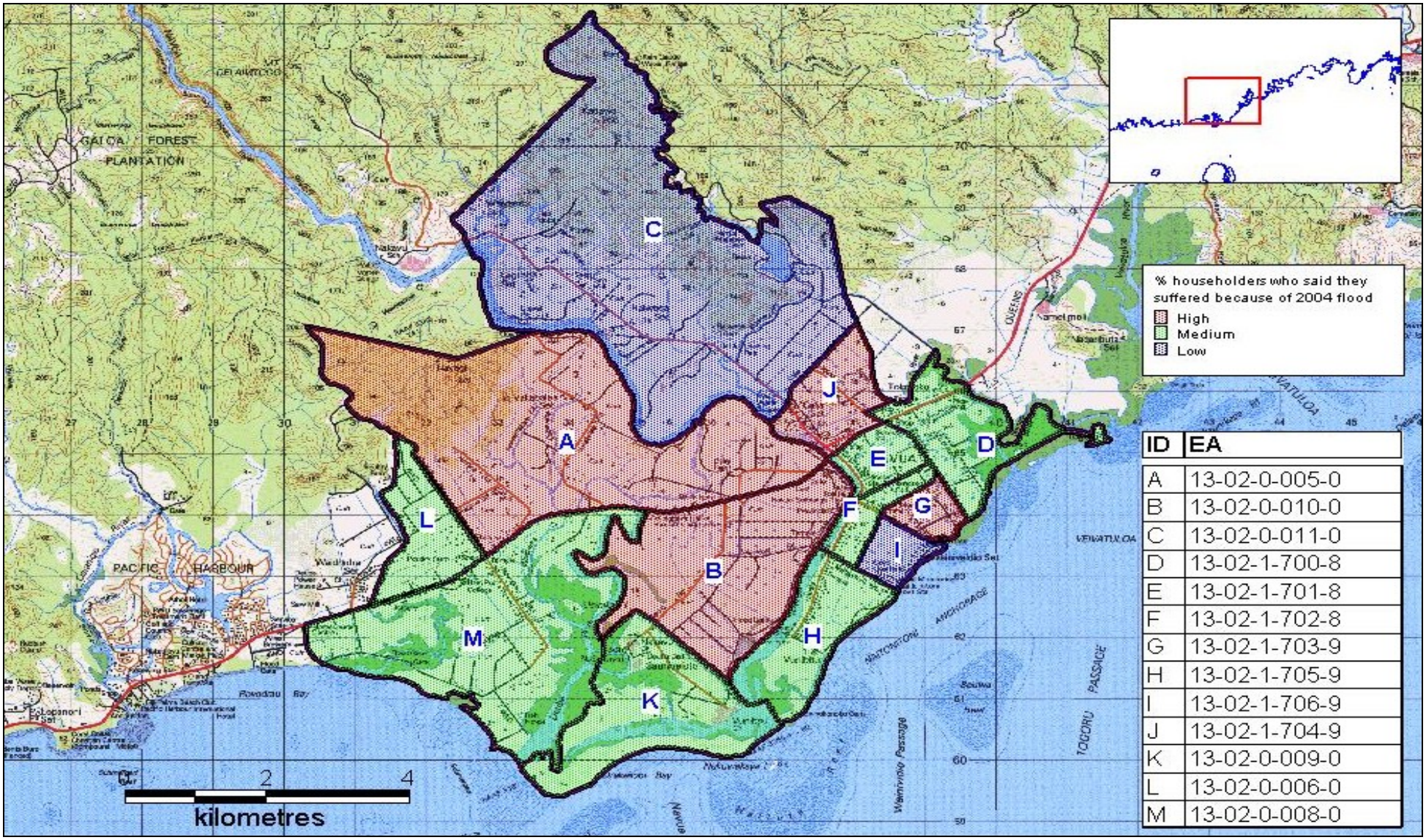

Figure 9. Frequency of suffering from the 2004 Navua floods.

Value of losses and suffering

Information generated from the household survey was used to determine the different types of losses (household costs) arising from the 2004 flood:

- Direct:
  - Material losses (damage to/loss of housing, possessions) resulting in financial harm
  - Physical harm arising directly from the flood (injuries sustained)
  - Income losses (inability to work because of health problems, inability to reach work, damaged premises etc.)
  - Costs of evacuating
- Indirect:
  - Physical harm arising following the flood (such as diarrhoea from lack of access to clean water)
  - Disruption to power, transport etc.
- Intangible losses such as trauma.

Efforts were made to value the first two sets of these items. No effort was made to estimate the value of intangible losses such as trauma although this is likely to be important, given the severity of past floods. In the case of material losses, householders were invited to identify possessions damaged/lost and assign a money value to those possessions. No households included (commercial) agricultural or fisheries losses in their responses although the occasional family reported the loss of a domestic chicken etc. Agricultural and fisheries losses are therefore not included in household values and are discussed separately under 'commercial losses' below.

Survey responses on the value of material losses had gaps as many householders stated that they suffered materially as a result of the flood but did not specify in what way, preventing the estimation of values. Furthermore, there was a problem with recall with many people not assigning values to losses even though they knew that they had lost out. For instance, several Navua families evacuated the area in 2004 and noted that they consequently sustained costs for transport and fuel but they were unable to recall the costs so no values were then recorded for these losses.
A key issue is that the 2004 floods had occurred three years earlier so families were at risk of forgetting the details of what had happened during a traumatic time.

These risks with recall in surveys is to be expected to a certain degree and is not novel to Fiji. For instance, a flood impact survey conducted in Samoa in 2007 similarly identified problems in securing values from householders on household losses (Woodruff 2008). In this case, respondents were asked to identify the value of material losses arising from floods taking place six years earlier, but the responses were so poor that estimation of household losses using survey data had to be abandoned altogether in the end.

The recall problems arising in Navua were anticipated to a degree. However, the figures generated seriously affected estimates of Navua household losses, with the average overall household loss associated with the 2004 flood being around FJ$27.25 per household. This compares with:

- Estimations by Mataki et al. (2006; Programme Manager – Pacific Centre for Environment and Sustainable Development, University of the South Pacific, personal communication 23 May 2007) of the value of losses of the 2004 flood. Mataki et al. were operating in Navua at the time of the 2004 flood and were able to conduct a brief survey

of economic losses with householders at the time disaster actually struck. Although interviews covered fewer households (42) than the SOPAC/EU Project survey, and although these interviews were limited to household in the direct line of flooding (rather than the broader Navua area), householders acutely aware of their losses because they were there in front them at the time. Consequently, their estimations of losses to Mataki et al. were probably more accurate. Mataki et al. data reveals that the average householder across their survey area lost around FJ$4 815 as a result of the 2004 floods.

- Estimations of the value of flood damage in Labasa, Fiji in 2007 (Bonte-Grapentin, personal communication). In this case, 45 Labasa householders were interviewed about the material losses sustained as a result of floods occurring at that minute and the costs generated per household were estimated to be in FJ$2 362 per household. Like the Mataki et al estimates, the Labasa results are likely to more accurately represent the cost of flooding facing a town like Navua since the Labasa survey was conducted during the actual flood event. Consequently, people were acutely aware of their losses and were therefore probably able to identify the value of what they had lost more accurately.

Because household survey figures were so unreliable, and because no detailed household damage surveys had been conducted since the 2004 flood, Mataki et al.'s figures are used as an indication of a more accurate value of losses to householders of a 2004 flood for Navua. Using household data from Mataki et al. (2006), therefore, the cost of material losses to households for the Navua survey area was estimated to be around FJ$6.7 million over the survey district (Table 12).

Medical damage arising from the flood was estimated on the basis of how much householders recalled having to pay for medical treatment required as a result of the flood. These costs are extremely low. This is partly because of recall problems and partly because, as noted by several respondents, the government and humanitarian agencies provided medical relief for free as part of disaster relief. In addition, the Navua Hospital was flooded and closed for several weeks, which meant that many families had to go without medical treatment. Despite these problems, the household survey data was used to estimate medical costs. The values generated, while most likely underestimated, were the only Navua-related medical information available since information on medical costs to Navua families was not available from other surveys.

Likewise, data on the cost of evacuating homes was not available from any survey other than the Navua household survey. This information was therefore used although the values generated are most likely underestimated.

For lost income, householders were asked whether they had been forced to lose days off work and, if so, the number of days lost and the average losses (either from salary or self employment) per day. All householders were asked whether they were forced to evacuate their homes and, if so, whether they sustained any costs in the process.

Based on the survey conducted and Mataki et al. (2006), the average household covered in the survey sustained total economic losses of around FJ$4818 as a result of the 2004 flood (Table 12). This gives a total loss to householders of over FJ$6.7 million (multiplying by 1400 households).

Table 12. Estimated costs of 2004 flood to householders.

District	Immediate financial losses	Immediate medical costs	Subsequent medical costs	Lost income	Costs of evacuating	Total financial costs
Average observed costs per district	n.a*.	7.23	3.70	239.60	3.83	n.a.*
Average per hh	4815.48 *	0.07	0.04	2.40	0.04	4818
Estimated household losses across survey region	6 741 667	101.17	51.73	3354.43	53.57	6 745 228

Final numbers may not exactly equal due to rounding but are correct.
* Taken from Mataki et al. (2006; Programme Manager – Pacific Centre for Environment and Sustainable Development, University of the South Pacific, personal communication 23 May 2007) and estimated on household basis.

Commercial losses

The data for commercial losses arising from the 2004 floods was taken from the Navua economic survey. Unlike the data for households, the values generated here were considered to be reliable, mainly because of the existence of financial records, but also because targeting of the business interests means that people tend to be more focused on incomes than (household) losses. The values generated were also consistent with those generated in the Labasa flood damage survey (Bonte-Grapentin, personal communication).

In the survey, most business operators interviewed stated that they lost commercially as a result of the 2004 flood. All large businesses (category A) that were interviewed except one recorded losses. Losses recorded reflected damage to properties, supplies and days business lost. Losses for the most part did not reflect agricultural losses although the single largest business loss did reflect livestock losses. However, the proportion of values associated with livestock losses was not identified. Agricultural and livestock losses are therefore addressed separately further below.

Individual business losses claimed in the Navua survey ranged from just over FJ$160 to $1.5 million. This latter loss was so significant that it was treated separately to other category businesses to avoid skewing results. The value of its losses was subsequently added to the total of all other losses.

75 per cent of medium-size businesses (category B) stated that they sustained losses as a result of the 2004 flood with average losses worth around FJ$7700 in total, including lost earnings and assets. Two thirds of small-scale businesses (category C – mainly market stalls but one other small business, too) recorded losses. Total losses recorded by interviewees valued FJ$1.53 million, of which the vast majority was attributable to the largest losing business of all. Losses are summarised in Table 13.

Table 13. Commercial losses arising from the 2004 flood.

Category	% suffered because of the flood	Average estimated commercial losses	Total estimated losses for region
A *	100	27 206	788 977
B	75	7 673	675 191
C (small businesses and market stalls)	67	160	16 669
Other **	100	1 500 000	1 500 000
TOTAL BUSINESS		1 535 039	2 980 837

* Does not include one significant business

** Significant business treated separately

When average losses for the business types were extrapolated to the entire survey region, business losses arising from the 2004 flood were estimated to be in the region of FJ$3 million.

The average estimated costs to businesses are consistent with those estimated in the 2007 Labasa flood survey (Bonte-Grapentin, personal communication). Having said this, the estimates of commercial losses are likely to underestimate losses for a number of reasons. First, business operators sometimes noted that they sustained additional costs as a result of the flood (for instance, by relocating and incurring extra transport costs) but were unable to assign a value to those losses. Second, as with the household survey, operators are expected to experience some memory lags where they either had forgotten about specific losses, were not able to remember the value of some losses or have not included the losses of specific items because they could not assign a value.

Primary production losses

Primary production losses include the loss of production of land as well as that from fishing. The value of both losses are given in District Officer – Navua (2004). Although losses to primary production accrued to families and businesses, the majority of these were not included in household or business responses which rather focused instead on other activities (taxis, hardware agencies etc.). There is the possibility that the losses to the single largest commercial enterprise covered in the business survey (FJ$1.5 million) are partially included in District Officer records for livestock but this is unknown at this point. Further, the proportion attributable to a single company could not be determined since (i) the companies harmed by the flood were not identified by name (ii) many of the losses identified by the large company were only determined later on, not immediately. Accordingly primary production losses in this analysis were added to losses estimated from the business survey but it means that those estimates might be an *overestimate.*

Agricultural losses across the greater Navua area were estimated to be in the vicinity of FJ$2.3 million (Table 14).

According to the same report, several boats and engines were partially or wholly destroyed as a result of the 2004 floods with a total estimated cost of FJ$53 000 sustained by local residents or businesses. This gives a total production loss across the entire Navua area of over FJ$2.3 million (Table 13).

Table 14. Estimated agricultural losses for the greater Navua area.

Area	*Damage to crops*	*Damage to livestock*
Serua	*1121444*	*318830*
Namosi	*800558*	*24963*
TOTAL	*1922002*	*343793*
TOTAL AGRICULTURE AND FISHING LOSSES	*2 265 795*	
Boat and engine losses	*53 000*	
TOTAL PRODUCTION LOSSES	*2 318 795*	

This value overestimates the losses that accrue to the people residing or working in the area covered by this analysis. Some of the people affected may live outside of the area although it is still within the Namosi and Serua provinces (such as Deuba which is outside the study area). As the values provided by the District Office – Navua (2004) cover only the Navua area, and as the Navua area contains up to 39 enumeration districts in total (GOF Bureau of Statistics 1998), this equals an average loss per enumeration district of FJ$59 456 – or FJ$594.6 per household. This is worth an estimated loss of production across the study area of around FJ$832 388.

Government losses

Information on the damage and costs to Navua of previous floods were provided by the National Disaster Management Office (NDMO). Local and national departments are required submit information on the costs of losses and assistance provided in floods to the NDMO which acts as a central data base. Losses accruing to the government as a result of the 2004 flood comprise:

- Replacement of private buildings (provision of compensation and replacement of buildings).
- Repairs to public amenities (power, roads etc.).
- Provision of medical and education services.
- Provision of emergency supplies (water tanks, clothing, rations etc.).
- Other intangible losses.

Loss of domestic buildings

Records provided to the NDMO during the 2004 floods indicate that, while no buildings were partially destroyed as a result of the 2004 floods, several buildings were totally destroyed. The number of buildings totally destroyed varied depending on the records reviewed. Documentation from 24 April 2004 indicated that 34 lean to buildings from Navua (across Namosi and Serua) were totally destroyed whereas later documents (12 May 2004) indicated the number of lean tos destroyed was 29. The latter record was used because it was more up to date.

NDMO documentation (12 May 2004) stated that the Government of Fiji provided assistance to owners of destroyed lean tos (small structures with roots) by providing compensation of FJ$1200 per lean to. The total cost of this compensation would therefore be FJ$34 800.

Repairs to infrastructure

The costs faced by government departments in repairing damage to public infrastructure is difficult to determine with any certainty due to the variation in reporting provided following the 2004 floods. Some reports are available at town level, others at District level and still others only at national level. The figures could not be reconciled because they often overlapped. For instance, the District Officer – Navua (2004) reported that damage to roads and bridges in Navua specifically following the floods was in the vicinity of FJ$400 000. However, other amenities (water supplies and energy supplies) were also damaged. The total value of damage to amenities was then only published at national level with an estimated FJ$3.001 million spent by the Ministry of Works and Energy on having to rehabilitate damage to power and amenities across Fiji (NDMO records). Some of these values may include the FJ$400 000 sustained from damage to roads although this was not clear from NDMO records.

If it was assumed that the damage to amenities was evenly spread across the nation, this would imply an average Ministry of Works and Energy loss of around FJ$2303 per enumeration district nationally (there are 1346 across the country) or FJ$23 per household. Over a total of 1400 Navua households, this means that Navua experienced losses in the Ministry of Works and Energy of around FJ$32 244. This value was clearly well short of the average value of losses from the Ministry of Works and Energy. The figure provided by the District Officer – Navua (2004) was therefore more relevant but remains an *underestimate* because it does not necessarily include all infrastructure repairs.

Medical services

The Navua Town Hospital was located around 100 metres from the overflowing Navua River. Parts of the hospital were under several feet of water (Figure 10) with the resulting loss of equipment and supplies as well as damage to buildings. Eight patients also had to be evacuated from Navua to Suva Hospital (District Officer – Navua 2004). According to the District Officer – Navua (2004), damages to the Navua hospital were estimated to be around FJ$2 million including all hospital equipment/facilities and belongings of medical personnel.

Additionally, health services provided by the hospital had to be temporarily suspended with:

- deferral of special clinics, maternal and child health and antenatal care services; and
- referral to Suva for mothers in labour including those with urgent dental treatment.

The cost of delaying these services was not recorded by the government (at least not in the NDMO records) and could not be determined at the time of the analysis.

Figure 10. Navua hospital under water, April 2004.

Education services

No information was available on the cost to the Department of Education of the 2004 floods in Navua specifically. NDMO information (Government of Fiji 2004) noted that, nationally, the country suffered a total loss in education facilities (classrooms, provision of temporarily quarters, destruction of toilets, books and furniture etc) worth FJ$854 150.

Nationally, there are 884 schools (719 primary and 165 secondary) across the country of which 3 per cent (26 schools – 21 primary and 5 secondary) are located in Serua and Namosi (Manisha Prakash, Senior Education Officer – Statistics, Ministry of Education, personal communication 17 May 2007). If this value was used as a very crude estimate of losses to Navua, this would put educational losses in Navua at around FJ$25 624.50. Given the impact of the floods on Navua specifically compared to some other areas of the country, this is likely to be an underestimate.

Figure 11. A Navua school partly under water. Source: http://www.fiji.gov.fj/cgi-bin/cms/exec/view.cgi/19/2257

In addition to physical costs, there were disruptions to education services. In the case of Vashist Muni and Rampur Institutes, the school premises were used as evacuation centres while the local Navua Catholic Primary School introduced an early school break due to the loss of freshwater facilities on site. This loss of education opportunities can only be assessed qualitatively.

Provision of water tanks

According to NDMO documentation on the Navua flood, the National Emergency Operation Centre (NEOC) loaned 7 water tanks of 5000 ml for water supplies across Fiji during the 2004 floods. Navua township requested access to three water tanks but no documentation was provided on whether their request was met or whether the tanks went elsewhere. The monetary cost of the seven water tanks was estimated to be around FJ$2933.48 at the time (based on the cost of buying replacements from Vinod Patel (NDMO documentation)). In any event, since the tanks were subsequently retuned to the NEOC, the economic cost of provision was estimated to be zero.

Provision of relief clothing supplies

A consignment of emergency clothing supplies for disaster victims was provided by the Division of Home Affairs (Immigration and National Disaster Management), valued at FJ$1000.

Provision of food rations and disaster sundries

According to District Officer – Navua (2004), FJ$8569 was spent on food rations in Navua in 2004. Other items were also bought including lights, tyres, refreshments and stationery. The total value of DISMAC expenditure for Navua in this respect – including food rations – was FJ$10 908.

Coordination by government

The Government of Fiji incurred costs by coordinating government responses to flood disasters. Costs include the costs of meal allowances for government staff who have to work out of town providing assistance as well as delays in existing services caused by their absence from the

office. There were no records of the actual cost of meal allowances incurred as a result of the 2004 floods (although there was documentation noting that it had to be paid in some cases and assigning the responsibility of whichever department for looking after these costs). Likewise there was no information on the cost to the nation of reallocating staff from standard government activities to emergency relief.

Humanitarian aid

A number of organisations provided assistance to the community of Navua during the 2004 floods.

Australian High Commission

The Australian High Commission (AHC) provided a package of aid to the people of Fiji following the 2004 floods (Table 15). The package, valued at FJ$150 000 was available at national level so the value provided to Navua is not specified[6]. If averaged out across the country, the AHC contribution is worth about FJ$111.44 per enumeration district – or FJ$1.11 per household in Navua. This would be worth approximately FJ$1560 if spread evenly across the Navua area. Realistically, this figure would underestimate aid to Navua given the severity of the floods it experienced and the fact that not all the country suffered to the same degree. However, it provided an order of magnitude.

Table 15. Australian High Commission aid.

Item	Value
202167 water purification tablets	Not given but included in total by the AHC
402 tarpaulins	Not given but included in total by the AHC
460 x 20 litre water containers	Not given but included in total by the AHC
cash contribution to Fiji red Cross for local procurement of kitchen sets	Not given but included in total by the AHC
contribution towards helicopter hire for distribution of food rations	Not given but included in total by the AHC
Donation	30 000
TOTAL	150 000

French Embassy

The French Embassy provided FJ$20 000 to the Government of Fiji to assist in the wake of the floods, together with a consignment of blankets (unvalued). Again, these donations were provided at national level. If averaged out across the country, the French Embassy contribution was worth about FJ$14.86 per enumeration district – or FJ$0.15 per household in Navua. This would be worth approximately FJ$208 if spread evenly across the Navua area.

Other charities

UNICEF provided 10 000 oral dehydration salts and Natural Waters Viti Ltd provided 2400 litres of water (Fiji Red Cross Society 2004). Of these, 593 Navua families benefited out of 1581. Each

[6] For instance, information on the enumeration districts assisted by the package was not available.

family received: 2 to 3 packets of 36 water purification tablets, 2 bottles of water and 5 packets of Oral Dehydration Salts (Fiji Red Cross Society 2004).

Fiji Water provided 11 very large cartons of Fiji mineral water for distribution to vacation centres (District Officer – Navua 2004). The size of these cartons was never given in official documentation (although they are described as 'huge' – see District Officer – Navua 2004) making it difficult to determine their value.

The Fiji Red Cross Society assisted 3100 people in Navua (Fiji Red Cross Society 2004). Assistance involved the provision of:

- black packs (containing blankets, clothing for a family of two adults and four kids, towels, mosquito coils and first aid provisions);
- emergency family packs;
- water buckets;
- cooking materials;
- blankets;
- hurricane lanterns;
- 20 litre water containers;
- 5x4 m tarpaulins;
- mosquito coils; and
- new clothing.

Some of these items were provided from other charitable agencies (such as the Australian High Commission donating tarpaulin, water containers etc.; possibly the French Embassy donation blankets; and possibly the Division of Home Affairs in relation to clothing). The values for some of these items have therefore already been included in this analysis. In other cases, it is unclear when the items were newly contributed (say from the Red Cross itself or other donors) or not. In any event the items were not valued by the Red Cross and there was insufficient information on the materials provided (type of cooking materials, size and type of lamps, number of coils etc) to permit estimation of the values.

Other losses

Some other costs associated with responding to the 2004 flood were not included in this analysis because of the difficulty in securing data. First, no information was provided on the value of volunteer labour used to assist flood stricken areas during the 2004 floods. Volunteer labour was provided by the Fiji Military Forces (Army and Navy) as well as private volunteers who assisted in evacuating people, distributing rations and providing vehicles (see District Officer – Navua 2004).

Second, there was no attempt to measure the value of trauma experienced by families during this time. Third, no attempt is made to measure the value of the loss of irreplaceable personal or administrative items such as photos, pets, or government or business records. Although the methodologies to estimate the value of trauma exists to some degree ('expressed preference techniques – see Tietenberg (2000) and Hajkowicz and Otakai (2005) for further information), it is unlikely that these would generate meaningful information in this instance. These values must nevertheless be recognised as important.

Summary of losses from 2004 flood

Overall losses arising from the 2004 floods in Navua are summarised in Table 16. Depending on which estimate was used for household losses – the Navua survey or the Labasa survey – the overall losses associated with the 2004 Navua flood event were estimated to be around FJ$13 million.

The value estimated is likely to be an underestimate because it:

- involves averages of national or divisional values when Navua was likely to represent a more harshly impacted area than the national or divisional 'average'; and
- it does not include unvalued costs associated with:
  - Government coordination of assistance activities;
  - certain humanitarian aid;
  - loss of education opportunities;
  - use of volunteers (especially the military) to assist in distributing aid; and
  - trauma.

Table 16. Estimated economic losses to Navua of the 2004 floods.

Item	National cost	Navua value	Comment
Household losses *		67 45 228	
Business losses		2 980 837	Probable underestimate
Agricultural and fisheries losses		832 388	Agriculture component possible overestimate
Government losses:			
▪ Replacement of destroyed lean tos		34 800	
▪ Infrastructure rehabilitation		400 000	Underestimate
▪ Medical services		2 000 000	
▪ Education		25 625	Underestimate
▪ Provision of water tanks		0	
▪ Provision of emergency clothing		1000	
▪ Provision of food rations and disaster sundries		10 908	
▪ Coordination by government		Not known	
Humanitarian aid valued:			
▪ Australian High Commission	150 000	1560	Underestimate
▪ French Embassy	20 000	208	
Unvalued humanitarian aid:			
▪ Blankets	Not known	Not known	
▪ 10000 oral dehydration salts	*	Not known	
▪ 2400 litres bottled water	*	Not known	
▪ 11 cartons Fiji water	*	Not known	
▪ Red Cross provisions	Not known	Not known	
Other losses			
▪ Early school break for Catholic primary School due to need for fresh water	Not known	Not known	
▪ Volunteers to government and NGOs	Not known	Not known	
▪ Trauma and irreplaceable items	Not known	Not known	

ESTIMATED TOTAL (not including 'unknown' values)		13032554	

* Household losses estimated from Mataki et al. (2006).

The distribution of losses is displayed in Figure 2. The greatest proportion of losses was sustained by the household sector in Navua (52 per cent of overall estimated losses), followed by the business sector (23 per cent). Government losses to the medical sector – through losses to the Navua Hospital – represented the third largest component of losses arising from the 2004 flood. Together these three sectors accounted for 90 per cent of all estimated economic losses.

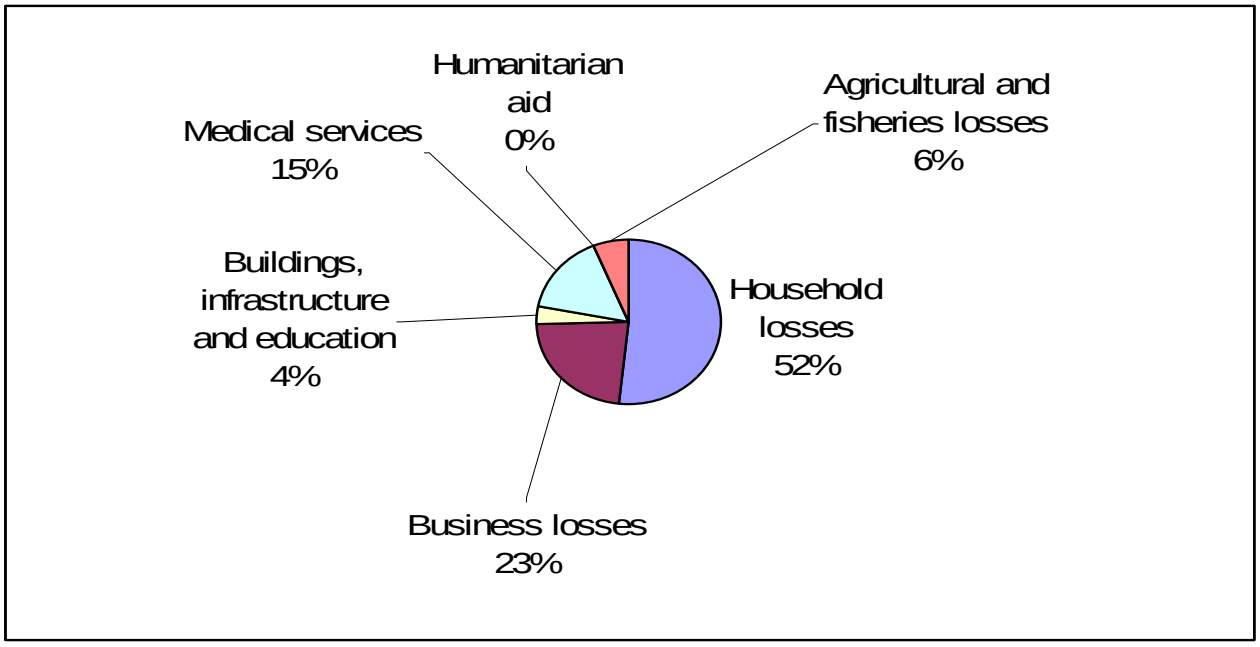

Figure 12. Estimated value of losses from the 2004 flood.

F POTENTIAL BENEFITS OF A FLOOD WARNING SYSTEM

Assumptions about the scale of benefits

The losses sustained as a result of the 2004 flood in Navua do not equal the benefits of a flood warning system to the area. As noted in section C, not all economic losses that occurred in 2004 would have been avoidable had a successful flood warning system been in operation. This is because the flood would have happened anyway so some damage – such as destruction to lean tos and large-scale items that could not be rapidly moved (large-scale equipment etc.) would probably have occurred regardless. On the other hand, with sufficient warning, some smaller items might have been protected by moving them to higher ground (livestock, personal possessions) and some injuries might have been avoided by vacating the area earlier.

The estimated costs of the 2004 flood may be used to estimate some of the losses that could be avoided if a warning system were successfully implemented around Navua. The first step is to estimate how many floods of the 2004 magnitude are likely to occur during the lifetime of the system. The second is to determine what changes would have occurred to which items.

Likely floods during the life of the system

The 2004 flood was particularly severe with hundreds of people seeking shelter in evacuation areas and severe damage incurred on buildings, infrastructure and on local agriculture. On the basis of a 35-year-old gauged flood record for Navua and findings from the USP work by Mataki et al, the 2004 flood is estimated to be a 1-in-10 year event. However, if more sketchy information on earlier flooding is also included, the 2004 flood might be closer to a 1-in-20 year event (Michael Bonte-Grapentin, SOPAC Risk Assessment Specialist, personal communication, 1 May 2007). Since the flood is therefore somewhere between a 1-in-10 and a 1-in-20 year event, estimates of the losses arising from it would be made for both cases.

Possible benefits of the warning system

The scale of cost savings that could be made using a warning system in Navua needs to be identified. Unfortunately, there is no way of knowing with any certainty what losses would be avoided next time with the warning system in operation so assumptions need to be made. Accordingly, information on the types of impacts that a warning could have had on the Navua community was taken from individual consultations with stakeholders and through a facilitated exercise conducted with government and community groups in October 2007. Information found during the Navua business and household survey were included in the exercise to remind participants of the experiences people had. Because of uncertainty on the future impacts of the warning system on damage and losses, a range of assumptions are used to estimate losses. Losses are estimated assuming a worst case scenario (generating the least likely benefits from the system), most likely case and a best case scenario (generating maximum benefits from the warning system). The assumptions selected for this analysis and their rationale are given below.

Possible personal benefits

- Avoided immediate medical costs

Sufficient warning of an oncoming flood would theoretically enable people to evacuate the area and avoid personal injury. This assumes that people have a rational incentive to protect the lives of themselves and their families. This is likely, especially in light of the economic survey

undertaken for this analysis which indicates that people largely respond to warnings. On the other hand, some injuries – such as those sustained during rescue attempts – are unlikely to be avoided. There was considerable disparity between stakeholders consulted on the extent to which they thought immediate personal injuries could be avoided through a flood warning. Town representatives consulted during a participatory meeting felt that the impact on reducing immediate injuries from a flood could be considerable (up to 80 per cent). Health staff consulted considered that immediate injuries could be reduced by over half but noted that little impact could be made on injuries sustained during rescue attempts (which would always happen) and that a one-hour warning would still result in some degree of panic in the township, although to a lesser degree. To accommodate the range of views, a best case saving of 50 per cent was assumed for the flood warning system with a worst case outcome of 10 per cent.

- Reductions in the loss of personal possessions

Sufficient warning of an oncoming flood would enable people to protect some possessions (say, by water proofing them) or moving them to safer ground (vehicles, televisions, clothes, money). The fact that few people have insurance may be an inducement to protect possessions and act on the warning. Having said this, individuals would realistically be unable to remove all the possessions that they would otherwise lose in the event of a flood. The less warning they receive, the less they can carry. This fact is corroborated by the household component of the economic survey which indicated that a key reason many items were lost was because of the lack of time that people had to move items. Consultations with stakeholders indicated that the most the average household might hope to save given a flood warning would be just over half (55 per cent) while at worst, families might only save 20 per cent of their possessions.

- Avoided subsequent medical costs

Sufficient warning would enable individuals to prepare for the possibility of being without shelter or functioning water supplies etc. for a limited time. Preparations could include filling containers of water and storing them in an accessible and safe place as well as storing medical needs in the event of floods (antiseptic creams, plasters, bleach etc.). Based on consultations with stakeholders including Dr Tiko of the Navua Hospital, savings from subsequent illness could be reduced by up to 10 cent.

- Reductions in lost income

Savings in lost income could theoretically be achieved using a flood warning system because it reduces personal injuries and saves business assets, allowing people to return to work earlier. In the economic survey conducted, personal injury was not raised as a reason for losing income. The saving of business assets could be important although cost saving were unlikely to be high. This is because damage to infrastructure, buildings and land would occur regardless of any warning. Consequently, many employees would remain either unable to reach places of work in the first place, or be able to work even if they got there since owners would be cleaning up or fixing damaged premises. On the basis of discussions with stakeholders, a conservative range of savings from lost income is assumed to be 15 to 30 per cent.

- Reductions in evacuation costs

It is unlikely that a flood warning would provide opportunities to not evacuate the area. Rather, the system should enable people to better plan their evacuations and make it to safe ground more effectively. It is possible that better planning would reduce the costs of evacuation. However, given the low costs associated with evacuation to begin with and the fact that warnings would actually increase evacuations, the savings impact on this cost are considered to be nil.

Possible business benefits

- Reductions in the loss of business assets

As with personal possessions, sufficient warning of an oncoming flood would enable people to protect some assets such as vehicles, computers (say by water proofing them or moving them to safer ground (etc.). However, businesses would be unlikely to be able to remove all the possessions that they would lose in the event of a flood because of the volume of material and limited time. This is particularly the case where large equipment, shelving etc. are involved. Discussions with stakeholders focused on the likelihood that assets could be protected in large, medium and small scale businesses. Stakeholders consulted felt that small businesses were probably best placed to save possessions in the event of a flood because a larger proportion of the fewer items could be moved quickly whereas larger businesses would have less scope to move all their items. Stakeholders consulted felt that medium size businesses were possibly in the hardest position to save items because they had more assets to remove than small businesses but few employees to help move things. A range of savings of between 10-60 per cent was agreed, depending on the size of the business.

Reduced agricultural and fisheries losses

Realistically, no warning would ever be sufficient to enable families, businesses or the government to protect agricultural land because it was simply not moveable. Even a three-hour flood warning would be insufficient for people to harvest crops to protect them from flooding because of other priorities – such as protecting life and moveable assets (vehicles, money) taking precedence. Consequently, discussions with stakeholders indicated that no savings were expected to be realistically achieved in agriculture, even with a flood warning. On the other hand, sufficient warning might enable mariners to relocate boats to safer areas or protect key assets. Discussions with Department of Fisheries officials suggest that Navua fishermen respond quickly when they consider a flood would occur, moving nets and boats to higher ground and/or securing them at safe houses. On the basis of consultations, it was assumed that savings of up to 20 per cent could be achieved with a flood warning (Laisenia Balenigi, Officer-In-Charge, Department of Fisheries, personal communication, 14 November 2007).

Possible government benefits

- Protection to buildings (e.g. lean tos) and infrastructure

Realistically, no degree of warning would ever be sufficient to enable families, businesses or the government to protect buildings, roads or bridges from an oncoming flood because the items are simply not moveable. On the basis of discussions with stakeholders, it was expected that the flood warning system would at best have a 10 per cent impact on the protection of buildings (where people have time to secure doors and windows).

- Cost savings in medical services

Discussions held with staff of the Navua Hospital indicate that the scope to reduce costs to the medical service of a flood are high. According to Dr K. Tiko (Sub-Divisional Medical Officer, Navua Hospital, personal communication, 18 May 2007 and 15 November 2007), much damage sustained during the 2004 floods was to valuable equipment which could not be moved to safe ground at the time due to lack of warning. Since the 2004 floods, Dr Tiko advised that internal procedures for dealing with the floods since 2004 had improved dramatically. An advance warning of a flood would enable activation of the hospital disaster committee and enable the hospital to relay warnings to the community about issues such as safe and unsafe quality,

hygiene practices and the safe keeping of water. With a one to three hour warning provided by the proposed Navua flood warning system, Dr Tiko suggested that most key machinery could be removed so that at least 25 per cent of losses (at worst) and 50 per cent of losses (at best) could be avoided.

- Cost savings to education services

Warning of an oncoming flood would possibly enable schools to protect moveable assets such as records, books and computers but would not equip them to protect premises from the flood, nor avoid the need for temporary accommodation elsewhere. Savings brought about by advance warning would therefore be limited in total. Based on discussions with stakeholders, a range of savings of 25 to 60 per cent was assumed.

On related matters, an effective flood warning system would not prevent losses arising from lost education opportunities. This was because flood damage to water infrastructure would occur regardless of whether a flood warning was issued or not.

- Cost savings in emergency clothing provisions

Humanitarian assistance distributed after a flood was usually provided on the basis of a needs assessment (Red Cross, personal communication, 25 October 2007). Discussions held with stakeholders suggested that families were expected to take emergency clothing with them when given sufficient notice of a disaster. Consultations suggested that, at worst, clothing needs might be reduced by 50 per cent in the event of a warning and, at best, by up to 90 per cent.

- Cost savings in food rations and sundries

As with clothing needs, emergency food assistance was provided on the basis of a needs assessment. Sufficient warnings of an incoming flood would be expected to reduce the need for food rationing as families could carry essentials with them (canned and dried food such as rice, dhal etc.) or store them in higher places. Having said this, families would still be limited in the degree to which they could carry food. On the basis of consultations with stakeholders, savings to food rations and sundries were assumed to range between 25 and 75 per cent.

- Cost savings in government disaster coordination

(NDMO, personal communication, 25 October 2007) indicate that an effectively issued warning of floods in Navua could substantially reduce the scale of disaster management and coordination required by NSDMO. However, the costs to Navua alone of disaster coordination are not known so a final cost saving cannot be determined at this point.

Other humanitarian aid

Consultations with stakeholders including the Red Cross indicate that humanitarian aid to flood victims was usually needs based. Therefore, the greater the savings from the flood system (in terms of possessions, food etc.) the greater the humanitarian savings would be. Consultations indicated that humanitarian costs could be reduced between 10 per cent at worst and 50 per cent at best.

Other benefits that may be possible

- Reduced need for volunteers

While personal injury and some loss of assets and personal possessions would be expected to arise as a result of an effective warning system, it is expected that volunteers would still be needed to distribute materials and assist businesses and families in the recovery following a flood. The length of the time of need – or the number of volunteers required – to do this might, however, be reduced. The value of this saving cannot be determined quantitatively and can only be incorporated qualitatively.

- Reduced trauma

Sufficient warning of an oncoming flood would almost certainly reduce the scale of trauma imposed by a disaster, especially where it enables families to avoid personal injury and the loss of irreplaceable personal possessions. These values are not estimated because of the difficulty in converting human emotion to monetary values.

- Use of Navua warning system for other purposes

It is possible that the Navua flood warning system – if successful – could be used to benefit the community of Navua in other ways such as the notification of other disasters. Any use of the flood warning system for other purposes would require careful consideration since the warnings would need to be tailored to remain clear to the community on what the warning is about and therefore how to act. The benefits from using the warning system as part of a broad community warning system cannot be determined quantitatively at this point.

- Environmental management

Data collected by the hydrological network could potentially be used to increase understanding of water supply, hydropower and irrigation impacts/relationships within the catchment and beyond. In this case, the system could be used to benefit water resource management. Likewise, data collected in the system could be used to monitor changes in hydrological parameters due to climate change and climate variability, potentially benefiting environmental management.

- Lessons to elsewhere

The proposed Navua flood warning system is the first in a new series of warning systems proposed for Fiji and across most of the Pacific. The system offers state-of-the-art flood forecasting with radio-transmitted automatic warnings. While the system will be new in Fiji and the Pacific, it offers intangible valuable design and operational lessons for other similar warning systems proposed elsewhere (such as in Rewa, Fiji and Samoa – see Pelesikoti et al. in press).

Assumptions for benefits achieved as a result of an effectively operating warning system are summarised in Table 17.

Table 17. Assumed benefit rates from the warning system.

Item	Impact	% Assumed benefits		
		Worst case	Most likely	Best case
Personal losses				
▪ Immediate medical costs	High	10	30	50
▪ Loss of personal possessions such as televisions, clothing, vehicles	Medium	20	40	55
▪ Subsequent medical costs	Medium to high	0	5	10
▪ Lost earnings	Negligible	15	20	30
▪ Reductions in evacuation costs	Nil	0	0	0
Business losses				
▪ Large companies (Bus.A)	Limited	10	30	50
▪ Medium size companies (Bus. B)	Limited	20	30	40
▪ Small companies	Limited	20	40	60
Primary production				
▪ Agricultural land	Nil	0	0	0
▪ Boats and engines	Low to medium	0	10	20
Government losses				
▪ Buildings (e.g. lean tos)	Nil	0	5	10
▪ Infrastructure rehabilitation	Nil	0	5	10
▪ Medical services	Low	25	40	50
▪ Education services	Low	25	40	60
▪ Clothing	Nil	50	70	90
▪ Food rations and sundries	Low to moderate	25	50	75
▪ Coordination by government	Moderate	30	60	90
Humanitarian aid	Nil	10	30	50
Other losses				
▪ Lost education opportunities	Nil	0	0	0
▪ Volunteers	Low to medium	?	?	?
▪ Trauma from flooding, loss of irreplaceable items.	Medium?	?	?	?
▪ Use of warning system for other local purposes	?	?	?	?
▪ Environmental management	?	?	?	?
▪ Lessons to other warning systems in the Pacific	?	?	?	?

Estimated gross present value of benefits

If a flood of the 2004 magnitude represented the only threat to the Navua community, the likelihood is that the community would benefit from the warning system at least once (in the case of a 1-in-20 year event) and possibly twice (in the case of a 1-in-10 year event) over the expected lifespan of the warning system (20 years)[7]. The expected benefits from the warning system assuming the occurrence of one to two 2004-style floods were estimated and annualised over the lifespan of the system, then discounted to generate the expected present value of benefits (not including costs to run the system) to the Fijian community in current day terms.

[7] Depending on whether the 2004 flood was a 1-in-10-or 1-in-20 year event.

The benefits estimated from the system were thus calculated:

- assuming a major flood happens only once every 20 years or as much as once every 10 years; and
- using discount rates of 3, 7 and 10 per cent; and
- under worst case, most likely case and best case scenarios.

By estimating flood benefits under all these conditions, the savings from a flood warning could be one of up to 18 values. This range is important because it covers for all possible eventualities. However, it makes reporting unwieldly and difficult to follow. Therefore, for ease of reading and to get an order of magnitude, values in the text below represent the *most likely* values assuming a 10 per cent discount rate (highly conservative and reflecting that this is the value most commonly used in the Pacific). Details for the best case, mostly like case and worst case scenarios are given in Annex 4.

Benefits

It is most likely that a successfully executed warning system for Navua would generate average *minimum* benefits of between FJ$ 2.1-4.2 million (Table 18). These values do not include valuable benefits arising from:

- reduced lost education opportunities;
- savings in terms of volunteer labour, especially in relation to the military;
- reduced trauma;
- potential use of the warning system for other local warnings; and
- lessons to other warning systems in Fiji and across the Pacific.

The actual value of these unvalued benefits may be significant so it is critical to recognise that the FJ$2.1-4.2 million benefit is an *absolute minimum*. Furthermore:

- in all likelihood, the warning system would be used *more frequently* during a 20-year period since it would be available for use for more frequent, less harmful floods. For instance, at least three major floods occurred in Navua over the 20-year period of the 1980s-early 2000s so the benefits of the flood warning system in the Navua catchment would actually be much higher in practice.
- If the system were to be used to generate warnings in advance of a more serious flood during its lifetime (such as a one in fifty year flood), the benefits could substantially be even higher.
- The warning system is likely to be able to offer warnings for other major threats to the community. For instance, the flood modelling and prediction system may potentially have use in predicting landslides associated with persistent and heavy rain while the dissemination system might have application for other threats to the area (e.g. civil disturbance).
- The population of Navua is likely to increase in the forthcoming years as the area is being used to house increasing numbers of tenants whose land leases in the cane farming belt have expired. In this case, increasing numbers of families and businesses are likely to benefit from the system, reducing personal and commercial losses; and the amount of relief work required of the national government and humanitarian agencies.

- The accuracy of the warning system is expected to improve over time as regular time series data on rainfall and river levels is added to the flood model and warning times increase.

Table 18. Most likely gross value of benefits (10 per cent discount rate).

Item	Minimum of 1 major flood	Minimum of 2 major floods
▪ Immediate medical costs	14	28
▪ Loss of personal possessions such as televisions, clothing, vehicles	1 262 703	2 525 407
▪ Subsequent medical costs	1	2
▪ Lost earnings	314	628
Business losses		
▪ Loss of assets such as computers, electricals, vehicles	419 510	839 020
Government losses		
▪ Buildings (e.g. lean tos)	986	1972
▪ Infrastructure rehabilitation	9365	18730
▪ Medical services	374 597	749 194
▪ Education services	4800	9599
▪ Coordination by government	0	0
▪ Clothing	328	656
▪ Food rations and sundries	2554	5108
▪ Primary production		
– Agricultural land	0	0
– Boats and engines	891	1782
Humanitarian aid		
▪ Other valued aid	248	497
▪ Unvalued aid	unknown	unknown
Other losses		
▪ Lost education opportunities	unknown	unknown
▪ Volunteers	unknown	unknown
▪ Trauma from flooding, loss of personal possessions, pets etc.	unknown	unknown
▪ Use of warning system for other local warnings	unknown	unknown
▪ Lessons to other warning systems in the Pacific	unknown	unknown
TOTAL	2 076 311	4 152 622

There is wide variation around these minimum values. The values are 'most likely', but in the 'best case', savings would be considerably higher. Conversely, in the 'worst case', the savings would be much lower. For example, the benefits to the medical services of the warning system would depend on how quickly and efficiently medical staff are able to react to the warning. It was most likely that the benefits to the Navua Hospital would be worth around FJ$0.4-0.7 million (Table 18). However, it could be as high as FJ$0.5-0.9 million if the response from medical personnel were rapid and highly efficient. However, an ineffective response would be expected to save the hospital only FJ$0.2-0.5 million. Savings of FJ$0.4-0.7 million are the most likely outcome.

Similarly, the benefits to the business sector of a flood warning would depend on how keenly business operators respond. If sufficient time were given and operators acted swiftly to move key assets (vehicles, computers, etc.) to safe ground, the very best that the business community could wish for would be to save up to FJ$0.7-1.3 million in total. However, with insufficient

warning or disinterest in action, benefits could fall to a quarter of this (FJ$0.2-0.3 million). The value of FJ$0.4-0.8 million given in Table 18 is the most likely outcome.

Clearly the ability and willingness of people in the Navua community to respond to warnings generated through the system are therefore critical to whether it would benefit anyone.

The largest benefits of the Navua warning system are likely to come in the form of potential savings to Navua households, followed by savings to Navua-based businesses and the government medical services (the protection of supplies and staff possessions), provided sufficient warning can be given (and adopted).

If the discount rate is reduced to 7 per cent to account for the long-term nature of flood warning benefits, the most likely benefits of the system could be estimated to rise to around FJ$2.5-5.0 million (Table 19). If the more clement discount rate of 3 per cent is used (as recommended for development projects by the British Treasury), the benefits rise significantly to around FJ$3.4-6.7 million (Table 20). In all cases, there are additional unvalued benefits to be considered relating to:

- reduced lost education opportunities;
- savings in terms of volunteer labour, especially in relation to the military;
- reduced trauma, loss of irreplaceable items;
- potential use of the warning system for other local warnings; and
- lessons to other warning systems in Fiji and across the Pacific.

Additionally, in all cases, Fijians would in practice benefit from the use of the Navua warning system in the event of all lesser floods that might occur, not to mention any more serious floods (such as a one-in-fifty-year event). Fijians would also benefit from the use of the warning system to address other threats that might be arise. All total estimates are therefore *minimum* estimates of the actual benefit from using the proposed Navua flood warning system.

Table 19. Most likely gross value of benefits (7 per cent discount rate).

Item	Minimum of 1 major flood	Minimum of 2 major floods
▪ Immediate medical costs	17	34
▪ Loss of personal possessions such as televisions, clothing, vehicles	1 528 416	3056832
▪ Subsequent medical costs	1	3
▪ Lost earnings	380	760
Business losses		
▪ Loss of assets such as computers, electricals, vehicles	507 788	1 015 576
Government losses		
▪ Buildings (e.g. lean tos)	986	1972
▪ Infrastructure rehabilitation	11 336	22 671
▪ Medical services	453 424	906 848
▪ Education services	5809	11 619
▪ Coordination by government	0	0
▪ Clothing	397	793
▪ Food rations and sundries	3091	6182
▪ Primary production		
– Agricultural land	0	0
– Boats and engines	1078	2157
Humanitarian aid		
▪ Other valued aid	301	601
▪ Unvalued aid	unknown	unknown
Other losses		
▪ Lost education opportunities	unknown	unknown
▪ Volunteers	unknown	unknown
▪ Trauma from flooding, loss of personal possessions, pets etc.	unknown	unknown
▪ Use of warning system for other local warnings	unknown	unknown
▪ Lessons to other warning systems in the Pacific	unknown	unknown
TOTAL	2 513 025	5 026 050

Table 20. Most likely gross value of benefits (3 per cent discount rate).

Item	Minimum of 1 major flood	Minimum of 2 major floods
▪ Immediate medical costs	23	47
▪ Loss of personal possessions such as televisions, clothing, vehicles	2 066 159	4 132 318
▪ Subsequent medical costs	2	4
▪ Lost earnings	514	1028
Business losses		
▪ Loss of assets such as computers, electricals, vehicles	646 051	1 292 103
Government losses		
▪ Buildings (e.g. lean tos)	1333	2666
▪ Infrastructure rehabilitation	11 336	22 671
▪ Medical services	612 952	1 225 904
▪ Education services	7853	15 707
▪ Coordination by government	0	0
▪ Clothing	536	1073
▪ Food rations and sundries	4179	8358
▪ Primary production		
– Agricultural land	0	0
– Boats and engines	1458	2915
Humanitarian aid		

▪ Other valued aid	406	813
▪ Unvalued aid	unknown	unknown
Other losses		
▪ Lost education opportunities	unknown	unknown
▪ Volunteers	unknown	unknown
▪ Trauma from flooding, loss of personal possessions, pets etc.	unknown	unknown
▪ Use of warning system for other local warnings	unknown	unknown
▪ Lessons to other warning systems in the Pacific	unknown	unknown
TOTAL	3 352 803	6 705 606

Costs of the warning system

The cost of the warning system involves a number of fixed costs (one-off costs for the purchase and establishment of infrastructure, software etc.) as well as some ongoing costs (maintenance, awareness etc.). The key costs include:

- the technical establishment of the system (hardware and software infrastructure);
- in-kind and financial contributions from the Government of Fiji;
- in-kind contributions and training from SOPAC; and
- communications and dissemination costs.

The costs are itemised in Table 21 and explained below.

Hardware and software infrastructure (one-off costs)

The greater part of the costs of establishing the system reflects hardware and software investments. These costs are covered by the SOPAC/EU Project and the majority of the service was provided through the New Zealand NIWA. Costs cover the establishment or upgrade of rainfall and river monitoring stations as well as training in the use of the software and maintenance of hardware.

In addition, the SOPAC/EU Project covered the cost of a technical consultancy to a local supplier to provide radio services to support the monitoring and alert system. These costs are FJ$10 000.

Costs to the Government of Fiji

Although international donors would meet most of the costs of establishing the warning system for Navua, the Government of Fiji would be involved in some establishment work such as the fencing of stations, installation of pipes for river gauges, fixing of poles for solar and radio antenna and the clearing of sites for work. This work was estimated at a one-off investment totalling around FJ$58 600 at the time of analysis.

Additionally, the Government of Fiji would be required to maintain operation of the system and therefore cover any associated costs. Maintenance costs of the system would involve the upkeep of physical items at the rainfall and river monitoring stations, provision and installation of repairs, as well as dealing with any IT problems. Correspondingly, costs would also be incurred in travelling to and from the rainfall and river gauges to conduct work. The costs of maintaining the

system are not known with certainty in advance so an annual provision of 15 per cent of the NIWA establishment cost has been assumed. This generous value (around FJ$22 000) has been discussed with the Department of Public Works and agreed with SOPAC.

A key issue in ensuring that the system works, would be awareness by the Navua community on what to do once a warning was issued. Although initial awareness raising and communication activities would be conducted under the SOPAC/EU Project to establish the system, the Government would need to ensure that communication and awareness work continued throughout the year – particularly at the onset of the cyclone season. This was to ensure that families and businesses are reminded of the actions they need to take if they receive a warning. Awareness work for this purpose fits in largely with other awareness activities that may need to be undertaken nationally in advance of cyclone seasons so these costs are not included in the Navua warning system costs. However, other specific activities would be needed for Navua, such as what to do if residents hear a warning siren (see section G). A hypothetical annual allocation of FJ$10 000 was assigned for this purpose and the issuing of warnings in operation, following discussions with SOPAC Risk Advisor, Michael Bonte-Grapentin.

The Government of Fiji would need to coordinate the operation of the system. This involves dedicating the time of staff in key agencies (NDMO and Department of Public Works Hydrology Unit in Suva as well as the Meteorological Office in Nadi) to maintain the system as well as oversee awareness and communication activities. Staff would be expected to accommodate the additional needs for coordinating the system into existing work roles. The cost of extra time and manpower required to operate the system are included in 'maintenance costs'.

In-kind contributions and training from SOPAC (one-off cost)

SOPAC provided technical input to the design and establishment of the Navua flood warning system. The costs for this were footed by the SOPAC/EU Project but are separate from other establishment costs such as software and hardware. Technical input in the form of in-kind and training contributions from SOPAC include the execution of this economic analysis, consultations with Government and design of the system.

Communications and dissemination activities (one-off cost)

To establish the system, the communication activities listed below need to be undertaken.

- Conduct workshops with community leaders and local government officials to determine dissemination options and processes.
- Conduct a 'dry run' exercise to test the warning system; and subsequent review of its operation (e.g. dissemination).
- Conduct an initial public awareness raising.

SOPAC has made provisional estimates of the costs of these activities (FJ$10 500 in total – see Table 21) although there is no certainty yet on whether the SOPAC/EU Project can cover these costs or not. For the purpose of this analysis, the costs of communication and dissemination activities needed to establish the warning system are assigned hypothetically to the SOPAC/EU Project although it is possible that they may need to be sourced from elsewhere. If so, this would have implications for the returns to investment that different stakeholder groups achieve from investing in the warning system (see below).

The total cost of designing, installing and operating the system over a 20-year period are estimated to be in the region of FJ$0.6 million (Table 21). The most significant proportion of costs

reflect initial infrastructure and establishment investment and therefore occurred in the first year (2007). Infrastructure and establishment costs account for around half of total system cost over the entire period (47 per cent). Annual costs following this are low but amount to just over half the total costs over the 20-year lifespan of the system (53 per cent).

Table 21. Total costs of the warning system.

Item	Cost (quoted currency)*	Cost FJ$
Fixed costs		
Software and hardware (NIWA) NZ$		
▪ Sabata flow station (establish)	16 674	19 785
▪ Nakavu flow station (upgrade)	4849	5754
▪ Equip Public Works Hydrology unit in Suva	10 450	12 400
▪ Establish second base station	6700	7950
▪ New rainfall station at Tikitura	8225	9760
▪ Upgrade Nabukelevu and Wainimakutu rainfall stations	16 450	19 520
▪ Upgrade Cabe, Namuamua and Wainikavika rainfall stations	20 775	24 652
▪ Basic flood modelling	3200	3797
▪ Flood modelling using flow and rainfall data	10 000	11 866
▪ Public river display	4800	5696
▪ Training workshops (how to use hard and software), reporting etc.	20 400	24 207
In-kind and financial contributions from the Government of Fiji FJ$		
▪ In-kind contributions from Department of Public Works (labour and building materials)**		58 600
Communications and dissemination activities FJ$(SOPAC)		
▪ Workshops with community leaders and local government officials ▪ Exercise to test and review system		4000
▪ Implementation of public awareness system		6500
▪ In-kind contributions and training from SOPAC FJ$		44288
▪ Radio services from local supplier (SOPAC/EDF) FJ$		10000
Variable costs (VC annual)		
In-kind and financial contributions from the Government of Fiji FJ$		
▪ Physical maintenance of the monitoring system including travel and man power (15% of NIWA infrastructure)		21 808
▪ On-going awareness raising		10 000
Total present day value fixed costs FJ$	n.a.	268 774
Total nominal VC FJ$per year for 20 years	n.a.	31808
Total present day value VC FJ$	n.a.	297 878
TOTAL COSTS OVER 20 YEARS (discounted)		566 652

Source: Adapted and extended from SOPAC/EU Project, Michael Bonte-Grapentin, SOPAC Risk Assessment Specialist, personal communication, January 2007.

* Based on exchange rates of 14 May 2007

** Michael Bonte-Grapentin, SOPAC Risk Assessment Specialist, personal communication, 18 May 2007

Returns from investing in the Navua warning system

The proposed Navua flood warning system offers a range of potential benefits at different levels – from the families of Navua who may benefit from reduced personal losses in the form of material losses, health risks and trauma; through to the international community (donors etc.) who gain in the form of lessons learned for future warning systems. The potential beneficiaries of the proposed system are identified in %Table 22.

Table 22. Potential beneficiaries of the proposed warning system.

Item	Beneficiary
Personal losses	
▪ Immediate medical costs	Households
▪ Loss of personal possessions such as televisions, clothing, vehicles	Households
▪ Subsequent medical costs	Households
▪ Lost earnings	Households
Business losses	
▪ Loss of assets such as computers, electricals, vehicles	Businesses
Government losses	
▪ Buildings (e.g. lean tos)	National government
▪ Infrastructure rehabilitation	National government
▪ Medical services	National government
▪ Education services	National government
▪ Coordination by government	National government
▪ Clothing	National government
▪ Food rations and sundries	National government
▪ Primary production	
– Agricultural land	Households and businesses
– Boats and engines	Households and businesses
Humanitarian aid	
▪ Other valued aid	International community
▪ Unvalued aid	National and international community
Other losses	
▪ Lost education opportunities	Households
▪ Volunteers	National government
▪ Trauma from flooding, loss of personal possessions, pets etc.	Households
▪ Use of warning system for other local warnings	Households
▪ Lessons to other warning systems in the Pacific	International community only

* National and government benefits all benefit the international community.

The different stakeholders who may benefit from the warning system may be viewed as a hierarchy (Figure 13).

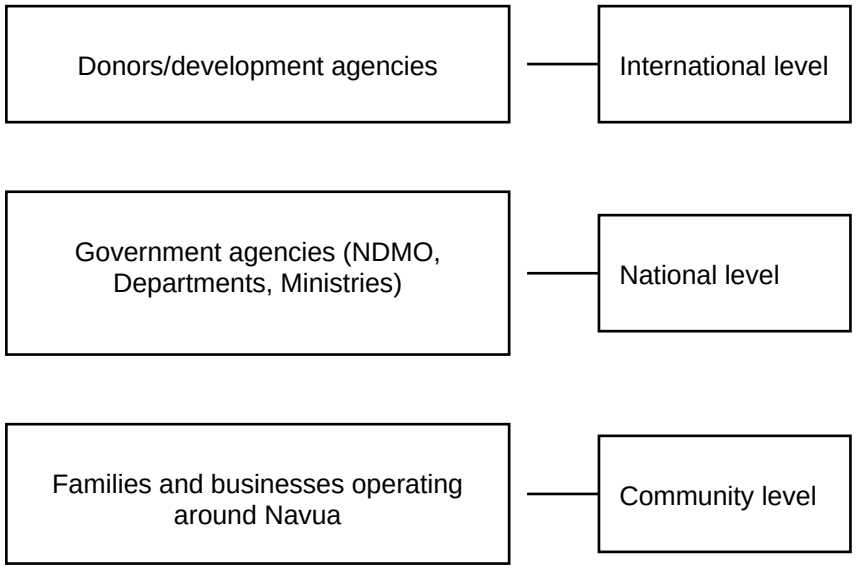

Figure 13. Beneficiaries of the warning system.

On the basis of the warning system benefits estimated above, the most likely investment returns on the warning systems at a community, national and international level are given below. Investment returns under worst and best case scenarios and using different discount rates are detailed in Annex 4.

Community returns on investment

Using a 10 per cent discount rate, the most likely gross benefits of the warning system that would be felt specifically and solely by the community of Navua were estimated to be in the region of FJ$1.7-3.4 million (Table 23). These values do not include unvalued benefits, particularly in terms of use for warning about other disasters in the town or the reduction of trauma.

Table 23. Most likely gross benefits to the Navua community.

	Minimum of 1 major flood	Minimum of 2 major floods
▪ Reduction in immediate medical costs	14	28
▪ Protection of personal possessions such as televisions, clothing, vehicles	1 262 703	*2 525 407*
▪		
▪ Reduction in subsequent medical costs	1	*2*
▪ Protected earnings	*314*	*628*
▪ Protection of assets such as computers, electricals, vehicles	419 510	*839 020*
– Protection of agricultural land	0	*0*
– Protection of boats and engines	891	*1782*
	1 683 434	*3 366 868*

The costs to the community of designing and implementing the system are negligible. This is because the system has been designed and equipped using SOPAC/EU Project funding, together with contributions from the Fiji Government and other international or national agencies. Any costs to the community of Navua should only take the form of effort to inform others of the warning and to act. Accordingly, the most likely net benefits to the community remain at FJ$1.7-3.4 million (depending on the frequency of the flood) which is an infinitely high return on effort (Table 24). The return to the community is in fact higher given that the warning system would realistically be used to advise against lesser floods accruing over its lifespan. Also the value is higher still if a lower discount rate is used. If a lower discount rate is used, the net present value of the system to the Government – and the benefit:cost ratio – will be even higher.

Table 24. Most likely net benefits and investment returns to the Navua community.

	1 flood event	2 flood events
Total costs	0	0
NPV (and gross benefits)	1 683 434	3 366 868
Benefit/ cost ratio	∞	∞

National returns on investment

Using a 10 per cent discount rate, the most likely gross benefits that are experienced by the Government of Fiji are around FJ$0.4-0.8 million (Table 25).

Table 25. Most likely gross benefits to the Government of Fiji.

	Minimum of 1 major flood	Minimum of 2 major floods
▪ Buildings (e.g. lean tos)	986	1972
▪ Infrastructure rehabilitation	9365	18 730
▪ Medical services	374 597	749 194
▪ Education services	4800	9599
▪ Coordination by government		0
▪ Clothing	328	656
▪ Food rations and sundries	2554	5108
	392 629	785 258

The costs to the Government of designing and implementing the system mainly reflected the need for ongoing commitment to maintenance and awareness raising activities. The total investment by the Government of Fiji is estimated to be around FJ$0.4 million over the 20-year lifespan of the warning system (Table 26).

Table 26. Warning system costs to the Government of Fiji.

Government of Fiji costs	FJ$
In-kind contributions from Department of Public Works (labour and building materials)	58600
Maintenance and awareness raising (15% of NIWA infrastructure, plus manpower*) plus on-going awareness raising) over 20 years	297878
TOTAL COSTS	356478

* Michael Bonte-Grapentin, SOPAC Risk Assessment Specialist, personal communication, 18 May 2007.

The most likely net present value of the system to the Government of Fiji is therefore estimated to be between FJ$0.04 and FJ$0.4 million over its lifetime (Table 27). The returns to investment for the Government of Fiji are between 1.1 and 2.2. In other words, for every dollar the Government of Fiji invests in the system, it will most likely return that same investment in savings or even double its money.

Table 27. Most likely net benefits and investment returns to the Government of Fiji (10 per cent discount rate).

	1 flood event	2 flood events
Government benefits	392 629	785 258
Total costs	356 478	356 478
NPV	36 151	428 780
B:C ratio	1.10	2.20

It is important to note that these returns are an *underestimate* for the Government of Fiji. The estimated values and returns do not include unvalued benefits to the Government of Fiji, particularly in terms of lessons for other warning systems in the country so the true value of the Navua flood warning system is therefore likely to be higher. Additionally the net present value of the system to the Government – and the benefit: cost ratio – would be higher when the use of the system to mitigate lesser floods is considered and if a lower discount rate were used.

In one unlikely and rare case, it is possible that the Government might not cover the costs of its investment. This would occur only when 'worst cases' (e.g. very poor response rates) occurred over a period of only one flood. In this unlikely case, the lowest return for the Government would be a saving of FJ$0.67 in the dollar. For all other occasions, the Government would be financially better off by investing in the warning system.

International returns on investment

International returns on investment are determined by looking at all economic benefits and all economic costs related to the design, implementation and operation of the proposed Navua flood warning system – regardless of who they affect. They include the value of other humanitarian aid not provided by the Fiji Government, as well as all benefits to the Government and the community. On the basis of the benefits reported for the Navua community and the Government of Fiji, the most likely gross benefits of the system to all stakeholders totals around FJ$2.1-4.2 million (Table 18). The overall costs of designing and implementing the system were estimated to be around FJ$566 652 over its 20-year lifetime (Table 21). The estimated most likely net present value of the system at the international level is therefore around FJ$1.5-3.6 million (Table 28). This generates a benefit:cost ratio of between 3.7:1 and 7.3:1 (Table 28). In other words, for every dollar invested in the system between FJ$3.7 and FJ$7.3 of savings are achieved. This is a highly positive return.

Table 28. Most likely net benefits and investment returns at international level.

	1 flood event	2 flood events
Total benefits 1:20 year flood @10% DR	2 076 311	4 152 622
Total costs over 20 years	566 652	566 652
NPV	1 509 659	3 585 971
B/C ratio	3.66	7.33

The estimated most likely net present value of the Navua flood warning system in international terms is a gross underestimate as it does not include unvalued benefits, particularly in terms of lessons for other warning systems in the Pacific. Additionally the net present value of the system to international stakeholders – and the benefit:cost ratio – would be higher if used during lesser floods, as the accuracy of the flood predictions improve, as the township population increases and if a lower discount rate were used. Investment returns to different stakeholders are summarised in Table 29.

Table 29. Summary of most likely investment returns for different stakeholders (10 per cent discount rate).

Stakeholder	Net present value over 20 years FJ$	Benefit: cost ratio over 20 years
Navua community	1.7-3.4 million	∞
Government of Fiji	0.04-0.4 million	1.1-2.2
International stakeholders	1.5-3.6 million	3.7-7.3

G REALISATION OF BENEFITS AND POLICY IMPLICATIONS

The potential benefits of a flood warning system in Navua would only materialise if a number of conditions were met that include:

- warnings are disseminated sufficiently widely to reach all people who would suffer as a result of the flood.
- People acted on those warnings to reduce the losses that they would otherwise incur.
- The system is physically reliable.

Dissemination of warnings in 2004

In 2004, the majority of people around Navua stated that they recognised that a flood was imminent, not because of warnings they received from other people but because they (almost half) saw the rise in river level. Otherwise, they were notified through the radio (25 per cent) although almost as many people who were notified by radio interpreted the persistent rain as a warning. Despite the availability of mobile phones, no one used texting as a means to contact people and very few people relied on the phone (Figure 14).

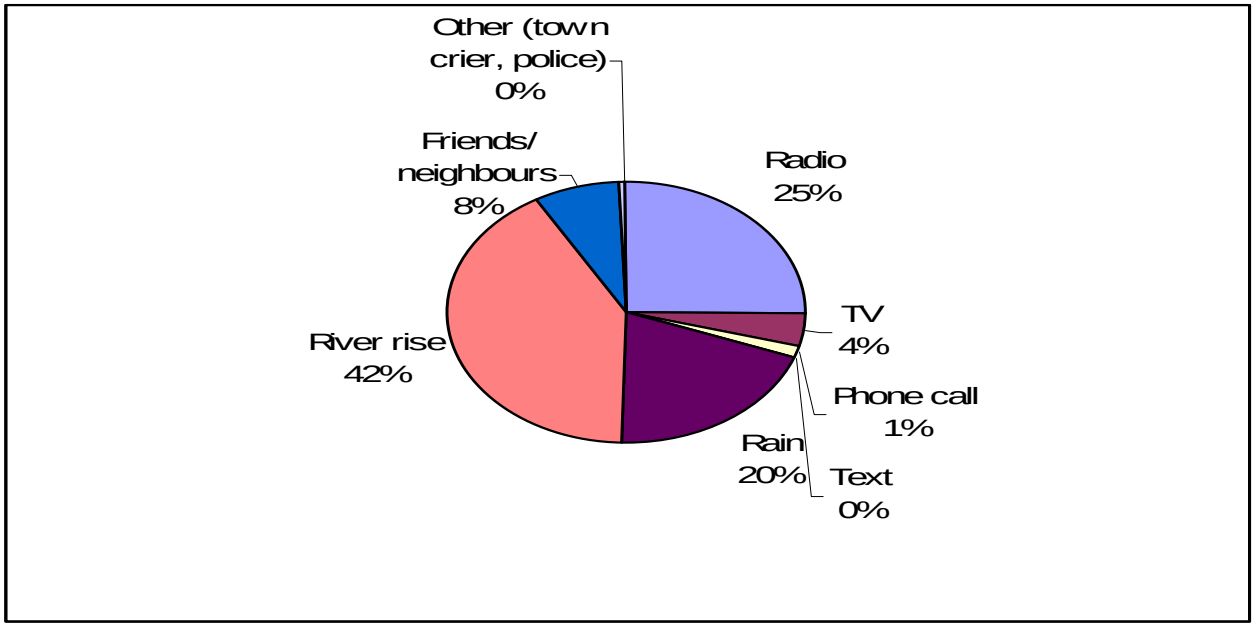

Figure 14 . Dissemination of warnings in 2004.

One explanation for the lack of dissemination by radio, TV or person to person is likely to be the timing of the flood which occurred early in the morning (around 5 to 6 am) when radios and TVs and personal exchange would not have been in widespread use. It might therefore be presumed that those who anticipated the flood from heavy rain and rising river levels did so from the evening before. A key question is whether more people would have received warnings had the flood warning system been in operation (see below).

Acting on an advance warning in 2004

Seeing the flood level rise is evidence of an imminent flood. Not surprisingly, since most people in Navua became aware of the 2004 flood by observing the river level (presumably during daylight), less than half the individuals interviewed (44 per cent) felt that they had sufficient warning time in 2004 to act to protect their possessions (Table 30).

Table 30. Receiving sufficient time to act.

	Sample	Sufficient time to act received	%
Average resident	225	98	44
Bus. A	10	2	20
Bus. B	40	16	40
Bus. C (not statistically significant *	n.a	n.a	n.a

* Market omitted and only single sample for small size businesses

There was a wide variation in views across the town, however (Table 31). Those who most felt they had time to prepare were residents located in districts A, K and H, with 72, 71 and 60 per cent of residents feeling that they had had sufficient time to act, respectively. Those most frequently considering that they had insufficient time to act were residents in districts I and F, located close to the sea and the centre of town and large-scale businesses. In the case of the latter, part of the reason would presumably be the sheer scale of operations that would be required to protect possessions in the face of an oncoming and imminent flood.

Table 31. Perceptions of whether people had time to prepare for the 2004 flood.

	Sufficient time to act received	% receiving time to act
A	13	72
B	6	38
C	4	31
D	9	53
E	9	47
F	5	29
G	10	56
H	9	60
I	2	12
J	6	32
K	10	71
L	5	36
M	4	31
Nakavu	6	40
Bus. A	2	20
Bus. B	16	40
Bus. C (not statistically significant) *	n.a	n.a

* Market omitted and only single sample for small size businesses

Overall, the majority of people interviewed made some effort to protect their possessions before or during the flood (Table 32) with around two thirds of households and businesses moving some of their possessions to higher ground. (Note that market stalls were not asked this question.) Many of the individuals interviewed, of course, did not know in advance that a flood was imminent.

Table 32. Responses to flood warnings (acting to move possessions).

	Sufficient time to act received	Individuals removing possessions	% moving possessions
AVERAGE RESIDENT	225	143	64
Bus. A	10	6	60
Bus. B	40	23	58
Bus. C (not statistically significant)	n.a.	n.a.	n.a.

* Market omitted and only single sample for small size businesses

A critical question in relation to the potential success of the Navua flood warning system is whether residents and businesses would have responded more effectively if given warning about an oncoming flood. In 2004, the majority of interviewees who claimed no warning of the flood stated that they had nevertheless acted to protect at least some of their possessions (Table 33). However, many commented that the sudden onset of the flood limited what they could do.

Table 33. People acting without warning in 2004.

	Sample with no advance warning	Sample moving possessions to safer ground	% moving possessions
AVERAGE RESIDENT	114	68	60
Bus. A	8	5	63
Bus. B	16	9	56
Bus. C (not statistically significant)*	n.a.	n.a.	n.a.

* Market omitted and only single sample for small size businesses

The proportion of people acting to protect possessions increased when they received warning (Table 34). Of those individuals that had some advance warning of the flood, over three quarters of householders (78 per cent) and four fifths of medium-size businesses (88 per cent) acted to move some of their possessions to safer ground or prepare them for the flood. This is a sizeable increase compared to those without warning. Only half of those large businesses who had warning about the flood acted to protect possessions. This is partly due to the difficulty in moving large amounts of materials and equipment. If the warning system was accompanied by a strong awareness campaign on how to act in the event of a flood, it is probable that the proportion of the community (families and businesses) protecting possessions and acting in the event of a flood would have been higher.

Table 34. People acting on warnings in 2004.

	Sample who had advance warning	Sample moving possessions to safer ground	%
AVERAGE RESIDENT	98	76	78
Bus A	2	1	50
Bus B	16	14	88
Bus C (not statistically significant) *	n.a.	n.a	n.a.

* Market omitted and only single sample for small size businesses

A key incentive for people to act upon warnings may well be whether they are insured against losses. Of the 293 people interviewed, only 7 per cent (19 respondents) claimed to have taken out any insurance. While lack of insurance is not a surprise for householders in an area of relatively low expected incomes, it is a concern commercially as only 15 per cent of medium-size businesses had any insurance to fall back on if their assets were lost (Table 35). Discussions with representatives of the Navua community indicated that medium-size and small businesses in Navua may not have insurance because of the high premiums related to flood risk. Additionally, insurers apparently require businesses dealing with food to locate food three to four feet above ground in order to be covered – and this is not very practical for smaller operators.

Table 35. Insurance around Navua.

District	Insurance taken	% people with insurance
Households	7	3
Business type A	6	60
Business type B	6	15
Business type C	n.a. *	n.a.

* Market operators not asked because of limited value of stalls. Aggregate value statistically insignificant for small businesses.

The fact that so few people around Navua appear to have any insurance means that there should be a greater incentive for people to act on warnings of a flood because they know that they will have to rely on their personal savings or donations to get back on their feet.

Communicating warnings under the warning system

The success of a warning system for Navua hinges partly on the ability of authorities and the community to alert families and businesses to oncoming floods.

Target groups

The first issue to consider in relation to this is the type of target groups in the community. Back in 1996, the population around the Serua area which houses most of the Navua community was predominantly indigenous Fijian and Christian. However, of the households interviewed in this survey, the population was predominantly Indo-Fijian and Hindu. Determining ethnicity was not the intention of the economic survey but ethnicity can – for the large part – be discerned by the names of the interviewees. Accordingly, over half the families participating in the survey were determined to be Indo-Fijian (58 per cent), compared with over a third of families who were Indigenous Fijian (39 per cent). Although all interviews were conducted in English, there is still as much a need for warnings to be disseminated in Hindustani and Fijian as well as information on how to respond to warning to be communicated in these languages. There is a definite need for awareness materials to be communicated in Hindustani.

Dissemination options

Options available for disseminating information include:

- use of information and communications technology (e.g. phones, television);
- word of mouth; and
- other forms of communication.

ICT as a dissemination method

ICT options that could be used to disseminate warnings include phones (landline or mobile), TV, radio, internet and, in the case of businesses, fax machines. The vast majority of households and families have access to a radio (Table 36), with radios commonly being played in businesses during the day. Virtually every business and family have a radio which provides a good opportunity to disseminate warnings and advice on flooding. On the other hand, the 2004 floods hit Navua in the early morning when hadn't been switched on. A warning system would need to by-pass this. A valuable option is the use of mobile phones which are more popular around Navua than land lines (Table 36). Three quarters of households stated that someone in the house had access to a mobile phone while around 90 per cent of businesses had access to a mobile phone. A network of phone links could provide an option to contact families and businesses of imminent floods, if well organised and coordinated.

Having said this, some of the more rural areas within the Navua survey coverage were unable to pick up signals on mobile phones. To ensure that all mobile phones could pick up calls in the area, additional receivers would ideally need to be installed. Otherwise some families/ businesses may not be reachable. The design of the current SOPAC/EU Project does not accommodate the purchase and establishment of additional infrastructure for better mobile phone reception. The Government and community of Navua would need to either consider raising the funds to cover this issue in preparation for cyclone season and or establish other dissemination options for rural areas (e.g. the use of word of mouth through targeted community groups – see below).

Table 36. Access to telecommunications around Navua.

	% land line phone	% mobile phone	% radio	% TV	% internet	% newspaper	% fax
Householders	60	75	95	90	9	64	-
Bus A	80	90	80	10	30	0	8
Bus B	73	88	90	23	23	8	50
Bus C	n.a. *	44	22	n.a. *	n.a. *	n.a. *	n.a. *

* Market omitted and only single sample for small size businesses

Because of the time lag between releasing warnings and printing press, printed media is naturally not a wise option for disseminations flood warnings. However, it should provide a useful opportunity to raise awareness of key steps to take if a flood alert is issued so that families and businesses could prepare in advance for a flood warning. Only a limited number of businesses have access to a fax machine so this has restricted potential as a means of dissemination (Table 36). The internet has such limited use around Navua that it is not practical to target this as a dissemination method.

Word of mouth as a dissemination method

Of the 293 responses collected across the entire survey, 73 per cent of respondents (213) stated that they were active members of a community or church organisation. This could provide an important opportunity for disseminating warnings if needed. Unfortunately not all respondents were exact about which community group they frequented, some only nominating a non-specific 'village group' or 'church group' or 'women's group'. This makes it difficult to target specific organisations for dissemination purposes without a detailed understanding of the community. It would naturally be important for the Navua community to establish key links with local organisations for dissemination purposes. However, the Government of Fiji is still able to target those key community organisations around Navua in their dissemination plans that were

specified. The key groups that were identified by the community were Hindu and Christian groups, which made up 88 per cent of community groups of interest (Figure 15). The proportions of specific groups are shown in Figures 16 to 19.

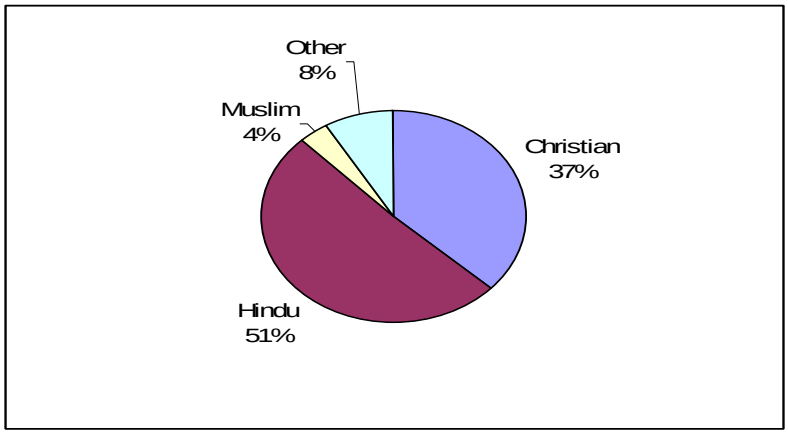

Figure 15. Key community groups as a dissemination option.

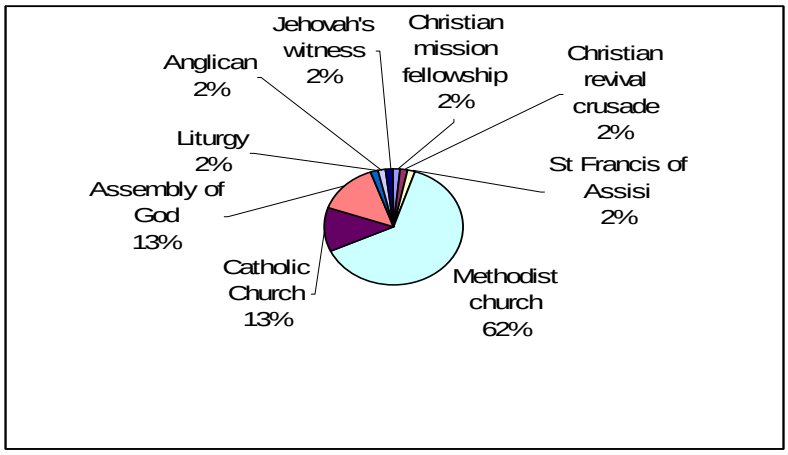

Figure 16. Christian community groups.

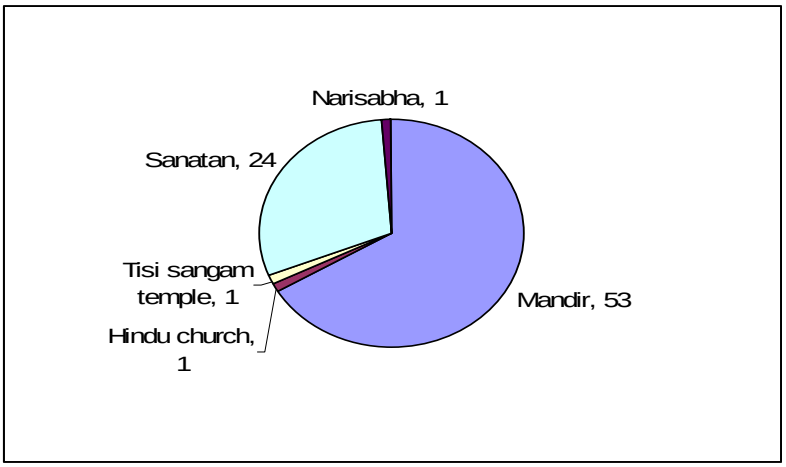

Figure 17. Hindu community groups.

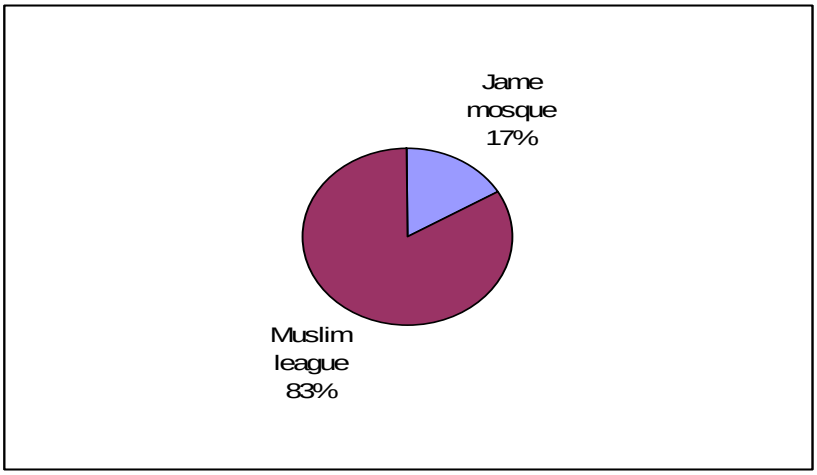

Figure 18. Muslim community groups.

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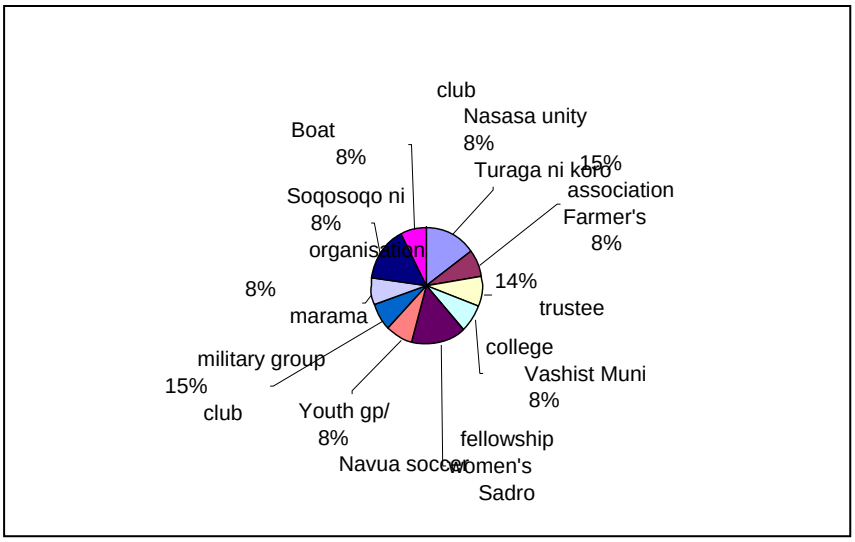

Figure 19. Nonreligious community groups.

Table 37. Key community groups around Navua.

▪ *Christian*	▪ *Hindu*	▪ *Muslim*	▪ *Non religious*
▪ *Christian mission fellowship* ▪ *Christian revival crusade* ▪ *St Francis of Assisi* ▪ *Methodist church* ▪ *Catholic Church* ▪ *Assembly of God* ▪ *Liturgy* ▪ *Anglican* ▪ *Jehovah's witness*	▪ *Mandir* ▪ *Hindu church* ▪ *Tisi sangam temple* ▪ *Sanatan* ▪ *Narisabha*	▪ *Jame mosque* ▪ *Muslim league*	▪ *Vashist Muni college trustee* ▪ *Sadro women's fellowship* ▪ *Turaga ni koro* ▪ *Nasasa unity club* ▪ *Farmer's association* ▪ *Soqosoqo ni marama* ▪ *Boat organisation* ▪ *Navua soccer* ▪ *Youth group/ club* ▪ *military group*

The single largest organisation/community group in the area is the Mandir which involves almost a fifth of the population (18 per cent). Following this, the most commonly used community organisations are the Methodist Church (12 per cent) and Sanatan groups (8 per cent). Targeting

these three community groups would assist in disseminating messages to over a third (38 per cent) of the local population.

Other forms of communication

The Navua fire station has a siren which may be useful as a way of disseminating warnings of an imminent flood. The siren is located in the centre of town and is estimated to have a sound range of 1 km (Nabi Buksh, Fire Services Navua, personal communication, 2007). According to the survey, individuals around the centre would be most likely to benefit from a siren warning because of their immediate proximity whereas those located further out would not hear the siren and would be none the wiser (Table 38). For instance, the vast majority of individuals located in districts B, D, E, F, G and I stated that they could hear the siren which bodes well for alerting these residents to the threat of flood. Additionally, around half the individuals in H and J were able to pick up the siren. Districts further out could not be reached by this method of dissemination.

Table 38. Ability to hear the Navua fire siren.

District	Respondents who could hear siren	%
A	0	0
B	12	75
C	3	23
D	12	71
E	19	100
F	14	82
G	17	94
H	6	40
I	17	100
J	10	53
K	3	21
L	3	21
M	0	0
Nakavu	0	0
Business type A	0	0
Business type B	0	0
Business type C	15	83

Unfortunately, most business operators asked about the siren did not answer whether or not they could hear it. However, it is clear that those operating in districts B, D, E, F, G and I would be likely to benefit, just as householders could, whereas businesses further out would be unlikely to gain from the siren.

Realising the potential benefits of the warning system would be easier if additional infrastructure – such as more sirens – were available for use. However, this would cost an as yet unknown value of money.

The success of the proposed warning system relies almost wholly on the degree to which warnings can be disseminated to the Navua community and the extent to which they choose to act on those warnings to protect themselves and those possessions over which they have control. Getting the messages to the community is a challenge, especially in light of the 2004 flood which came in the early hours of the morning. The economic survey conducted as part of this analysis revealed that less than a third of the community was notified of the oncoming flood through the use of the media (TV and radio). The majority of people instead relied on their own observations of the river rise – an event which for the most part means that there is not much time left to do

anything. Consequently, relying on the media to disseminate warnings is of limited value. Further, given that it reached less than one third of the community in 2004, means that the potential benefits of the warning system would be reduced by over two thirds, rendering the system more costly to implement than it might be beneficial, at least if the Navua household survey is to be believed. (If the Labasa survey is used, the system would, however, be expected to continue to generate more benefits than costs.) A more effective option would be to work through community groups – particularly mandirs and the Methodist church and to communicate messages via mobile phone, since the vast majority of households have access to one of these and most respondents commented that it was left on all the time.

Additionally, there may be scope to seek out funding to cover additional infrastructure to assist in warning dissemination (e.g. additional receivers for the rural mobile network, additional sirens etc.). The costs of these items are not known. They would increase the likely benefits of the warning system by ensuring greater dissemination of flood warnings, but would slightly impact net benefits and investment ratios. For instance, if an extra FJ$100000 was needed to provide additional receivers and sirens, the total cost for the warning system would rise to FJ$566 652 over the life of the system (assuming that the receivers and sirens were purchased up front). In this case the global B/C ratio would fall to between 3:1 and 6:1. Nevertheless, the returns on investing in the system are still clearly high.

Whatever system was used to disseminate warnings through the community in Navua, it would be important to ensure that only genuine warnings were communicated. Otherwise the credibility of the system would be questioned and it would be likely to fail. Woodruff (2008) noted the need to educate, for instance, mobile phone users to ensure credibility and effectiveness when receiving and passing on flood warnings.

Awareness and education

Part of the success of the warning system would be in educating users of the system on what to do and where to go in the event of a flood. Realistically, this is not information that would be communicated over the warning itself, but is information that would need to be communicated in advance and on a regular basis so that household and business responses to the actual flood warning were automatic.

An important aspect of awareness and education is the location of evacuation centres to ensure personal safety. The majority of respondents knew the location of their nearest evacuation point (Table 39). However, reaching it was another matter. Several respondents commented that their nearest evacuation point was up to one or two hours away by boat which is not a safe option during an oncoming flood. If the potential benefits of the warning system are to be achieved, there may be a need to establish additional evacuation centres or establish additional means to assist families and businesses to reach their nearest centre.

Table 39. Proportion of residents who knew where the local evacuation centre was.

	Sample	Yes	%
A	18	15	83
B	16	15	94
C	13	10	77
D	17	12	71
E	19	12	63
F	17	17	100
G	18	17	94
H	15	14	93
I	17	17	100

J	19	18	95
K	14	11	79
L	14	14	100
M	13	13	100
Nakavu	15	15	100
Bus. A	10	9	90
Bus. B	40	34	85
Bus. C + market	18	14	78

Long-term awareness

Long-term awareness raising is needed to ensure that families and business operators know what to do in preparation for a flood. The radio is the most common media item that individuals around the Navua region have, with almost all families and businesses owning a radio. Key steps for what to do in the event of an incoming flood could be advertised on this. In addition, the Fiji Times is unquestionably the most favoured newspaper in the Navua region and key steps could be advertised in this publication. For families, 90 per cent of households have a television which is used in the evenings and could also be targeted for education and awareness purposes.

Investing in ongoing awareness of the system is likely to be a factor in ensuring that community response to warnings is efficient. In this respect, it has been assumed that FJ$10 000 has been assigned for *annual* awareness raising in Navua. If investment in ongoing awareness is reduced, it is probable that responses to warnings would be less effective and total benefits from the system would fall. It might be tempting to reduce ongoing costs in system operation by reducing investment in these areas; however, that cut would need to be considered in light of potentially harming the effectiveness of the system.

Physical reliability of the system

Benefits from the system would be jeopardised if breakdowns occurred. A key issue is the need to ensure that links between key government departments are strong. This is especially important for the Fiji Bureau of Meteorology and Department of Public Works (Hydrology Office) both of which must ensure the sharing of data on which alerts and warnings hinge.

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ANNEX 1 – TERMS OF REFERENCE

Tasks to be performed

- Review documentation relevant to the EDF flood disaster risk reduction work project in the Pacific including EDF work conducted in Fiji and relevant work conducted by other agencies;
- Assess the likely net economic benefits of establishing and implementing the flood warning system envisaged for Navua:
  - Identify key stakeholders who are likely impacted by the flood in Navua and broadly how they are impacted;
  - identify the types and extent of market and non market effects of a flood across Navua and beyond[8];
  - estimate where reasonable the likely monetary value of those economic effects, commenting on the robustness of the assumptions underpinning them and the estimates generated. Where quantitative estimates are not possible or appropriate, provide rationale for non quantification and provide appropriate economic qualitative information on economic effects;
  - identify the likely benefits of the flood warning system and their distribution in reducing economic costs from flooding;
  - Identify the different costs involved in implementing and maintaining the various key components of Navua flood warning system, noting alternative components that might affect its effectiveness and costs;
  - Estimate the likely net economic net benefits of the system;
  - Identify the different costs involved in implementing the system, noting alternative components that might affect its effectiveness;
  - Comment on the distribution of net benefits/benefits and costs across the community, as appropriate;
- Identify any design issues that might be used to increase benefits from the system (e.g. the use of alternative inputs to produce a more effective package, communications issues such as who to contact, how and why, monitoring needs);
- Identify any constraints to achieving the potential benefits from the use of the geoscience outputs (e.g. social issues, political issues, local capacity, access to power utilities by implementers or households, policy needs, awareness raising /communications issues, operational/viability issues, data needs, maintenance issues, etc.) and identify potential ways to overcome these constraints to maximise benefits;
- Note key policy implications for the appropriateness of the system, including any wider public interest concerns and governance issues needed to support implementation (e.g. legislative or planning issues, communications issues, education, awareness or advocacy in implementing flood warning systems) in the future;
- Document activities conducted and findings in two drafts report to SOPAC and other relevant stakeholders, and incorporate comments into a final report, as relevant; and
- Present findings to SOPAC-EU Project staff, key Government of Fiji stakeholders and other stakeholders, as relevant.

[8] Type (scale) to be determined in consultation with the NDMO and SOPAC staff

ANNEX 2 – QUESTIONNAIRES FOR THE ECONOMIC SURVEY OF THIS STUDY

NAVUA ECONOMIC STUDY QUESTIONNAIRES

Questionnaires for:

Households
Businesses
Market stalls

NAVUA FLOOD HOUSEHOLD SURVEY FOR HOUSEHOLDS

Questionnaire #
(data entry)

Date	
Interviewer's name	

Survey district: _____

Mark house on map provided and/or provide the street address:

_____

A PERSONAL BACKGROUND

The purpose in this section in get an understanding of the number of people affected by floods and who is at risk.

A1 Name of interviewee_____

A2 Position in the household (head of household, etc.)_____

A3 When did you come to Navua to live? (circle/complete)

(i) Always lived here

(ii) Moved here from (town, island) _____ in (year) _____

A4 How many people normally live in this house?

	Age
Person 1	
Person 2	
Person 3	
Person 4	
Person 5	
Person 6	
Person 7	
Person 8	
Person 9	
Person 10	

A5 Do the people in your house know where the nearest evacuation centre is? Y N
If no go to question A8

A6 Where is it?_____

A7 How do you get there?_____

A8 How much time would you and the other members of your house need to get to the next evacuation centre?_____

A9 Realistically, how much time do you need to pack and store your possessions to a higher level?_____

A10 Can you hear the Navua fire siren from where you live? Y N

A11 Were you in Navua when the 2004 flood occurred? Y N

B FLOOD HISTORY

The purpose in this section in get an understanding of what information people might need to know when sending out warnings and when to send out the messages. It also gives us information on how people find out about and cope with floods so that we can work out how to reach them using the early warning system.

B1 When the 2004 flood happened, how did you first find out about it? (circle)

(i) Radio (ii) Television (iii) Phone call (iv) Text message

(v) Saw heavy rain (vi) Saw river rise (vii) Contacted in person by friends/neighbours

(viii) Other (specify)

B2 Did you get any advance warning to act? Y N

B3 Did you lift or remove any of your possessions? Y N

If YES, - Details (what? how? did it help?)

_____

B4 Did you take any other measures to protect your property? Y N

If YES, - Details (what did you do? did it help?_____

_____

C PERSONAL LOSSES

The purpose in this section in get an understanding of how much an early warning system can save householders.

C1 Did you lose any personal possessions, suffer physically or were disadvantaged personally as a result of the 2004 flood? Y N

If NO, go section D.

C2 If YES, what would you say was the value of the losses you experienced?

	Cost FJ$
Electrical appliances	
Television	
Radio	
Telephone	
Mobile phone	
Computer, printer, software	
DVD player	
Washing machine	
Refrigerator	
Oven	
Other _____ _____ _____ _____ _____	
Furniture	
Sofas	
Chairs	
Mats	

Beds and mattresses	
Tables	
Other _____ _____ _____ _____ _____	
Other	
Structural damage to house from flooding	
Livestock/Animals	
Cash Crops	
Food items	
Clothing, books	
Bedding	
Tools	
Car/truck	
Other valuable possessions	

C3 How did you replace the lost items?

(i) Didn't replace (ii) Insurance (iii) Private savings (iv) Extended family

(v) Charity donations (vi) Government assistance

(vii) Other (specify)_____

C4 Did you or other members of your household suffer any sickness or injury during the flood itself? Y N

If NO, go to question C7.

C5 If YES, - Details (how many household members affected and what were the sicknesses/ injuries?)

_____

_____

_____

C6. How much roughly did it cost to treat the sicknesses/injuries?

	FJ$
Doctors visits	
Medicine (painkillers, creams, antibiotics etc.) dressings (purchase of bandages etc.)	
Days in hospital	
Other	

C7 Did you or other members of your household suffer any sickness later on because of the effects of the flood (e.g. diarrhea from contaminated water, sickness from lack of access to food or shelter etc.)? Y N

If NO, go to question C10.

C8 If YES, – Details (what sicknesses? how many persons affected?): _____

_____

C9 How much roughly did it cost to treat these subsequent illnesses?

	FJ$
Doctors visits	
Medicine (painkillers, creams, antibiotics etc.) dressings (purchase of bandages etc.)	
Days in hospital	
Other	

C10 Did you lose any paid days off work because of the flood? Y N

If NO, go to question C12.

C11 If YES how much did you lose?

Number of days lost ____ wages lost $_____/day

C12 How many days did it take to clean up your house and land after the flood?_____ days

C13 Did you experience disruption in basic services?

Transport	[ ]Yes [ ]No	Number of days_____
Water supply	[ ]Yes [ ]No	Number of days_____
Electricity	[ ]Yes [ ]No	Number of days_____
Telephone	[ ]Yes [ ]No	Number of days_____

C14 Did you have to evacuate your home? Y N

If NO, go to question C23.

C15 If YES, how did you evacuate? (circle) (i) own vehicle (ii) taxi (iii) bus

(iv) used family/friend's vehicle (v) boat (vi) evacuation team (vii) other_____

C16 For how long did you evacuate?_____ days

C17 Where did you go?_____

C18 What things did you take with you?_____

_____

_____

C19 Were you provided with food while you were out? Y N

_____

If NO, go to question C21.

C20 If YES, who provided the food? (circle) (i) Government (ii) Charity

(iii) Family (iv) Other

C21 Did evacuating your home cost you anything? And if YES, why?_____

C22 How much did evacuating cost you?_____

C23 Are you currently covered by flood insurance for your personal possessions? Y N

D HOME ACCESS TO COMMUNICATIONS

The purpose in this section in get an understanding of how we might be able to advise people of an on coming flood.

D1 Does the house where you live have access to electricity? Y N

D2 Does the house where you live have a working phone? Y N

D3 Does the house where you live have a mobile phone? Y N

D4 Do you have a working mobile phone yourself? Y N

If NO go to question D7.

D5 Is the mobile phone always switched on? Y N

D6 Which hours is it switched off? From _____ Until _____

D7 Does the house where you live have a radio? Y N

If NO, go to Question D9.

D8 If YES, does it run off electricity or a battery? (circle)

(i) electricity (ii) *battery* (iii) *other*

D9 Does the house where you live have a television? Y N

If NO, go to question D11.

D10 If YES, approximately when is it most commonly watched?

From _____ Until _____

D11 Does the house where you live have a computer with access to the internet? Y N

If NO, go to question D13.

D12 If YES, approximately when is it most commonly used?

From _____ Until _____

D13 Do you – or anyone else in your house – read a daily newspaper? Y N

If NO, go to section J.

D14 If YES, which one?_____

D15 What time of day do you/they usually read the paper?_____

J INFORMATION AND EDUCATION

The purpose in this section in get an understanding of how to pitch messages and awareness information to people.

J1 How many people are there in your household or business over the age of 16?_____

J2 What are the educational backgrounds of the people in your household/business?

Name	Age	Top level of education

J3 Are you an active member of a community or church group where you obtain information about Navua? Y N

J4 If YES, which one (s)?_____

_____

_____

J5 How do you get information on the latest developments in town? (circle)

(i) Family (ii) Friends (iii) Church (iv) Community group

(v) Public notice board (vi) Newspaper (vii) Radio (viii) District Officer

(ix) other _____

K FINAL COMMENTS

Explain that this is the end of questionnaire.

Thank the respondent for their time and effort.

K1 Would you like to add any comments about flooding or an early flood warning system in Navua?

_____

_____

_____

Explain that the results of the survey and the first trial of the early warning system will occur towards the end of the year. The results of the survey will be produced in a report that goes to the NDMO and a committee of Navua town officials.

If respondents would like to find out more about the early warning system project, they should in the first instance contact:

Michael Bonte-Grapentin
Community Risk Programme
SOPAC
Ph. 338-1377 x 250

Joeli Rokovada
Director
National Disaster Management Office
Ph. 331-3361

THANK YOU FOR HELPING US IN THIS WORK.

NAVUA FLOOD COMMERCIAL SURVEY

Questionnaire # (data entry)

Date	
Interviewer's name	

Survey district No: _____ or team: Business (1), (2) or (3)

Mark house on map provided and/or provide the street address:

_____

E COMMERCIAL BACKGROUND

E1 Name of interviewee_____

E2 Kind of business_____

E3 Location of business_____

E4 Do the people in your business know where the nearest evacuation centre is? Y N

If No go to question E8

E5 Where is it?_____

E6 How do you get there from your business? _____

E7 How much time would you and your staff need to get to this evacuation centre from your business?_____

E8 Realistically, how much time do you need to pack and store your critical assets to a higher level?_____

E9 Can you hear the Navua fire siren from the business? Y N

F COMMERCIAL LOSSES

The purpose in this section in get an understanding of how much an early warning system can save businesses.

F1 Were you operating your business in Navua when the 2004 flood occurred? Y N

If NO, go to section H.

F2 When the 2004 flood happened, how did you first find out about it? (circle):

(i) Radio (ii) Television (iii) Phone call (iv) Text message

(v) Saw heavy rain (vi) Saw river rise (vii) Contacted by friends/neighbours

(viii) Other (specify)

F3 Did you get any advance warning to act to protect your business? Y N

F4 Did you lift or remove any of your business assets? Y N

Details_____

_____

F5 Did you take any other measures to protect the business? Y N
(e.g. wrapped assets etc.)

Details _____

_____

F6 If some of your business assets were damaged or lost because of the flood, what would you say was the value of those losses?

Appliances	
Oven	
Refrigerators	
Television	
Radio	
Telephone	
Mobile phone	
Computer, printer, software	
Other _____ _____ _____ _____ _____	
Office furniture	
Tables and chairs	
Other _____ _____ _____ _____ _____	
Other	
Books	
Other valuable possessions	
Store stock	
Machinery/equipment	
Tools	
Display cases, counters	
Car/truck	
Cash Crops	
Livestock/Animals	
Structural damage to buildings	
Damage to floors, floor covering	
Damage to doors, windows etc.	
Damage to piping (water in, waste water out)	
Electricals, air conditioning	
Clean up costs (disinfecting, buying new cleaning materials)	
Other non costed items	
Files, records	

F7 During the flood, did you have to evacuate the business premises at all? Y N

If NO, go to question F10.

F8 If YES, how did you evacuate? (circle) (i) own vehicle (ii) taxi (iii) bus

(iv) used family/friend's vehicle (v) boat (vi) evacuation team (vii) other_____

F9 For how long did you evacuate? _____ days

F10 Did you relocate your business to somewhere else? Y N

If NO, go to question F12.

F11 If YES, where did you go?_____

_____

_____

F12 Did you have to pay for any temporary quarters, additional transportation, communications, or storage expenses? Y N

F13 Following the flood, did you have to use any paid staff to clean up premises rather than producing or selling for you? Y N

If NO, go to question F15.

F14 If YES, how many staff days did you have to cover?

No of paid staff _____ No of days paid to clean up _____

F15 Did you lose any days production/business? Y N

If NO, go to question F17.

F16 Roughly how much did this cost your business?

(i) Number of days lost ____

(ii) Revenue lost $_____/day

F17 How did you replace the lost items/costs? (circle)

(i) Didn't replace (ii) Insurance (iii) Government

(iv) Charity (v) Private savings (vi) Family

(vii) Other (specify)

F18 Is your business (property and assets) currently covered by insurance? Y N

H COMMERCIAL ACCESS TO COMMUNICATIONS

The purpose in this section in get an understanding of how we might be able to advise business people of an on coming flood.

H1 Does your business have access to electricity? Y N

H2 Does your business have a working phone? Y N

H3 Do you have a mobile phone? Y N

If NO, go to Question H6.

H4 Is your mobile phone always switched on? Y N

If YES, go to question H6.

H5 Which hours is it switched off? From _____ Until _____

H6 Do you have a radio playing during work hours? Y N

If NO, go to Question H8.

H7 If YES, does it run off electricity or a battery? (circle)

(i) *electricity* (ii) *battery* (iii) *other*

H8 Do you have a television running during work hours? Y N

If NO, go to question H10.

H9 If YES, approximately when is it most commonly watched?

From _____ Until _____

H10 Does your business have a fax machine? Y N

H11 Does your business have a computer with access to the internet? Y N

If NO, go to section J.

H12 If YES, approximately when is it most commonly used?

From _____ Until _____

J INFORMATION AND EDUCATION

The purpose in this section in get an understanding of how to pitch messages and awareness information to people.

J1 How many people are there in your household or business over the age of 16?

J2 What are the educational backgrounds of the people in your household/business?

Name	Age	Top level of education

J3 Are you an active member of a community or church group where you obtain information about Navua? Y N

J4 If YES, which one (s)?_____

_____

_____

J5 How do you get information on the latest developments in town? (circle)

(i) Family (ii) Friends (iii) Church (iv) Community group

(v) Public notice board (vi) Newspaper (vii) Radio (viii) District Officer

(ix) other _____

K FINAL COMMENTS

Explain that this is the end of questionnaire.

Thank the respondent for their time and effort.

K1 Would you like to add any comments about flooding or an early flood warning system in Navua?

_____

_____

_____

_____

Explain that the results of the survey and the first trial of the early warning system will occur towards the end of the year. The results of the survey will be produced in a report that goes to the NDMO and a committee of Navua town officials.

If respondents would like to find out more about the early warning system project, they should in the first instance contact:

Michael Bonte-Grapentin
Community Risk Programme
SOPAC
Ph. 338-1377 x 250

Joeli Rokovada
Director
National Disaster Management Office
Ph. 331-3361

THANK YOU FOR HELPING US IN THIS WORK.

NAVUA FLOOD MARKET SURVEY

Questionnaire #
(data entry)

Date	
Interviewer's name	

G MARKET LOSSES

The purpose in this section in get an understanding of how much an early warning system can save market vendors.

G1 Name of interviewee _____

G2 Kind of market business _____

G3 Do you know where the nearest evacuation centre to the market is? Y N

If No got to question G6

G4 Where is it?_____

G5 How do you get there from the market?_____

G6 How much time would you need to get to the next evacuation centre from the market?
_____

G7 Realistically, how much time do you need to pack and store your possessions to a higher level?
_____

G8 Can you hear the Navua fire siren from the market? Y N

G9 Were you operating at the Navua market the year the 2004 flood occurred? Y N

If NO, go to section I.

G10 If you made any losses at the market because of the 2004 flood, what would you say was the value of those losses?

	Cost FJ$
Produce	
Tables	
Bags	
Other _____ _____ _____ _____	

G11 How did you replace the items? (circle)

(i) Didn't replace (ii) Insurance (iii) Private savings

(iv) Extended family (v) Charity donations (vi) Government assistance

(vii) Other (specify) _____

G12 During the flood, did you have to evacuate from the market? Y N

If NO, go to question F15.

G13 If YES, how did you evacuate? (circle) (i) own vehicle (ii) taxi (iii) bus

(iv) used family/friend's vehicle (v) boat (vi) evacuation team (vii) other_____

G14 For how long did you evacuate? _____ days

G15 Did you relocate your stall to somewhere else? Y N

If NO, go to section I.

G16 If YES, where did you go?_____

_____

_____

I MARKET ACCESS TO COMMUNICATIONS

The purpose in this section in get an understanding of how we might be able to advise market vendors of an on coming flood.

I1 Do you have a mobile phone? Y N

If NO, go to Question I4.

I2 Is your mobile phone always switched on? Y N

If YES, go to question I4.

I3 Which hours is it switched off? From _____ Until _____

I4 Do you have a radio playing during the day? Y N

J INFORMATION AND EDUCATION

The purpose in this section in get an understanding of how to pitch messages and awareness information to people.

J1 How many people are there at the market stall over the age of 16? _____

J2 What are the educational backgrounds of the people at your market stall?

Name	Age	Top level of education

J3 Are you an active member of a community or church group where you obtain information about Navua? Y N

J4 If YES, which one (s)? _____

_____

_____

J5 How do you get information on the latest developments in town? (circle)

(i) Family (ii) Friends (iii) Church (iv) Community group

(v) Public notice board (vi) Newspaper (vii) Radio (viii) District Officer

(ix) other _____

K FINAL COMMENTS

Explain that this is the end of questionnaire.

Thank the respondent for their time and effort.

K1 Would you like to add any comments about flooding or an early flood warning system in Navua?

_____

_____

_____

Explain that the results of the survey and the first trial of the early warning system will occur towards the end of the year. The results of the survey will be produced in a report that goes to the NDMO and a committee of Navua town officials.

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THANK YOU FOR HELPING US IN THIS WORK.

ANNEX 3 – PEOPLE CONSULTED

A series of discussions was held with different agencies and individuals involved in the sectors that were hit during the 2004 Navua floods. In some cases, individuals representing agencies provided their views on how a warning in 2004 might have impacted damages and what impact a warning today might have. A meeting was held with agencies and individuals sitting on the Navua flood warning system steering committee. The following people were consulted, either individually or jointly in a participatory exercise, regarding assumptions for the analysis:

Sairusi Bosenaqali	Provincial Administration Serua
Vijay Maharaj	District Advisory Council
Atunaisa Lacabuka	Serua Provincial Council
Sgt Illiesa Bolablu	Navua Police
Dr Kusitino Tiko	Sub-Divisional Medical Officer, Navua Hospital
Veniana Anthony	DAC Navua
Ismail Yusuf	DAC Navua
Nabi Buksh	Fire Station
Rev Isala Tuinuku	Methodist Church, Navua
Rev Demesi Sitei	Anglican Church, Navua
Ashok Kumar Bah	Telecom Navua
Malakai Rarawa	Fiji Navy
Akheem	Forestry Officer, Navua
Raveen Gopal	PWD Hydrology, Suva
Faga Finiasi	PWD Hydrology Suva
Laisenia Balenigi	Officer-In-Charge, Department of Fisheries
Mattiasi Nadauleu	Health Officer, Navua
Tomasi Mucunabitu	NDMO

Additionally participatory exercise was conducted in which representatives were asked their views on the likely impact that a warning might have had/might have on damage to them. Agreement was sought during the exercise on likely impacts. Agencies represented during the participatory exercise included:

National agencies
Department of Public Works (Hydrology)
NDMO
National Fire Authority
Department of Agriculture
Republic of Fiji Military Forces
Navy
Department of Forestry
Land and Water Resource Management
Telecom
Water Supply

International agencies
FSPI
Red Cross

Provincial/town agencies
MEA/PA
Nakavu Village Youth
Turaga Ni Kao
T/K Dranukula
T/K Vunibau
T/K Goloa
Namei Provincial Council
Serua Provincial Council
Advisory Council
Police/, Navua
Anglican Church
Methodist Church

Following the participatory exercise, assumptions were finalised on the basis of final consultations. A list of people consulted throughout the analysis is given below.

ANNEX 4 – DETAILED RESULTS

Savings from a flood warning system under different assumptions

Estimated savings from 1 flood (1-in-20 year flood), 10% discount rate

Item	Worst case scenario	Most likely case	Best case scenario
Personal losses			
▪ Immediate medical costs	5	14	24
▪ Loss of personal possessions such as televisions, clothing, vehicles	631352	1262703	1736217
▪ Subsequent medical costs	0	1	2
▪ Lost earnings	236	314	942
Business losses			
▪ Loss of assets such as computers, electricals, vehicles	172301	419510	667047
Government losses			
▪ Buildings (e.g. lean tos)	0	986	1629
▪ Infrastructure rehabilitation	0	9365	18730
▪ Medical services	234123	374597	468246
▪ Education services	3000	4800	7199
▪ Coordination by government	0	0	0
▪ Clothing	234	328	421
▪ Food rations and sundries	1277	2554	3831
▪ Primary production			
- Agricultural land	0	0	0
- Boats and engines	0	891	3563
Humanitarian aid			
▪ other valued aid	83	248	414
▪ unvalued aid	unknown	unknown	unknown
Other losses			
▪ Lost education opportunities	unknown	unknown	Unknown
▪ Volunteers	unknown	unknown	Unknown
▪ Trauma from flooding, loss of personal possessions, pets etc.	unknown	unknown	Unknown
▪ Use of warning system for other local warnings	unknown	unknown	unknown
▪ Lessons to other warning systems in the Pacific	unknown	unknown	Unknown
TOTAL	1042610	2076311	2908267

Estimated savings from 1 flood (1-in-20 year flood), 7% discount rate

Item	Worst case scenario	Most likely case	Best case scenario
Personal losses			
▪ Immediate medical costs	6	17	29
▪ Loss of personal possessions such as televisions, clothing, vehicles	764208	1528416	2101572
▪ Subsequent medical costs	0	1	3
▪ Lost earnings	285	380	570
Business losses			
▪ Loss of assets such as computers, electricals, vehicles	208161	507788	807415
Government losses			
▪ Buildings (e.g. lean tos)	0	986	1972
▪ Infrastructure rehabilitation	0	11336	22671
▪ Medical services	283390	453424	566780
▪ Education services	3631	5809	8714
▪ Coordination by government	0	0	0
▪ Clothing	283	397	510
▪ Food rations and sundries	1546	3091	4637
▪ Primary production			
- Agricultural land	0	0	0
- Boats and engines	0	1078	2157
Humanitarian aid			
▪ other valued aid	100	301	501
▪ unvalued aid	unknown	unknown	unknown
Other losses			
▪ Lost education opportunities	unknown	unknown	Unknown
▪ Volunteers	unknown	unknown	Unknown
▪ Trauma from flooding, loss of personal possessions, pets etc.	unknown	unknown	Unknown
▪ Use of warning system for other local warnings	unknown	unknown	unknown
▪ Lessons to other warning systems in the Pacific	unknown	unknown	Unknown
TOTAL	1261610	2513025	3517532

Estimated savings from 1 flood (1-in-20 year flood), 3% discount rate

Item	Worst case scenario	Most likely case	Best case scenario
Personal losses			
▪ Immediate medical costs	8	23	39
▪ Loss of personal possessions such as televisions, clothing, vehicles	1033079	2066159	2840969
▪ Subsequent medical costs	0	2	4
▪ Lost earnings	386	514	771
Business losses			
▪ Loss of assets such as computers, electricals, vehicles	281398	646051	1761454
Government losses			
▪ Buildings (e.g. lean tos)	0	1333	2666
▪ Infrastructure rehabilitation	0	11336	30648
▪ Medical services	383095	612952	766190
▪ Education services	4908	7853	11780
▪ Coordination by government	0	0	0
▪ Clothing	383	536	690
▪ Food rations and sundries	2089	4179	12536
▪ Primary production			
- Agricultural land	0	0	0
- Boats and engines	0	1458	2915
Humanitarian aid			
▪ other valued aid	135	406	677
▪ unvalued aid	unknown	unknown	unknown
Other losses			
▪ Lost education opportunities	unknown	unknown	Unknown
▪ Volunteers	unknown	unknown	Unknown
▪ Trauma from flooding, loss of personal possessions, pets etc.	unknown	unknown	Unknown
▪ Use of warning system for other local warnings	unknown	unknown	unknown
▪ Lessons to other warning systems in the Pacific	unknown	unknown	Unknown
TOTAL	1705482	3352803	5431339

Estimated savings from 2 floods (1-in-10 year flood), 10% discount rate

Item	Worst case scenario	Most likely case	Best case scenario
Personal losses			
▪ Immediate medical costs	9	28	47
▪ Loss of personal possessions such as televisions, clothing, vehicles	1262703	2525407	3472434
▪ Subsequent medical costs	0	2	5
▪ Lost earnings	471	628	942
Business losses			
▪ Loss of assets such as computers, electricals, vehicles	344602	839020	1334095
Government losses			
▪ Buildings (e.g. lean tos)	0	1972	3259
▪ Infrastructure rehabilitation	0	18730	37460
▪ Medical services	468246	749194	936492
▪ Education services	5999	9599	14399
▪ Coordination by government	0	0	0
▪ Clothing	468	656	843
▪ Food rations and sundries	2554	5108	7661
▪ Primary production			
- Agricultural land	0	0	0
- Boats and engines	0	1782	3563
Humanitarian aid			
▪ other valued aid	166	497	828
▪ unvalued aid	unknown	unknown	unknown
Other losses			
▪ Lost education opportunities	unknown	unknown	Unknown
▪ Volunteers	unknown	unknown	Unknown
▪ Trauma from flooding, loss of personal possessions, pets etc.	unknown	unknown	Unknown
▪ Use of warning system for other local warnings	unknown	unknown	unknown
▪ Lessons to other warning systems in the Pacific	unknown	unknown	Unknown
TOTAL	2085219	4152622	5812029

Estimated savings from 2 floods (1-in-10 year flood), 7% discount rate

Item	Worst case scenario	Most likely case	Best case scenario
Personal losses			
▪ Immediate medical costs	11	34	57
▪ Loss of personal possessions such as televisions, clothing, vehicles	1528416	3056832	4203144
▪ Subsequent medical costs	0	3	6
▪ Lost earnings	570	760	1141
Business losses			
▪ Loss of assets such as computers, electricals, vehicles	416322	1015576	1614831
Government losses			
▪ Buildings (e.g. lean tos)	0	1972	3945
▪ Infrastructure rehabilitation	0	22671	45342
▪ Medical services	566780	906848	1133560
▪ Education services	7262	11619	17428
▪ Coordination by government	0	0	0
▪ Clothing	567	793	1020
▪ Food rations and sundries	3091	6182	9274
▪ Primary production			
- Agricultural land	0	0	0
- Boats and engines	0	2157	4313
Humanitarian aid			
▪ other valued aid	200	601	1002
▪ unvalued aid	unknown	unknown	unknown
Other losses			
▪ Lost education opportunities	unknown	unknown	Unknown
▪ Volunteers	unknown	unknown	Unknown
▪ Trauma from flooding, loss of personal possessions, pets etc.	unknown	unknown	Unknown
▪ Use of warning system for other local warnings	unknown	unknown	unknown
▪ Lessons to other warning systems in the Pacific	unknown	unknown	Unknown
TOTAL	2523220	5026050	7035063

Estimated savings from 2 floods (1-in-10 year flood), 3% discount rate

Item	Worst case scenario	Most likely case	Best case scenario
Personal losses			
▪ Immediate medical costs	16	47	78
▪ Loss of personal possessions such as televisions, clothing, vehicles	2066159	4132318	5681937
▪ Subsequent medical costs	0	4	8
▪ Lost earnings	771	1028	1542
Business losses			
▪ Loss of assets such as computers, electricals, vehicles	562797	1292103	3522909
Government losses			
▪ Buildings (e.g. lean tos)	0	2666	5333
▪ Infrastructure rehabilitation	0	22671	61295
▪ Medical services	766190	1225904	1532380
▪ Education services	9817	15707	23560
▪ Coordination by government	0	0	0
▪ Clothing	766	1073	1379
▪ Food rations and sundries	4179	8358	12536
▪ Primary production			
- Agricultural land	0	0	0
- Boats and engines	0	2915	5831
Humanitarian aid			
▪ other valued aid	271	813	1355
▪ unvalued aid	unknown	unknown	unknown
Other losses			
▪ Lost education opportunities	unknown	unknown	Unknown
▪ Volunteers	unknown	unknown	Unknown
▪ Trauma from flooding, loss of personal possessions, pets etc.	unknown	unknown	Unknown
▪ Use of warning system for other local warnings	unknown	unknown	unknown
▪ Lessons to other warning systems in the Pacific	unknown	unknown	Unknown
TOTAL	3410965	6705606	10850142

Investment returns from a flood warning system under different assumptions

Global returns

Global return on investing in warning system over 20 years @10% discount rate and assuming 1 in 20 year flood			
	WC	ML	BC
Total benefits	1042610	2076311	2908267
Total costs	566652	566652	566652
Net present value	475958	1509659	2341615
B/C ratio	1.84	3.66	5.13

Global return on investing in warning system over 20 years @3% discount rate and assuming 1 in 20 year flood			
	WC	ML	BC
Total benefits	1705482	3352803	5431339
Total costs	566652	566652	566652
Net present value	1138830	2786151	4864687
B/C ratio	3.01	5.92	9.58

Global return on investing in warning system over 20 years @10% discount rate and assuming 1 in 10 year flood			
	WC	ML	BC
Total benefits	2085219	4152622	5812029
Total costs	566652	566652	566652
Net present value	1518567	3585971	5245377
B/C ratio	3.68	7.33	10.26

Global return on investing in warning system over 20 years @7% discount rate and assuming 1 in 10 year flood			
	WC	ML	BC
Total benefits	2523220	5026050	7035063
Total costs	566652	566652	566652
Net present value	1956568	4459398	6468411
B/C ratio	4.45	8.87	12.42

Global return on investing in warning system over 20 years @3% discount rate and assuming 1 in 10 year flood			
	WC	ML	BC
Total benefits	3410965	6705606	10850142
Total costs	566652	566652	566652
Net present value	2844313	6138954	10283490
B/C ratio	6.02	11.83	19.15

Government returns

Fiji government return on investing in warning system over 20 years @10% discount rate and assuming 1 in 20 year flood			
	WC	ML	BC
Total benefits	238634	392629	500057
Total costs	356478	356478	356478
Net present value	-117844	36151	143579
B/C ratio	0.67	1.10	1.40

Fiji government return on investing in warning system over 20 years @7% discount rate and assuming 1 in 20 year flood			
	WC	ML	BC
Total benefits	288950	475344	605786
Total costs	356478	356478	356478
Net present value	-67528	118866	249307
B/C ratio	0.81	1.33	1.70

Fiji government return on investing in warning system over 20 years @3% discount rate and assuming 1in 20 year flood			
	WC	ML	BC
Total benefits	390611	638596	825187
Total costs	356478	356478	356478
Net present value	34133	282118	468709
B/C ratio	1.10	1.79	2.31

Fiji government return on investing in warning system over 20 years @10% discount rate and assuming 1 in 10 year flood			
	WC	ML	BC
Total benefits	477267	785258	1000114
Total costs	356478	356478	356478
Net present value	120789	428780	643635
B/C ratio	1.34	2.20	2.81

Fiji government return on investing in warning system over 20 years @7% discount rate and assuming 1 in 10 year flood			
	WC	ML	BC
Total benefits	577900	950687	1211571
Total costs	356478	356478	356478
Net present value	221422	594209	855093
B/C ratio	1.62	2.67	3.40

Fiji government return on investing in warning system over 20 years @3% discount rate and assuming 1 in 10 year flood			
	WC	ML	BC
Total benefits	781223	1277191	1637838
Total costs	356478	356478	356478
Net present value	424745	920713	1281360
B/C ratio	2.19	3.58	4.59