REDUCING THE IMPACT OF ENVIRONMENTAL EMERGENCIES THROUGH EARLY WARNING AND PREPAREDNESS - THE CASE OF EL NIÑO-SOUTHERN OSCILLATION (ENSO)

SOPAC | FMS | MOH | MEHA | USP | NDMO | MOA | FSC | UNU

IMPACTS OF THE 1997-98 EL NIÑO EVENT IN Fiji

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Acknowledgments

The decade of the 1990s will be well remembered as the UN-declared International Decade for Natural Disaster Reduction (IDNDR). This was the initiative that prompted Pacific Island Countries (PICs) to formulate and implement the South Pacific Disaster Reduction Programme. Driven from UNDP funding, the program is largely responsible for heightening awareness in the region for better preparedness and mitigation planning related to natural disasters. Hence, with the onset of the 1997-98 El Niño-related drought, the Fiji government was ready and keen to assess potential and actual impacts and to define mitigation measures. Two drought studies funded by the UNDP (*UNDAC Fiji Drought Study* (Kaloumaira et al., 1998) and the *Regional El Niño Social and Economic Drought Impact Assessment and Mitigation Study* (Lightfoot, 1999) did all the groundbreaking work and, as a result, created a logical association with this UNEP-NCAR-UNFIP study.

There have been many valuable contributions to this study from participants, which are too many to thank individually. This study is indebted to them all, very senior people from within and outside government as well as friends from regional and international institutions. They have been responsible for maintaining interest at a very high level and spared their time and efforts willingly to forge the links among all three studies.

The National Disaster Management Office was a pillar of strength and smoothly coordinated all in-country activities and national workshops, despite the political climate and hardships befalling the country over the duration of this study. Pacific island colleagues and participants to the regional workshop on *ENSO Impacts on Water Resources* (gave a valuable regional overview in their assessments and exchanges and provided useful practical information of forecasting capabilities and needs. By sharing experiences and knowledge of El Ni o, other study leaders from various countries around the world provided the central direction as to how this study was to be implemented.

Without detracting anyone's contribution, mention needs to be made of the following resource people and institutions who provided technical support: Dr. Mike Hamnett and Ms. Cheryl Henderson of the Social Science Research Institute, University of Hawaii; Dr. Chip Guard of the Water and Environmental Research Institute, University of Guam; Ms Nazmin Bi of the Fiji Meteorological Service; Kaliopate Tavola the Team Leader of UNDP Fiji drought studies and Chris Lightfoot the UNDP consultant; and all Team Members of this study.

I am much indebted to three people who carried most of the workload but at different levels. Mr. Sakenasa Varea, the Deputy Study Team Leader who collated all departmental reports and organized the national workshop, Dr. Michael Glantz, the project's Principal Investigator, and Ms. D. Jan Stewart, the study's administrator.

Finally this would not have been possible without the people who provided funds and resources – UNEP, UNFIP, NCAR, WMO, IDNDR and UNU. Thank you all very much for the support and the encouragement to see this through even beyond this study and into a realization of the vision you have defined.

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The Fiji Setting

Background to the Study

In 1997-98 the most intense El Niño of the 20th century occurred. It prompted the UNFIP to support 16 country case studies to document El Niño's societal impacts. These countries were affected in a variety of ways by the 1997-98 event. The overriding objective of these case studies has been to determine how countries affected by either of ENSO's extremes can be better assisted through improved use of El Niño Southern Oscillation (ENSO) forecasts. Fiji is very grateful to have been selected, along with Papua New Guinea (PNG), as the two island countries to represent the Pacific island countries (PICs). In September 1999 UNEP concluded a Memorandum of Understanding (MOU) agreement with the South Pacific Applied GeoScience Commission (SOPAC) to undertake the Fiji case study. Immediately following this, the Fiji government endorsed the undertaking of the Fiji case study project. This endorsement facilitated the access of our research team to government information and the release of civil servants to be Team members.

The Early El Niño

El Niño, in its first usage by the fishermen along the coasts of Ecuador and Peru, referred to the times when warm ocean current periodically appeared, typically around Christmas time, and flowed southward along the coast of Ecuador and Northern Peru. It is a Spanish word meaning 'the Christ child' or 'the boy child' describing these warm ocean intervals which may last several months and extend into May and June in very severe cases. The southward flowing current is in reverse direction to the much cooler, normal northward flowing current. Generally fish were less abundant so fishermen used these

breaks to repair equipment and spend more time with their families[1]. It was noted that heavy rainstorms and floods often accompanied this phenomena causing acute disruptions to their normal lives and livelihoods. Today some argue that following El Niño, when cold currents revert back to normal, there is upwelling that brings up fish nutrients, resulting in bumper fish catches in the season that follows.

El Niño and Teleconnections Today

Science today links El Niño to the heating up of the sea's surface waters along the equator in the Pacific Ocean. The heating progresses eastward, forcing dislocations in atmospheric circulation and convection above the eastward shifting warm surface water. Concurrent major shifts are induced with the ocean currents flowing along the equator from the West to the East Pacific coast and southward down the Southern American coast. The combined effects of these anomalies cause remarkable and variable changes in climate pattern, in the first instance, for all countries draining into the Pacific. With increasing scientific research over the last three decades, direct links or teleconnections were also established with climate changes in regions that drain into the Indian and Atlantic Oceans

Fiji is located within the transition zone of the Southern Oscillation. This is a reason why distinct impacts are realized only with high intensity El Niños.

Geophysical, Social and Political Setting

Fiji is a small island nation in the South Pacific. In common with other small Pacific Island states it receives much support from regional inter-governmental organizations.

Regional Management Support

The Pacific Ocean is the single biggest feature of the planet. It is more than 70,000,000 square miles and more than 10,000 miles from North to South and East to West and is currently home to 21 developing PICs. The PIC leaders have, over the years, established regional organizations that bond them together to serve the direct interests of the countries. The regional organizations provide applied management support in many sectors and are prominent in providing direct educational, scientific, technical, policies and good governance support. Evolving regional cooperation has grown to be one of the strongest and most resilient management features among PICs. The Forum Council of Government Leaders directs the programmes of all regional organizations.

[1] In *Currents of Change* (1996) M. Glantz noted that in old traditional fishing, fishermen coming across pockets of cold upsurges always caught fish in abundance.

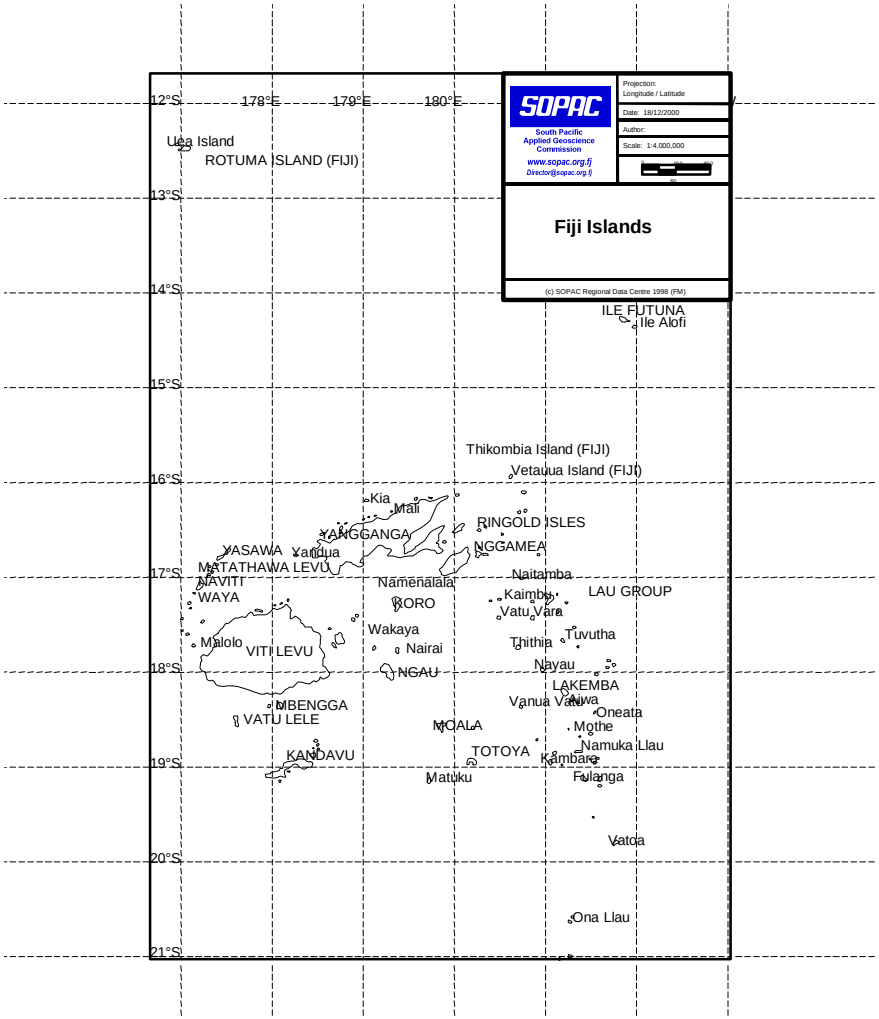


Figure 1: Map of the Fiji Group of Islands

The South Pacific Applied GeoScience Commission (SOPAC) is one such independent, inter-governmental technical regional organization. One of its mandates is to improve and strengthen national capacities of PICs to better manage natural disasters. Disaster management structures are being

established in the PICs, similar to that described here for Fiji. For technical hazard information on climate and environmental affairs, the responsibility i placed with the South Pacific Regional Environment Programme (SPREP). Recently, the WMO established a regional office in the region co-located with SPREP. This is bringing a better WMO focus on PIC national meteorological needs. There are three other regional organizations that respectively look at tourism, fisheries and shipping.

Geo-Physical Features

The Fiji group of islands lies between 15-18 degrees South and 175 degree East to 177 degree West. It consists of over 300 islands of which about 97 are inhabited. There are small atoll limestone islands, which are very vulnerable to drought and storm surges. The bigger islands are volcanic in origin and have well-established gullies and river systems. They rise to peaks of 1000 meters and have clearly demarcated wet and dry zones.

The total landmass is about 18,272 km^2. There are two main islands of Viti Levu (10.4K km^2) and Vanua Levu (5.5K km^2) that comprise 88% of the total landmass. The terrain for Fiji's main island is very rugged with less than 18% of the land arable as the interior is rugged, deeply serrated and steep. The prevailing Southeast trade winds bring rains to the heavily rainforested eastern zones, leaving dry the western leeward zone. With very heavy and high intensity rainfall, soil erosion remains a very big and constant concern. The cumulative effects of erosion over the years have resulted in raised riverbeds leading to increasing incidences of flooding.

Socio-Economic Features

Fiji is an independent island nation having a two-house parliament. The Lower House was elected every five years. Participation in the Senate (or Upper House) was done by nominations. The population of Fiji is 775,077 at the 1996 census.[2] In May 2000, the Prime Minister and members of the Congress were held hostage in a coup attempt that lasted a few months. Eventually, the military ended the coup and tool control of the government.

There are two predominant races, Fijians and Indians. The Indians are traditionally successful traders, professionals, business entrepreneurs and sugarcane farmers, whereas Fijians have historically opted for the service industries and subsistence farming. Fijians own about 85% of the land and derive subsistence livelihood from it. Of the total population of around 775,000 over 75% live on the main island of Viti Levu and 18% in Vanua Levu. The remaining 7% are distributed over 95 other islands in a scatter that makes it difficult for emergency and development planning.

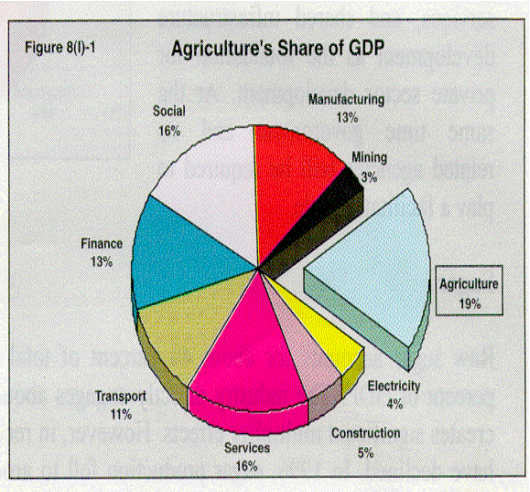
[2] Bureau of Statistic 1996 Census of Population and Housing. Current population is closer to 800,000.

Fiji has historically been heavily reliant on export revenue earnings from its sugar sales with a little bit of support from mining and other agricultural produce. With a large populace reliant on subsistence farming, agriculture is fundamental to the livelihood of about three-quarters of Fiji's population. This heavy reliance on agriculture, and its attendant high risk to natural disasters (Fiji is particularly vulnerable in the cyclone season), has prompted a policy shift for the past two decades in which the government actively promoted tourism and the garment industry.

Suburban development in Fiji has taken place along the coastal belt and flood plains. In past cyclones and flood disasters the sectors that had been hit hardest were housing, water supplies, infrastructure and agriculture. Drought has also adversely impacted water resources and agriculture. Understanding the social and economic impacts of drought is important, as Fiji relies very heavily on agriculture and tourism for employment and the generation of foreign revenue. It has been estimated that natural disasters reduced by up to 50% the economic growth rate of Fiji[3] (Benson, 1996).

[3] Benson, C. (1996). The Economic Impact of Natural Disasters, Case Study Fiji. This study done by the British Government and includes case studies in Asia as well.

Sugarcane comprises the major agriculture activity and has been the economic backbone for the country. It is planted as rain-fed production on the dry leeward side for higher sugar quality content. This, however, makes it very vulnerable to El Niño-induced droughts and their associated community social problems as the industry is very farm-labor intensive with a majority of Fijians living on income bordering on a poverty threshold for Fiji.



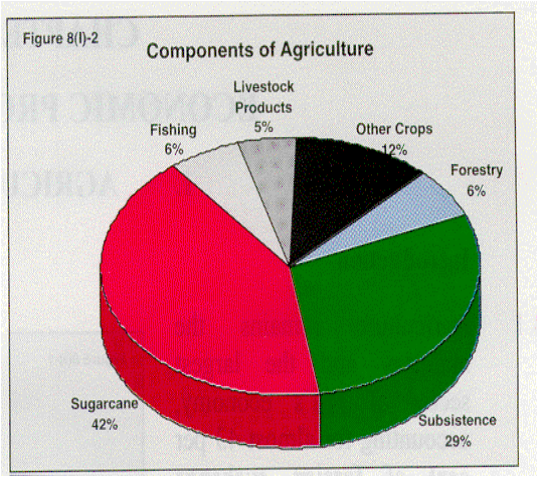


Figure 2: Agriculture Share of the National GDP (Source: Development Strategy for Fiji 1997; Ministry of National Planning).

The contribution of other sectors to GDP is presented in Table 1.

Table 1: Gross Domestic Product by Sector 1993-1998
(constant 1989 factor cost, F$million)

Sector	1993 (F$m)	1994 (F$m)	1995 (F$m)	1996 (F$m)	1997 (F$m)	1998 (F$m)
Agriculture, Forestry and Fishing	337.8	374.8	362.8	369.7	323.6	289.8
of which - Sugarcane	147.8	172.5	153.1	152.1	116.3	72.1
- Subsistence	104.0	105.0	106.1	107.5	108.4	109.3
Mining and Quarrying	50.9	46.2	46.7	61.2	62.7	49.8
Manufacturing	249.7	267.2	267.7	276.9	267.5	258.7
Construction	78.0	77.3	81.4	83.1	82.3	80.7
Trade, Hotels, Cafes, etc.	258.7	273.1	299.4	307.9	310.2	286.0
Transport and Communications	192.7	202.9	222.7	236.3	245.3	252.1
Finance, Insurance, Real Estate	242.3	252.0	257.0	255.5	249.1	249.0
GDP at Factor Cost	1,707.5	1,794.3	1,840.1	1,902.3	1,868.5	1,795.3
Memorandum Items						
GDP at Market Prices	2,521	2,672	2,799	2,976	3,033	3,129
Sugar Production ('000 tons)	442	517	454	454	347	215
Visitor Arrivals ('000)	287	319	318	340	359	373

Source: Government of the Fiji Islands: Supplement to the 1999 Budget Address

Reference: Regional El Niño Social and Economic Drought Impact Assessment and Mitigation Study (Lightfoot, 1999).

Political Setting

The beginning period of the study, in late 1998, coincided with high political campaigning in the Fiji Islands culminating in the 1999 May general election that saw a new government voted in. There was strong racial undercurrents and tension, as the campaigns were on racial divides propelled by a lack of public understanding of the new Constitution pushed through during the height of the 1997 drought. The new government was just a year in office, when armed civilians in May 2000 stormed Parliament in staging a coup. To date Fiji is under martial law with the Constitution abrogated and rebels in the Parliament Complex held the former Prime Minister and colleagues hostage until their release on July 12th. These events created challenges to the study team to stay focused on the task at hand, particularly in the latter period coinciding with compiling the final report when tension was high in the country.

Natural Hazards in Fiji

Fiji generally has a wet and hot season from November to April and a cold and dry season from May to October. When El Niño forms in the late and early part of the year, dry conditions are accentuated. Similarly La Nina can cause heavier rains and floods in the wet season. Cyclones are most likely to occur between October to May, known as the cyclone season. Other climate-related hazards affecting Fiji include floods, drought, storm surges, landslides and forest fires.

Disaster Management Structure in Fiji

The Pacific Island countries are vulnerable to a number of natural disasters as indicated in the Table 2.

Table 2: Pacific island countries -Estimated level of vulnerability to specific natural hazards [South Pacific Disaster Reduction Programme "Final Report for International Decade For Natural Disaster Reduction" *-Dr.Jack Rynn)*]

Country	Population	Land Area Km2	Tropical Cyclone	Storm Surge	Flood Coast	Flood River	Earthquake	Drought	Tsunami	Landslide	Volcano
Cook Islands	19,500	240	H	H	M	M	L	H	M	L	-
Federated States of Micronesia	114,800	701	M	M	H	-	L	H	H	L	-
Fiji	752,700	18,272	H	H	H	H	H	H	H	H	L
Kiribati	76,000	725	L	M	H	-	L	H	H	L	-
Marshall Islands	50,000	181	H	H	H	-	L	H	H	L	-
Nauru	10,500	21	L	L	L	-	L	H	L	L	-
Niue	2,300	258	H	H	L	-	M	H	M	L	-
Palau	21,600	494	H	H	M	-	L	H	M	L	-
Papua New Guinea	4,056,000	462,243	H	H	H	H	H	H	H	H	H

Samoa	163,000	2,935	H	H	H	H	M	L	H	H	M
Solomon Islands	337,000	28,370	H	H	H	H	H	H	H	H	H
Tokelau	1,600	12	H	H	H	-	L	H	H	L	-
Tonga	97,400	720	H	H	H	M	H	H	H	L	H
Tuvalu	9,100	24	H	M	H	-	L	M	H	L	-
Vanuatu	156,500	12,200	H	H	H	H	H	H	H	H	H

In 1994 with the assistance of the UNDP the PICs started the implementation of the current regional "South Pacific Disaster Reduction Programme" aimed to strengthen national capacities and institution building in disaster management.

Fiji now has a National Disaster Management Office (NDMO), which is secretariat to a National Disaster Management Council (NDMC) that reports directly to the Cabinet. The NDMC has subcommittees for mitigation; emergency operations; education and preparedness. The NDMO coordinates operations at the national level for which it has set up cross-sectoral working groups. The structure is taken down through national administrative structures to the divisional, district and village levels. The non-governmental sector is included at all levels.

Disaster Management is supported by Fiji's National Disaster Management Plan and the 1999 Fiji Natural Disaster Act that gave the plan legislative powers.

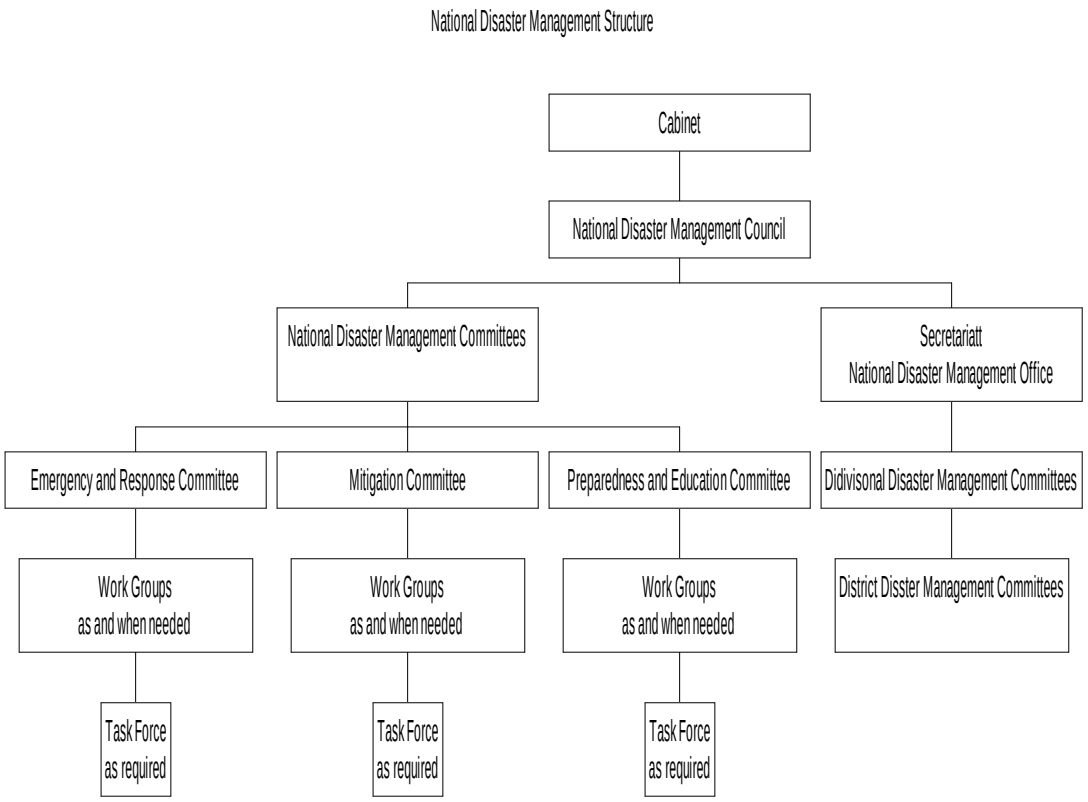


Figure 3. Disaster Management structure in Fiji.

Under the guidance of SPDRP other PICs are developing similarly as Fiji in establishing their disaster management structures. All are supported by training, education and awareness programs, development of manuals and implementation of pilot mitigation projects.

Level of Scientific Research

Not much is known to people outside research circles of the level of scientific research relating to El Niño in Fiji. The Fiji Meteorological Service has reported undertaking studies on the relationships between ENSO and Fiji's climate, particularly on rainfall and tropical cyclones (running statistical analysis of the frequency and severity of tropical cyclones during past ENSO and normal years, since 1840). But as research does not include sophisticated studies such as interactions among SSTs, Fiji's climate and the behavior of South Pacific Convergence Zone (SPCZ).

The Fiji Meteorology Services (FMS)

FMS is responsible for weather research and forecasting and is the sole agency with interest in weather research in Fiji. Prior to the 1992 El Niño drought, there has been little El Niño research in Fiji. However since the Fiji Meteorology Services has a long-term close association with the national meteorological services of New Zealand and Australia, it is recipient to their research findings and analysis. Establishing the Pacific ENSO Application Centre (PEAC) in Hawaii has added another support agency to Fiji. Recently the FMS Nadi Centre has been designated a Regional World Meteorology Office increasing the number of supporting agencies to Fiji and the region.

The Fiji ENSO Phenomenon

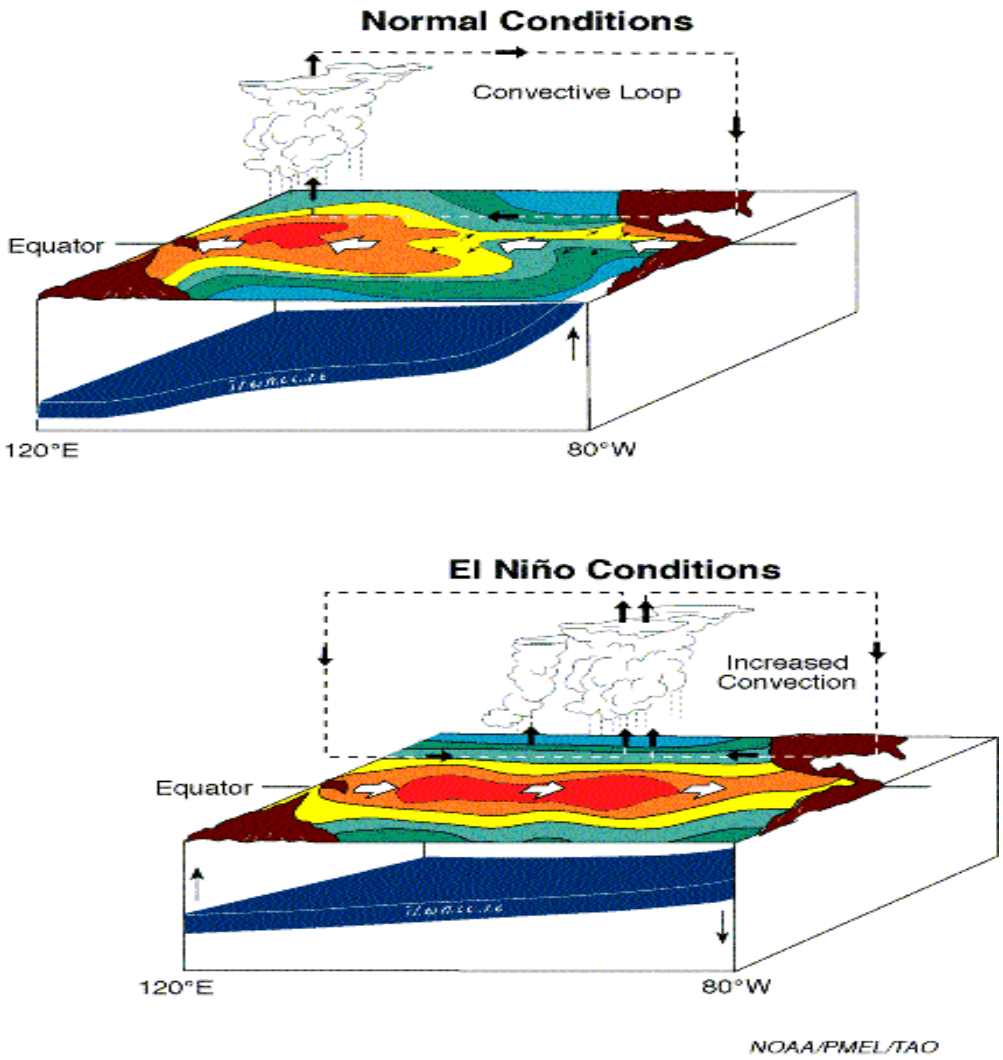
The FMS acknowledged in its country report presented at "The Regional Workshop on ENSO Impacts On Water Resources in the Pacific" that it is important to identify the level of scientific research relating to El Niño in Fiji. It provided the following description of El Niño in relation to the region surrounding Fiji:

El Niño is the term used for the oceanographic phenomenon that is an extensive warming of the upper ocean in the tropical eastern Pacific, lasting three or more seasons. In normal conditions, known as the Walker Circulation, the relatively cold water of the Humboldt Current flows northward along the coasts of Peru and Ecuador to the Equator when it turns westward and flows into the central Pacific along the Equator. As it flows west along the equator, the tropical sun heats the water. During these normal conditions, the equatorial western Pacific is about three to eight degrees centigrade warmer than the Eastern waters. Typically, the trade winds collect moisture from these warm seas and carry it towards Indonesia. Moving over normally warm waters, moist air rises to high altitudes and is associated with regions of low air pressure that produces cumulonimbus clouds and rain. At high altitudes the air circulates back toward the east before sinking over the eastern Pacific Ocean bringing with it high pressure systems and dry conditions. This pressure gradient draws the moist trade winds toward the Australian/Indonesian region. This climatic system is illustrated in Figure 3. The intensity of this system varies between years. The consequent shift back and forth of the atmospheric mass and pressure patterns along the equator is known as *Southern Oscillation* (SO). The oscillation is irregular, but normally occurs every two to seven years.

Since El Niño events are closely linked with SO, they are collectively known as El Niño-Southern Oscillation (ENSO). The magnitude and the phase of ENSO events are measured by calculating the difference in atmospheric pressure at surface between Tahiti and Darwin. The relationship is known as the Southern Oscillation Index (SOI).

During ENSO years the Walker Circulation weakens. An early sign of an approaching El Niño event is the appearance of anomalously warm surface waters in the eastern tropical Pacific off the coast of Peru. As the event develops, the trade winds weaken and may even turn eastward. The area of warm water usually found in the western Pacific cools with the warmest water being displaced eastward to the central and eastern Pacific. Sustained warming in excess of one degree centigrade above normal is observed in this NIÑO3 region (the expanse of ocean from 150ºW to 90ºW between 5ºN to 5ºS). Lower than normal pressure is observed in the eastern tropical Pacific and higher than normal pressure is observed over Indonesia and northern Australia. The region of high pressure develops over the western Pacific, whereas regions of low pressure develop over central and eastern Pacific, hence the SOI is strongly negative. Abnormally dry conditions are observed in the western Pacific with the eastward shift of the thunderstorm activities to the central and eastern Pacific.

Figure 4: Sea Temperature Differences During Normal and El Niño Conditions



Reference: FMS Paper: 1997-98 Drought Assessment and Forecasting Systems Used by Fiji Meteorological Service; Nazmin Bi, Fiji Meteorological Service.

Concurrent El Niño Impact Studies in Fiji

Owing to the unprecedented damaging impacts of the 1997-98 El Niño, the Fiji government asked the United Nations in August 1998 to undertake an independent assessment of the impacts of the El Niño-induced drought and advise on measures that could be used to alleviate its adverse effects. The UN Disaster Assessment and Coordination (UNDAC) Team identified emergency measures required to alleviate the immediate situation and its findings were used by the Fiji Government to help in planning the relief effort. It undertook damage, needs and impact assessments of the worst affected areas and sectors. In addition to the initial UNDAC study, the UNDP and New Zealand's Overseas Development Assistance (NZODA) jointly sponsored a regional initiative entitled "The 1997-98 El Niño Socio-Economic Regional Study." This regional study was piloted in Fiji and Tonga and assessed the long-term impacts; identified vulnerable groups, estimated the likely extent and timing of the impacts, and recommended medium and long-term measures that could be used to mitigate the impact of future events.

There were a couple of important drought study-related events in 1999.

- In June 1999 a national Fiji workshop was convened to discuss the findings of the UNDP/NZODA study and in association with the University of Hawaii. They provided two resource persons who had earlier completed drought-response-mitigation research work in the North Pacific countries based on the 1997-98 El Niño event.

- With additional funding support from UNEP's Water Unit and the British High Commission, in October 1999 Fiji hosted the Pacific Regional ENSO Water Resource Impacts Workshop. The Workshop, convened by SOPAC, was aimed at upgrading climate-related forecasting, assessment, planning and adaptation skills. It brought together water resource planners, water supply managers, meteorologists and disaster managers, and gave them access to the necessary information and tools to benefit from new forecasting capabilities and understanding of the ENSO phenomenon. There were eighty participants from Pacific Island Countries together with representative of international and regional organizations.

Because SOPAC was coordinating these activities, it had the opportunity to extend the Fiji case study questionnaire survey to other Pacific countries. An exciting discussion ensued at the regional workshop on forecasting needs. Recommendations from this regional to improve forecasting and warning system are included in this report.

Mention of El Niño in the Print Media

Neither the local media nor the general public was significantly aware of ENSO's extremes, until the 1992 drought event. It is probable the local media first reported on El Niño in 1987, but not much search has been undertaken to determine for certain if El Niño had been publicly reported along with the earlier drought events. However scientific journals and overseas dailies are accessible in the country by interested groups and individuals who seek to keep up with international news and events. In 1997, the FMS had forecasted in April the development of an El Niño condition. However, this was first reported in the media only in October.

Teleconnections

Teleconnection is a bit difficult to explain explicitly to a non-meteorological audience. Mr. W.W.R. Kininmonth, Bureau of Meteorology, Australia explains that teleconnection patterns are a consistent climatological response of large-scale features of the atmosphere to systematic forcing. Empirical teleconnection patterns derived from identifying characteristic climate responses during past El Niño events (systematic forcing of the equatorial Pacific Ocean) have been used to describe large-scale features of the variability of the atmospheric circulation, as well as tropical and extratropical precipitation and temperature relationships.

General Statements of ENSO Effects in the Region Around Fiji

The islands of the South Pacific have small land masses with very quick response to climatological changes. During a typical El Niño event the easterly Trade Winds across the tropical Pacific Ocean weaken or even reverse and the South Pacific Convergence Zone (SPCZ) shifts eastward. As a result of the eastward shift in convection, islands of the southwest Pacific, including Fiji, experience reduced rainfall while those near the International Date Line and further east received enhanced rainfall.

Cyclones and ENSO

In normal non-El Niño years, Fiji cyclones are generated from equatorial heat and climatic low pressures in the region of Solomon Island and Vanuatu.[4] These then track away to cooler regions mostly in a southerly to easterly direction. Those that behave as such build up intensity as they move over the Fiji and Tonga groups to die out southward in the cooler latitudes.

[4] Dr. Basher and Dr. Zheng of NIWA researched 20 years of past data calculating the average chance of a cyclone affecting each place in the region.

During the 1997-98 El Niño, the eastward shift of the SPCZ to the central Pacific of equatorial ocean heating manifested itself, for the regions south of the equator, it meant that tropical cyclones were also generated more eastward and to the north of Fiji. Tropical cyclones (TC) Wes, Martin, Ron and Alan typified these. The tropical cyclones built up intensity as they moved south-eastward and brought wind and rain damage to Samoa and the northern Cooks to the east of Fiji. The eastward shift of the weather patterns meant that Fiji and Tonga did not receive their normal seasonal rainfall.

Drought and ENSO

Many islands of the southwest Pacific suffered drought during the 1997-98 El Niño event. Papua New Guinea in the west was first affected, then the Solomon Islands, Fiji, and Tonga as the equatorial convection and SPCA shifted eastward. The typical climate anomaly for Fiji during an El Niño event is for drier and hotter conditions during the wet and hot season, particularly from December to February and drier and cooler conditions in the cool and dry season, particularly between June to August.

Scientific Views About the Existence and Strength of El Niño Teleconnections to the Fiji region

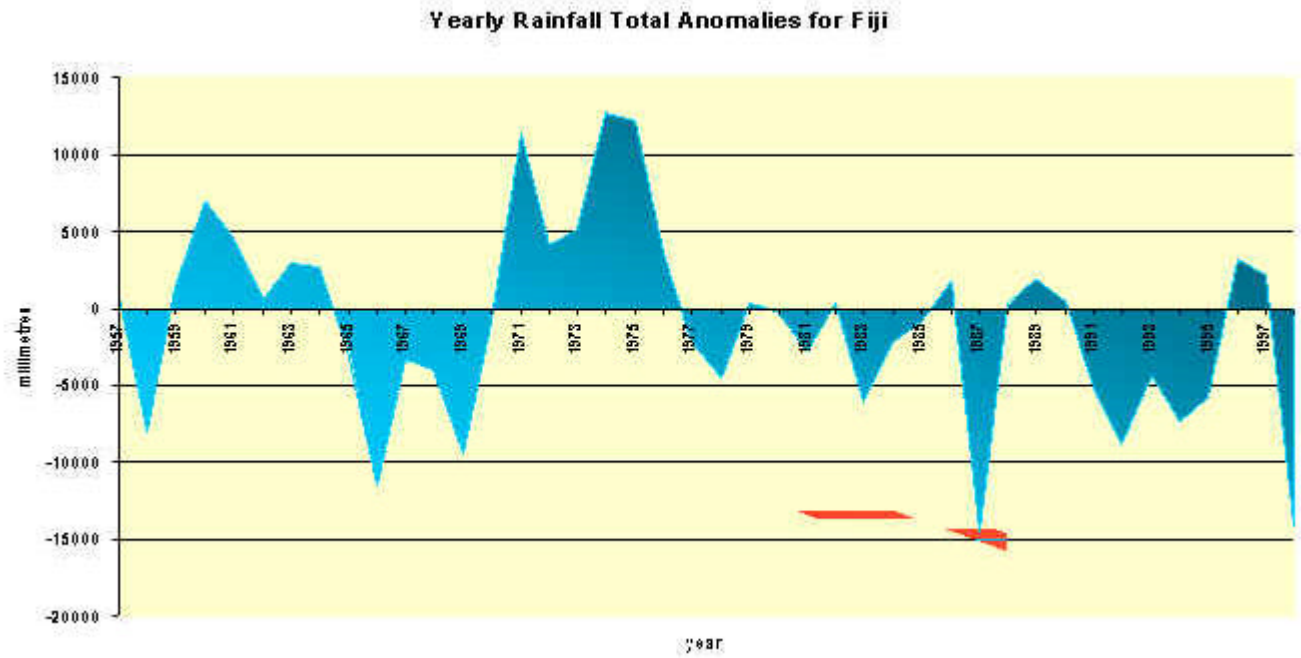
From its current research into ENSO, the FMS has provided the following information.

The correlation between the SOI and rainfall in Fiji is not clearly defined, but the relationship between the SOI and the rainfall in Fiji is most pronounced during ENSO events. To some extent, it does indicate how much rainfall Fiji may receive in coming months, and therefore, there is more confidence in forecasts of Fiji rainfall during strong ENSO events.

El Niño is recognized as the major cause of drought in Fiji. However, since Fiji is in the transition zone of the SPCZ the timing of onset and duration can vary. The delay between the onset of an ENSO event and the impact on the climate of Fiji depends on when the SPCZ begins to shift eastward.

There have been frequent occurrences of ENSO events in the last three decades. The effect of ENSO on rainfall is clearly evident in Fiji (Figure 5). Note that La Niña (the cold phase of ENSO and positive SOI) has a positive affect on Fiji's rainfall, i.e. above-normal rainfall may be expected during a La Niña event. There is also a delay between the SOI phases and the impact on rainfall in Fiji. This delay was quite evident during past events, like the 1997 event (Figure 6). The phase delay provides the opportunity of four to six months lead-time for the nation to prepare for a period of dry weather and possibly drought.

Figure 5: Yearly Rainfall Anomalies for Fiji

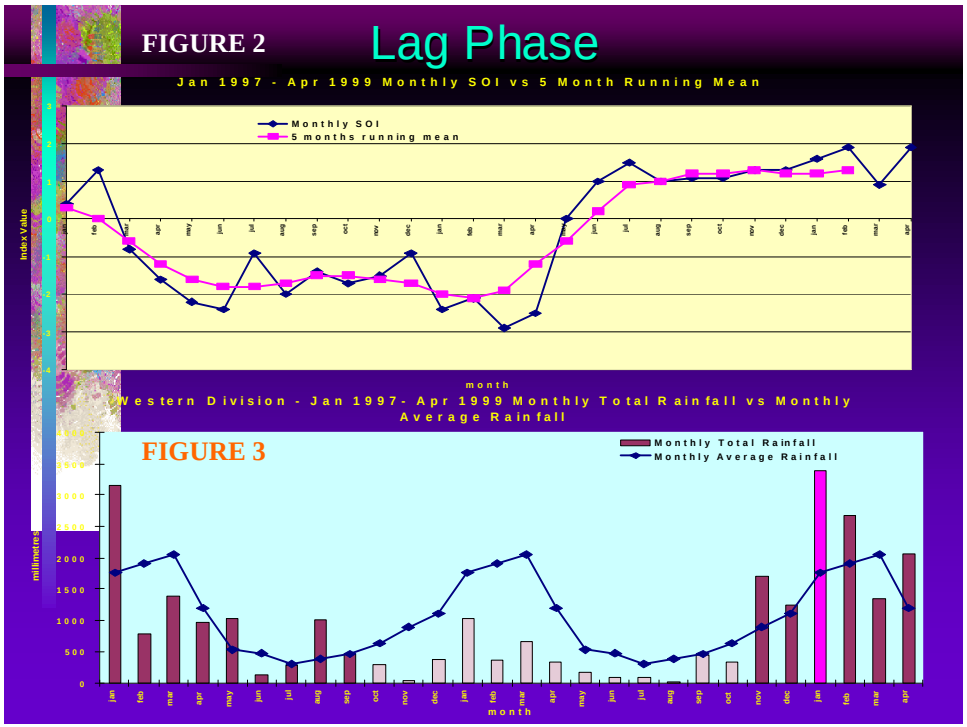


Note the El Niño and the La Niña years in the above two figures.

El Niño: 1957; 1965; 1969; 1977; 1982; 1987; 1991-1995; 1997.
La Niña: 1971; 1973; 1975; 1989; 1996.

Reference: FMS Paper: 97/98 Drought Assessment and Forecasting Systems Used by Fiji Meteorological Service; Nazmin Bi, Fiji Meteorological Service.

Figure 6: Delay Phase Between SOI and Rainfall Impact



Reference: FMS Paper: 1997-98 Drought Assessment and Forecasting Systems Used by Fiji Meteorological Service; Nazmin Bi, Fiji Meteorological Service.

Local Observation on the Progression of 1997-98 El Niño

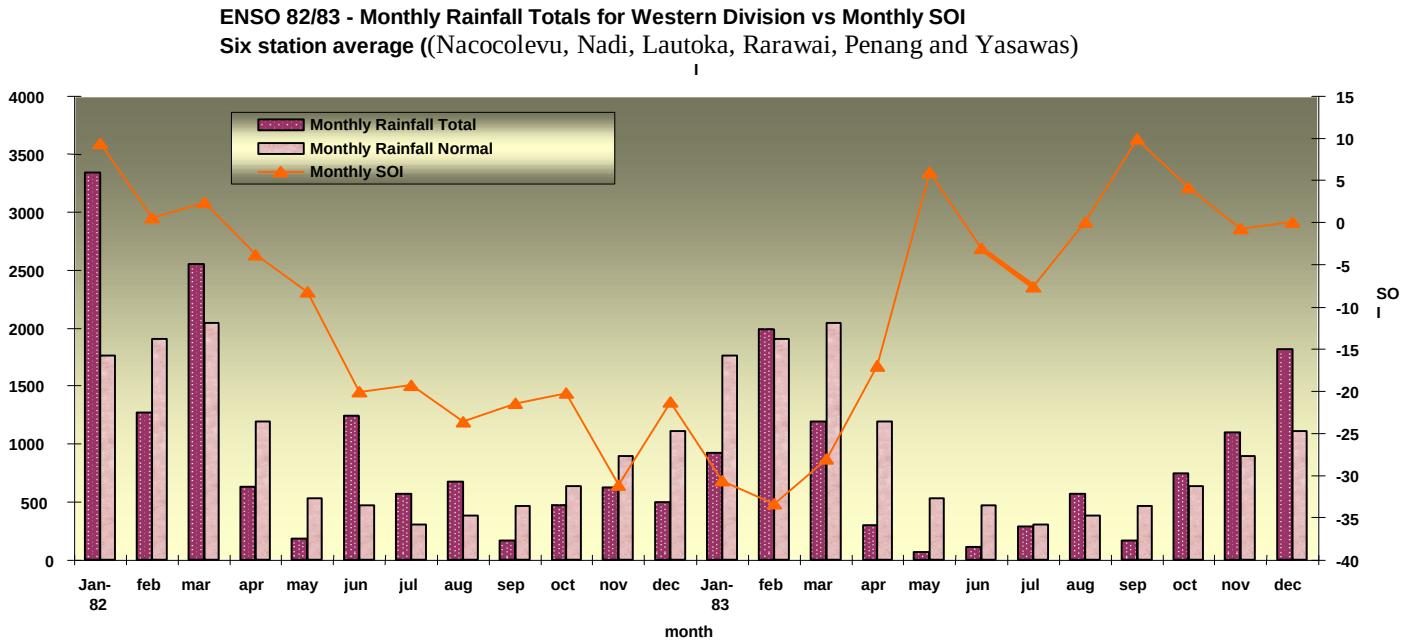
The impacts of the 1997-98 drought on water sources and agriculture were first felt in the northwest Yasawa Island groups in late 1997 around November. By April 1998 the agricultural drought had progressed to the north coastal belt of Viti Levu and by August the effects were being felt on the northwestern coast of Vanua Levu. By October the agriculture impacts were felt on the smaller islands of the Lau group to the southeast of Fiji.

In October 1998 the southeastern coastal belt of Viti Levu began experiencing low stream flows and surface water shortages (hydrologic drought). However, the windward foothills continued to receive rainfall without any apparent impacts of the El Niño. The local topography and prevailing southeasterly trade winds provided sufficient low-level convergence to generate convection and rainfall despite the regional Teleconnection Pattern that was unfavorable to rainfall. Such connections and interactions at the local or micro level are poorly understood and require more scientific study.

Climate-related Anomalies and Impacts of the 1982-83 Event

In the analysis of 1982 El Niño, the SOI started dipping negatively from end of March 1982 and reached its lowest (–35) about a year later in February 1983. There was a lag of about five months to the start of the year-long drought extending September 1982 to September 1983. However since Fiji in September was coming into its wet season, there was still enough rainfall to support agriculture. Impact on the rainfall and agriculture was acutely felt March 1983 through to September 1983, overrunning the dry and cold season with drier-than-normal conditions. In many areas it was the worst-ever recorded drought till then. Figure 7 shows the 1982-83 six station-monthly rainfall totals in the leeward Western Division of Viti Levu island where the bulk of Fiji's sugarcane is grown.

Figure 7: Reference: "1997-98 Drought Assessment and Forecasting Systems Used by Fiji Meteorological Service"; Ms Nazmin Bi, Fiji Meteorological Service



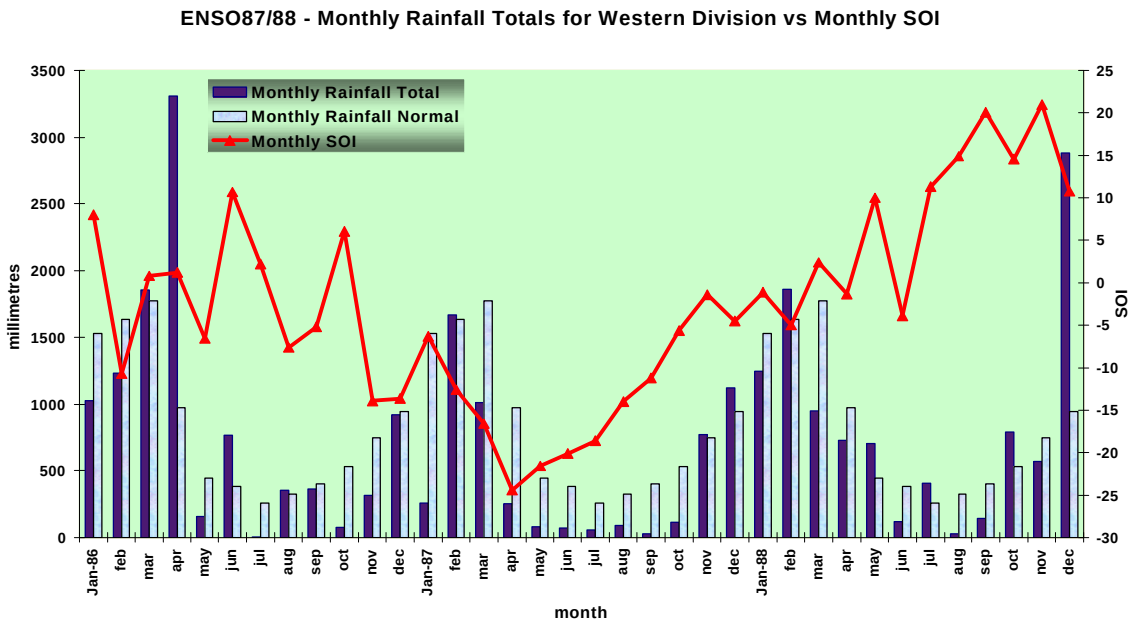
Drought 1987

The 1986 El Niño was certain from about October, but before then were a series of fluctuations in the SOI. It reached its lowest value of –25 in April 1988. The effect on Fiji's rainfall was more immediate because the El Niño established over the dry and cool season of 1987. Areas in the northwestern Viti Levu were the most severely affected. For the six-month period from November 1986 to April 1987 it received less than 1,000mm of rainfall, which is less than half of the period's normal value. In the next six months, from May to October 1987, rainfall was less than 150 mm, compared to the 500mm average normal rainfall for that period. The hydrological drought continued through to the whole of 1988 though rainfall had approached nearer to normal. Again there was a deficit rainfall track progressing across Fiji from west to east. Figure 8 depicts the rainfall anomaly for the Western Division.

Although the1982-83 El Niño event was more severe globally, the 1987 event had more impact on Fiji's rainfall and caused the country's worse drought in at least 100 years.

Figure 8: Rainfall Anomaly 1987

ENSO 1987-88 - Monthly Rainfall Totals for the Western Division vs. Monthly SOI



Reference: “1997-98 Drought Assessment and Forecasting Systems Used by Fiji Meteorological Service”; Ms Nazmin Bi, Fiji Meteorological Service.

1997-98 climate-related physical and social impacts of El Niño

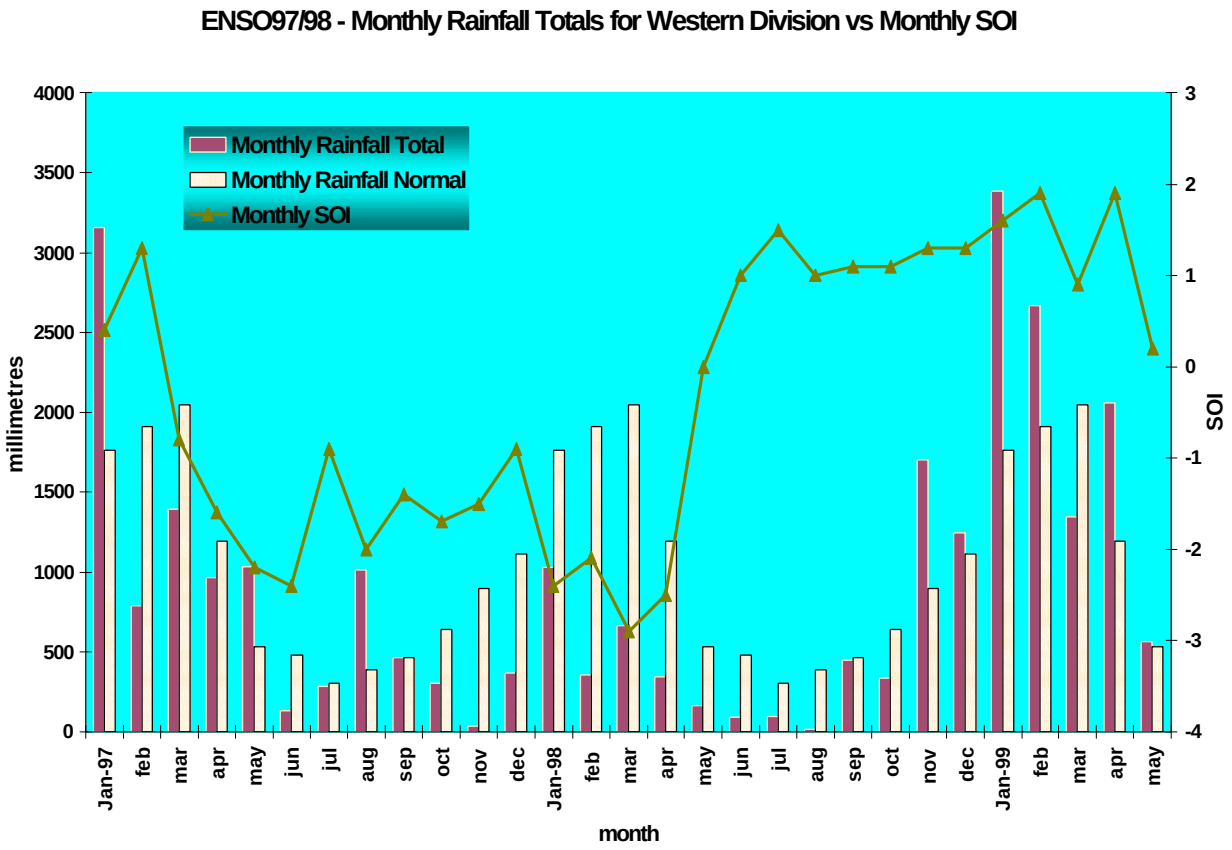
Of all El Niño induced drought, the 1997-98 event was significant from disaster management perspectives in that it brought together in consultations the meteorologists, the users of rainfall information and disaster managers.

The Physical Impacts of the 1997-98 El Niño Event

From March 1997, the SOI dipped sharply below zero and in its April 1997 Monthly Weather Summary; Fiji Meteorological Services stated that there was a possibility of an El Niño-drought situation later in the year. It confirmed this in the May Monthly Weather Summary. The SOI reached a low (-28) in March 1998 before it started recovering to rise above zero from May 1998.

There was a two-month lag until the El Niño-related drought developed around May 1997, heralding the 18-month drought that continued into Novembe 1998. With respect to damages, this is now known to be the worst drought on record. This is represented in Figure 9.

Figure 9



Reference: 1997-98 Drought Assessment and Forecasting Systems Used by Fiji Meteorological Service: Ms Nazmin Bi, Fiji Meteorological Service

Hydrologic Drought 1997-98

The effect of the 1997-98 El Niño was not evident until September 1997, when most parts of Fiji recorded 20 to 50 percent below normal rainfall. The pattern of the drought hit Yasawa Groups and western Viti Levu first and then progressed eastward to Vanua Levu. The island groups of Lomaiviti and Lau to the southeast were the last to be impacted.

The western and northwestern parts of Fiji were the most severely affected by drought, with monthly rainfall in the western parts of Fiji generally far below normal, until October 1998.
All sites in the northern, central and western parts of Fiji recorded their lowest-ever rainfall totals for nine consecutive months from February to October 1998. Total rainfall ranged between 22 percent and 42 percent of normal.

Illustrative Rainfall Monthly Anomalies

In November 1997 the western parts of Viti Levu received less than 10mm of the rainfall. This amounted to less than seven percent of the normal rainfall. Nadi recorded only 4mm (three percent of average), which was by far the worst on record; its previous lowest rainfall was 7mm in 1953. By June and July 1998 the drought had intensified in northwestern Viti Levu. The Yasawas received less than 7mm of rainfall for the entire month of June and in July Nadi and Ba received a total of 1mm of rain. Other sites in western Viti Levu recorded less than 10 percent of normal rainfall. In August the situation worsened as stations in Viti Levu, Mamanuca and Yasawa received almost no rainfall.

The rainfall deficit for Vanua Levu appeared in March 1998 when Labasa received only 15mm of rain (four percent of normal); its previous lowest rainfall was 76mm in 1959. The Labasa July rainfall dropped to 1mm. However, other rainfall sites in Vanua Levu lagged behind receiving between six percent and 19 percent of the normal rainfall in August 1998. The impacts were starting to be felt also in the inland areas of Viti Levu in the third quarter of 1998.

The Socio-Economic Impact of the 1997-98 ENSO Event

In the six years preceding the 1997-98 El Niño, Fiji had faced six major natural disasters; a drought in 1992, tropical cyclone Joni and Kina in 1992-93, Gavin and June in 1996 and the 1997-98 drought. Cumulatively, the socio-economic impacts have been worsening and further magnified in very severe (record-setting) 1997-98 drought. The safety checks in the resilient informal sector, particularly the extended family support system have been stretched to the limit, leaving it exposed and vulnerable. The informal sector is the worst hit in this drought.

The 1997-98 drought is recognized now as Fiji's most damaging drought. And, as Fiji is fundamentally agriculturally based, the adverse drought impacts on food security and water supply created an increase in social stresses and in the deterioration in health conditions. The impacts of the drought are well documented in an UNDAC Mission Fiji Drought Report (Kaloumaira et al., 1998). When the drought broke, the quick recovery of the

agricultural sector substantially limited the impacts to short term, as was concluded by the second UNDP study[5] that looked at the long term impacts of the 1997-98 ENSO-induced drought.

The high number of natural disasters created challenging debates about how to attribute the socio-economic impacts due to each disaster so as to reach a clear conclusion on socio-economic impacts of the 1997-98 drought. However, some impacts, like income figures, are readily definable.

Impacts on Primary Industries

Agriculture in Fiji has four major sub-sectors as, depicted in Figure 2:

1. Sugarcane
2. Agricultural crops and Natural Forests
3. Commercial Forests
4. Fisheries

Damage to Fisheries was negligible but this sub-sector is very important as a resource base that time and again supplements Fijian food and income during disasters.

Sugarcane

The Fiji Sugar Corporation (FSC) manages Fiji's sugar industry. Sugarcane areas are well defined in Fiji, grown on the drought-vulnerable leeward northwestern halves of the two main islands of Viti Levu and Vanua Levu. There are four sugar mills; three on northwestern Viti Levu and one in Western Vanua Levu. It is very labor-intensive; from planting and fertilization through to harvesting. The only two mechanized activities are plowing for the planting new cane seeds and cartage of harvested sugarcane to the mills. New planting is far between, as cane is grown from ratoons with new plantings varying from about five to fifteen years.

The industry is very well structured. It is organized into ten cane districts, which are divided into 40 sectors. A grower includes his own family labor and some may have up to four or five other farm-dependent families totally reliant on the success of the grower. A family averages four to five people. There are about 17,500 growers and 20,000 farm-dependent families. In Viti Levu, generally, more growers' sons and daughters move on to non-farm

[5] Chris Lightfoot is the author of this UNDP study "Regional El Niño Social and Economic Drought Impact Assessment and Mitigation Study." The report has been given to the Fiji government. It looked at the identification of the medium to long term impact of the 1997-98 drought; recommended appropriate strategies to mitigate the impact of future droughts and developed of a generalized approach to estimating the medium to long term impact of drought on small island economies.

occupations. As a result, there are a relatively larger number of farm-dependent families replacing family labor. For Vanua Levu, family labor is strong on the farm, and farm-dependent families are less in number. During the harvest season, which runs at least ten months, more labor is hired as harvesting gangs of which a big number comes from outside the cane belts. These figures indicate why the industry is very important to Fiji generally and to disaster managers especially for the purpose of logistic relief planning during the drought or other natural disaster. Inclusive of direct FSC employees, the industry is providing direct support to about 25 percent of the population.

Production Losses

In the natural disasters of the past four years (the drought of 1992, tropical cyclones Joni and Kina in1992-93, Gavin and June in 1996), the total area cultivated under cane has varied between 73,300 to 74,300 hectares. Cane production varied between 3.3 million tons to 4.4 million tons. By comparison the 1998 dry conditions reduced planted area to 70,400 Hectare and of this 17,300 hectares of crops (about 25 percent) were wiped out. Of the harvested crop, there were further yield losses from drought conditions, because sugarcane is grown throughout as a rain-fed crop. National production loss was around 50 percent or 2 million metric tons representing a loss in revenue to the industry of F$104 million.

Short-term Impacts on the Sugar Sub-Sector

- Marginal Lands

Within the sugarcane belt, the worst production losses were in the marginal lands closest to the sea and those planted on slopes of twelve degrees and greater (Table 3). These sloping lands are actually classed as unsuitable for fine tillage cultivation. These areas are also where sugarcane cropping is known to be most vulnerable to the weather. Normal average yields from these marginal lands are much less than the national average. Fijians must ask themselves whether to accept such losses year in and out. These farmers face chronic indebtedness, which has been made worse by the drought.

Table 3: Sugarcane District / Sectors > 30% Area Losses
Source FSC; Reference: UNDAC Fiji Drought Report (Kaloumaira et al., 1998)

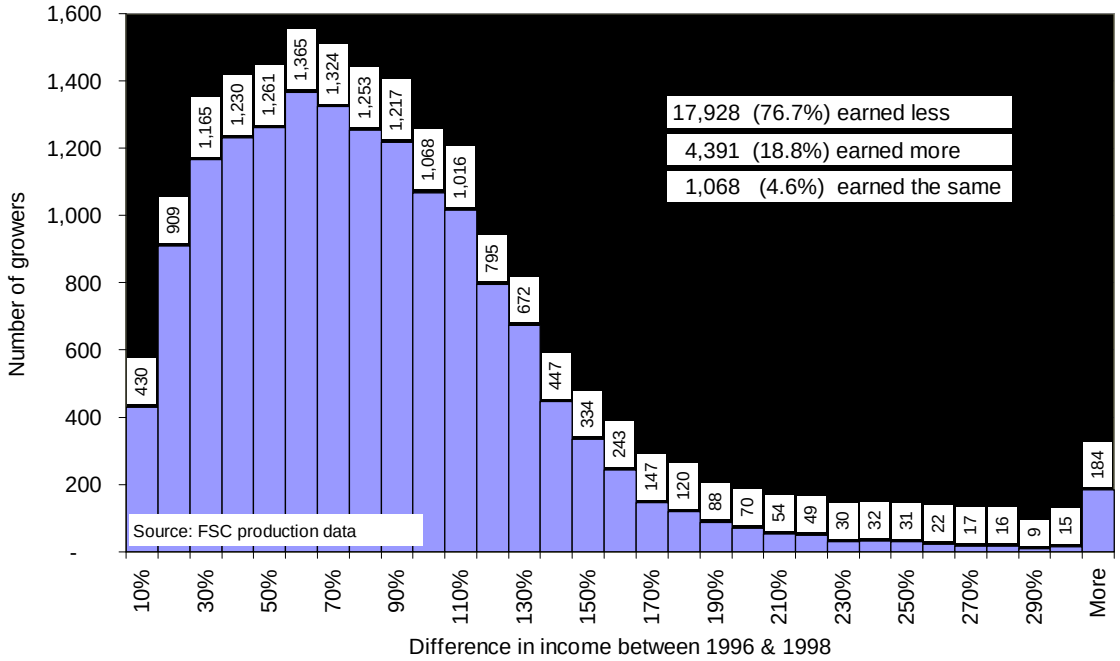
Lautoka Mill District	Sector Area Loss	Area Loss Ha	% of Total Sector Area
Lautoka (total six sectors)	Drasa Saweni	850 320	35 30
Nadi (total 7 sectors)	Yako Malolo	702 1122	44 56

	Nawaicoba	1168	58
Sigatoka (total three sectors)	Lomawai Cuvu Olosara	690 1000 715	35 58 66
Rarawai Mill District (Ba)			
Rarawai (total eight sectors)	Veisaru Varavu	800 1380	37 69
Tavua (total 3 sectors)	Tagitagi Drumasi Yalodro	1220 1455 630	63 61 39
Penang Mill (Rakiraki)			
Penang (total 4 sectors)	Nanuku	896	62
Labasa Mill			
Labasa (eight sectors)	FSC		

- Farm Incomes

The UNDP study (Lightfoot, 1999) pointed out that the impact on 1998 income was buffered by pricing protection to the European Union (under the Lomé Convention) which virtually bought the entire 1998 production of sugar at about three times the prevailing world price. As the sugarcane growers receive a weighted average of the price received from all buyers, although export income fell by 30 percent, payments for sugarcane rose by close to 50% per metric ton. The differences in growers' incomes between 1996 and 1998 are presented in Figure 10.

Figure 10: Differences In Sugarcane Grower Income between 1996 & 1998



Source: UNDP Report: Regional El Niño Social and Economic Drought Impact Assessment and Mitigation Study (C. Lightfoot, 1999)

The graph shows that 18% of farmers received a windfall because of favorable prices. However, the majority (77%) received less or nothing at all. The drought made no difference to the earning capacity of about 5% of the farmers.

The Fiji UNDAC report indicated that in normal years farm-dependent families and cane cutters average of F$3,500 per farm labor annual income but families had access to a house and a small piece of land for a home garden. Even with access to these, however, they border on the poverty threshold for Fiji, which is pegged at an equivalent of F$5000 annual income. During the drought, this income was drastically reduced to F$1,500 and below. The

prolonged drought of 1997-98 made this population sector very vulnerable, as their home gardens withered. It increased acute poverty with more people going into the poverty bracket. Poor people were not only more exposed, they were also less able to cope.

Fire Risk

Burning fields is a common farm practice. Most fires that were lit in this drought burned out of control because of ignorance of higher fire risks associated with organic fuel material during drought situations. There is no "fire risk indexing" system. Higher risks were associated with

- sugarcane farms adjoining pine forest plantations.
- cane fields bordering very close onto residential houses.

Stipulating non-cane border strips of 30 to 50 meters wide around the house is a good idea to reduce fire risks. This will also allow more room for vegetable gardening and fruit tress.

Response Within Sugarcane Sector

(i) Most food that was supplied was as a supplementary ration through community organizations, Red Cross and the government. While NGOs had targeted certain groups, the government had mixed policies. While in Viti Levu, deliveries were to everyone in the defined worst-affected areas, in Vanua Levu, rations were given to the worst-affected farms, being defined as those producing < 30 metric tons of cane. The UNDAC report raised the question with Fiji government of how to define the appropriate criteria for food assistance and ration policies. It also suggested that families be supplied with seeds and vegetable planting material to supplement their rations.

(ii) Non-government organizations were the first to mobilize and they targeted the special needs groups in affected communities such as children and lactating mothers.

(iii) With the great importance of the sugar industry to Fiji's economy, the government channeled funds to the FSC for a Crop Rehabilitation Programme (CRP). This catered mostly to the purchase of farm inputs. The benefits that did reach the vulnerable groups as farm wages was just a trickle at 6% of total assistance. The rest went to land preparation 26%; seed-cane purchase 37%; fertilizer purchase 27% and herbicides 4%. Well-to-do farmers with the capacity to access additional enabling funds and resources were better able to exploit the CRP.

Needs in Sugarcane Areas

To review food relief criteria and policies

To discontinue sugarcane planting on steep-slope land and change to other tree crops in line with good land-use recommendations and practices.
To introduce irrigation, intensify production on flat land and diversify other uses on sloping land to include perennial fruit orchards and pastures.
To provide grants for drainage maintenance in sugarcane areas. Currently drainage maintenance is funded from taxes on farmers.
To supply seeds and to supply rations on a food-for-work basis.
To provide for access to credit and microfinancing.

Long-term Impacts on Sugarcane Sub-Sector

The UNDP study on long-term impacts of drought could not quantify definitively the long-term impacts within the sugarcane sector. Fiji was very fortunate that the drought broke early and the sugar industry recovered very quickly with the assistance of the government-funded Crop Rehabilitation Programme.

- Beneficial Farm Investment

Most farms are leaseholds, because 85% of the land in Fiji is owned and held communally in trust and cannot be sold. The terms for lease are currently under review with many landowners wanting changes to their leasing conditions or the return of leased land to native owners. Consequently, many farmers, prior to the drought, had been cutting back on soil fertilization and other farm investments as the expiration of their leases approached. The CRP enabled farm investment in soil fertilization and the well-overdue replacement of old ratoons with new cane-seed planting.

Other impacts of the sugar industry on the Fiji economy was viewed by the UNDP study from two perspectives; (1) the businesses and people whose goods and services help produce the sugar and (2) those that purchase the output for their own use or to help in the production of other goods and services. The sugar industry contributes 22% of the national profit and taxes and absorbs 5% of the national wage and salary. Thus any disruption to sugar production has implications on the supply of goods and services to other sectors of the economy. The figures in Table 4 show the proportions of business activity absorbed by the sugar industry. It provides a guide to the importance of the sugar industry to each sector."

Table 4: Absorption of Goods & Services by Sugar Industry

Item		Share of national expenditure
Wages		
Professional		0.32%
Sub-professional		0.43%
Skilled		1.86%
Unskilled		2.61%
	Total	5.21%
Surplus		
Unincorporated		17.7%
Public sector		4.6%
	Total	22.3%
Goods & Services		
Services & Utilities		0.6%
Transport & Fuel		3.9%
Fertilizer		82.6%
Manufactured Goods		2.5%
Share of Total		7.3%

Source: Sturton Input Output

(Reference: UNDP Report: Regional El Niño Social and Economic Drought Impact Assessment and Mitigation Study (Lightfoot, 1999).

Agriculture (Non-Sugar) and Natural Forests

Rural subsistence farming plays a very significant and vibrant role in supporting 80% of Fiji's population. It contributes 3.8 % to national GDP and, within the agriculture sector, it is ranked second in the sector's contribution to the national GDP.

Two years prior to the El Niño-related drought, the Fiji government initiated a special program to commercially develop a number of selected high-value crops – kava, dalo, coconut and pineapple. Called the Commodity Development Framework (CDF), it was aimed at reducing vulnerability of the subsistence rural community by increasing their economic robustness.

Both the food security and the CDF agricultural program were aimed at addressing the rural subsistence farmers and their needs. The drought of 1997-98 hit hardest in the rural areas. Impacts on the agriculture sector were not apparent until early 1998. Awareness then increased quickly, as the impacts on food supply became widespread. In affected areas it totally destroyed existing farm garden crops and delayed any new plantings until the rains came in November 1998.

- Area Affected

The agricultural drought first hit northwest Fiji and generally fanned out north and south as it impacted over the Fiji groups in the 18 months of below normal rainfall. Cakaudrove Province and the wetter zones of Bua were experiencing the beginnings of agricultural drought, when rain started to fall again in late September. The Lomaiviti and Lau groups to the east of Fiji were similarly just starting to experience the drought but not to the same severity as the longer-affected west and north regions. Central Viti Levu and the southern coastal belt in the rain shadow, windward side of Viti Levu remained relatively unaffected. Produce from these least-affected areas was supplying local food to markets and households in the drought-stricken areas.

Irrigated agriculture is not very significant but does exist. This comprises the following:

Some small pumped borehole sprinkler systems in Sigatoka, Viti Levu for irrigation of vegetable crops managed jointly with government.
A major commercial pumped micro-jet irrigation system for citrus in Batiri (Vanua Levu)
A small number of major gravity fed rice irrigation schemes of Navua in Viti Levu and those adjoining the Bua-Macuata borders in Vanua Levu, managed jointly with the Agriculture department.
Two privately managed hydroponics establishments in Nadi, Viti Levu.

Short-Term Impacts on Agricultural Crops

The Agriculture Department started to monitor the drought's impacts for food security purposes from March 1998. The Director for Agriculture Extension estimated a national crop revenue loss of F$15 Million. Most of the crop area revenue losses in Vanua Levu were from new planting. The absence of drought rating classification and indicator monitoring systems has to be a lesson learnt from this drought.

Vegetables

Assorted vegetables and pulses, some kumala and rain fed-rice are normally the only crops grown for food within the sugarcane belt. These were completely devastated in areas affected by the prolonged drought. Export vegetables and root crops were reduced to only 50%.

Normally, the months of June and July are the peak domestic crop-maturity season. As these months passed and no new plantings were still possible, food self-sufficiency took a "nose-dive." Planting material was very badly affected and was completely wiped out in some areas.

Fires

Fire was a secondary El Niño-related hazard. Damages to agricultural crops were confined mostly to Cakaudrove in Vanua Levu, where fire contributed to 40% of the damages to cultivated crops. The localities of Tunuloa, Navatu and Natewa were badly affected. Along Natewa Bay, out-of-control burning damaged close to 10% of the natural forest. A vicious circle developed, as fire damaged traditional food sourced naturally from the forests; e.g., yams and other root crops, leafy vegetables, fruit and nuts. These events adversely affected food supply, income and the recovery capacity of the rural population.

Animal Stock

Agriculture reported that the majority of the nation's 28,221 cattle (55.4%) are located in the drought-affected areas of Ba, Ra , Nadroga and Navosa. They also rear 56% of the nation small ruminants (a total of 194,235 goats and sheep). These are mostly in small holdings. It is a very important household source of milk and protein to a majority of the drought victims. The drought demolished green feed and threatened the stock population. Fatalities were beginning when the rains came. The total loss in milk production and stock loss was estimated at F$10 million.[6] It disclosed the need to explore the introduction of supplementary stock feed to small holders.

Natural and Commercial Forests

Fires on commercial plantations have frequently occurred over the years. However, during the 1997-98 drought the instances and extent of fire were much more than before, triggered by increased drought-induced fuel material and dryness (absence of moisture) in the air. Young pine forests of eight years old in Rakiraki, being on thin topsoil above rocks, have died in this period. The Fiji Pine Commission undertook it's own inventory of damages, but did not release the information it had gathered.

A survey of hardwood mahogany forests found incidences of mortality in plantations in this drought period. Most of the plants affected were believed to have been still weakened and stressed from past cyclones and droughts.

Damage was also reported on natural forests grown on thin soil overlying volcanic rock. Along the foreshore of affected districts, coconut trees withered and toppled over in droves.

[6] Agriculture report "Proposal for Drought Assistance for Ruminant Livestock" provided by the Animal Health and Production Division, 1998

National Response to Agricultural Damage

From May 1998, the Agriculture Department approved a rehabilitation program targeted at re-establishing food security. This was expanded in October to include the rehabilitation of commercial crops established under the Commodity Development Framework. The rehabilitation strategy included stocking planting material on "stock" farms both within drought-affected areas and also in other safe localities outside the drought-affected areas.

Non-government Assistance

The FAO did its own impact assessment. It followed up with the provision of seed material and project funds to improve information systems. More specifically, food gardens for over 137 boarding and day schools were completely damaged. They were being assisted by the Fiji branch of the non-government organization "Foundation for the Peoples of the South Pacific" (FSP Fiji) to re-establish the food gardens. The Red Cross and another NGO, "Save the Children Fund," provided food rations and bus fares.

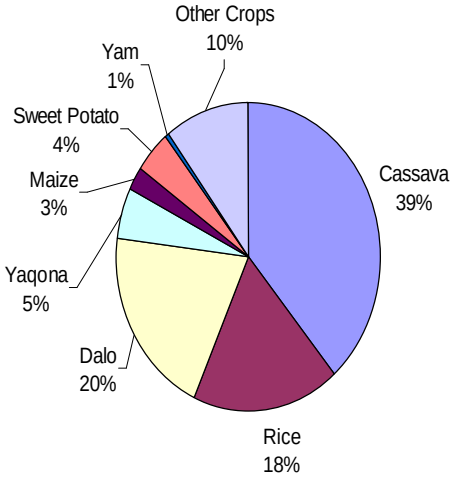
Needs in Agriculture Sector

Most needs in the agricultural sector were those to meet food and planting material shortages. There was concern that closer links were needed among the National Food and Nutrition Committee and the Ministry of Health were required to address the long-term preventive measures for malnutrition and anemia. The impact on the loss of planting material raised discussions on tissue culture. However, it was felt that tissue culture was high tech and that farmers could avert many hardships by being better prepared. Departments, too, need to have disaster-management plans complete with preparedness and mitigation plans. This calls for the establishment of databases to better monitor and plan preventive measures. As lessons learned from the drought, more research is needed in drought rating classification and identification of reliable indicators for monitoring. The department needs to re-evaluate its public education awareness program in line with available forecasts from FMS.

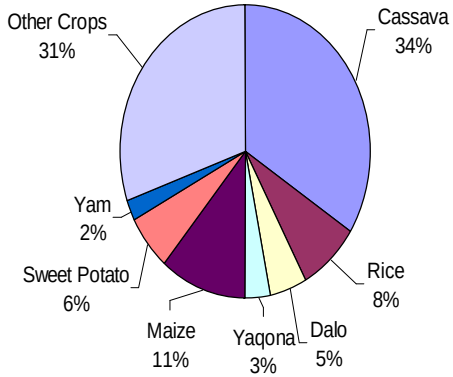
Long-Term Impacts in the Agriculture Sector

Figure 11: Cropping Patterns by Province

Central Province

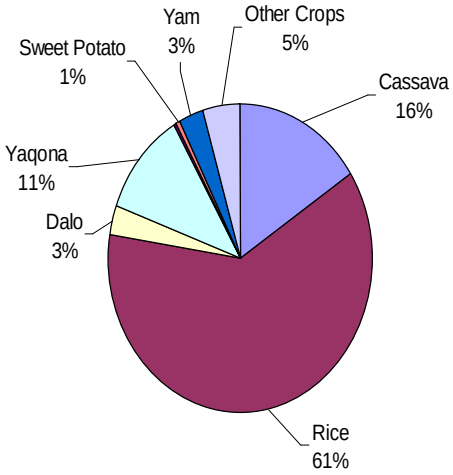


Western Province

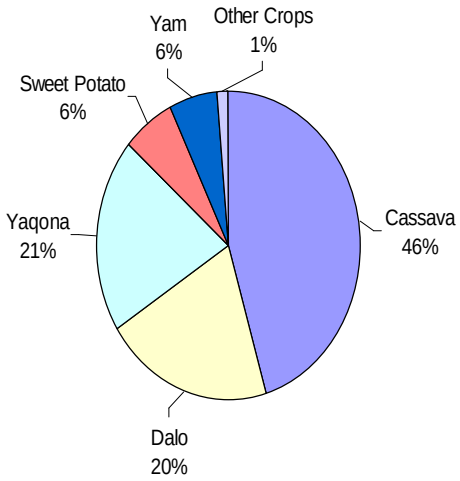


Source: 1991 Agricultural Census

Northern Province



Eastern Province



Vegetables and Root Crops
Since the end of the drought in October 1998, the vegetable and root crops have been replanted and production has returned to normal, the medium to long-term impact is apparently slight.

Tree Crops
Several tree crops have suffered longer-term damage and have shaped up to be the most seriously impacted crop in the medium to long term. If replanted the crops would take years to return to pre-drought levels of production. The cocoa trees were setback by the drought and became susceptible to fungal attack, following the rains that broke the drought in late 1998. Coconut palms also suffered severely, with many dropping their fronds and failing to set nuts. Again, it is too early to be sure of the long-term impact, but it appears that many palms will be forced into premature senility. Yaqona production will recover more quickly than the tree crops and should be back to pre-drought production levels within three to four years.

Beef and dairy farmers
The improved pastures that commercial beef and dairy farmers rely on also suffered severely. Most of the pastures in the western areas of the main islands were killed or at best degraded to such an extent that they will need re-establishment.

Logging
The drought benefited the forestry sector. The dry conditions improved access to the forests, thereby enabling an increased rate of logging and better plantation management. The dry
conditions restricted the planting of trees, but this short-term effect could easily be made up and would have little, if any, impact on the long-term viability of the industry.

Fisheries
The El Niño event that caused the drought had a serious impact on the commercial fishing industry. The catch composition of the long-line fleet changed markedly with few of the higher valued yellowfin and bigeye tuna being caught in 1998 while the catch of the lower value albacore increased dramatically. Most of the established operators were able to survive the change, but all suffered significant drops in profitability. By early 1999 the composition of the catch had returned to “normal” with a significant increase in the catch of yellowfin and bigeye. In the medium to long term it is likely that future events will trigger similar changes in catch composition.

Impacts on Water Supply Systems

Water supply for human health and hygiene was the key concern across all sectors. In Fiji water supply is categorized under two headings: (1) metered and non-metered or (2) urban and rural. Metered supply is the responsibility of the Ministry of Works while the development of non-metered rural supply is the responsibility of the Ministry of Rural Development. All metered supplies are from surface sources, the largest being the Vaturu Dam water storage reservoir. About 70% of Fiji's population has clean, piped water multi-sourced. In rural areas 27% of villages and 40% of non-village settlement have this amenity[7].

In the Western Division, master plans are in place for the larger urban communities. These plans maximize the usage of surface water for Sigatoka, Nadi/Lautoka, Ba, Tavua and Rakiraki. There also exists an extensive collection of hydrogeological information available in the form of reports and studies kept by the Mineral Resources Division (MRD).

With respect to the outer island groups, MRD's own investigations are on file for more than 55 islands. In addition, MRD investigations often leave protected test boreholes in place.

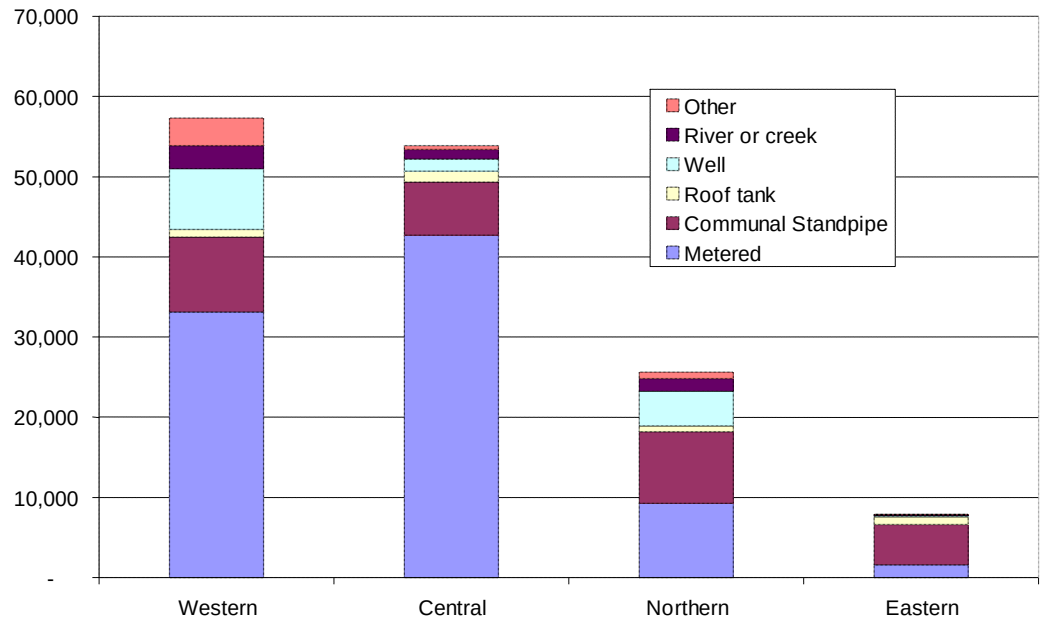
Areas Affected
Water supply shortages affected both urban and rural systems in drought affected areas. This included nearly all of the Western Division, Northern Vanua Levu in the Northern Division and many of the islands of the Yasawa, Mamanuca, Lau, Macuata and Lomaiviti groups.

Short-Term Impact
Rural development policy entices communities to contribute a third of development costs. The capacity of the Public Works Department and of the beneficiary community to pay its requirement to implement water supply schemes was found to be clearly lagging.

Impact on Water Quantity
Roof catchment systems with a communal standpipe are very popular in rural Fiji. So high is the country's annual rainfall that installed storage tanks are normally small without thoughts for long periods of zero rainfall. A lot of guttering exists only to channel rainwater to waste. A large number of rural people was affected by inadequate water-tank storage in the 18-month drought of 1997-98. Particularly schools in drought-affected areas were badly impacted with the shortage of essential water for health and hygiene.

[7] An Atlas of Fiji, Dept. of Geography, USP (Editors: Rajesh Chandra, Keith Mason)1998

Figure 12: Source of Water by Province



Source: UNDP Report: Regional El Niño Social and Economic Drought Impact Assessment and Mitigation Study (C. Lightfoot, 1999).

Groundwater was a proven valuable resource, especially in the Western Viti Levu and Northern Vanua Levu areas where the vast majority of all Fiji's operational boreholes are found. Though some bores failed, a lot more bores provided adequate water resources in rural communities. These fresh water aquifers, through individual and communal pumped-systems, supplied the scattered rural households, farms and communities.

With metered supply there were reports of water shortages due to maintenance and operational problems, inadequate piping and networking capacity. In its report to this study, the PWD estimated that the number of people receiving continuous and adequate supplies of piped water had fallen from 60% in the first quarter to approximately 23% in the third quarter. They also reported on the impact on other sources of water.

Table 5: Effects on Other Traditional Means of Water Sources Supply –1997

Percentage (%) In Operation

Type of Supply	Jan-Mar	Apr – May	June – Aug	Sept - Dec
Communal	29	18	12.8	10.2
Well /Borehole	13	8	3.5	2.9
Rainwater (Roof)	4	1.5	0	1.2
Surface Water	3.5	2.2	0.5	1.3

Sourced from PWD Report to the Fiji study on "Reducing the Impacts on Environmental Vulnerabilities through Early Warning and Preparedness: the Case of the El Niño Southern Oscillation" (1998).

Impact on Water Quality

The UNDAC report noted that in the Western Division where both the drought impact and monitoring were greatest, more than a third of drinking water samples collected proved to be bacteriologically unsafe for consumption. Thirty percent of those were in fact from the PWD treated, piped water supplies. It also noted that follow-up on unsatisfactory results was generally lacking and that there was little coordination among the funding and authorizing agency (MRD), the supplier (PWD) and the quality monitoring agency (MOH). For example, chlorination is a key safeguard for piped water and has a special role in emergency "carted" water, yet chlorine monitoring is not widely practiced.

Impact on Hygiene

The UNDAC report noted that the use of toilets of cistern or pour-flush design decreased substantially in the Western Division while the use of pit latrines almost doubled and shared use also increased. Widespread littering of waste (mainly plastic and tin containers) emerged as a problem reflecting a sharp increase in supermarket shopping. These created major health hazards as breeding places for mosquitoes, especially around villages, settlements and schools.

National Response to Water Shortage

The Government response to water shortages was to fund the delivery of water to all those in need. Countrywide, more than F$1m was spent to deliver emergency supplies to rural individuals, schools and communities. Delivery started in October 1997, with hauling or 'carting' of water by truck and by

sea at costs of more than F$188,000 per month. In some urban areas, the Nadi-Lautoka corridor in particular, water was carted due to under-development of the water supply delivery infrastructure. Rationing was practiced effectively by recipients of these emergency supplies. In less frequented outer islands such as Viwa, Vatulele, Dravuni and the Lau Group water was rationed according to circumstances from as little as 2 buckets (16 liters) per family per week. Individual homes recycled water using poor quality water for general washing and toilet flushing. In schools, however, new pit latrines were constructed. Much of this response was initiated through the Ministry of Health with its public education and awareness program in rural areas.

Needs in Water Sector [8]

A countrywide, strongly supported public education and awareness program needs to be run for schools and rural dwellers to uplift roof and gutter maintenance and make other improvements to their rain water catchment systems. The groundwater aquifers fared well in the drought. The nation needs to focus on packaging proper technical and financial assistance to ensure sustainable development of groundwater aquifers in outer locations. For urban dwellers, the government needs to quickly implement its urban water supply master plans.

Guidelines for water quality monitoring, rectification and chlorination are needed for respective sectors to follow. Particularly, improvement is needed in health authority procedures for bacteriological monitoring and alleviating the sources of contamination.

Trials and research are needed on solar distillation plants (evaporation and condensation of seawater) as an option to desalination plants. The latter require a high level of technical expertise to operate and maintain. Trials should be considered on remote islands where minimal quantities of drinking water (e.g. 150 liters per day for a community) could remove the need for costly fresh-water deliveries.

Long-Term Impacts

All the studies concurred that there were no significant long-term impacts of the drought on water sources themselves. Fiji's problems are two-fold. Firstly, the general indifference of the public to take proper care and maintenance of water supply systems.[9] An underlying reason perhaps is that Fiji has rainfall distributed throughout the year. The second problem arises from the consistent readiness of government to supply water in just about any emergency. This creates dependency and may have actually deterred the public from investing in their water supply systems. It has become increasingly common for individuals and communities to rely on water deliveries rather than to improve maintenance and conservation of their own water supplies.

[8] UNDAC Report on 1997-98 El Niño Fiji Drought

[9] The UNDAC report noted many instances of damaged and neglected water supply systems.

Impacts on Health and Nutrition

In analyzing the drought's impacts, the Ministry of Health[10] summarized that, when the drought broke, a potentially dangerous situation was emerging. This was indicated by the increasing but sporadic instances of a wide variety of health and social problems. Fortunately from a health perspective, the drought ended early and the situation did not worsen. The disruptions to community food and income sources mostly affected the poorer rural communities and their daily living standards. As a result, a high rate of sporadic cases of dysentery, diarrhea and skin infection recorded in remote areas

Owing to the decrease in domestic farm production, an increase in malnutrition was observed, particularly amongst the poorer sections of the community (cane cutters, the unemployed and subsistence farmers). In addition, a high incidence of anemia was observed in pregnant mothers. Although food rations reached drought victims, it was nutritionally unbalanced.

Health and sanitary standards were also affected because of the poor water supply or the unavailability of water for basic sanitary and night soil disposals. The rural communities were particularly affected. In worse scenarios, a few households were relocated as local sources of water dried up. This adverse environment was an unfamiliar experience to those affected. It was the catalyst to greater human misery and frustration which manifested itself in an increased incidence of sporadic social and domestic problems and violence.

There were no lives lost directly due to the effects of drought, although several people lost their lives in indirectly related events (e.g., carbon monoxide poisoning while digging wells). However, generally speaking, the drought seemed to have exacerbated the effects of previously existing malnutrition and micronutrient deficiencies.

The drought reduced available household food supply, resulting in adverse health impacts. These were analyzed against known differences in culture and dietary habits of the two predominant ethnic groups – Fijians and Indians.

Areas Affected

The impact on health spread sporadically throughout drought-affected areas. However, more severe impacts were more prominent within the sugarcane growing areas, involving the community most vulnerable to drought. In all areas, babies, lactating mothers and elderly citizens were worst affected as a result of dietary deficiencies.

[10] The section has combined both the health report to the Study Team and the findings of the UNDAC study.

Short-Term Impacts

In its report to this study, the Ministry of Health concurred with the UNDAC Report and stated that these had been an observed increase in infantile diarrhea, malnutrition (especially in children) and nutritional deficiencies in pregnant and lactating mothers. Major contributing factors were as follows: the poor quality of delivered water, the loss of up to 90% of home gardens and the poverty level restricting low-income households from buying nutritional foods which were widely available in municipal supermarkets.[11]

National Response

The Fiji Government assisted the worst-affected families by providing emergency water and food rations. These were supplemented with donations supplied through NGOs, donors and international agencies in the form of cash, food, planting materials and other essentials.

For the impacts on health there were no strategies on a national scale. However, health intervention to correct iron deficiencies and anemia was prescribed individually after examination by doctors. It is certain that the medical authority is unaware of many more victims. The findings of the drought impact study have supported the call from nutritional agencies to provide iron-fortified food (such as flour) to foster preventive health practices.

A total of around 250,000 people were given various rations from sources detailed in Table 6.

Table 6: Main Types of Rations Distributed

Ration type	Target group	Distribution Mechanism	Distributor/ Donor	Quantity/ VALUE
Rice, Flour, Sugar and Canned Fish	1.cane farmers 2. non-cane	Affected Households	Government of Fiji	Total: 18,912 bags

[11] The UNDAC report described medical data from surveys of a total of 1,800 children under 5 years of age (U5) that showed a shift toward the lower limits of the recommended weight for age.

(monthly adult supplementary ration = 4 kg rice, 4 kg flour, 2 kg sugar, 4 tin fish)	farmers in cane belt 3.subsistence farmers in non cane belt, including islands Areas: Western Division, Northern Division	identified in Government of Fiji (GoF) surveys		of rice 17,020 bags flour 17,730 cartons tin fish 8,510 bags of sugar
Humanitarian Daily Ration (HDR) Packs	School children in Western Division	Schools in need of assistance	Red Cross / USA	200,000 Units, (0.5 Million US$)
Rice, flour, dhal, oil, milk and where feasible fresh fruit and vegetables	Most affected Households in Western Division	Households identified in GoF surveys	Red Cross / Government of Japan	F$ 124,000
Breakfast crackers, coconut biscuits, whole milk powder	School children Western Division Northern Division	Schools responding to appeal	Save the Children Fund/ Navtarang / Donations	F$ 180,000

Source: UNDAC Fiji Drought Report

Short-Term Needs on Health and Nutrition

Due to ignorance of the causes and effects of micro-nutritional deficiencies, greater effort is needed to run a national awareness program targeted at women of child-bearing age. The two leading agencies, the National Food and Nutrition Committee (NFNC) and the National Centre for Health Promotion, require financial support from the central government to run this program.

The Fiji Plan of Action for Nutrition, which was endorsed by the cabinet in early 1998, provides a multi-sectoral instrument to promote food security in Fiji. Given the extent of nutritional problems in Fiji, it was recommended that its implementation under the guidance of the NFNC be given a high priority by all ministries concerned in 1999.

Also noted was a need to strengthen the concept of household food security within the overall framework of the Ministry of Agriculture. Moreover, the integration of nutritional aspects, in particular educational feeding practices, needed strengthening within the policy of the Ministry of Education.

There should be special nutritional considerations in the issuing of drought rations for consumption by children and young mothers. Items to include dhal, milk-biscuits or milk powder. If it were deemed necessary by regional health officials, feeding centers would be set up to target malnourished children.

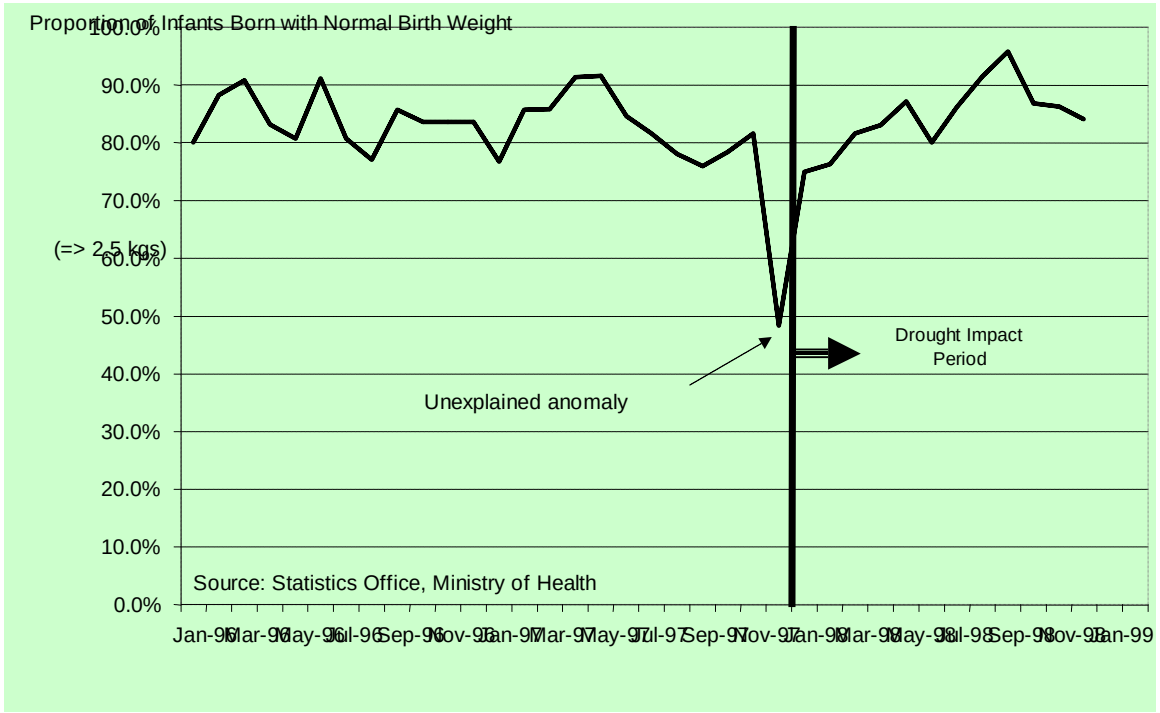
Long-Term Impacts

The UNDP study [12]examined long-term trends in hospital data. These did not suggest abnormal increases in infectious diseases and low birth weights due to the drought. Data from the Ba, Lautoka and Nadi hospitals show no significant difference between the frequency of low birth weight of infants during 1998 and the incidence in previous years. The trend for Ba Hospital on low birth weights is shown on Fig. 13 and the trend for anemia in pregnant women is presented in Fig. 14. It is likely that the relief interventions in supply of good drinking water arrested the problems of infectious diseases observed at the beginning of the drought.

Fiji was very fortunate that the drought did not continue and that the government and the non-government organizations had responded effectively.

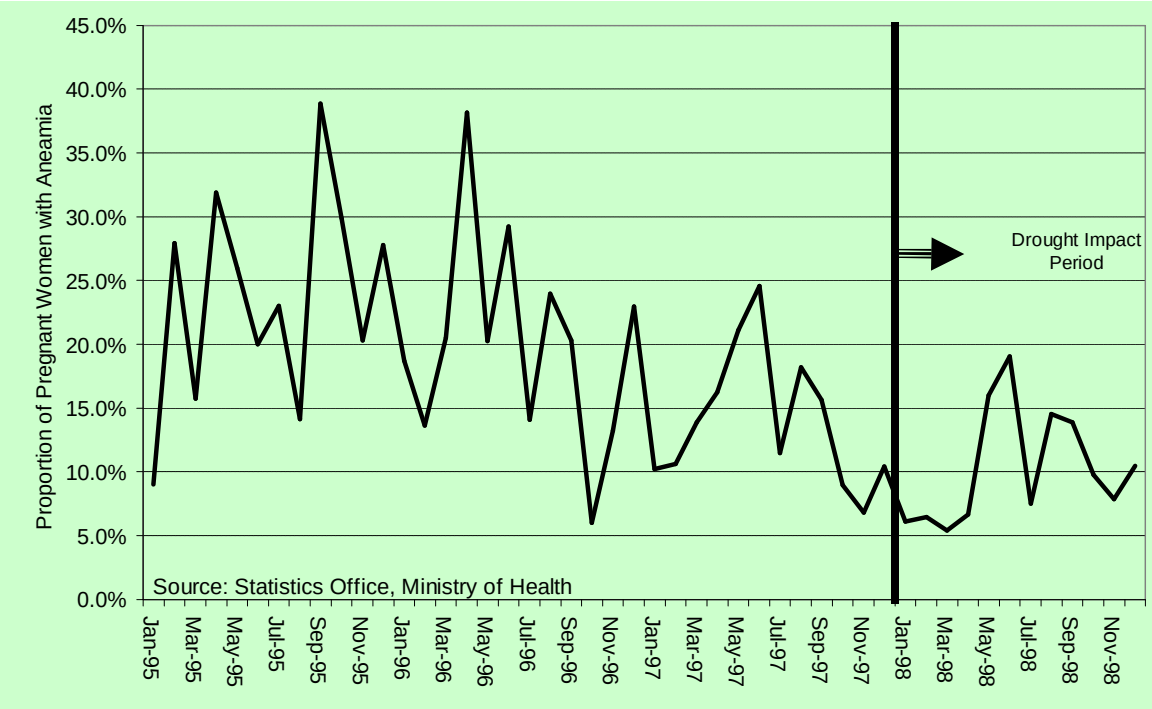
Figure 13: Birth Weights at Ba Hospital

[12] The UNDP report by Chris Lightfoot, citing that anemia is a chronic problem in Fiji, is supported by reports of our study team.



Source: UNDP Report: Regional El Niño Social and Economic Drought Impact Assessment and Mitigation Study (Lightfoot, 1999).

Figure 14: Pregnant Women with Anemia at Ba Hospital



Source: UNDP Report: Regional El Niño Social and Economic Drought Impact Assessment and Mitigation Study (Lightfoot, 1999). Note that in June 1997, forecasters identified the development of a strong El Niño event.

Impacts in the Education Sector

Most schools had interruptions in their water supplies during the drought. This applied to both metered and non-metered sources. Water was supplied through water delivery trucks.

Short-Term Impacts

At times schools were closed through concerns about the health risks the children faced because of unsanitary conditions. Other schools were closed because they were poorly prepared for the drought. Not only did they run out of potable water, but those that had installed flush toilets and water closets found it difficult to maintain basic sanitary arrangements. Some schools reverted to using pit latrines.

School absenteeism increased. As parents had neither cash for bus fare nor food for school lunches, they kept their children at home. However, most children continued to attend school throughout the drought period and, at worst, those that missed some school may have their schooling set back by a year.

National Response

The non-government organizations (NGOs) were much more responsive to addressing the financial difficulties of school children. Notably the Fiji Red Cross Society, the Foundation for the Peoples of the South Pacific and the Save the Children put in considerable efforts to ease the various difficulties children had in making it to school.

Needs in the Education Sector

The main need was to have adequate water and school gardens. All short-term needs were addressed by other intervening measures.

Long-Term Impacts

It is very difficult to draw conclusions and find links between short absenteeism and children's subsequent academic/employment performance. Also, concern was raised about whether social non-curriculum habits developed during these periods of absenteeism have long-term impacts. However, it is clear that lower levels of education or delayed completion of schooling will ultimately affect the development of a country.

Impacts on National Economy

Macroeconomic Impacts

The 1997-98 drought was classed as the most catastrophic natural disaster to hit Fiji in the 20th century. Fiji has a narrow economic base that is driven primarily by the sugar industry with a contribution from tourism. The 1997-98 growth in other sectors was not strong enough to offset the retarded growth due to the drought in the sugar industry and in the export crops, dalo and kava. The drought drove the economy into recession, reducing the 199

GDP by three percent [13] and 1998 GDP by a further five per cent. In comparison, Fiji had achieved an average growth of 3.0 percent per annum over the last five years. The effect on national GDP reflects the aggregate impacts on domestic production, employment and prices.

The rapid recovery of the agricultural sector from late November 1998 helped to minimize the long-term impact of the drought and is likely to be insignificant within 3 to 4 years. However, the compounding effects of all droughts and other natural disasters on the economic growth of Fiji are significant. It has been estimated that natural disasters have cut up to 50 percent from the economic growth rate of Fiji (Benson, 1996).

The UNDP Report did not find any lasting impact of the drought on prices. Non-affected areas from the Central Division were able to replenish Western Division markets but the reduction of the disposable income of drought victims and the provision of rations kept buying demand low and prices stable.

The UNDP study stated also that the drought did not have any impact on interest rates. It believed that the January 1998 Fiji currency devaluation of 20% might have masked any deflationary effects of a general reduction in demand. As for wages and employment, the short-term impact was severe mostly because of the damage in the sugar sector but this quickly returned to normal with the bumper crop of 1999 that forestalled any long-term impacts on wages and employment.

Household Income

Impact on household income was felt mostly within the drought-affected sugar producing districts, with hardly any felt impact external to these areas. Within these areas the worst affected totaled about 17,000 households, which had no other alternative to sugar production and 93,000 households less affected. The latter normally supplemented their income from other sources. In addition, there are many landless laborers in Fiji who rely on casual work to support their families.

Subsistence agriculture, which accounts for 3% of the GDP and supports 85% of the population, was also adversely impacted. As the figures suggest, most in this group are among the poorest in the country with very little savings. The loss of their household gardens and cash crops in the drought, their primary source of food and income, was life threatening. If not for the food ration distribution that addressed the immediate problem of food, a food crisis would have developed. At the best of times the bulk of those reliant on subsistence agriculture struggle to maintain a decent standard of living. As the UNDP report noted, the loss of a year's income is major setback for these families; a setback some can never recover from, particularly those with few reserves.

[13] UNDP Report by Chris Lightfoot (1999).

Reliability of Attributions

The Fiji Meteorological Service has a very close professional relationship with equivalent bodies in Australia and New Zealand. For 1997-98 the El Niño warning was initially sent from the Darwin Territory Regional Office of the Bureau of Meteorology in Australia. These Weekly Tropical Climate Notes are sent to the FMS via email. Relevant web sites such as those of NOAA, the UKMO, the IRI, ECMWF and WMO were accessed for the updates.

The Fiji Meteorological Service has, since 1991, continually studied the relationships between ENSO and Fiji's climate, particularly ENSO's impacts on rainfall and tropical cyclones (running statistical analysis of the frequency and severity of tropical cyclones during past El Niño and normal years, since 1840).

The more sophisticated studies, such as those focused on the interaction of SSTs and Fiji's climate and the behavior of the SPCZ (South Pacific Convergence Zone), are left with foreign scientific organizations, which share their findings with Fiji. Foremost among these is New Zealand's Institute of Water and Atmospheric Research Ltd. (NIWA), which has carried out studies on ENSO's extremes and climate-related hazards such as tropical cyclones. One of its publications is currently a very valuable reference text in the region "El-Niño-likely Impacts on the South Pacific Island Countries" (Dr. Reid Basher, NIWA).

The 1997-98 El Niño impacts have been well documented because of the scale of disaster that arose and government interest to address the problem. However, the socio-economic impacts of the earlier El Niño-related droughts of 1982-83 and 1987 were not as well recorded. Interestingly, the 1982-83 event was not as severe in Fiji as that of 1987. However, the fact that Fiji went through two military coups in 1987 restricted normal scientific and government functions and recording of drought impacts.

Responses

Government Response or Statement Issued Before the Impact of the 1997-98 EL Niño Appeared

The Fiji Meteorological Service routinely issues a Monthly Weather Summary. Acting on the early warning sent by the Bureau of Meteorology Australia (Darwin Territory Regional Office) and checking with its own models, the FMS stated in its April (1997) Monthly Weather Summary the possibility of the return of an El Niño condition later in the year. It confirmed this in its May summary, and in June indicated the possibility of a significant drought in Fiji.

Even though the circulation of these summaries reached all key agencies, for some reason no response was generated. This was possibly due both to a general state of unpreparedness and to a lesser extent the difficulty of identifying with meteorological terminology. The country was hit hard as it was not prepared for the disastrous event.

Statement Issued After the Impact

The FMS released several reports on the drought including the forecast of the subsequent season: May 1998, August 1998; October 1998. These reports were distributed to the National Disaster Management Office (NDMO) and relevant government departments and ministries.

The Fiji Meteorological Service was approached to advise on the severity of the drought and its duration during the event by representatives of the government and the sugarcane industry.
The impacts eventually proved so devastating that the government declared a state of emergency. Senior administrators from affected areas monitored the situation and regularly compiled progressive damage reports, which were submitted to the National Disaster Management Office. This formed the basis for the response decisions from the government. The damage soon reached a scale beyond Fiji's capacity to cope, such that it sought UNDP assistance (e.g., UNDAC Report) to help assess damage, relief and response requirements. Fiji also requested UNDP to assess and report on the medium to long-term impacts.

In addition, national workshops were convened by the Sugarcane Growers Council as well as by UNDP that addressed the drought, its impacts and possible mitigation measures. Additionally SOPAC conducted a regional workshop in October 1998 that brought together water managers, weather scientists and disaster managers from Pacific Island Countries (PICs), almost all of which had been affected by the drought. Foreign scientific organizations, particularly the Pacific ENSO Application Center (PEAC) continued to monitor the event and regularly published a newsletter on physical impacts around the Pacific.

Major Responses to the Event

More information on the response of worst-hit sectors was provided in a previous section (The Socio-Economic Impacts). An overview of the major responses is as follows:

The magnitude of the drought generated consultations between relevant scientific organizations based in Fiji that turned over more El Niño-drought information to the public. The government declared a national disaster, which was justified eventually, as the drought was the worst of all natural disasters to impact Fiji in the twentieth century.

The Government of Fiji assisted the worst-affected families by providing emergency water and food rations. While essential, this relief went only part-way toward addressing the immediate needs of those most severely affected. NGOs, donors and international agencies provided further assistance in the form of cash, food, planting materials and other essentials. The Fiji government provided food rations to about 250,000 people (33% of the population) at a monthly cost of US$3.3 million. Over half the population was supplied limited water, which cost government $0.5 million. This rationing was insufficient to address the needs of special attention groups such as infants and elderly people.

NGOs such as the Red Cross, Save the Children Fund, church groups and social/charitable organizations were very active, assisting with food and cash to school children and organizing public appeals. Another NGO, the FSP (Foundation for the People of the South Pacific), worked with schools on upgrading water systems and establishing food gardens.

The Fiji Meteorological Service, as earlier mentioned, had issued Drought warnings in its Monthly Weather Summaries to the news media and its other recipients.

Emergency water supplies were provided to the rural areas and outer islands badly affected by the drought. Additionally more bore holes were quickly established at designated areas. Due to the prolonged nature of the drought, the Public Works Department took precautionary measures enforcing temporary water cuts and activating legal water restrictions.

Level of National Research on ENSO in the Last 20 years

Fiji does not have specific meteorological research institutions. The Department of Meteorology undertakes limited studies on historical and statistical relationships between ENSO and Fiji's climate. It looks particularly at the interrelationship between rainfall, tropical cyclones, the Southern Oscillation Index and seasonal variation. This is strengthened with research results available from more research projects run by foreign scientific organizations. Recently the WMO has upgraded the Department facilities and status as a South Pacific regional meteorological office. Coincident with this is a raised level in rainfall-drought prediction skills. However, for pure scientific research, island countries rely on initiatives of their richer and more resourced development partners.

Small island countries have limited water resources, particularly surface water, which is in great demand. The regional scientific organizations of SPREP and SOPAC also have undertaken applied research on the relationship between climate and ocean impacts on development planning.

In Fiji there are currently some studies to determine the relationship between catchment conditions, stream flows and ENSO, based on similar studies that had been done in New Zealand and Australia. It is run jointly by the University of the South Pacific and the Hydrology Unit housed within the

Public Works Department. In reporting on this work, PWD states [14] "that analysis of hydrometeorological data for two stream catchments on Viti Levu island shows how persistent adverse El Niño conditions caused the failure of two successive dry season rainfalls and, more significantly, the failure of the normally reliable wet season rainfall in-between. This produced the lowest stream baseflows on record and led to serious water shortages for rural areas. Surplus rainfall brought by tropical cyclones in early 1997 did little to offset the drought, because this moisture was lost from the hydrological system as rapid runoff and failed to sustain streamflows later on. Overall, the evidence suggested that water resources on high islands in the humid tropics are influenced both by climatic parameters and stream hydrological responses to the pattern of rainfall through the year."

National Plan to Respond to a Disaster

The decade 1991-1999 was declared by the United Nations the International Decade for Natural Disaster Reduction. In response to this, the regional island leaders under the guidance and sponsorship of the UNDP designed and implemented the quite successful South Pacific Disaster Reduction Programme (SPDRP). As a region beset with many disasters, the focus of SPDRP was on risk reduction, preparedness and mitigation measures. It promoted the establishment in Fiji of a national infrastructure for the management of natural hazards supported by a National Disaster Management Plan with relevant legislation noted earlier.

The Level of International Research About the Impacts of El Niño in Fiji.

Many studies are done by foreign scientific organizations on ENSO impacts in the Pacific which implicate Fiji directly. Notable among them is the work by the Honolulu-based Pacific ENSO Application Center, which regularly updates the Pacific Island Countries through newsletters. Similarly, the New Zealand National Institute of Water and National and Atmospheric Research Limited (NIWA) is one of several foreign scientific organizations carrying out studies on ENSO and climate-related hazards such as tropical cyclones and SPCZ displacement in Fiji. The Bureau of Meteorology, Australia and the Natural Hazards Research Centre, Macquarie University in Sydney are other institutions well known in the region for scientific research works on ENSO (with a focus on El Niño) as well as other climatic disasters.

Forecasting by Analogy

In its report to the Fiji workshops, the FMS stated it now has modern sophisticated weather forecasting equipment, which is highly responsive to sudden weather changes. Together with its in-house skills, the Fiji Meteorology Service can now forecast with some authority the likely development of El Niño conditions as early as several months before its onset.

[14] Sourced from PWD Report to the study.

FMS Forecasting Systems[15]

The FMS combines four ways to forecast rainfall in Fiji.

(a) General Monthly Rainfall Pattern
Based on the analysis of historical records, this has defined Fiji's wet season (Nov-Mar), dry season (May-Sept) and transition months (Apr-Oct). This provides also the base rainfall figures for analyzing probabilities.

(b) Analysis of Past ENSO Events
Studies on the characteristics of past ENSO warm and cold events have given guidance for the forecasting of upcoming events. A significant proportion of rainfall variability is associated with strong El Niño events where drier and hotter than normal conditions can be expected from December to February and drier and cooler conditions can be expected from June to August. These studies have also indicated the presence of the lag phase, which is put to good use in forecasting rainfall for upcoming months. The good correlation seen between SOI and strong El Niño event allowed the FMS to successfully forecast in May 1998 the end of the 1997-98 drought in November 1998.

(c) Rain Forecast Models
Since 1991, the FMS has routinely published rainfall forecast advice, "*Outlook For The Following Two Months"* using 30-year normals as a reference point with three classes of advice – *below normal, normal and above normal*. This system was strengthened with the implementation in 1999 of a Fiji Rainfall Prediction Model and the Australian Rainman. The two models are being used together with the Regional Climate Model that provides the larger-scale picture.

(d) Regional Prediction Model
The FMS receives SOI values from Darwin. In addition it has other models and web sites to assist it put together a regional forecast. The eight main models FMS uses are:

BMRC – Intermediate Coupled Ocean Atmosphere Model
CCA – Statistical Model
COLA – Coupled General Circulation Model
ECMWF – Coupled General Circulation Model
LDEO (3) - Intermediate Coupled Ocean Atmosphere Model

[15] Sourced from FMS report *97-98 Drought Assessment and Forecasting Systems Used by Fiji Meteorological Services, Ms Nazim Bi, Fiji Meteorological Services*

NCEP - Coupled General Circulation Model
NOAA (LINEAR INVERSE) - Statistical Model
SCRIPPS/MPI - Hybrid Coupled Ocean Atmospheric Model (Statistical Atmosphere; Ocean General Circulation)

Responses to 1997-98 Forecasts

In 1997 FMS had forecast in April the development of an El Niño episode, but the response capacity and support mechanisms from within the country had not yet been developed to utilize drought forecast skills.

To strengthen response capacity, the two workshops conducted in Fiji included sessions and exercises on drought forecasting. The finding was interesting in that relief actions taken during the drought were the correct relief actions, but were very costly to Fiji as they were taken too late. Forecast information will definitely allow better preparedness by disaster managers as well as drought victims. The workshops also noted that no new technology is warranted to support preparedness but that a lot more effort is needed for public education and awareness programs. People would then be more responsive.

A telling case study was given of the country of the Federated States of Micronesia where a concerted public education awareness program was driven with new drought-forecast information given for 1997-98 by the Pacific ENSO Application Center. Conservative usage along with the repair of line losses helped to reduce water consumption during drought by up to 90% without any adverse impacts on the population.

Policy Implications, Recommendations and Conclusion

The 1997-98 El Niño-related drought had great significance for disaster management in Fiji. There was a determination by the government to understand and assess the full socio-economic impacts. There were two studies initiated by the government with one focusing at assessing drought relief needs and the other specifically to identify long-term impacts and mitigation measures. This UNEP/NCAR project supplemented these studies in merging the local study with its global study. As components of these studies, two national workshops and a regional workshop were held in Fiji, focusing on greater understanding of El Niño and its impacts and to derive recommendations for government and affected agencies and groups on measures to mitigate against such future events.

Understanding El Niño, Definitions, Indicators and Impacts of Past El Niño Events

There is a great need to educate the public on El Niño (and the broader notion of climate affairs) and its impacts on society to reduce community vulnerability through better understanding of this phenomenon. As well as through national institutions, some proactive role for the media to do this

consciously and constantly has to be generated, since it has the widest reach into the community. This Fiji study questioned the appropriateness of using rainfall to indicate "drought". It embraced the growing desires to better define drought through drought classes according to meteorological drought, hydrological drought, agricultural drought and environmental drought. Within each class there is a need to define an appropriate drought indicator, as suggested in the following paragraphs.

For meteorological drought a lot of users could not translate directly the rainfall parameters to their specific and different needs. A second transformation process is needed to convert rainfall data to water depth in rivers, or volume in storage tanks, or depth of ground infiltration, or intrusion of salt water into groundwater aquifer. More work is needed in the use of appropriate terminology to meet users' needs.

For water resources in drought times, the Fiji El Niño-hydrology study found that stream flow is a better indicator than rainfall amount on the availability of water resources. For agricultural drought, crop yield and production are logical parameters or indicators. In "socio-environmental drought," parameters could be defined from an increase of social crimes or deterioration in health and living standards.

These are good parameters to use in future impact forecast. However to realize this, much more analysis on impacts of the past El Niño events needs to be made. This Fiji study also indicated the complexities in assessment due to the compounding effects of other recent natural disasters. Even though the 1992 drought was a weak El Niño event, it had telling impacts. So, for water practitioners and drought victims, the impacts of such events need also to be included in the equation for the consideration of long-term mitigation plans. The support of bilateral donors, international and regional funding organizations is needed for such a program to materialize.

Policy Considerations at Sectoral Levels

Water is a basic commodity essential and fundamental to all things natural and in the creation of things on earth. Its shortage impacts all sectors of society and the environment. There are a number of grounds common and equally important to all sectors to enable them to prepare better against hardships that accrue from future El Niño-related droughts.

Public Education and Awareness Programs – National policies need to be established to support and pro-actively promote public education awareness programs in health care and sanitary issues; community and household water management and food and nutrition.
Organizational Drought Plans – Now that forecasting skills are quite advanced, each agency needs to develop drought plans that are guided by a national drought plan. Such a plan will alleviate most relief needs, which have always put a major demand on national resources.
Legislative review – Review of regulations to cater for needs and controls during droughts.
Strengthening Information Management Systems - The studies reveal the difficulty to obtain data, since there is no recognized information infrastructure within ministries. A key requirement for all planning is a well-managed information system. This needs to be driven in all sectors and from the national level. The pertinent policy implications specific to each sector, identified as lessons learned, are listed below.

Water Resources and the Environment

A concerted effort has to be put in place by government to establish a national water resources plan that maps the major sources as well as the major consumptive users including commercial forestry plantations. The plan needs to link with drought management planning and include appropriate structural and non-structural mitigation measures to ensure efficient usage of water to minimize losses at all times as pertaining to each different system of water supply. There need to be provisions to promote small-scale irrigation schemes of low capital investment.

Due to the extensive areas affected by drought, extending into areas with little infrastructure, the use of information technology such as remote sensing needs to be encouraged to produced broad-based vulnerability maps for water use and conservation purposes. Much assistance and input needs to be sourced from donors and developed countries as this technological tool, though known and appreciated, is currently beyond the financial capacity of developing PICs to own and use. For the Pacific, support can be very effective when directed through the regional organizations, which will build capacity in individual countries according to its needs. SOPAC is the secretariat of the regional organizations responsible for co-coordinating remote sensing development programs.

The lack of user response to drought forecasts in Fiji reflects that the message is not directly meaningful and that users do not have the ready knowledge to convert rainfall figures to other useful parameters. Particularly with respect to forecasting water availability, more research support is needed to study the relationship between water catchment, streamflows, roof catchment and ENSO's extreme events.

Some concerns have been raised in Fiji questioning the current expensive policy to supply water on demand. The concern is that this practice is counter-productive to promoting people to become more self-reliant. Particularly when all drought impact studies have pointed to human negligence, lack of foresight, failure of institutional planning and a general public indifference as the real causes for the bulk of Fiji's water problems, and not water shortages created by natural factors. A strong stand is advocated in order to encourage the people to fend more for themselves.

Food and Nutrition

It is recognized that problems of food and nutrition are chronic issues. The 1997-98 drought revealed that around 30% of the population was on the threshold of dietary deficiency and malnutrition. The fear now is that a potential exists for accelerated national disaster, given Fiji's vulnerability to natural disasters, especially if government does not formulate ground actions now to improve food supply sufficiency and food security. These issues must be addressed at the grassroots (or community) level. Ground-level development agencies must recognize nutrition and malnutrition problems exist and take a coordinated and integrated community development approach, changing current individual agency development approaches, to coordinate in

partnership the uses of their resources in cooperative field programs. The main community agencies include, but are not limited to, agriculture, community health and nutrition, district developments, community organizations and church groups.

Although the government supplied food rations during the drought, these did not meet the nutritional needs of drought victims. The rations were based on food supplied during cyclone disasters when people could still supplement their food by foraging partly damaged garden crops. The cyclone disaster phase is normally a week or two in duration. In the drought, home gardens were completely destroyed and the adverse impacts lasted up to 18 months in the worst-affected areas. The government must examine closely the cost implications of supplying nutritionally balanced food rations in times of disasters.

Given that up to 12-month forecasts are now available with varying degrees of uncertainty and, therefore, unreliability, the nation needs to promote food preservation, particularly traditional methods used in the less accessible rural areas and in the outer islands. This will have many beneficial spin-offs through, for example, monetary savings to the government and the ready availability of nutritious food for disaster victims. The inventory of traditional technologies needs to be accompanied with an objective to attain a commercial final product in the preserved food, thereby offering villagers an alternative source of income while sustaining knowledge.

A long-term measure, which the government had approved after the drought, is flour fortification with iron to combat iron deficiency in the general population. However a lot more food vehicles can be used to make other needed micronutrients widely available to the public. This issue of food fortification needs more public discussions and public support for the government to make appropriate regulations.

Agriculture

Existing policies are adequate to fortify the agricultural sector against future drought, but the risks have not been fully considered. The 1997-98 drought has quantified the cost and studies revealed that mitigation measures need not be expensive or require bringing in high-level technology. The practical approach formulated from Fiji's national workshop was to adopt to a greater extent a strategic planning mode e.g., preparing ahead for drought, given that FMS can provide good forecasts.

The drought's impact on the sugar sector involved the greatest human misery (17,000 families) and the crop failure placed the biggest burden on the nation. Fiji needs to seriously accelerate and intensify its crop diversification program in the sugar sector. Proper criteria need to be established in the selection of commercial crops and where to grow them. Land zoning falls in place logically and easily, if government is strong-willed enough to enforce provisions in the land conservation laws pertaining to proper land use.

The loss of farm animals illustrated the important contribution that small stockholders provide to food supply (milk and protein) at the national level. The Agriculture Department proposed a formula for supplementary food using molasses from the sugar mills. The government needs to establish a mechanism to involve farmers and the sugar industry with the objective of developing this venture into a commercial entity for the farmers.

Meteorology, Planning and Other Services

For forecasting to be really an effective and useful disaster mitigation tool, more dialogue and exchange need to be arranged between the meteorological services and end users to review the scientific terminology in use related to meteorological processes (such as drought, El Niño, and La Niña). The government must take the lead in allocating the required resources to determine this critical issue in collaboration with the non-government sector and the media.

Fiji has recognized the high cost of being ill-prepared for an infrequent hazard, such as drought. Thus, developing drought vulnerability and risk maps will assist everyone plan better for future events. Drought vulnerability and risk maps are important tools to review zoning and other planning policies.

More than anything the drought demonstrated a general lack of knowledge of El Niño and its potential impacts. WMO and other international research organizations need to promote strategies and provide materials to meet the needs of educational institutions, operational agencies, community trainers, national scientists and researchers.

With regard to Fiji schools, hardships faced by school children have highlighted many issues. Perhaps a measure to reduce financial burden on parents is to introduce residentially based control on school placement. This may reduce the burden of long-distance bus fares faced by many students today. It will also encourage greater local community attention to improving school water and sanitation facilities and active participation in drought-response plans.

To complement the drive for water resource planning, the conservative use of water and self-sufficiency in water supply, the government needs to review minimum housing standards to include adequate conduit and storage structures. This is a critical requirement to ensure that essential water is harvested and that there is a move to reduce presently uncontrolled water losses and wastage from individual households, community buildings, schools and rural institutions.

Some of the problems at the rural level are driven by its difficulty to access funds, as requirements of commercial banks are too stringent. Studies have pointed out to government that there is a need to develop and support micro-financing (financing at the local level).

Policy Considerations – National Activities

The national workshops in Fiji disaggregated the drought impacts and came to the following conclusions.

Social and Health Impacts - The studies into drought impacts in Fiji were unable to conclusively determine the medium- to long-term social and health impacts of this El Niño-related drought. This was due to the paucity of data, although observations during the drought tended to indicate increases in key health and social indicator ailments. This shows the need for better record keeping and analysis. Additionally, questions were asked of the long-lasting impacts on drought-induced absenteeism from schools and various family distresses as well as short-term health intervention strategies. More research is needed on social and health aspects of drought.

Economic Impacts – The economic impacts were the most pronounced, including the following: greater soil erosion and environmental losses from rains after the drought (which subsequently caused flooding from silted waterways); loss of income to many farmers; and the adverse national impact of a reduced growth rate. This indicates that the nation needs to put in place both mitigation and alleviation measures.

Generalized Approach to Assessing Medium to Long Term Social and Economic Impacts –The study in Fiji perhaps was the first in the region to try and separate the relief needs from longer term needs by clearly determining the medium to long term impacts. An approach was conceptualized using sugarcane as an indicator crop to establish a realistic drought intensity index derived from correlation analysis between production and rainfall using long-term records. This was not realized because of the restricted accessibility to long-term data. The industry destroys data over one year old. Every attempt should be given to securing a working definition of drought, one that can be usefully applied in domestic situations. The refining of methods for estimating the impact of drought should lead to estimating costs of drought, costs of mitigating the impact of drought, cost-benefit analysis of mitigation, and costs of mitigation as against alleviation. Such methods should incorporate remote sensing techniques into producing an estimation of drought impacts.

Forecasting – FMS should be proactively supported toward refining the science of El Niño and the climate system in order to improve the reliability of its predictions. Every attempt should be made to identify a working definition of drought that can be usefully applied in domestic situations.

Recommendations

The impact of the three studies in Fiji were timely as the nation grappled to understand El Niño drought and to define measures to reduce individual as well as national damages. Involving very senior operational people, the studies generated very practical recommendations. A good number of these have threading through them, common needs for good public education and awareness programs, upgrading data collection and analysis, improving

information management systems and, finally, developing organizational drought preparedness plans to fit in with an overarching national drought support plans.

General Statements on Applied Research Needs

This study has identified a need for more applied El Niño-related impacts research, particularly on the relationship between rainfall-roof catchment-storage; El Niño-stream flows-catchment conditions; and water planning based on total catchment consumptive uses. In the dissemination of scientific results, user-friendly formatting is needed. Pacific countries currently not provided with El Niño forecasting urge the establishment of network services such as those provided by the Pacific ENSO Application Centre (PEAC) to USA-affiliated countries. The suggestion was raised with PEAC if it could explore with the United States government an extension of the Center's services to provide country-specific information to other independent Pacific island states.

Any strategies for mitigating the medium to long term social and economic impacts of the drought are to be composed within a National Drought Support Plan. Organizational drought contingency plans are to be generated in conformity with this national drought plan. The plans will need to clearly define the extension of disaster management organizational structures down to village levels. The Plan itself needs to build in an early warning system that spells out clearly the required response, preparedness and/or preventive actions.

The Fiji study has proposed a five-stage drought alert sequence, similar to the cyclone warning procedure.

a) ***general preparedness***, involves planning and public education.
b) ***nine-month indicative warning***, an early warning and advice to households and farmers on how to start preparing for a possible drought.
c) ***six-month firm warning***, confirmed that drought is imminent.
d) ***three-month severity warning***, advise the severity and provide specific warning to districts likely to be worst affected.
e) ***alleviation***, initiate alleviation measures.
f) ***breaking of the drought***, declare the drought over.

For household water supplies, a concerted effort is required to promote plain "house keeping" matters and have these placed within a development framework.

The extent of damages in the agriculture and environment has given rise to recommendations that drought-risk mapping is required to assist better national planning. The use of remote sensing images has been highly recommended to the government. However, due to the lack of the right technical

resources in individual countries, promotion in the application of remote sensing images needs to be coordinated through SOPAC, which has the mandate.

Livestock holdings within potentially drought-affected areas contain a high proportion of Fiji's total ruminant and small animal populations. Much of the land was rendered devoid of pastures for grazing and this was recognized as a continuing problem requiring supplementary feeding to alleviate hardships. Supplementary feeding is in its early stages in Fiji and will require management support to make this commercially viable for farmers.

Forecasting Needs Identified from the Regional Workshop

The Regional Workshop noted that effective planning requires an accurate, relevant and reliable forecast and proper recording and documentation of impacts. In recognizing that forecasting will allow timely application of response measures, the workshop noted that response plans need to re-visit past events and impacts to further improve effective planning. It also concluded that from the onset and into the early El Niño phases there is a need to target specific vulnerable groups and boost public education and awareness programs, since some difficulties were experienced with interpreting available forecast information.

Conclusion

This study was timely since it enabled the compilation, analysis and dissemination of many lessons learned (in many different sectors) about how Fiji responded to the El Niño-related drought. The disastrous impacts in the socio-economic, agriculture and health sectors were on the verge of snowballing before its end. Government and NGO agencies responded to the drought impacts across many sectors, but most of these responses were late, or sometimes unsuitable (e.g., the nutritional balance in emergency rations) and all responses were reaction-oriented. As it was, the measures taken by the whole nation were sufficient to moderate the economic and social distress caused by the drought. In particular, the Sugarcane Crop Rehabilitation Programme was most effective in aiding economic recovery of the nation. However, the need is clear that more timely and better-planned drought responses are required, starting from monitoring and research, through to warnings, operation plans, and community sel- reliance.

Applied Research

The 1997-98 El Niño-related drought was an important wake-up call to disaster managers and water users in the country to work together with meteorologists and develop drought forecasting, such as has been is done for cyclones. Better warnings are required, including developing appropriate drought terminology and indicators. Damage could have been minimized if drought victims and disaster managers had timely and accurate drought forecast information to guide preparedness and relief response. Despite the fact that the Fiji Meteorological Service provided a drought forecast in May 1997, forecast users hardly responded, most probably because of the difficulties to utilize the information that had been provided in meteorological terms. The present level of forecasting skill is quite high, but it is the further use of this information in its present delivered form that is lacking.

Other areas of research are required to establish baselines and indices for drought damage in different categories (e.g., agricultural drought, socio-economic drought). These indices need to be sourced from studies of past events, but will provide valuable data for assessing future losses and needs for future drought responses. In addition, more research is required to demonstrate teleconnection links to Fiji and to investigate local-scale climatic processes that appear to impact on different parts of the country.

Information Management

The paucity of data is a major problem in assessing impacts of past El Niño-related disasters. This in turn is required to assist in making a cost-benefit economic analysis of long-term mitigation measures. A good example is health statistics that showed increases in skin and nutritional diseases during the drought. However, these effects were hard to separate according to contributions of individual hazards that had hit Fiji in the last six years. The solution to this data shortage is to establish indices of drought impacts and use these for future events.

In summary, some of the key lessons to be learned from the 1997-98 drought are the need for:

a) Planning

i. An effective overall drought-response strategy
ii. Better dissemination of forecasts
iii. Education of the community in appropriate responses to drought
iv. Appropriate and timely multi-sectoral alleviation plans
v. Well-directed and nutritionally balanced food assistance

b) Water and Environment

i. Improved household self-reliance for drinking water
ii. Better management of the reticulated water system
iii. Identification and mapping of groundwater resources
iv. Clearer understanding of the impact of pine plantations on stream flows
v. More active management of the various watersheds

c) Income and Production

i. Improved understanding of drought-tolerant crops
ii. Acceleration of agricultural diversification programs

iii. Better understanding of where and when to plant
iv. Procedures for moving stock out of drought-affected areas

d) Forecasting and Early Warning Systems

i. Simple housekeeping chores are still the best actions and basic first mitigation response
ii. Strengthen working relationships among meteorologists, water managers and disaster managers
iii. Undertake assessment of vulnerability of water sources to drought – wells, streams and roof catchments
iv. Aim to provide users with at least 6 – 12 months lead-time to purchase materials and make other preparations
v. Establish good linkages and working relationship with media

The most effective mitigation strategy is to prepare and publicize timely forecasts, along with providing good public education. If properly warned, mos people will take action to minimize the impact of a drought disaster.

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