Economic and Social Commission for Asia and the Pacific

CGPRT Centre WORKING PAPER No. 73

Stabilization of Upland Agriculture under El Nino-induced Climatic Risk: Impact Assessment and Mitigation Measures in Papua New Guinea

Sergie K. Bang
Spencer Poloma
Bryant Allen

United Nations

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Stabilization of Upland Agriculture under El Nino-induced Climatic Risk: Impact Assessment and Mitigation Measures in Papua New Guinea

"CGPRT Centre Works Towards Reducing Poverty Through Enhancing Sustainable Agriculture in Asia and the Pacific Region"

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Foreword

El Nino-induced abnormal weather tends to be increasing in its frequency, magnitude, duration and irregularity in recent years. Accordingly, it is urgent for rainfed upland agriculture, where most CGPRT crops are grown, to establish technological and institutional countermeasures to predict, avoid or minimize and recover from the damage caused by the abnormal weather, drought in particular. Responding to this vital need, the CGPRT Centre implemented a three-year project, "Stabilization of Upland Agriculture and Rural Development in El Nino Vulnerable Countries (ELNINO)" (April 2000 - March 2003) in collaboration with five participating countries, Indonesia, Malaysia, Papua New Guinea, the Philippines and Thailand.

It is my pleasure to publish **Stabilization of Upland Agriculture under El Nino-induced Climatic Risk: Impact Assessment and Mitigation Measures in Papua New Guinea** as one of the results of the project. The volume focuses on the details of drought and consequent frost damage in the 1997/98 El Nino and responses of the national government, local people and international aid delivery. I believe the documentation provides valuable lessons for policy makers to establish effective and practical policy measures against any climatic risk.

I thank Dr. Sergie K. Bang, Mr. Spencer Poloma, and Dr. Bryant Allen for their earnest and fruitful work. They successfully conducted extensive and intensive field surveys. This interdisciplinary study could only be accomplished with continuous support from PNG National Agricultural Research Institute (NARI) and the Australian National University (ANU). Dr. Rogelio N. Concepcion, Bureau of Soils and Water Management, the Philippines Department of Agriculture, and Mr. Shigeki Yokoyama provided useful guidance at every stage of the study as the Regional Advisor and the Project Leader respectively. I extend thanks to Mr. Matthew Burrows for his English editing. Finally, I would like to express my sincere appreciation to the Japanese Government for its financial support of the project.

September 2003

Nobuyoshi Maeno
Director
CGPRT Centre

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Many other individuals also contributed in one way or another to this study. Among them, Mr. Bill Humphrey (formerly with NARI), for the initial assessment of the drought survey data. Mr. John Demerua, scientist with NARI, provided information on the analysis of droughts. Ms. Debbie Kapal, also a scientist of NARI assisted with data sorting and type setting. Dr. Geoff Wiles, Chief Scientist of NARI, provided very valuable comments and suggestions.

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September 2003

Sergie K. Bang
Spencer Poloma
Bryant Allen

Executive Summary

In 1997, a drought associated with a severe ENSO (El Nino-Southern Oscillation) event was the cause of significant disruptions to village food and water supplies in PNG, as well as the failure of the water supply to towns and smaller service centres, mine closures and disruption to the supply of electricity.

There were severe shortages of food and water, with garden produce declining by 80 per cent (Allen *et al*., 1997). Up to 40 per cent of the rural population (1.2 million people) were without locally available food by the end of 1997 (Allen and Bourke, 2001). The health of rural people declined and in many isolated places the mortality rate increased. Many thousands of people migrated to towns and cities to live with wage-earning relatives. A traditional social support system (known as the *wantok* system) saw town dwelling people buying imported food for rural dwelling relatives in distress.

The government's response was slow and inadequate, partly because there was no advance warning of the drought and partly because the organizations responsible for responding were ill prepared for an event of this scale. The Government of Australia (GOA), through AusAID, established food relief to remote areas and later supported a seed distribution program. The Japanese government purchased rice and other governments contributed to a relief trust fund. Relief delivery by NGOs included food, medical supplies, water containers, tanks and seeds for rehabilitation. However, the majority of Papua New Guineans supported themselves through the famine period. In 1997, Trukai Rice Ltd sold an additional 66,000 tons of rice compared to 1996. Of the additional 66,000 tons, 54,500 tons or 82 per cent was purchased directly by Papua New Guineans through retail outlets and only 15 per cent was distributed by Australian, Japanese or PNG relief programs.

The drought resulted in widespread wild fires that killed people and animals and did considerable damage to houses, trees and sago as well as creating a smoke haze that became a navigational hazard for aircraft. Hydro-electrical power generation was severely reduced. The large mines at Ok Tedi and Porgera were forced to close, Ok Tedi for some months, which impacted adversely on PNG's foreign exchange reserves. The value of the national currency, the kina, fell sharply during 1997.

There was a significant reduction in exports of copper, gold and tree crops in 1997 compared to 1996. The greatest declines were in copper, rubber and tea. Copper exports dropped by 39 per cent, while exports of rubber and tea by 35 per cent and 30 per cent respectively. Coffee exports declined by only 5 per cent in the drought year but increased by 34 per cent in 1998. Oil palm exports increased by 2 per cent. The trade of highland sweet potato to Port Moresby declined sharply.

1. Introduction

1.1 PNG climate

Papua New Guinea is a mountainous country, rising to 4,500 m, with steeply sloping ridges separated by deep v-shaped valleys. It consists of the mainland and three large islands together with hundreds of small islands. Large areas are covered by volcanic deposits, while high rainfall and seismic activity cause high rates of erosion and the development of large, low lying alluvial plains and swamps. The spines of the mainland and the large islands are rugged mountains, but in the central area of the mainland are a number of flat floored valleys at about 1,500 masl.

The major climatic influence is the position of the Inter-Tropical Convergence Zone (ITCZ) and the change in prevailing winds that results from its movement north and south. Between May and October, when the ITCZ lies to the north of PNG, southeast winds prevail. The southeast season, in most places, produces little rain. From December to April, when the ITCZ lies to the south of PNG, strong northwest wind prevail. This season brings most parts of PNG its heaviest rainfall. The predominant orientation of high mountain ranges causes for some places, the normal 'wet' and 'dry' seasons to be reversed.

Large areas of PNG 'normally' receive over 4,000 mm of rain each year. A number of much smaller areas receive less than 2,000 mm, most of which is received in one 'wet' season. Lowland areas experience constantly high temperatures throughout the year with maximums between 28 and 34ºC and minimums between 20 and 25ºC. In general, the lapse rate is 0.5ºC per 100 m of altitude. Highland valleys experience maximums of between 20-29ºC and minimums of 10-18ºC. At altitudes above 2,000 m, minimum temperatures can fall below zero during the southeast season when night skies are clear of cloud.

About every 6 to 13 years PNG suffers from a lack of rainfall in many parts of the country, including those parts that do not "normally" have a dry season. These events are almost always without fail associated with what is known as the El Nino-Southern Oscillation (ENSO) phenomenon.

While there is a pattern to the Southern Oscillation, it is not a regular one and is therefore difficult to predict. This is because the most important factor in driving this phenomenon is the temperature of the sea surface, which receives heat from the sun. The sea is a huge body of water and the way in which it absorbs, holds and releases heat is not yet well understood.

Normally, the sea surface in the western Pacific is warmer than that of the eastern Pacific. As a result, air rises high over PNG, moves east across the Pacific at a high altitude where it descends and returns back across the Pacific as westerly winds. When the sea is warmer and the air pressure is lower, large amounts of water can be absorbed by the air and be carried over the land to be released as rain. The outcome is very high rainfall over much of PNG much of the time.

An El Nino event occurs when the sea surface in the eastern Pacific (near Chile) begins to warm. As the El Nino develops, the sea surface in the western Pacific becomes cooler than that of the eastern Pacific and the circulation of air across the Pacific reverses and goes in the opposite direction.

Under these conditions cooler drier air descends over PNG. Cooler, descending air carries little water and causes higher air pressure. When this happens PNG experiences low rainfall and clear skies with little of the usual large amounts of cloud. By examining government reports, newspapers and oral accounts, it is possible to count the years in which a range of outcomes associated with severe ENSO events have occurred in PNG. These outcomes are drought, repeated frost, food shortages, bush fires and migrations. In 11 of the 125 years

between 1877 and 2002 all these events occurred, or can safely be assumed to have occurred, with a frequency of 12 years, on average. This suggests that about 85 per cent of all severe ENSO events have serious outcomes in PNG (Allen B., 2003).

A number of important points arise from this record

This imperfect association makes it difficult to predict whether any ENSO event will have serious outcomes in PNG. On the basis of the historical records we are likely to be wrong at least 15 per cent of the time.

The outcome in PNG of most of these 11 events was not as severe as the 1997 event. The severe 1972 ENSO event for example, caused a long dry season in many places and repeated frosts at high altitudes in PNG. The frosts resulted in a major food relief and rehabilitation program (which was later criticized for delivering too much food for too long), but overall, the impacts were much less serious than 1997. The 1982 ENSO event caused a severe dry season but few severe frosts. The food shortages that occurred in 1982 were caused by excessive rain in many highland provinces late in 1981.

Of the 11 years in which serious ENSO events occurred in PNG, there are only four that are probably of the same order of severity as the 1997 event, which is an average of once every 25 years, and possibly only one, 1914, that was as severe as 1997. If we are trying to predict which ENSO events are likely to be as severe as 1997, the historical records suggest we will only be right less than 50 per cent of the time, or worse, only 10 per cent of the time.

1.2 Food production systems in PNG

PNG has a large number of agricultural systems that produce food. Table 1.1 lists the most important food crops in PNG in terms of the proportion of the population they support and the calories they provide. A number of important points about PNG food production systems follow the table:

Table 1.1 Most important foods in PNG

Crop	% Population most important food	% Total calories	Estimated PNG production (tons)
Sweet potato	61.2	30.1	1,286,000
Banana	8.1	7.4	413,000
Taro (including Chinese taro)	15.8	7.3	314,000
Coconut	n.a.	10.9	195,000
Sago	10.4	6.3	95,000
Sugarcane	n.a.	3.2	190,000
Cassava	1.7	3.1	124,000
Greens	n.a.	3.0	304,000
Yam	3.1	2.6	143,000
Pork	n.a.	3.0	60,000
Rice (imported)		9.4	

Note: Imported and processed foods, fish and chicken not included.
Source: % population – Agricultural Systems of PNG; % calories and estimated PNG production – Gibson (2001).

- Sweet potato is the most important crop in PNG. It provides 30 per cent of the total calories consumed in PNG and on its own or supplemented by other crops, is the most important food for 61 per cent of the total population, an estimated 3 million people in 2002.
- The proportion of the total calories obtained from sweet potato alone is equivalent to the calories obtained from the next four most important foods (coconuts, bananas, taro and Chinese taro and sago).

- Almost 10 per cent of the total calories are obtained from imported rice. Although rice is more important in urban areas than in rural areas, any consideration of food shortages needs to take into account imported foods as well as locally produced ones.
- Food shortages in PNG are usually the result of climatic events interrupting the production of these foods from agricultural systems, or food production systems.

In simple terms, in PNG, three main types of food production systems occur:

1.2.1 Shifting cultivation systems

Most agricultural systems in PNG are shifting cultivation systems. The main points to remember about shifting cultivation systems are:

- Every year at about the same time, land is cleared of trees, scrub or grasses and is planted with a large number of different crops. It is common for fire to be used to clear land for planting.
- After one, two or sometimes three plantings of crops, the land is left uncultivated or 'fallow'. In most of these systems the time land is cultivated is always much less than the time it is left fallow.
- Crops are planted only once each year and food is produced throughout the year by using a large number of different crops which mature at different times after planting. Food is also obtained from the land planted in the previous year and replanted in the present year.
- The most important crops are bananas, taro, sweet potato, yams, Chinese taro and cassava. Sugarcane and many green vegetables are also grown.
- Trees and palms are also planted for leaves, nuts and fruit, notably coconuts.

1.2.2 Continuous production systems

In some parts of PNG, mainly in the Highlands, food is produced continuously throughout the year. There are a number of places in the PNG lowlands where bananas are produced continuously for long periods of time from the same piece of land. Continuous production banana systems are well adapted to dry periods and will only be impacted by very strong ENSO events when the bananas may stop producing for some time, but will normally recommence production when rain is received.

The main points about continuous production sweet potato systems are:

- Land is cultivated for long periods of time and left uncultivated for only short periods between plantings of crops.
- In these systems, sweet potato is the most important single crop. Most of the food is produced from land planted with sweet potato.
- Supplementary crops including Irish potato, taro, sugar, Highlands pitpit, cabbages and corn are often grown with the sweet potato, or in shifting cultivation systems on sloping land nearby.
- Food is produced throughout the year by planting sweet potato throughout the year. The supplementary crops may be planted only once a year.
- In PNG, sweet potato is grown from sea level to around 2,800 meters above sea level (masl). The main highland valleys are between 1,500 and 2,000 masl, but considerable numbers of people live above 2,000 masl.
- For most people using sweet potato as a staple food, food becomes available in a normal year from 4 to 6 months after planting but at higher altitudes food will not be available until 12 months after planting.

- Sweet potato is a drought tolerant crop and it does not produce well in soils that are saturated. In saturated soils, sweet potato produces luxuriant top growth (leaves and vines) but very small tubers.
- In these systems, domestic pigs are important and they eat up to half of the sweet potato produced, usually the smallest tubers that are thought to be not fit for human consumption.

1.2.3 Sago systems

The other important food in PNG is sago, eaten by around 600,000 people as their most important food.

- Sago does not grow above around 1,100 masl.
- Some sago is planted and some is not. Where 'wild' sago is used, people may not know how to plant new sago.
- Food is produced from a mature palm (about 15 years from planting) by cutting down the palm, chopping the trunk into fine chips and leaching out the starch from the chips with water.
- The starch produced can be stored for some months but most often sago starch is produced as needed. Provided mature palms are available it is an 'instant' source of food.

Some people who depend on sago do not cultivate other crops, but hunt and fish.

1.3 The impact of El Nino on food production

People have been practicing agriculture in PNG for thousands of years. They have adapted their agricultural practices to the most common environmental conditions of the areas where they live. They have developed an impressive knowledge of their local agricultural environments and how to manage them.

1.3.1 Dry seasons and food production

In areas which have regular seasonal periods of low rainfall and severe seasonal soil-water deficits, agricultural systems are adapted to deal with these conditions. Where dry seasons are very severe, people have found some other way to deal with the constraints that the lack of rainfall places on food production.

For example, in many places that have severe dry seasons, trading is very important. Along the Central Province's coast, where there is a severe regular dry season, mountain people trade pots for sago from the Gulf of Papua, where there is no dry season but where there is usually a large soil-water surplus. In Milne Bay, islanders travel long distances over open seas in sailing canoes to trade for food with people on larger islands and on the mainland.

In many places today, these trading systems have become defunct. Where people can now earn cash, they use it to buy supplementary food, usually imported rice or flour, to get them through the dry season. Where they cannot earn cash, living conditions have deteriorated.

Elsewhere, on the north coast of mainland Milne Bay and in parts of Morobe, channel or flood irrigation systems have been developed. They remain important today at places like Wedau. In addition, in these seasonally dry areas, there are many agricultural techniques for dealing with the dry season. Planting material is kept alive during the dry season in swamps, particular crops, such as yams, are favoured. Tree crops are important. Today the ability to earn cash and to buy food during the dry season is very important.

1.3.2 Areas with no seasonality

For most of PNG however, most of the time, too much, not too little, water was and is the major agricultural problem. Many PNG agricultural systems are located on steep slopes that encourage water to run off. In flatter areas, drains are a common feature of many systems, especially where sweet potato is a staple because sweet potato does not produce well in wet conditions. Mounds are widely used to provide the plant with a well-drained environment. Sweet potato growing in soil that contains too much water produces abundant top growth, leaves and vines, but fails to produce tubers. Around two-thirds of people in PNG now depend on sweet potato as their main source of food, so this is not an insignificant problem.

It is probable, over the long-term, that more people in PNG are affected by food shortages caused by too much rain than by food shortages brought about by too little rain. However, shortages caused by too much rain are difficult to detect because PNG is normally a wet place and because the food shortages usually occur some months after the heavy rain has fallen (when the sweet potato fails to produce tubers), whereas shortages caused by too little rain occur almost immediately and the damage caused by drought and frost is spectacular.

Nevertheless, about once every 14 years a severe ENSO event causes widespread drought. Around every 6 years, less severe ENSO events cause widespread frosts in high altitude areas.

Below the frost zone in the Highlands, drought causes severe problems. Agriculture is adapted to deal with too much water and it is difficult to continuously guard against an unpredictable event that occurs only once every 14 years or so. It is widely recognized in the Highlands that many gardens, located in more than one environment, growing a wide variety of sweet potato cultivars, as well as an extensive network of exchange relationships with people in other environments, are the best forms of insurance against food shortages of all origins.

1.3.3 Sago

In lowland areas, sago is the most important insurance against famine and in most years it is able to be used as a fallback food to maintain the population during a shortage, both by people who eat sago as a staple and by others who normally grow crops in gardens and only make sago from time to time. One of the surprises of 1997 was that a very severe drought also seriously constrains sago production through a lack of water to process the sago, by reducing the starch content of the palms and by the penetration of sea water into normally freshwater estuaries because of the reduction in the flow of large rivers. Fire can also destroy sago stands.

1.4 Drought and frost in PNG

A drought is an extended period of abnormally dry weather when precipitation or rainfall is less than evapo-transpiration, which leads to a serious soil moisture deficit and results in a significant reduction in agricultural productivity. Severe drought can be defined statistically as the lowest 5 per cent of the driest years in a location and a moderate drought as the lowest 10 per cent of driest years (Maiha, 2002).

A frost occurs when clear night skies allow outgoing radiation from the earth's surface and temperatures fall below freezing. In PNG, this can occur regularly at altitudes above 2,100 m and in ENSO event years, down as low as 1,800 m.

PNG has experienced 26 droughts since 1800 (McRae, 2002). Of these, 18 were associated with low SOI values (SOI below –10) according to the Bureau of Meteorology, 2002. The drought years were; 1882 (El Nino), 1885, 1888 (El Nino), 1896 (El Nino), 1902, 1905 (El Nino), 1910, 1914 (El Nino), 1940 (El Nino), 1941 (El Nino), 1946 (El Nino), 1953 (El Nino), 1955, 1956, 1960, 1965 (El Nino) 1972 (El Nino), 1977 (El Nino), 1982 (El Nino), 1987 (El Nino), 1991 (El Nino), 1992, 1993 (El Nino), 1994 (El Nino), 1995 and 1997 (El Nino).

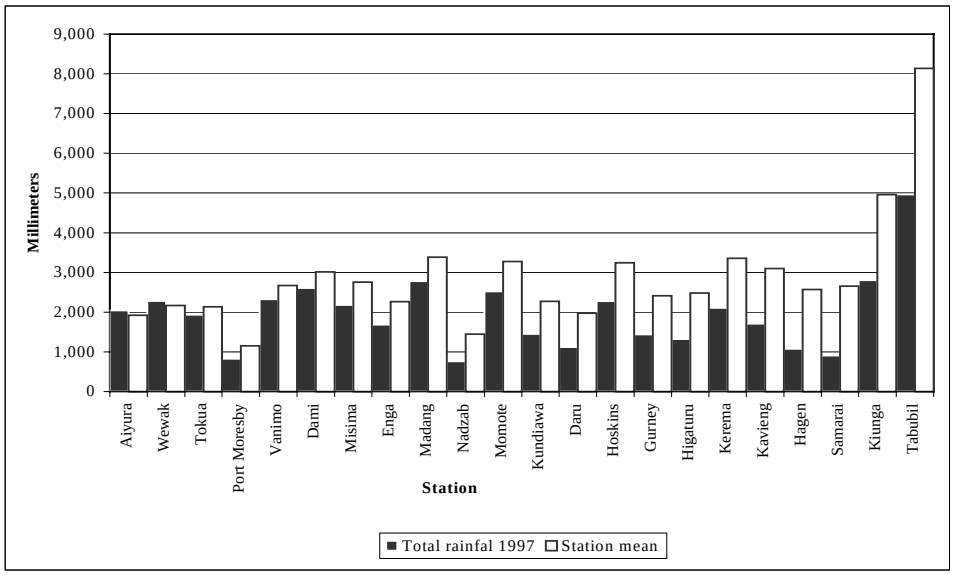
Based on German colonial reports, it is likely severe droughts occurred in 1887 in Papua and in 1888 in New Guinea. In 1896, drought destroyed cotton and tobacco fields in Madang owned by German Neu Guinea Compagnie. The 1901 and 1902 drought caused famine along the southern region's coast and Milne Bay and fires in sago swamps in Northern Province, while in New Ireland, taro died and people survived on sago and coconut. People "starved" in southeast Papua. The drought event of 1914 was severe throughout the country. In New Ireland, village populations "scattered" and were said to be "wandering about in desperation". Another report stated, "a large section of the population simply died". Papuan villages were described as being "destitute". Forest fires were widespread in Papua and New Guinea in 1914 (Allen, *et al.*, 1989).

In 1941, smoke from widespread swamp and forest fires along the Sepik River caused problems with shipping while there were widespread food shortages. Australian patrol officers, who entered the high altitude valleys of Western Highlands for the first time in the early1950s, reported numerous stories of deaths and migration due to the frosts of 1941. The drought of 1972 produced a series of frosts, which destroyed food crops and disrupted food supply in the high altitude valleys. The Fly River's water level dropped significantly, impeding transport of food and other supplies upstream.

The drought event of 1982 affected most parts of the country except the New Guinea Islands but did not produce serious impacts on food or water supplies. In 1987, drought affected the Markham Valley and parts of Eastern Highlands only.

The 1997 drought event is thought to be the worst in since 1941 and possibly since 1914 (Bourke, 2000). The degree to which rainfall was reduced in 1997 is shown in Figure 1.1.

Figure 1.1 Rainfall in 1997 for selected stations compared to the long-term mean at the same stations



Source: PNG National Weather Service.

2. Methods

The objectives of the project were achieved by collaboration with various organizations and by drawing information from various sources.

2.1 Information obtained from collaborating agencies

The institutions that collaborated to implement this project are the Australian National University (ANU) and the PNG National Weather Service (NWS). Bound copies of the 1997 national drought survey and the databases created from them were obtained from the leaders of the 1997 assessment teams. These forms and the assessment level data provide the basis for this report. The Land Management Group at the Research School of Pacific and Asian Studies at The Australian National University (ANU) provided copies of more than fifty papers and reports on past droughts and frosts in Papua New Guinea.

The National Weather Service (NWS) provided historical rainfall data. The historical rainfall data was analysed under NARI's Drought Response Research Project funded by the World Bank. The Drought Response Research Project selected drought tolerant crops, demonstrated appropriate soil water management techniques and produced an on-farm drought contingency plan document.

2.2 Information from surveys following the 1997 drought event

Surveys were conducted throughout the country during the 1997-98 ENSO event to assess the agricultural and socio-economic impacts. All provinces except Bougainville were visited (because of the armed conflict there). The survey obtained a wealth of information including various coping strategies people used, types of 'famine food' that were eaten, food crops that were able to survive drought, local methods used to mitigate the impact of frost and the state of government services, including infrastructure such as roads and airstrips at the time. The quality of survey information varied depending on the assessors, who ranged from trained agriculturalists to missionaries and literate villagers.

Thirteen assessment teams conducted the first two surveys in October and December 1997, organized by Bryant Allen and Mike Bourke from ANU. The teams comprised of staff from the Department of Agriculture and Livestock, Ok Tedi Mining Ltd, Cocoa Coconut Research Institute, Cocoa Coconut Extension Agency and the Australian National University. Provincial staff accompanied all teams. AusAID, the Royal Australian Air Force (RAAF) and the National Disaster and Emergency Service provided operational support. An Access database was established in the Department of Provincial Affairs and the incoming information mapped into Census Divisions as a MapInfo GIS. From this database, estimates were made of the numbers of people affected at various levels of severity. The estimates were provided to the GOPNG and the GOA who made relief program decisions using this information.

The teams reported on direct personal observations and the surveys covered a range of indicators which included the examination of gardens, women's carrying bags, cook houses and dwelling houses, road side and urban market places, the cash earning abilities of people and their cash reserves and how long cash income would continue to be available, their management of domesticated animals and their use of famine foods. Aid posts and health centres were observed. Water supplies were examined where available and drinking water on hand was examined (Allen *et al.*, 1997).

In a post-drought evaluation carried out by AusAID (Lea *et al*., 1999), the surveys were criticized for underestimating the cash reserves available to people with which to purchase food. However, the assessment team leaders believe this is an unfair conclusion because much of the cash that was used to buy food came from the close relatives of affected people who were employed and living in towns. The 1997 surveys did underestimate the degree to which people with cash reserves were prepared to assist their relatives in distress, but there was no way these reserves could be estimated from field assessments.

The third survey was carried out in February 1998 by DAL under the leadership of the late Mr B. Wayi and only included the most severely affected census divisions identified in the December 1997 survey.

2.2.1 Mapping drought and frost impacts

During the first (October) and second (December) assessments, a five-point scale was used to distinguish areas on the severity of the impact. Areas were categorised on a scale of 1 to 5, with 5 being an extreme situation where only famine foods were available and water was very short. The five categories used in the assessments are given in the Appendices. In this report the five categories are represented as:

No food/water shortage.
Mild food/water shortage.
Serious food/water shortage.
Severe food/water shortage.
No food/water available locally.

Figures 3.1 and 3.2 (in Chapter 3) show the food and water assessments as of December 1997 by Census Division[*]. The impacts are described by province in Section 3.0.

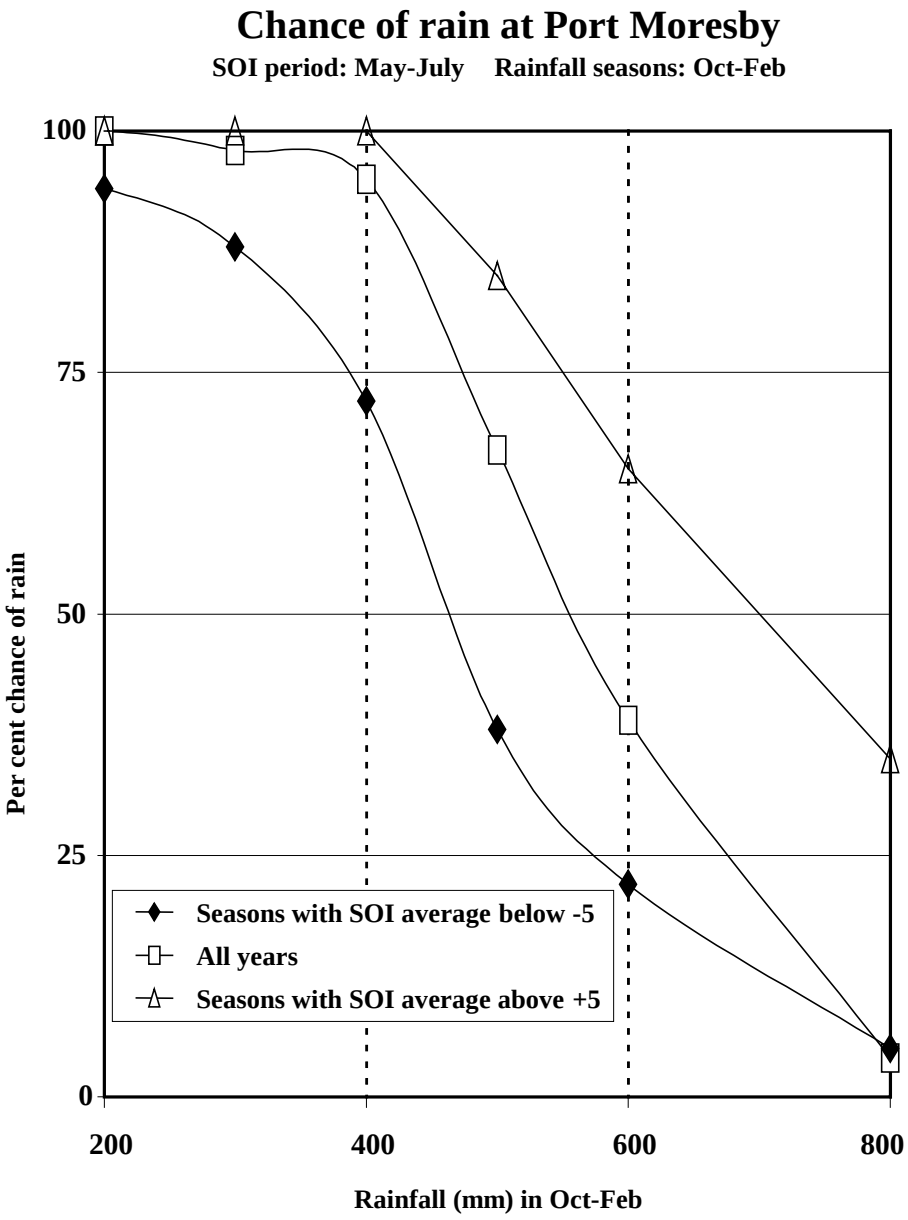
2.3 Historical rainfall data and prediction

The project also investigated whether it was possible to predict severe droughts from existing records. Droughts have been recorded in PNG in 1885, 1896, 1902, 1910, 1914, 1940-1941, 1955-56, 1960, 1965, 1972, 1982, 1987, 1991-1995 and 1997. Extremely wet years were experienced in 1908, 1916-1917, 1921, 1938-1939, 1943-1944, 1952-1953, 1961-1963, 1964, 1971-1972, 1985-1986 and 1988-1989. In most cases, the drought and wet events were associated with significant variations in the El Nino/Southern Oscillation phenomena (ENSO).

The *International Rainman* software was used to investigate the historical relationship between rainfall and SOI. According to McRae (2002), drought in the lowlands of PNG is significantly influenced by the SOI and ENSO phases. He argues that SOI is a good predictor of rainfall in Port Moresby (Figure 2.1).

[*] This census unit disappeared from PNG in the most recent National Census of 2000. It has possibly become the 'Ward" within 'Local Level Government Areas' but this is not certain. Until further work has been done to link the 1990 and 1980 censuses with the 2000 census, the change of census units means the 2000 census cannot be compared to any previous censuses.

Figure 2.1 Relationship between rainfall and SOI phases in Port Moresby



Source: Demerua, 2002.

The following are weather stations in PNG with a good correlation between drought occurrences and negative SOI. Of the 24 stations given only 3 (starred) are located in the highlands (Table 2.1).

Table 2.1 Locations in PNG with good relationships between negative SOI and droughts during the period from 1957 to 1980

Location	Province	Number of droughts	Average rainfall (mm) in drought years	SOI phase or value (average)	Altitude (masl)
BEREINA DAL STATION	Central	6	175	-1.9	40
KWIKILA	Central	4	180	-3.0	40
DOGURA	Milne Bay	4	248	-5.1	40
DARU A/F	Western	6	283	-2.1	<20
ITIKINUMU ESTATE	Central	4	478	-9.6	600
BAIUNE UPPER (2)	Morobe	5	558	1.2	600
GOROKA AERADIO A/F*	Eastern Highlands	6	570	2.7	1,600
WEWAK WO	East Sepik	3	582	-9.7	<40
SAMARAI (COMPOSITE)	Milne Bay	7	589	-2.5	<20
KOITAKI PLTN (MF3)	Central	6	603	-6.7	480
RABAUL WO	East New Britian	3	607	13.8	<40
ILOLO PLTN SOGERI	Central	4	635	-4.7	520
MENDI A/F*	Southern Highlands	1	660	-12.7	1,760
MISIMA AIRPORT	Milne Bay	6	668	-5.3	<40
MADANG DASF	Madang	3	699	-5.9	<20
KAVIENG WO	New Ireland	2	789	2.6	<40
GARAINA TEA PROJECT*	Morobe	5	807	-4.5	200-500
KEREMA	Gulf	5	895	-2.6	40
MOMOTE	Manus	7	1,086	5.3	<40
LAKE KUTUBU	Southern Highlands	3	1,185	-10.2	80
KOKODA (YODDA)	Central	5	1,213	-6.0	360
LOSUIA	Milne Bay	1	1,380	4.9	<20
KOKODA SDO II	Oro	8	1,418	1.5	360
LAE AIRPORT	Morobe	5	1,582	3.7	<40

Source: Demerua, 2002.

3. Impact of the 1997 Drought

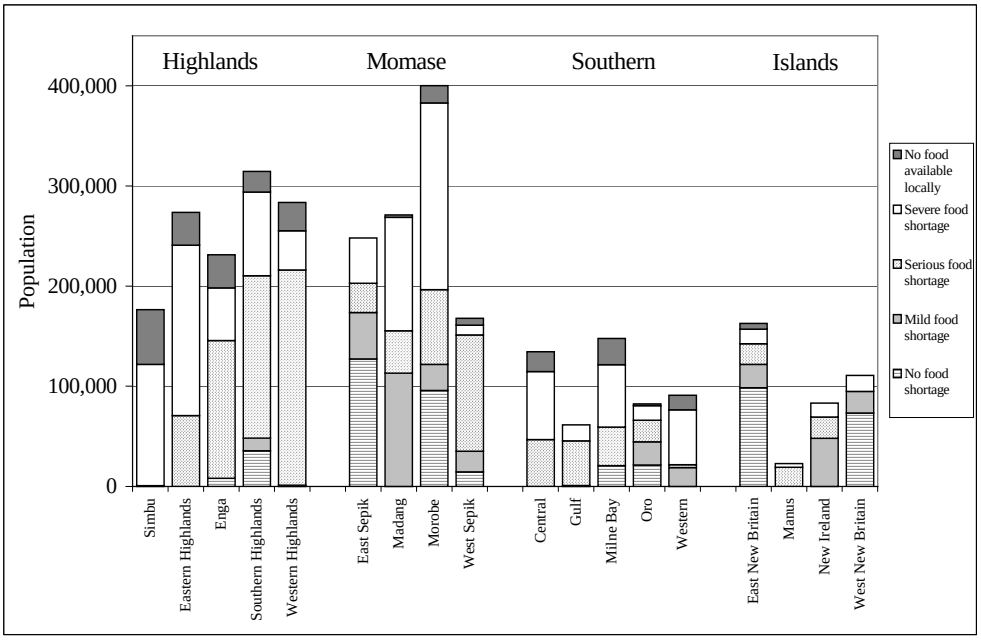
The drought of 1997/98 has been well documented. Surveys of impacts were carried out three times during the drought period. A summary of the conditions found in each province is contained in Table 3.1. The assessments collected information on food and water problems faced, health problems faced, government and international aid, social and economic activities during the drought, effects on services like schools and health establishments and agricultural recovery. They also attempted to assess peoples' ability to use cash resources and other sources to purchase food themselves.

The following sections provide estimates of the numbers of people affected in different provinces and the severity of the impact on food and water supply. It must be recognized that even within provinces, there was considerable variation in impact. This occurred mainly because there is environmental, social and economic variation within provinces. Nevertheless, a provincial overview provides a reasonable summary of the national impact. The detailed impact assessments by Census Division are attached in Appendices.

3.1 Food supply in rural areas

Most of PNG's droughts had major impacts on food production by villagers. In addition, high altitude areas above around 1,800 masl were affected by repeated frosts. Food shortages were widespread and severe by around August 1997. Allen and Bourke (1997) reported that by October 1997, 150,000 rural people had virtually nothing to eat except very small amounts of 'wild' plants. Around 80,000 people were in life threatening situations, with no food except famine foods and a further 70,000 were approaching this situation (Appendix 1; Figure 3.1; Table 3.2).

Figure 3.1 Food supply assessment by population affected and province, December 1997



Source: After Allen *et al*., 1997.

Table 3.1 Summary of conditions in the provinces of PNG in 1997-1998

Highlands Region

Province	Geographical profile	Direct impacts	Damage	Mitigation measures	Recovery process
Simbu	800-2,400 m, steep. Mountainous, high population density. Sweet potato staple. Small holder coffee important above 1,400 m.	Frosts above 1,800 m Elsewhere significant reductions in rainfall.	Frost damage to sweet potato and serious decline in production. Town water supply failed.	Rice supplied by national and provincial governments. Local work for food program instigated by World Bank.	Rainfall in December, but a six months recovery period assisted by work for food program.
Eastern Highlands	500-2,100 m, highland valleys. Sweet potato staple. Medium to high population densities with considerable numbers below 1,400 m. Small holder coffee important above 1,400 m.	Drought. Only small areas frosted. Extensive fires in some areas.	Severe loss of sweet potato production. Loss of export production of sweet potato to Lae and Port Moresby.	National food relief program. Australian relief in isolated areas.	Rapid replanting of sweet potato in December 1997. Sweet potato exporting recovered by mid-1998. Large coffee harvest in 1998.
Enga	800-2,700 m highland valleys and high altitude plateaus. Largest number of people living above 2,400 m. Very high population densities.	Widespread and repeated frosts. Drought in lower valleys.	All sweet potato and Irish potato production lost at high altitudes. Lower valleys severe loss of production for 6 months. Porgera gold mine closed for 4 weeks due to lack of hydropower generation.	High altitude populations migrate to lower areas and towns. National and provincial relief programs. Porgera mine assisted with isolated groups in west.	High altitude areas take >12 months to recover but Irish potato produced within 4 months. Vines transported to these area for replanting. Elsewhere rapid replanting.
Southern Highlands	Large area, from 500-2,700 m. High population densities. Considerable populations isolated and at lower altitudes. Smallholder coffee important.	Frosts at high altitude. Drought. Extensive fires.	Loss of sweet potato production. Widespread fires. Loss of sago in areas below 1,000 m.	National and provincial relief poorly organized. Australian relief in isolated places. Migration to towns.	Slower recovery than elsewhere in many areas. Replanting of sweet potato from January 1998 but recovery slowed by tribal fighting and lawlessness.

Source: Allen *et al*., 1997.

Continued……

Table 3.1 Summary of conditions in the provinces of PNG in 1997-1998 (continued)

Momase Region

Province	Geographical profile	Direct impacts	Damage	Mitigation measures	Recovery process
East Sepik	Lowland province with large Sepik River valley and swamps and low rugged mountains. Very high population densities in one area. Robusta coffee, cocoa and vanilla important. Seasonal climate.	Long dry period.	Extensive fires in grasslands and some sago destroyed. Food production did not fail and water supply not severely affected. 90 per cent have reasonable water supply.	No relief food distribution required.	Not applicable.
Madang	Coastal, lowland province with interior rising to 4,000 m. Large areas of hills and mountains and large river valley. Strongly seasonal climate. Cocoa important. Connected to highlands by road. Good port and airport.	Drought.	40 per cent of population short of food. Sago partially fails. Coconuts used extensively on coast. High altitude areas frosted and sweet potato fails. 35 per cent short of water.	Reasonably well-organized food relief programs.	Rapid recovery following good rain in December 1997 and early 1998.
Morobe	Very large and heterogeneous province from sea level to 2,400 m. Strongly seasonal in places. Isolated mountainous areas exist. Second largest city, Lae, connected to highlands by road. Good port and airport.	Drought. Minor areas frosted.	50 per cent of population short of food. Other 50 per cent have reasonable supply. 75 per cent of population has reasonable water available. Extensive fires in grasslands. Large numbers of people migrate temporarily into Lae City and vicinity.	National, provincial and Australian relief programs operate in province. Lae port is entry point for all imported food trucked into highlands.	Recovery rate variable depending on location. Generally good after January 1998.
West Sepik	Poorest province in PNG. Runs from coast inland to high altitude. Few roads and many isolated populations.	Long dry season on coast. Inland drought and frosts.	Loss of sweet potato production in highlands and extensive frost and grass fires at high altitudes. Severe water problems in highlands.	Australian relief dominated in high altitude areas. Local administration weak and disorganized. Ok Tedi copper mine assist with surveys and relief work.	Recovery at high altitudes slower than elsewhere due to poorer environment. Assisted in places by Ok Tedi mine.

Source: Allen *et al*., 1997.

Continued……

Table 3.1 Summary of conditions in the provinces of PNG in 1997-1998 (continued)

Southern Region

Province	Geographical profile	Direct impacts	Damage	Mitigation measures	Recovery process
Central	South coast of Papua. Narrow coastal plain and hills, high rugged mountains inland. Strongly seasonal climate. Location of Port Moresby, largest city, port and airport. Coastal settlements have high incomes from employment in city and access to city food markets.	Drought.	Loss of production on coast. Failure of sweet potato inland. Widespread fires. Loss of power generating capacity for city.	National and Australian relief program in mountains. Provincial program on coast. Migration into city from mountain areas.	Rain fell in December 1997 and from January 1998. Recovery in mountains slower because of lack of cash and isolation.
Gulf	Coastal area, the estuaries of two large rivers. Inland area of hills. Poor province. Sago an important staple.	Drought. Salt water contamination of sago swamps.	Loss of sweet potato staple inland. Higher than normal death rates reported. Loss of sago staple along coast.	Australian relief program inland. Migrations away from main rivers and inland. Some migration to city.	Inland area remains vulnerable from poor soils and isolation. Coast recovered when freshwater flow in rivers increased.
Western	Large area below 100 m in south, then rugged mountains in north. Fly River with large settlements dependent on sago. River is only access to Kiunga and Ok Tedi mine 300 km inland in mountains.	Drought, low levels on Fly River and saltwater penetration in Fly River mouth estuaries.	In mountains, failure of sweet potato crop. Along river fires in sago stands and lack of water to make sago. Gardens in lowlands fail, except for banana and coconut. Fly River levels low for almost 6 months and mine closes.	River people migrate to be nearer sago with water nearby. Ok Tedi mine assists in highlands and lowlands relief operation. Australian and national relief program operates.	Rain in mountains in December raises Fly River levels. Gardens recover quickly but sago stands lost in fires continue to reduce sago production for a further 3 years and more.
Milne Bay	Maritime province with mountainous mainland and large islands, with numerous small islands well offshore.	Drought.	Food and water supply fails on many small islands. Mainland and larger islands reduced to coconuts, banana and much-reduced root crops.	Australian Navy carries food and water to islands. Provincial relief programs well managed and effective.	Rain in January 1998 helps food production recovery, but small islands remain highly vulnerable to drought and food shortages.
Northern (Oro)	North coast of Papua to high mountains of central range. Oil palm resettlement blocks now main economic activity. Wide variation in farming systems.	Drought.	General serious reduction in food production. Fires in sago swamps. Water supply problems worse than food supply problems.		Relatively quick recovery in 1998 with good rains.

Source: Allen *et al*., 1997.

Continued……

Table 3.1 Summary of conditions in the provinces of PNG in 1997-1998 (continued)

Islands Region

Province	Geographical profile	Direct impacts	Damage	Mitigation measures	Recovery process
East New Britain	Northeast end of large island of New Britain. High population density on Gazelle Peninsula with good incomes from cocoa. Isolated populations inland relatively poor. Active volcanoes.	Drought (Gazelle area had also suffered from a volcanic eruption prior to drought)	Majority of people not severely affected by food shortages and most only mildly affected by water shortages. Worst impacts inland in Pomio area.	Relief programs minor compared to other provinces.	Fast.
Manus	Isolated island to the north of PNG with numerous small islands and atolls. Small population.	Drought.	Small islands suffered from both serious food and water shortages.	Province relatively well organized. Provincial government and NGOs sent relief food and water.	Reasonable quick recovery after rains in 1998 but small islands remains vulnerable.
New Ireland	Long thin island predominantly of limestone, northeast of New Britain with around 84,000 population. Small islands to northeast.	Drought.	Greatest impact shortage of water. Food supplies less affected. No populations in worst categories of food or water assessment.	Province relatively well organized. Provincial government and NGOs sent relief food and water.	Good recovery following rains.
West New Britain	Southwest end of large island of New Britain. Large oil palm resettlement areas in northwest. South and west coasts isolated and poor. Active volcanoes. Strong seasonal climate and high rainfall.	Drought.	Most areas relative unscathed. Southwest end of island suffered water and food problems. Oil palm areas not seriously affected.	National and Australian relief program.	Good recovery following rains in 1998.
Bougainville (North Solomon's)	Large island to southeast of New Britain. Not assessed in 1997 because of civil war in progress. Sweet potato important staple following taro blight in 1960s.	Drought.	Reduced food and water supplies, but over all not in severest categories.	None.	Recovery good following rains but damage from war and on-going uncertainty of peace process continues to handicap progress.

Source: Allen *et al*., 1997.

Table 3.2 Food supply assessment and population affected by province and region, Papua New Guinea, November 1997

HIGHLANDS	Simbu	%	Eastern Highlands	%	Enga	%	Southern Highlands	%	Western Highlands	%	Highlands	%
No food shortage					8,115	*4*	35,661	*11*		*0*	43,776	*3*
Mild food shortage	822	*0*		*0*		*0*	12,617	*4*	1,379	*0*	14,818	*1*
Serious food shortage		*0*	70,703	*26*	137,657	*60*	162,133	*52*	214,656	*76*	585,149	*46*
Severe food shortage	121,038	*69*	170,340	*62*	52,523	*23*	83,442	*27*	39,136	*14*	466,479	*36*
No food available	54,721	*31*	32,533	*12*	32,961	*14*	20,548	*7*	28,391	*10*	169,154	*13*
	176,581	*100*	273,576	*100*	231,256	*100*	314,401	*100*	283,562	*100*	1,279,376	*100*
MOMASE	East Sepik	%	Madang	%	Morobe	%	West Sepik	%			Momase	%
No food shortage	127,329	*51*		*0*	95,781	*24*	14,452	*9*			237,562	*22*
Mild food shortage	46,200	*19*	113,125	*42*	26,077	*7*	20,682	*12*			206,084	*19*
Serious food shortage	29,399	*12*	42,348	*16*	74,594	*19*	116,156	*69*			262,497	*24*
Severe food shortage	45,146	*18*	113,121	*42*	186,469	*47*	9,704	*6*			354,440	*33*
No food available		*0*	2,538	*1*	17,313	*4*	6,768	*4*			26,619	*2*
	248,074	*100*	271,132	*100*	400,234	*100*	167,762	*100*			1,087,202	*100*
SOUTHERN	Central	5	Gulf	%	Milne Bay	%	Oro	%	Western	%	Southern	%
No food shortage		*0*		*0*	20,714	*14*	21,282	*26*		*0*	41,996	*8*
Mild food shortage		*0*	939	*2*		*0*	23,207	*28*	18,805	*21*	42,951	*8*
Serious food shortage	46,743	*35*	44,485	*72*	38,507	*26*	21,687	*26*	2,912	*3*	154,334	*30*
Severe food shortage	68,045	*51*	16,026	*26*	62,289	*42*	14,392	*17*	54,699	*60*	215,451	*42*
No food available	19,626	*15*		*0*	26,196	*18*	1,870	*2*	14,548	*16*	62,240	*12*
	134,414	*100*	61,450	*100*	147,706	*100*	82,438	*100*	90,964	*100*	516,972	*100*
ISLANDS	ENB	%	Manus	%	New Ireland	%	WNB	%		%	Islands	%
No food shortage	98,584	*61*		*0*		*0*	73,408	*66*			171,992	*45*
Mild food shortage	23,235	*14*		*0*	48,149	*58*	21,532	*19*			92,916	*24*
Serious food shortage	20,514	*13*	19,124	*83*	21,172	*25*		*0*			60,810	*16*
Severe food shortage	14,733	*9*	3,796	*17*	13,922	*17*	15,799	*14*			48,250	*13*
No food available	5,822	*4*		*0*		*0*		*0*			5,822	*2*
	162,888	*100*	22,920	*100*	83,243	*100*	110,739	*100*			379,790	*100*

Source: Allen *et al*., 1997.

A further 175,000 people were, at that time, eating very small amounts of rapidly diminishing food from their gardens. Another 220,000 had limited food reserves in their gardens that would last only two months. Thus a total of 540,000 people were seriously affected by October 1997. By the end of 1997, a total of 1.2 million people were suffering from severe food shortages which were life threatening.

The two regions most severely impacted were the Highlands with 169,000 and the Southern region with 62,000 people with almost no food available locally (Table 3.1). Within these regions, about 30 per cent of the population of Simbu were in this situation and 18 per cent from Milne Bay. Simbu is a province with high population densities on relatively poor soils and steep slopes, and Milne Bay has many small islands and atolls and experiences regular seasonal dry periods. In all the Highlands provinces except Western Highlands, a further 25 per cent of the population were in a situation in which food supplies would run out within an estimated one month. A total of 466,500 people were in this situation in the Highlands alone and a further 355,000 in Momase and 215,000 in Southern region. These people were eating the final root crops and bananas from the previous year's gardens, the 1997 gardens having failed to produce or not been planted because of the lack of rain. They were supplementing this food with 'famine foods', the leaves of trees, banana roots, uncultivated yams and other foods that are normally not eaten.

The traditional response to frost in the high altitude areas is to migrate to lower areas below 1800 m. Strong social and cultural ties exist between high altitude highland valleys for this reason. In 1997, almost 75 per cent of the people left the high altitude areas but when they reached the lower valley, drought had severely reduced food production.

The Highlands' sweet potato staple systems are systems of continuous production, where planting occurs all year round. About half of all sweet potato produced is normally fed to pigs. As the drought progressed people stopped planting because newly planted vines were dying in the ground. They also reduced the food allocated to pigs, or killed pigs and sold them as fresh or cooked meat. Sweet potato is drought tolerant, but tubers in the ground that could have supplied the human population for some months were attacked by serious infestations of sweet potato weevil, which was able to penetrate to the root zone through cracks in the soil and the low levels of soil moisture. The weevils quickly made reserves of sweet potato inedible.

In Gulf Province, 72 per cent of the population faced serious food shortages, largely because it became impossible to manufacture sago. Sago is made from the trunk of palms that are felled, chopped into fine chips and soaked in water to leach out the starch. Three difficulties affected sago production; local water sources dried up, large coastal estuaries became brackish as seawater penetrated further inland than usual and the sago logs themselves became woodier and contained low levels of starch. In addition, fires broke out in sago stands and large areas close to settlements were destroyed (see below for further discussion of fires).

The areas least affected by food shortages were East Sepik, East New Britain and West New Britain. In East Sepik, the drought was not as severe as elsewhere and the large populations around Maprik depend on yams, which are drought tolerant. In East and West New Britain, cash incomes are high from sales of palm oil and cocoa, and people were able to purchase food.

The Government of Australia (GOA) at the request of the Government of Papua New Guinea (GOPNG) mounted an airborne food relief operation to all Census Divisions identified by the assessments as being either without food or about to be without food and that were not accessible by road. All other areas were left to the responsibility of the GOPNG. The GOPNG first gave Members of Parliament funds to purchase food but this was done for all Electorates regardless of their food and water status and many MPs, having purchased food, could not transport it to where it was needed. Most rural Papua New Guineans, who lived in areas with no food available, but outside the AusAID program, were saved from starvation by their relatives. Rice imports into PNG increased by 60 per cent in 1997. Of this increase, 85 per cent was sold through retail outlets and only 15 per cent was distributed as food relief, including the rice

distributed by the GOA. Much of the rice purchased through retail outlets was purchased by wage earners in towns on behalf of their rural relatives (Allen and Bourke, 2001).

The historical PNG experience with ENSO is that the northwest season is strong enough to bring rain late in the year. This was the case in 1997. By December, in many areas, there had been sufficient rain to enable new plantings. All over the country people rapidly planted large areas, often quick yielding crops, greens and maize. Until they became harvestable, however, food shortages remained critical. Sago processing also resumed. However, the supply of root crops remained limited until at least April 1998. In high altitude areas, food supply did not return to normal until June or July 1998 as sweet potato (the only staple apart from Irish potato) takes 9-12 months to mature at higher altitudes.

Subsistence crop losses were significant in 1997/98. National government food supply operations and emergency aid programs continued until at least February 1998. The major problem for farmers was that they had lost their seeds and planting material, had drawn on their cash reserves to survive and had sold assets, such as livestock and household goods. In many areas fires had destroyed economic trees and fallows. By December 1998, they needed seeds to replant but there was a critical shortage of quality seeds and other planting materials. The relief program was adapted during 1998 to supply seeds from Australia. Some sweet potato vines were transported from lowland areas, where recovery was faster, to high altitude areas. Irish potato seed tubers were imported.

3.2 Effect of drought on water

Water supply for drinking and washing was reduced to critical levels throughout the country during the drought of 1997 (Appendix 2, Figure 3.2, Table 3.3). Ponds, wells, creeks and smaller rivers dried up, but larger rivers continued to flow, although at much reduced levels. In many places, available water sources became contaminated, sometimes because wild and domestic animals used the same water source as humans and partly because on islands and coastal areas seawater infiltrated normally fresh water supplies. Many facilities, schools and health centres in particular, were caught with poorly maintained water collection systems. Tanks were holed and gutters and down pipes in poor condition. The great majority of schools closed and students were sent home, partly because they were hungry and weak and were assisting their parents search for food and partly because teachers left the schools because of a lack of drinking water. Water was carried and transported over long distances for domestic use. Where possible, people temporarily moved to be nearer to streams or rivers.

The water supply problem exhibited a different pattern to the food supply problem, although some areas suffered from both food and water supply problems. The Southern region was worst affected, with over 70 per cent of the population, or 280,000 people either with no drinking water available locally or only poor quality water available (Table 3.3, Figure 3.2). These were areas where strong seasonal droughts occur annually and people know how to dig for water and where sources can be found during dry spells. Nevertheless, in Milne Bay especially on small islands, and in Gulf, up to 50 per cent of the people were without local drinking water. The Australian Navy transported water to islands in Milne Bay, and in Gulf people moved to be near larger rivers. New Ireland and West New Britain were also badly affected, again mainly on small islands. The highland provinces, badly hit by food shortages, were not as severely affected by water shortages, although water had to be carried some kilometers from larger rivers in many places.

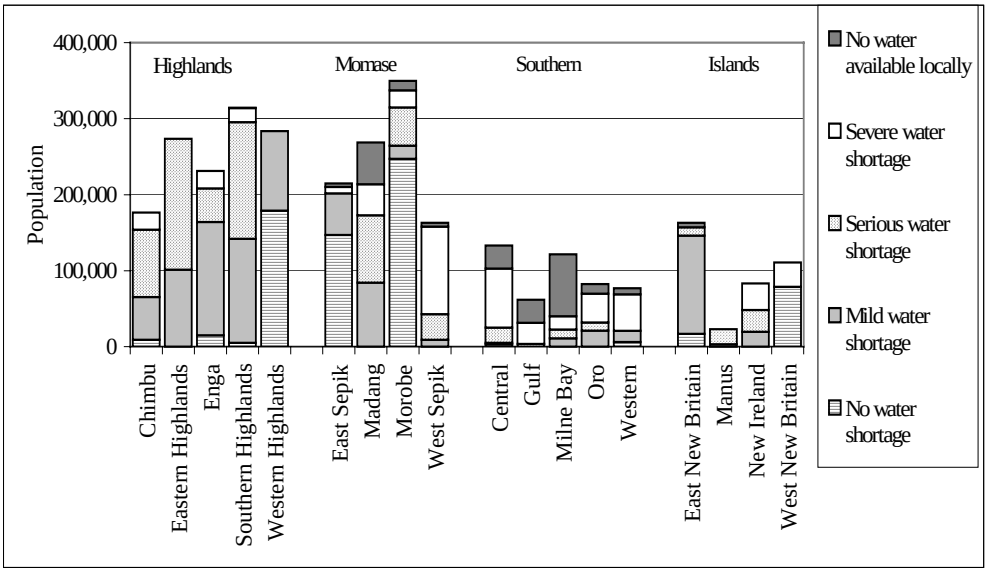
Diminishing water levels had a detrimental effect on the availability of game. The hunting of wild animals for food was difficult in some places as animals and birds migrated to other areas in search of water or were found dead in traditional hunting areas.

Table 3.3 Water supply assessment and population affected by province and region, Papua New Guinea, November 1997

HIGHLANDS	Simbu	%	Eastern Highlands	%	Enga	%	Southern Highlands	%	Western Highlands	%	Highlands	%
No water shortage	9,124	*0.0*		*0.0*	14,847	*6.4*	5,116	*1.6*	178,945	*63.1*	208,032	*16.3*
Mild water shortage	56179	*31.8*	101,352	*37.0*	149,180	*64.5*	136,708	*43.5*	104,617	*36.9*	548,036	*42.8*
Serious water shortage	88,493	*50.1*	172,224	*63.0*	44,153	*19.1*	153,588	*48.9*		*0.0*	458,458	*35.8*
Severe water shortage	22,785	*12.9*		*0.0*	23,076	*10.0*	18,543	*5.9*		*0.0*	64,404	*5.0*
No water available locally		*0.0*		*0.0*		*0.0*	446	*0.1*		*0.0*	446	*0.0*
	176,581	*100*	273,576	*100*	231,256	*100*	314,401	*100*	283,562	*100*	1,279,376	*100*
MOMASE	East Sepik	%	Madang	%	Morobe	%	West Sepik	%			Momase	%
No water shortage	180,497	*72.8*	2,538	*0.9*	297,677	*74.4*	4,911	*74.4*			485,623	*44.7*
Mild water shortage	54,747	*22.1*	84,058	*31.0*	17,052	*4.3*	9,120	*4.3*			164,977	*15.2*
Serious water shortage		*0.0*	88,957	*32.8*	50,552	*12.6*	33,554	*12.6*			173,063	*15.9*
Severe water shortage	8,096	*3.3*	40,609	*15.0*	22,447	*5.6*	115,382	*5.6*			186,534	*17.2*
No water available locally	4,734	*1.9*	54,970	*20.3*	12,506	*3.1*	4,795	*3.1*			77,005	*7.1*
	248,074	*100*	271,132	*100*	400,234	*100*	167,762	*100*			1,087,202	*100*
SOUTHERN	Central	%	Gulf	%	Milne Bay	%	Oro	%	Western	%	Southern	%
No water shortage	4,661	*3.5*		*0.0*	26,143	*17.7*		*0.0*	20,138	22.1	50,942	*9.9*
Mild water shortage	1,625	*1.2*		*0.0*	11,002	*7.4*	21,282	*25.8*	14,597	16.0	48,506	*9.4*
Serious water shortage	20,302	*15.1*	3,732	*6.1*	11,758	*8.0*	10,580	*12.8*		0.0	46,372	*9.0*
Severe water shortage	77,764	*57.9*	27,584	*44.9*	17,345	*11.7*	37,865	*45.9*	48,337	53.1	208,895	*40.4*
No water available locally	30,062	*22.4*	30,134	*49.0*	81,458	*55.1*	12,711	*15.4*	7,892	8.7	162,257	*31.4*
	134,414	*100*	61,450	*100*	147,706	*100*	82,438	*100*	90,964	*100*	516,972	*100*
ISLANDS	ENB	%	Manus	%	New Ireland	%	WNB	%			Islands	%
No water shortage	16,810	*10.3*		*0.0*		*0.0*	78,688	*71.1*			95,498	*25.1*
Mild water shortage	129,436	*79.5*	3,168	*13.8*	19,663	*23.6*		*0.0*			152,267	*40.1*
Serious water shortage	10,820	*6.6*	19,752	*86.2*	28,486	*34.2*		*0.0*			59,058	*15.6*
Severe water shortage		*0.0*		*0.0*	35,094	*42.2*	32,051	*28.9*			67,145	*17.7*
No water available locally	5,822	*3.6*		*0.0*		*0.0*		*0.0*			5,822	*1.5*
	162,888	*100*	22,920	*100*	83,243	*100*	110,739	*100*			379,790	*100*

Source: Allen *et al*., 1997.

Figure 3.2 Water supply assessment by population affected and province, December 1997



Source: Allen *et al*., 1997.

3.3 The effect of drought on bush fires

The use of fire to cook, to clear land for planting, to remove rubbish and to maintain grasslands for thatching and for hunting is widespread in PNG and because the country is normally wet, it does little damage. But in 1997, as the country dried out, bush fires were reported throughout the country. Fires killed people, burnt down villages, destroyed food crops in abandoned gardens and killed domestic and wild animals. Large areas of sago were destroyed in the Western and Gulf provinces.

Fires burned into unoccupied rainforest and reached the top of the main mountain ranges. In some places forest trees were killed and in others, only the dried out forest floor leaf litter burned. Swamps also dried out so that the peat caught fire and burned for months.

3.4 Health problems

Many health problems arose from drought induced or related causes. People suffering from a lack of adequate food were prone to disease. Diminishing water supplies became contaminated but there was little direct evidence of epidemic rates of water borne diseases. Nevertheless, it seems likely that dysentery, hepatitis, cholera and typhoid levels increased (Allen and Bourke, 2001). As normally flowing streams and springs were reduced to stagnant ponds, they provided breeding grounds for mosquitoes, which carry malaria parasites. As such, malaria became a common problem during and after the drought at the onset of rain. These health problems, in turn, put pressure on already depleted health facilities that lacked water and medical supplies.

Many people became sick from eating famine foods. It is believed that more than normal numbers of people, mainly children and the elderly, died during the drought in 1997. However, it was difficult to establish the exact figure during the assessments. There are no proper records of such cases as most government run health services were closed. Reports of unexplained

deaths were common, however, and included deaths following severe stomach pains and vomiting and deaths of children accompanying parents on long difficult walks across high mountain passes towards lower altitude areas or in search of food and water.

It is possible some of the deaths resulted from pig-bel, a disease once common among children in PNG in which the bowel becomes ulcerated and may perforate, caused by the Clostridium bacteria and that occurs after someone who normally eats a diet high in vegetables eats a lot of meat. Many people killed domestic pigs and ate them during 1997, both to use them as food and to reduce the amount of food being consumed by the pigs.

In general, there were more reports of increased deaths from remote, inland locations, where cash income and access was limited than from accessible coastal and highland villages. These locations include the Goilala mountains of Central Province and Angan speaking locations in inland Gulf Province. By November 1997, people of frost affected areas such as Kandep Basin in Enga, were also reporting higher than normal numbers of deaths.

3.5 Urban problems

The main impact of the drought on urban areas was in terms of restricted electrical and water supply. Port Moresby in particular, suffered power shedding and power failures for most of 1998. Kainantu in Simbu ran out of water and a number of other small towns also lost water supplies. Large numbers of people came into the towns to live with relatives. There is some evidence of increases in gambling related activities and thefts by immigrants in their struggle to survive.

3.6 Impact on institutions

The impact on institutions like schools, colleges, health centres and hospitals were variable but more adverse in rural PNG. Many primary schools were closed because they ran out of water and pupils were too weak to concentrate on lessons. Boarding high schools closed due to a lack of both water and food. Many health centres and aid posts closed throughout the country due to a lack of water. Two gaols were forced to release prisoners because of a lack of water.

3.7 Economic effects

The impact of the drought and frosts on the economy has been assessed both at the national and community level. Nationally, the reduction in the exports of minerals and commodity tree crops has been assessed (Table 3.4). The decline in the trade of sweet potato has also been assessed with the corresponding increase in rice imports. At the communal or village level, the economic activities of the people were centered on survival.

The mining industry earns 85 per cent of the country's income. It suffered as water for mineral processing depleted and river transport along the Fly River became difficult. The operations of Ok Tedi Ltd in Western Province, which produces copper, stopped production between August 1997 and March 1998. The operations of Porgera Joint Venture Ltd in Enga Province, was also adversely affected by an inability to generate electrical power for a number weeks.

The production of cocoa, copra, rubber and tea was reduced during the drought (Table 3.5). However, coffee production remained steady in 1997 and increased by 200,000 bags of Green Bean equivalent in the 1998 season (Figure 3.3). The increase in production resulted from an increased flowering of trees that were initially stressed by low soil water levels, followed by bountiful rain during the fruiting period (Hombunaka and Von Enden, 2001).

Table 3.4 PNG export of minerals and commodity tree crops in 1996, 1997 and 1998

Commodity	Unit	1996	1997	1998	% Change from 1996 to 1997
Minerals					
Gold	tons	46.9	44.3	58.2	-5
Copper	'000 tons	127.7	77.8	109.5	-39
Crude oil	'000 barrels	39,307.7	27,972.2	28,033.6	-29
Agriculture					
Coffee	tons	62,200	58,800	83,500	-5
Cocoa	tons	41,000	38,600	26,100	-6
Copra	tons	99,200	90,300	58,100	-9
Copra oil	tons	49,600	48.600	53,200	-2
Palm oil	tons	267,000	274,900	213,000	+2
Rubber	tons	7,019	4,586	4,900	-35
Tea	tons	9,300	6,500	6,600	-30
Logs	'000 m^3	2,607.4	2,375.9	1,066.9	-9
Marine products	'000 tons	2.8	2.2	10.0	-21

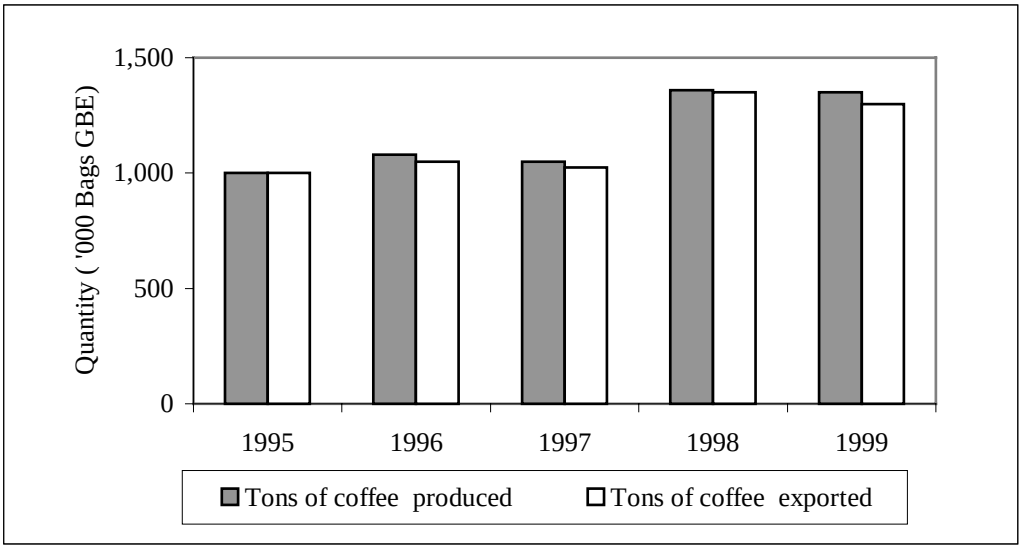
Source: Handbook on Agricultural Statistics, 2000.

Table 3.5 Summary of important growth indicators for PNG, 1980-2001

Indicator	Unit	Value in 2001	Average annual growth rate over 20 years	Average annual growth rate over past 3 to 5 years
1. Population	No.	5,268,060	2.7	2.7
2. Consumer Price Index (CPI)	Index	596.8	7.6	11.5
3. Exchange rate	US$	0.30	-7.1	-16.6
4. Total GDP (Nominal)	Million Kina	9,982.7	9.0	7.8
5. Agriculture GDP (Nominal)	Million Kina	2,592.5	7.7	5.9
6. Share of agriculture in total GDP	%	26.0	-1.1	-3.9
7. Real GDP (CPI adjusted)	Million Kina	1,967.1	1.1	-3.3
8. Real agriculture GDP (CPI adjusted)	Million Kina	510.9	-0.0	-4.9
9. Total GDP/capita (nominal)	Kina	1,894.9	6.1	5.0
10.Agricultural GDP/capita (nominal)	Kina	492.1	4.9	3.1
11.Real GDP/capita	Kina	373.4	-1.2	-5.8
12.Real agricultural GDP/capita	Kina	97.0	-2.3	-7.4
13. Value of total export	Million Kina	6,084.8	11.9	13.8
14. Value of agricultural export	Million Kina	796.3	11.0	-6.8
15. Real value of total export	Million Kina	1,339.7	4.0	1.8
16. Real value of agricultural export	Million Kina	175.3	3.3	-9.4
17. Share of agriculture in total export	%	13.1	0.8	-14.3
18. Value of non-export agriculture	Million Kina	1796.2	7.6	5.9
19. Real value on non-export agriculture	Million Kina	335.5	0.3	-4.9
20. Import of rice	Tons	157,667	3.5	-7.0
21. Import of wheat	Tons	125,667	6.3	2.0
22. Import of meat	Tons	42,677	3.8	1.0
23. Total import (rice + wheat + meat)	Tons	321,415	4.0	-3.1

Source: Office of National Planning, 1999.

Figure 3.3 Papua New Guinea coffee production and exports from 1995 to 1999



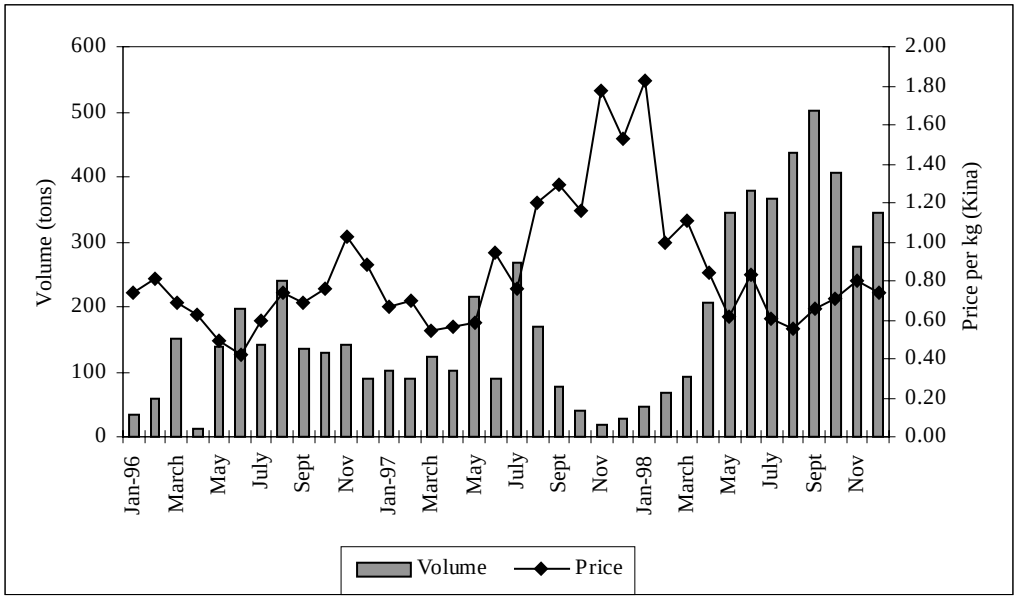
Source: After Hombunaka and Enden, 2001.

Table 3.4 shows the changes in the export of minerals and important tree crops in 1997-98 compared to 1996. Of the minerals, the decline was greatest for copper (39 per cent) and crude oil (29 per cent), which was not affected by the drought, but was in decline anyway. The tree crops rubber and tea fell by 35 per cent and 30 per cent respectively. The decline in cocoa exports was only 6 per cent in 1997 but dropped significantly in 1998 by 45 per cent, while palm oil exports increased by 2 per cent in 1997 but decreased in the following year. On the other hand, although coffee exports declined by 5 per cent in the drought year, exports increased by 34 per cent in 1998.

The trade of highland sweet potato to Port Moresby dropped by 16 per cent in 1997, on average, compared to 1996, but increased sharply (by 164 per cent) in the second half of 1998, probably in response to demand (Figure 3.4). Consequently, prices at Gordon's Market in Port Moresby increased by 37 per cent in the second half of 1997 over 1996. The price dropped by 11 per cent (on average) towards the end of 1998 as supply picked up due to the large areas planted as soon as the drought broke. The supply of sweet potato started to drop in August 1997 and reached its lowest point in November 1997 (about 25 tons) (Figure 3.4). During the period of low supply the price range was between Kina 0.90 and Kina 1.80[*] per kg.

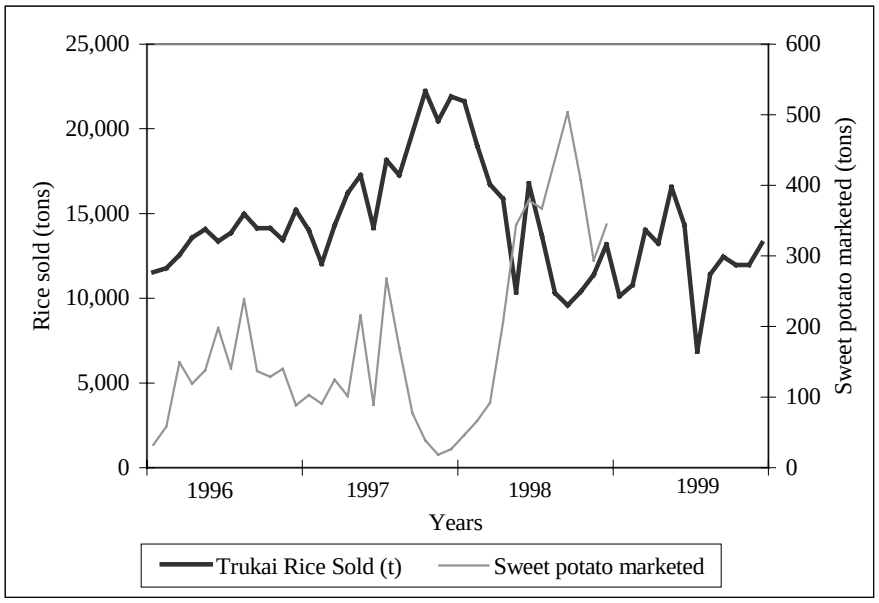
[*] In 1997, Kina 1.00 was approximately worth US$ 0.75. It is now worth US$ 0.27.

Figure 3.4 Volume of sweet potato shipped from the Highlands to Port Moresby in 1997 and corresponding price increase



Source: Fresh Produce Development Company.

Figure 3.5 Sales of rice and quantity of sweet potato shipped to Port Moresby, 1996 to 1999



Source: Trukai Rice and Fresh Produce Development Company.

If the shipment of sweet potato from the Highlands to Port Moresby is used as a surrogate measure of the availability of sweet potato in the Highlands, sales of rice rose as sweet potato availability fell (Figure 3.5). Conversely, as sweet potato supply picked up in 1998, extra rice purchases by wage earners for relatives declined because conditions for food cultivation had improved.

At the village level, economic activities were seriously affected. Throughout most of the country, markets were empty. The sale of fresh food is the most common cash earning activity in PNG and for most people, this source of cash ceased to exist. Areas that were able to continue producing took advantage of the high prices; there were unconfirmed reports of sweet potato being shipped to Port Moresby from Rabaul. People sold live pigs or cooked pork and bought rice. People with some cash or sweet potato reserves did things like purchasing cigarettes by the packet and selling them one by one, or selling sweet potato and purchasing bags of rice, cooking it and selling it in small amounts.

Many people with savings bought food from local markets or stores in towns. People living near rivers or in low lying areas, like the Waghi Valley, were able to continue producing vegetables and sweet potato which were sold at very high prices. For example, a normal marketable tuber size of sweet potato taken up to Tomba, in Tambul was sold at 2-3 times the normal price.

Many villagers throughout the country exhausted their cash reserves to buy food at very high prices. Retailers charged very high prices for basic foods such as rice. Normally sold in town for Kina 1.30 per kg, it was reportedly sold at Kina 3.00-4.00 per kilogram in rural areas, especially when air freighted. This occurred despite Trukai Rice Ltd not increasing prices for rice during 1997 to 1998, even though the fall in the value of the kina meant that the import costs increased.

3.8 Cultural and social effects

Prominent cultural ceremonies on the coast like the yam ceremonies were not celebrated due to poor harvests. In the Highlands, ceremonies such as paying bride price or compensation, which demand large amounts of pigs and cash, were deferred. People were more concerned with providing food for their families and devoted most of their efforts to hunting or fishing, and income generating activities that would sustain their lives.

3.9 Migration

In Papua New Guinea, widespread out migration was reported in severely affected areas (Allen and Bourke, 1997; Allen *et al*., 1997). People migrated from badly affected high altitude areas down to the lower valley, towns and even distant cities. Young people traveled long distances in search of food and water or migrated into towns, leaving elderly people behind. This meant the elderly were neglected.

The actual number of rural urban migrants is difficult to establish but was believed to be significant. There was little out migration from very remote areas because fewer villagers had relatives in wage employment in urban centres or they could not afford the high cost of transport. Examples are the people of Karamui district in Chimbu and Teptep district Madang.

Even in more accessible areas, migration was variable. For example, 20-25 per cent of the population in a group of villages in Elimbari Census Division in Simbu migrated to Goroka, Lae and Port Moresby. In contrast, no out going migration was reported in Dom or Yonggamugl areas of Simbu. It was observed that there was higher migration from areas with the least infrastructural development, over population and limited economic activities (Allen *et al*., 1997).

4. Analysis of Existing Resources, Technology, Infrastructure and Institutions in PNG

4.1 Resources

PNG has not used its mineral resources to their greatest potential. After two decades in which mining has led the foreign earnings, all of the present large mines are due to close within 10 years. No further mines are planned and little prospecting is occurring. Present gas and oil resources are also in decline. A failure to build and maintain infrastructure and a rapidly growing population means conditions in many rural areas have not improved since 1980.

Nor does PNG have large reserves of high quality land. Of the total land area of 459, 854 square kilometers, only 30 per cent (138,000 square kilometers) is considered suitable for smallholder agriculture (McAlpine and Quigley n.d.)

Smallholder agriculture sustains 85 per cent of the population of PNG. Food production appears to have kept pace with population growth since 1970. Imported food is not increasing at the same rate as population growth. While rice imports continue to increase, rice is being imported at a decreasing rate every year. One reason is the large increases in price with the decline of the kina.

Despite the importance of the agricultural sector, government spending has declined in real terms. In 1985, it was allocated 9.3 per cent of the national budget and in 1994 it received approximately only 2.0 per cent (Caven and McKillop, 2001).

4.2 Technology

The farming systems of PNG have developed over many centuries and have been in tune with the environment. However, this balance is now threatened as the population continues to increase. Technologies developed are connected with the cultures and values of the society that created it (Jansen and Tutua, 2001).

In subsistence agriculture, the components of arboriculture, shifting cultivation and animal husbandry have developed based on indigenous knowledge. Shifting cultivation allows the cropped soil to regain fertility without external inputs. In parts of the Highlands, sweet potato cultivation is integrated with pigs, which are tethered to till the soil and deposit manure while foraging. Rotation with peanut and maize is practiced in the Wahgi Valley, particular trees are planted to improve soil conditions and composted mounds maintain soil fertility in highland valleys.

Most PNG homes have an axe, bush knife and spade. However, there is limited use of small machinery and draught animals in the subsistence agricultural system. Irrigation technology is not common in most of PNG except in some coastal areas of Milne Bay, where flood irrigation is used on large sloping fans to sustain shifting cultivation of taro and bananas through regular severe dry seasons.

4.3 Infrastructure

In PNG, there is one national inter-provincial highway and several provincial highways. The capital, Port Moresby, is not connected to the rest of the country by road. The Okuk national highway connects the cities of Lae in Morobe Province and Madang in Madang Province to the highland provinces of Eastern Highlands, Simbu, Western Highlands, Southern

Highlands and Enga. Other provinces with highways are East Sepik, West Sepik, Madang, Morobe, New Ireland, Oro and Central. There are varying amounts of trunk and feeder roads in the provinces but the lack of maintenance in recent years has reduced their usefulness to a considerable degree. Approximately 73.4 per cent of the population of PNG have road access to urban centres (Allen *et al.*, 2001).

There are 3 international airports, 19 provincial airports and 438 airstrips in the country. Air Niugini, is the only larger airline and is government owned. There are several third level airlines, which are privately owned. Shipping and trucking companies are privately operated. There are wharf facilities in coastal provinces, some more developed than others, depending on economic activity. Table 4.1 summarizes the status of infrastructure in PNG.

Table 4.1 The status of infrastructure in PNG

Description	PNG	Southern	Highlands	Momase	Islands
Population with access to roads (per cent)	73.4	51.33	93.8	64.75	66.6
National roads, (usable >90 per cent of the year) (km) 1995	8,815	2,633	1,934	2,161	2,087
Trunk roads, (usable >75 per cent of the year) (km) 1995	7,737	844	3,581	1,288	2,024
Feeder roads, (usable >60 per cent of the year) (km) 1995	2,893	500	330	783	1,280
Airfields, number that are operational, 1990	438	139	69	183	47
Seaports, number that are operational, 1990	25	10	-	6	9

Source: Office of National Planning, 1999.

Infrastructure specific to agriculture is poorly developed and maintained. This includes roads, ports, market facilities, information, input supply and networks. Due to the closure of most provincial radio stations, communication with growers is not effective.

4.4 Institutions

There are 6 universities in PNG and 6 technical colleges for the training of skilled manpower to the public and private sectors. The performance of national government departments has suffered over the years due to the exodus of skilled manpower to the private sector where conditions are better. Hence, statutory organizations have been set up to carry out main line functions but are privately run and aim to provide an effective working environment and better conditions. A few examples are the Medical Research Institute, National Agricultural Research Institute, Fresh Produce Development Company, TELIKOM and PNG Power.

Private hospitals and clinics have sprung into business in the cities and main towns. Various Churches in PNG provide essential health clinics in remote parts of the country where government health services have not been maintained.

Non-Governmental Organizations are active in the country. Examples of them are Conservation Melanesia, Save the Children Fund and Red Cross.

4.5 Household economy

In PNG, the real GDP per capita is Kina 373.4 (Office of National Planning, 1999). There is an unbalanced (skewed) income distribution within and across various regions and socio-economic groups in the country, with approximately 20 per cent of the people having 80 per cent of the income.

A high level of unemployment and under employment exists in the country, with 74 per cent of the economically active population in the semi-subsistence sector being generally under employed (Office of National Planning, 1999). Potential exists for only 5 per cent of the total population and 18 per cent of the economically active population to be employed in the formal

sector. Poor living standards due to poverty are manifested by low life expectancy (54 years), under weight children (29per cent), poor health, malnutrition/under-nourishment and food insecurity.

The household economy is reflected in annual per capita income. At the regional level, income per capita ranges from Kina 28.77 to Kina 87.17, with Southern and Islands regions having the lowest and highest respectively (Allen *et al*., 2001). In the provinces, the people of East New Britain have the highest income per capita at Kina 128.96, followed by Western Highlands (Kina 97.40) and Sandaun with the lowest at Kina 12.76. In these three provinces access to markets is limited.

About one-third of the population of PNG (or 1.4 million) earn cash incomes of less than Kina 20 per person per year. On the other hand, almost 1 million people are estimated to earn more than Kina 150 per person per year. The people in the atolls and high altitude areas were the most severely affected in the drought of 1997 (Allen and Bourke, 2001). Resilience can be measured in income or wealth. It can be seen from Table 4.2 that people in the province of Milne Bay and the Southern Highlands and Enga earn less than Kina 40 per person per year.

Agriculture remains the main source of income in PNG. Household income has a positive impact on rural family nutrition (Allen *et al*., 2001). Gibson (2001) estimates that nutrition availability, measured in calories, rises between 4 and 7 per cent for every 10 per cent increase in household income. Rural villagers generate a total of Kina 195 million (US$ 48.75 million[*]) every year, according to estimates by Mapping Agricultural Systems of PNG (MASP) (Allen *et al*., 2001). This estimate is from a study conducted between 1994 and 1999.

Table 4.2 The differences in income per capita between provinces of PNG (ranked)

Province	Total income (Kina)	Population	Per capita income from agriculture
East New Britain	20,501,772	158,980	128.96
Western Highlands	35,427,552	363,749	97.40
Eastern Highlands	33,913,490	354,475	95.67
New Ireland	7,590,758	88,723	85.56
West New Britain	9,011,886	116,945	77.06
Manus	2,267,196	32,600	69.55
North Solomons	9,314,872	161,260	57.76
Oro	4,660,400	92,450	50.41
Central	7,070,298	164,874	42.88
Simbu	10,567,464	279,694	37.78
Morobe	12,782,578	360,411	35.47
Madang	9,818,792	284,268	34.54
Enga	7,884,828	260,039	30.32
Gulf	2,422,164	92,870	26.08
East Sepik	7,851,630	316,319	24.82
Milne Bay	4,337,304	190,046	22.82
Western	2,557,350	112,531	22.73
Southern Highlands	5,159,262	366,620	14.07
Sandaun	2,230,134	174,842	12.76

(After Allen *et al*., 2001)

The main agricultural cash earners are betel nut, coffee, oil palm and fresh food. The sale of fresh food is the most important source of income, in terms of the number of people involved. This activity earns over 3.0 million people an average of Kina 13 per person per year, (an estimated total of Kina 39 million). About 1.2 million people earn cash from the sale of betel nut, while 1.5 million people (mainly Highlanders) earn about Kina 65 million each year from coffee. Gibson (2001) believes that the PNG national accounts grossly underestimated the contribution of smallholder agriculture to the national economy.

[*] 1 PNG kina is equal to US$ 0.27 (March 17, 2003).

A great majority of the smallholders earn income from a combination of cash earning activities rather than any single one. The ability of these households to earn income from these activities depends on the quality of the land and its proximity to a market or accessibility (Allen *et al*., 2001). The difficult terrain limits cash income opportunities due to the isolation from markets and services.

5. Local Coping Strategies (Risk Minimization)

5.1 Strategies for risk management

People were at risk not only during the drought and frosts but also at the end of the period, i.e. the onset of the rains. The 1997 Drought Assessment Reports have provided the information for this chapter.

The local terrain and altitude impacted on the severity of the shortages of food and water. Generally, small islands on coral atolls (i.e. Iwa, Gawa and Kwaiwatta in Milne Bay) faced severe shortages (Bourke, 1998). On the mainland, areas featuring rugged mountains and steep gorges were more vulnerable than the valleys or flat areas. As an example, people in Gumine district in Simbu Province faced a more severe shortage of food and water than those in the Minj district (Wahgi Valley) of the WHP. Areas above 2,000 meters above sea level, such as Tambul (2, 240 masl) and Kandep (2,500 masl) were affected by frosts, exposing the inhabitants to more acute food shortages than those at mid-elevation.

Bourke (1998) reported that the impacts were greatest in remote locations where the effects were compounded by poverty and a lack of access to government services and markets.

5.2 Strategies during drought and frosts

There were five main strategies used by Papua New Guineans to withstand suffering and hardship through the period. They fall under the following categories; technology, infrastructure, farm management, social support and economic management. Institutions supported the first three whereas the other two were based on the initiatives of the people.

5.2.1 Technology

The three main techniques used were irrigation, use of crop cover and smoke (smudge) to minimize frost damage and the preservation of seed and plant materials.

Simple flood irrigation is traditionally practiced under dry conditions in Milne Bay. Irrigation of small taro gardens was also known from parts of Morobe and the Highlands provinces. This practice had gone into abeyance in most places. However, during the 1997 drought some villagers used bamboo to pipe water to their gardens to continue food production. The practice was reported from parts of Simbu and Eastern Highlands provinces in the Highlands and parts of Morobe and Milne Bay provinces on the lowlands (Bourke, 1998). At high altitude (Tambul and Kandep), attempts were made to minimize frost damage by covering the crops at night with grass and leaves or producing smoke/smudge in the early hours of the mornings. However, with repeated frosts, the amount of labour required became too much and most people gave up covering and uncovering crops every day, or staying up all night to keep fires burning.

Older members of the community advised others to store seeds and preserve vegetative planting materials for early planting on the return of the rains. This would shorten the period of food shortage during the post drought phase.

5.2.2 Infrastructure

Roads including bridges and airstrips were essential in accessing markets and services during the period of strife (Allen and Bourke, 1998). People in areas lacking this infrastructure suffered most as the flow of aid (food and medicines) was restricted. Proximity to good markets was also important. Farmers from Tambul could sell vegetables at the Hagen market to earn much needed cash due to its closeness and an operating road. Farmers in Kandep or Mt Wilhelm are further from sizeable urban markets and accessibility by road can be difficult.

Some airports were closed because of smoke for periods during the drought, thus depriving some people of vital services. River transport was also restricted up the Fly River (Western Province) because of low water levels.

5.2.3 Farm management practices

The following cultural practices proved useful during the drought and frost periods; cultivation of drought tolerant crops, conservation of soil moisture, cultivating swamp or marsh areas, gardening in wind sheltered areas and cultivating on slopes to minimize frost damage.

Farmers in Simbu and Bena in EHP found that vetiver grass planted as hedgerow retained soil moisture during the drought. In most other areas, farmers resorted to mulching or cultivating swamp/marsh areas. In highland areas, it was noticed that cool and wind sheltered areas gardened experienced better yields due to lower evapo-transpiration of crops cultivated there.

Drought tolerant crops

Certain varieties of crops are drought tolerant, i.e. they yield under dry conditions. An example is the sweet potato variety embenamb in the Whagi valley. NARI has selected five of eighteen varieties of highland sweet potato reputed by farmers as being drought tolerant. Similarly, four varieties of lowland sweet potato tolerant to drought have been released. Banana varieties Kalapua and Yawa yielded well. Cassava, being tolerant to drought, was the staff of life in areas where it was grown. It has since been widely cultivated in the Highlands and processed (flour) in Kundiawa, Simbu Province. NARI is promoting cassava varieties, which have acceptably low cyanide content.

Famine foods earnestly sought after were ferns, rungia, figus (Ficus sp) and pueraria or yam bean (Pueraria lobata) tubers in highland areas and wild taro, tulip and kumu mosong (Ficus wassa and Ficus copiosa) in the lowlands.

Impact of frost on food crops

Except for brassicas, which can withstand mild frost, all crops presently cultivated at high altitude are susceptible to frost damage. Farmers avoid damage by making gardens in a number of locations including slopes. Dwellers of frost prone areas are most vulnerable and resort to famine foods earlier than those at mid altitude. They were the focus of food aid during the 1997-98 drought and frosts and the first people to receive planting materials on the return of the rains.

Sweet potato production is significantly reduced during frosts. The leaves and vines defoliate and tubers left underground become soggy and distasteful. (Lutulel, R pers comm., 1998). The critical issue is the time it takes to re-vegetate and set tubers. Under normal growing conditions the crops mature between 9 and 12 months depending upon variety. The stopgap crop was potato (Solanum tuberosum) following the drought of 1997. It is the only other starch crop commonly grown at high altitude areas.

5.2.4 Social support system (Wantok system)*

Allen and Bourke (2001) reported that most Papua New Guineans got through this very difficult time with help of their relatives and friends (wantok system) and through their ability to withstand suffering and hardship. Those affected either remained in their localities and were supported by wage earning relatives or migrated to areas where the opportunities to obtain food were better.

There were cash remittances to rural people by relatives in wage employment so store food (rice, flour and cooking oil) could be purchased. At other times store food was sent to villages. The purchase of rice to support needy relatives and wantoks accounted for the extra 54,500 tons PNG imported during 1997 (Allen and Bourke, 2001 and Whitecross and Franklin, 2001).

Two types of migration were observed: rural to urban and rural to rural. For example, migration was reported from Obura district in the Eastern Highlands and Yangoru – Saussia in East Sepik. During that time, there was reportedly an expansion of squatter settlers in the major townships of the country.

The wantok system is a unique system of tribal and regional support for people who speak the same language in PNG. When no outside food aid reached an area during drought and frosts, this system ensured that people shared what little food they had with each other. In remote areas, where there was limited access to government services, people supported each other through this system. However, a lot of stealing from food gardens was reported (Allen *et al*., 1997).

5.2.5 Economic management

By the end of 1997, 40 per cent of rural villagers were very short of food (Allen and Bourke, 1997). Families had been using most of their savings and assets to sustain themselves. The level of wealth reflected their buffering capacity. All available garden food was either consumed directly by families and relatives or sold to buy store foods such as rice, wheat flour and cooking oil. For example, farmers in Tambul sold vegetables in the Mt Hagen public market and returned home with store goods. Farmers sold livestock, either live or cooked, for cash to secure food.

During the 12 months to March 1998, PNG imported 66,000 tons more rice than the year before (Allen and Bourke, 2001, Whitecross and Franklin, 2001). Of this, Papua New Guineans purchased 54,500 tons as a direct result of food shortages. Rice provided by aid organizations amounted to only 11,500 tons and was flown by the Australian Defence Force to remote areas. In other words, Papua New Guineans purchased 82 per cent of the extra rice imported due to local food shortages for themselves and their wantoks or relatives. Food aid only provided for a small portion of the population who had no road access.

5.3 During the onset of rain

After the drought and at the start of rain it was important to plant early maturing crop varieties to shorten the time of food shortage. Vegetables such as greens, beans and maize were planted alongside sweet potato, cassava, taro, banana or yams. There were seeds of corn, pumpkin, beans and potato also provided by AusAID and distributed by Fresh Produce Development Company Ltd (a statutory body).

A survey in February 1998 in Simbu and another in Eastern Highlands the following month revealed that post drought yields of sweet potato were reduced by 70 per cent and 30 per cent respectively (Kanua and Bang, 2001). Sweet potato planted immediately post drought

* Wantok System is a social system in PNG in which people of a region, who speak the same language and share ethnic ties, support or favor each other over other people.

tuberized poorly, either due to excessive nitrogen in the soil, possibly as a result of a build-up of dead microorganisms after the drought, or excessive soil-moisture. This meant farmers wasted labor and other limited resources in planting large areas of crops that subsequently failed, which prolonged the food shortage unnecessarily. Nevertheless, there was a glut of sweet potato by June 1998.

6. Government Response

6.1 Government response

The government responded in August of 1997 when the food and water shortages reached crisis point and following reports in Australian newspapers that people in PNG were dying of starvation. A proposal to establish a trust account for donations dragged on until well into October. Consequently, bilateral donors were reluctant to donate funds in the absence of a publicly audited trust account. In September, the PNG government released Kina 3.5 million for the drought relief operations. However, provincial drought relief committees were poorly organized and ineffective in assessing the real impact of the drought (Hughes *et al.*, 1998).

During the relief operations it was reported that funds were misused. After the drought, an audit of the trust funds in May 1998 by the Government Auditor, found numerous cases of funds used without proper accounting procedures and on expenditure not related to drought relief.

6.1.1 Assessment of impacts

The assessment of the impacts of drought and frost by the national and provincial governments was ineffective. The provincial disaster and relief committees were poorly organized and were neither financially nor technically capable of effectively assessing the situation. Hence, the government did not respond adequately until the impact of the drought was widespread.

Following newspaper and television publicity in Australia, the GOPNG requested assistance from the Australian Government. AusAID arranged for the assessments and followed them with restricted relief programs to isolated areas. It committed A$ 20 million for these programs with several consultants and NGO groups were contracted to assist. Before and after AusAID's involvement, the only reliable and accurate assessment reports received were from Christian missions in various places.

Assessments were made three times throughout the drought and associated frost event. The first assessment commenced in mid-September and was conducted over an 18-day period (Allen and Bourke, 1997). It assessed the extent of damage over parts of the country thought to be worst affected, especially the higher altitudes and on offshore islands and made recommendations for relief programs to assist those most affected.

The second survey was undertaken in November and December at the time aid delivery was well under way and was designed to provide an assessment for every Census Division in the country. Shortly after the second assessment was completed rain began falling in some places. The third and final survey was conducted in February/March 1998 by a national team organized by the Department of Agriculture and Livestock. By that time, rain had returned to most places and gardening had resumed throughout the country. People were mainly consuming quick growing green vegetables and maize (Allen *et al.*, 2001).

Many areas were well assessed, however, some places were visited only once while others were covered by all three assessments. Generally, the 1997/98 drought and frost event was the best documented of all such occurrences. The December assessment received reports for every Census Division except those on Bougainville, where civil war prevented field surveys.

6.2 Aid delivery

In general, the delivery of aid was late. When delivery was made it was poorly administered. Many badly affected places like Gembogl in Simbu Province and Tambul in Western Highlands only received food aid once or twice. Other places missed out completely.

AusAID played a major role in aid delivery and rehabilitation (Hughes *et al*., 1998). A total of A$20 million was expended in the Drought Relief Operations in Papua New Guinea. AusAID provided 2,700 tons of rice to approximately 100,000 people in very isolated areas in the country (Allen and Bourke, 2001). Cooking oil, flour, water containers and planting materials were also supplied. At the request of the Department of Health, AusAID distributed pharmaceuticals to the value of Kina 1.2 million (Sudradjat, 2001).

The PNG national government expended Kina 3.5 million from which 13,500 tons of rice were purchased for the relief effort. Japanese government aid provided 8,000 tons of rice. There were 18 other Humanitarian Organizations who also provided aid (Howie, 2001):

Organization	Area of activity
Adventist Development Relief Agency	Humanitarian Organization (HO) Coordination Food commodity distribution Funding of Community-Based Organizations (CBO's) Water supply Agricultural training Food supply
Anglican Chruch	Food distribution Seed distribution Water supply Health promotion
Appropriate Technology and Community Development Institute	Development and printing of resource of materials
Australian Volunteers International	Volunteers
CARE Australia	Food and seed distribution
CARITAS	Food distribution Medical assistance Seed distribution Water supply project
Evangelical Brotherhood Church	Seed distribution
Foundation for People and Community Development	Food distribution
Lutheran Development Services	Food and commodity distribution Agricultural training Seed distribution
Lions/Lionesses	Food distribution Funding of CBO's
Morabe Province *Kibung*	HO coordination
PNG Red Cross	HO coordination Food and commodity distribution Funding of CBO's Disaster response training Water supply
Rotary	Financial support to NGO's
Save the Children Fund	Food distribution and logistics Seed distribution Water supply Information dissemination Funding of CBO's and NGO's
World Publishing	Article in *Wantok* newspaper
World Vision	Food distribution

Source: After Howie, 2001.

6.2.1 Food

The Australian organized relief program was expensive but worked reasonably well. Military aircraft were used to transport food to isolated areas. Elsewhere food was delivered late. In Simbu for example, deaths were reported throughout the province, mainly children and the elderly died, before the food aid arrived. Reported figures in some areas were doubtfully high. Generally, food aid delivered by the PNG government was found to be inadequate. Up to 45 per cent of the rural population in the Highlands did not get enough food aid. Many areas received food only once, while none was delivered to other areas. In some places old people and other weaker members of the community did not receive food.

6.2.2 Seeds and planting materials

AusAID supplied potato seeds and other vegetables through their Drought/Frost Rehabilitation Project, which was distributed by the Fresh Produce Development Company. However, throughout the Highlands, demand was greater, especially for brassica seeds. People bought seeds and other planting materials from other farmers locally and from neighboring villages. In the Highlands, most sweet potato vines for planting post drought were collected from Waghi Valley and other low lying areas.

6.2.3 Information

Information on the implementation of aid delivery programs was further impeded by the poor communication network. There was no proper communication network to monitor aid delivery to various places within the provinces. Many provincial radio stations were not operating.

People have expressed the need for an efficient information system, which would not only provide early an warning but also report on the progress of droughts. Information on coping strategies at the various drought stages would have been very helpful.

6.3 Assessment of government response

6.3.1 Timeliness of government response

Overall, the government's response was late and inadequate. There were four reasons for this. Firstly, the country was in an economic recession. Secondly, the government was preparing for the National Election in 1997. Thirdly, there was a lack of organization and fourthly, fraud and corruption.

The country was in an economic recession and the government was implementing a structural adjustment program imposed by the IMF and World Bank. The government was short of money at the time when it was also going to the polls. When funds were made available, the country was slow in organizing the delivery of aid. Politicians tried to use the event to their personal advantage. During the implementation, a lot of money was misappropriated. These all resulted in reduced support to those who needed assistance.

6.3.2 Relevance of government response

The government's response, in terms of aid programs, although not enough in every case, was relevant. All aid of foods and goods or medical supplies delivered were appropriate.

However, AusAID and NGOs provided substantial aid and logistical support. Food supplied by AusAID between September 1997 and May 1998 included flour, rice, tinned fish and cooking oil. Other important items supplied were water containers and planting materials. The delivery was particularly useful for those in the high altitude areas. An important part of the recovery process was the rehabilitation process. The seeds of potato and vegetables supplied were planted from December 1997 onwards. Medical supplies were limited and were given only

to the most affected areas. Many health services were able to operate during the drought, the bulk of which were run by churches. Many aid posts in very remote areas were closed, either due to a lack of medical supplies or staff.

7. Conclusions and Recommendations

The overall conclusion based on the survey results is that the response by the PNG government was late in assisting people adversely impacted by the 1997 El Nino induced drought and frosts. Some deaths were reported. The majority of Papua New Guineans were either supported by their relatives or managed on their own through the famine period. The government, with logistical support from AusAID, was able to assist people in remote areas of PNG in the latter stages of the event, i.e. from October 1997 to May 1998.

On a regional basis, the worst affected provinces in the Southern region were Milne Bay, Central, Oro and parts of Gulf while those in the Northern region, were parts of Morobe and Madang. There were areas with food shortages in each province of the Islands region with Manus worst hit. The Highlands was also seriously affected, with Simbu and Eastern Highlands needing urgent aid support.

The following recommendations are made to improve the country's ability to respond to future adverse weather changes caused by the ENSO phenomenon. It includes early warning for contingency planning and improved technologies to stabilize agricultural production in the most vulnerable areas in the country.

7.1 Recommendation 1

It is recommended that the quality and availability of information provided by the National Weather Office be significantly improved.

This will involve an increase in the number of observation stations, membership of international ENSO monitoring organizations and assistance from the Australian Bureau of Meteorology Research Division. The NWO should be funded adequately so that it does not have to charge exorbitant prices for its data.

7.2 Recommendation 2

Prices of food in key markets in PNG should be monitored regularly.

Rises in prices of foods at market indicate shortages in the catchment area of the market. Rises in the prices of staples can be an early indicator of food supply problems.

7.3 Recommendation 3

In fulfilling its development mandate, the government should assist communities in vulnerable provinces/districts to set up water supplies, improve and maintain the road network and health services as mitigation measures.

Accessibility to market is crucial as people would have cash to purchase foods from stores or markets when their crops fail. Health centres need to be open to treat people sick from diseases related to insufficient food (malnutrition) or contaminated water (e.g. typhoid). Poor roads severely constrained delivery of relief in 1997.

7.4 Recommendation 4

It is recommended that NARI be supported to set up resource centres in provinces or regions that are highly vulnerable to drought and frosts, such as the high altitude Highlands and island atolls, to test and disseminate appropriate technologies so farmers can secure food during the drought (frosts) and flood periods.

Funding is needed to continue to select and demonstrate crops and varieties tolerant to drought and frost conditions and technologies to manage soil water for crop production under conditions of extreme soil water deficits and excess.

7.5 Recommendation 5

Poor areas should be identified and special assistance given to people living in them to earn cash.

The potential of high value-to-weight products such as chilies should be investigated. Cash earnings proved to be the best possible drought mitigation measure in 1997.

7.6 Recommendation 6

If people are interested and willing they should be supported to grow storable grain crops to supplement root crops so that if the root crops fail during a drought, locally grown rice can be used.

Local NGO programs and the Provincial Department of Primary Industries are teaching people how to grow rice in many parts of the country.

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