Economic and Social Commission for Asia and the Pacific

CGPRT Centre WORKING PAPER No. 74

Indigenous Drought Coping Strategies and Risk Management against El Nino in Papua New Guinea

Sergie K. Bang
Kud Sitango

United Nations

The CGPRT Centre

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Indigenous Drought Coping Strategies and Risk Management against El Nino in Papua New Guinea

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

WORKING PAPER 74

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Research and Development of Coarse Grains,
Pulses, Roots and Tuber Crops in the
Humid Tropics of Asia and the Pacific

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Foreword

The CGPRT Centre has successfully completed a three-year research 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.

The impacts of El Nino-induced abnormal weather vary from country to country and location to location depending on its natural and socio-economic conditions. Thus, it is vitally important to examine carefully the outbreak and consequences of El Nino in each country at a local level for establishing effective and practical mitigation measures against climatic risks. This volume, as research results of the second phase of the Papua New Guinea country study of the ELNINO project, provides relevant policy recommendations based on rich and useful information derived from in-depth case studies in the six research sites covering a wide range of natural and socio-economic environments, namely from low to high lands and good to poor infrastructure.

I thank Dr. Sergie K. Bang and Mr. Kud Sitango for their sincere efforts. Their fruitful work is truly appreciated. This three-year, wide ranging research project could only be accomplished with the continuous support from PNG National Agricultural Research Institute. 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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Special thanks are due to Dr. R.D. Ghodake, the Director General of the National Agricultural Research Institute (NARI), Papua New Guinea for allowing us to be involved in the study. Their understanding and support are highly appreciated.

Our utmost gratitude is directed to the Project Leader, Mr. Shigeki Yokoyama, and Dr. Roger Conception, the Regional Advisor. Both were instrumental in developing the framework of the study as well as in providing advice and guidance to ensure the successful implementation of the study.

The staff of NARI Aiyura are acknowledged for their involvement in conducting the surveys in all six districts. They are Debbie Kapal, Timothy Geob, Gend Bagl, Pus Wesis and Kai Lali. Mr. Jacob Kiara, Research Program Leader was very supportive in providing the necessary resources. John Demerua of NARI Laloki supplied information on drought analysis. Debbie Kapal assisted with type setting. Jimmy Maro of NARI GIS provided the vulnerability maps on droughts and frosts. Dr. Geoff Wiles, Chief Scientist of NARI provided valuable suggestions for the document.

We extend our thanks to the staff of CGPRT Centre; Mr. Matthew Burrows for his English editing, Mr. Muhamad Arif and Harry Zulfikar for graphical arrangement, and Ms. Agustina Mardyanti for typing.

September 2003

Sergie K. Bang
Kud Sitonga

Executive Summary

Papua New Guinea needs to have a National Agricultural Drought Mitigation Strategy against El Nino induced droughts. Since 1880, there have been 18 El Nino induced droughts, none as widely documented as the one in 1997. As global climatic changes make droughts a frequent threat, new and indigenous coping strategies need to be documented and widely used.

Six of the worst affected districts during the 1997 drought (and frosts) were surveyed in 2002. The objective of the study was to document indigenous coping strategies and to determine if people in some districts had coped better than others. The districts surveyed were Bogia and Raikos districts in Madang Province, Bena in Eastern Highlands, Gumine in Simbu Province, Tambul in Western Highlands and Kandep in Enga Province. The main parameters assessed were agricultural production, family income, water supply for household use, bush/famine foods eaten, migration, food aid received, human health and infrastructure and government services during the drought period.

Yields of all food crops were reduced significantly during the drought. Sixty per cent of respondents in all 6 districts earned income through the sale of livestock and food and cash crops. Over 40 per cent of respondents saved planting materials for rehabilitation, with respondents from Tambul and Kandep districts saving only seeds. The majority of respondents in all districts carted water for household use. A few respondents used bamboo piping and one village in Bogia had a well. Respondents reported more energy bush foods (yam and taros) in Bogia and Raikos, and Bena and Gumine districts and only leafy vegetables (ficus and rungia) in the wild in Tambul and Kandep districts. This is partly why respondents of Tambul and Kandep reported the highest (39 per cent) migration in search of food.

Generally, roads (bridges), health centres and schools were better in 1997 than 2002. Village water supply was either inadequate or non-existent in 1997 and the situation has not improved. Food aid in the form of rice, flour and cooking oil was received in all districts surveyed. The high altitude districts of Tambul and Kandep received rations up to 3 times, which was more frequent than the lowland districts. Stomach aches and dysentery were the main health problems experienced, due to the lack of food and contaminated water consumed. The number of deaths reported was higher in the high altitude districts.

The study showed market access did not influence the sale of food crops, livestock and fresh fish but did the sale of cash crops and betel nut. More respondents from poor market access districts also sold cash crops to obtain money to pay for their needs. The reason being that the income earned from cash crops carted to town was higher than from fresh food crops.

The study concludes that the inhabitants of Tambul and Kandep (high altitudes) are most at risk, followed by those in Bena and Gumine (mid-altitude). The inhabitants of Bogia and Raikos districts (lowlands) are least at risk. The outlook for the vulnerable districts is not good unless on-farm contingency plans, both short and long-term, are adopted. An advisory bulletin describing On-Farm Coping Strategies is available from the National Agricultural Research Institute. The document recommends coping strategies for the pre, mid and post stages of drought as well as ongoing or long-term (adaptive) strategies.

1. Introduction

Analysis of rainfall records for Papua New Guinea from 1910 to 1982 shows that severe droughts have occurred from time to time across the country. El Nino induced abnormal weather occurred in the past at different frequencies and intensities but the 1997 event is described to be one of the worst of the 20th century. The combined effects of drought and frost led to widespread food and water shortages across the country. There was an increase in human diseases related to food shortages and water contamination and also pests and diseases on food crops. Approximately 40 per cent of the rural population (1.2 million people) were starving towards the end of 1997 (Allen and Bourke, 2001).

This CGPRT project aims to stabilize upland agriculture and rural development in El Nino vulnerable countries through documentation. In Phase 1, the project assessed the impact of the 1997 El Nino induced drought on agricultural production and the rural economy. In the second phase, a study was conducted on the institutional preparedness to cope with future El Nino-induced risks on agriculture. Although people suffered shortages of food and water, each community had various coping strategies. This paper documents the indigenous coping strategies used by people in six worst affected districts in the highlands and lowlands of PNG. These districts were categorized as 4-5 during the assessments of the 1997 El Nino. Background information on these districts is provided in Appendix 1. Appendix 3 is a list of villages studied in each district.

1.1 Summary of the report on the impacts of drought (Phase 1)

Severely affected provinces in 1997 were Madang and parts of Morobe in the Momase region, Manus, New Ireland and North Solomons of New Guinea Islands region, Milne Bay, Central Province, Gulf Province and Western Province of Southern region and all of the 5 Highlands provinces. There were severe shortages of food and water, with the availability of garden produce reduced by 80 per cent, and 40 per cent of the rural population (1.2 million people) starving towards the end of 1997 (Allen *et al*., 1997). Typhoid and dysentery were common among the rural population and a lot of rural-urban and rural-rural migration was reported. What saw many people pull through the famine period was the social support system (the wantok system) and abstinence of socio-economic obligations. All efforts were devoted to sustaining their lives.

Government response was slow and inadequate partly because there was no advance warning of the drought. AusAID mounted a food relief and seed distribution program, which was complemented by food aid (rice) from Japan. Aid delivery by NGOs included food, health services and crop seeds for rehabilitation.

There was a significant reduction in exports of minerals, oil and commodity tree crops in 1997 compared to 1996. The largest disparity was in copper, oil, rubber and tea. Copper exports dropped by 39 per cent and crude oil by 29 per cent, while exports of rubber and tea plunged by 35 and 30 per cent respectively. On the other hand, coffee exports declined by only 5 per cent in the drought year and, in fact, increased by 34 per cent in 1998. The trade of Highlands fresh produce to Port Moresby dropped by 13 per cent in 1997 (vs.1996).

2. El Nino Induced Droughts and Normal Droughts in PNG

Drought years can be defined statistically as the driest 5 per cent or 10 per cent of all years in a location (International Rainman, 2001). It is considered abnormally dry weather when rainfall is below a critical level (median) and persists long enough to produce a serious hydrological imbalance, during which time agricultural production is adversely affected. The severity of droughts in PNG depends upon the degree of moisture deficiency, the duration and the size of the affected area (Maiha, 2002).

Generally for PNG, El Nino induced droughts have come about as a result of a warming of the eastern Pacific (sea surface temperature) and a corresponding decrease (negative phase) in the SOI. (International Rainman, 2001) The driest recorded 12-month periods (since 1950) in the equatorial regions of the Pacific were associated with strongly negative SOI values. This is referred to as abnormal inter-annual climate variability. The ENSO phenomenon influences this annual climate variability in the PNG climate (Maiha, 2002).

On the other hand, a 'normal' drought can be described as an extension of the normal dry season where rainfall is less than the evapo-transpiration rates of crop plants.

History reveals that PNG has experienced 26 droughts since 1880. Of these, there were 18 El Nino induced droughts where the SOI was less than –10[*]. The other 8 were normal droughts (Bureau of Meteorology, 2002). The El Nino drought years were 1882, 1888, 1896, 1905, 1914, 1940, 1941, 1946, 1953, 1965, 1972, 1977, 1982, 1987, 1991, 1993, 1994 and 1997.

[*] When the SOI has been less than –10, the impacts of droughts have been severe to very severe. When the SOI has been greater than –10, the impacts have not been severe.

3. Drought Vulnerability in PNG

3.1 Drought definition

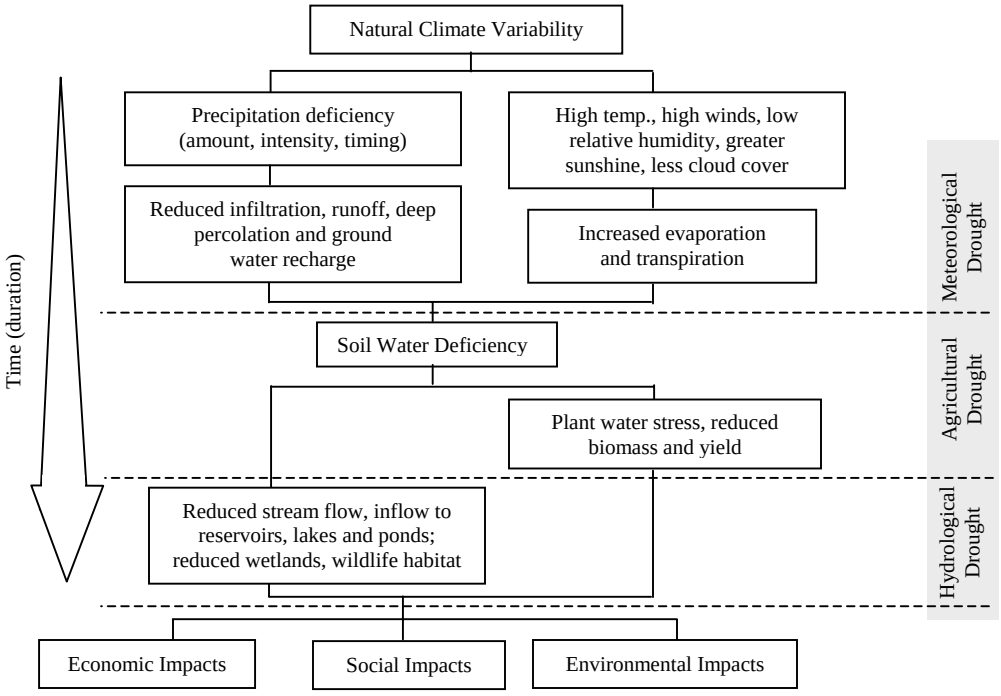
A drought is most often defined as a protracted period of deficient precipitation resulting in extensive damage to crops and in loss of yield.

It is actually a deficiency of precipitation from the expected or “normal” that, when extended over a season or longer period of time, is insufficient to meet demands. This may result in economic, social and environmental impacts. It should be considered a normal, recurrent feature of climate. Drought is a relative, rather than absolute, condition that should be defined for each region. Each drought differs in intensity, duration and spatial extent.

There are four perspectives on drought: meteorological, agricultural, hydrological and socio-economic. Meteorological drought is usually defined by the measure of the departure of precipitation from the normal and the duration of the dry period. Agricultural definitions refer to situations in which the moisture in the soil is no longer sufficient to meet the needs of the crops growing in the area. Hydrological drought deals with surface and subsurface water supplies (such as stream flow, reservoir/lake levels, ground water). Socio-economic drought refers to the situation that occurs when economic goods associated with the elements of meteorological, agricultural and hydrological drought fail to meet the demand. These perspectives or operational definitions help people identify the beginning, end and degree of severity of a drought. Figure 3.1 illustrates these perspectives of drought.

Agricultural drought is a period of abnormally dry weather during which rainfall is below a critical level and extends over a certain period resulting in major adverse impacts on agricultural production. It is an extended period where precipitation is less than evapo-transpiration.

Figure 3.1 Perspectives of a drought



Source: After National Drought Mitigation Centre, 2002.

3.2 Vulnerable provinces

3.2.1 Vulnerability

Vulnerability of a location is influenced by the characteristics of the population, activities and features of the environment that makes it susceptible to the effects of drought (Rao, 2002). The degree of vulnerability depends on the environmental and the socio-economic characteristics of the region and is measured by the ability of the inhabitants to anticipate, cope with, resist and recover from drought.

The following are considerations for classifying vulnerability:

Vulnerability	High	Low
Rainfall	High variation	Low variation
Rate of change	Sudden	Gradual
Duration	Longer	Shorter
Food sources	Single	Multiple
Supply reliability of food	Low	High
Relation to other disasters	High likelihood	Low likelihood
Preparedness	Acceptance	Advance Warning
Leadership on mitigation	Insensitive	Sensitive

3.2.2 Vulnerable areas

Areas susceptible to the effects of droughts in PNG are those that have the following characteristics:

- High rainfall variability.
- High land use intensity.

- High population density.
- Mostly steeply sloping agricultural land.
- Type of crops grown are not suited to long dry spells.
- Only one or two staple food crops are grown.
- Very high altitude (also affected by frosts).
- Heavily dependent on agriculture (as is the case for most of the population).
- No or limited diversity of the cropping systems.
- No irrigation systems used.

For instance, meteorologically, areas which were affected by the 2002 El Nino drought, include the following locations:

- Sepik Plains.
- Flat Plains of Western Province.
- Gazelle Peninsula.
- Highlands (also frosts).
- Papuan south coasts (Kwikila – Kerema).
- Milne Bay Province.

3.2.3 Drought analysis

We have used software developed by the Queensland Centre for Climate Applications to analyze the probability of droughts occurring in PNG. According to the 'International Rainman' Program, which uses correlations with the SOI and the Pacific SST to analyze droughts, two types of droughts can be predicted. Severe droughts are those experienced in years when rainfall received during a 6-month period is less than in the driest 5 per cent of calendar years, while moderate droughts are those in years when rainfall received during a 6-month period is less than in the driest 10 per cent of calendar years. Table 3.1 shows some weather stations in PNG, which have demonstrated a good relationship between SOI phases (or values) and drought occurrences according to the Rainman Program.

Table 3.1 Locations in PNG with a good SOI relationship that experienced severe droughts and rainfall deficiencies during the period between 1957 and 1980

Location	Province	Number of droughts	Average rainfall (mm) for 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 Britain	3	607	13.8	<40
ILOLO PLTN SOGERI	Central	4	635	4.7	520
MENDI A/F	Southern Highlands	1	660	12.7	1760
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	Central	8	1,418	1.5	360
LAE AIRPORT	Morobe	5	1,582	3.7	<40

Source: Demerua, 2002.

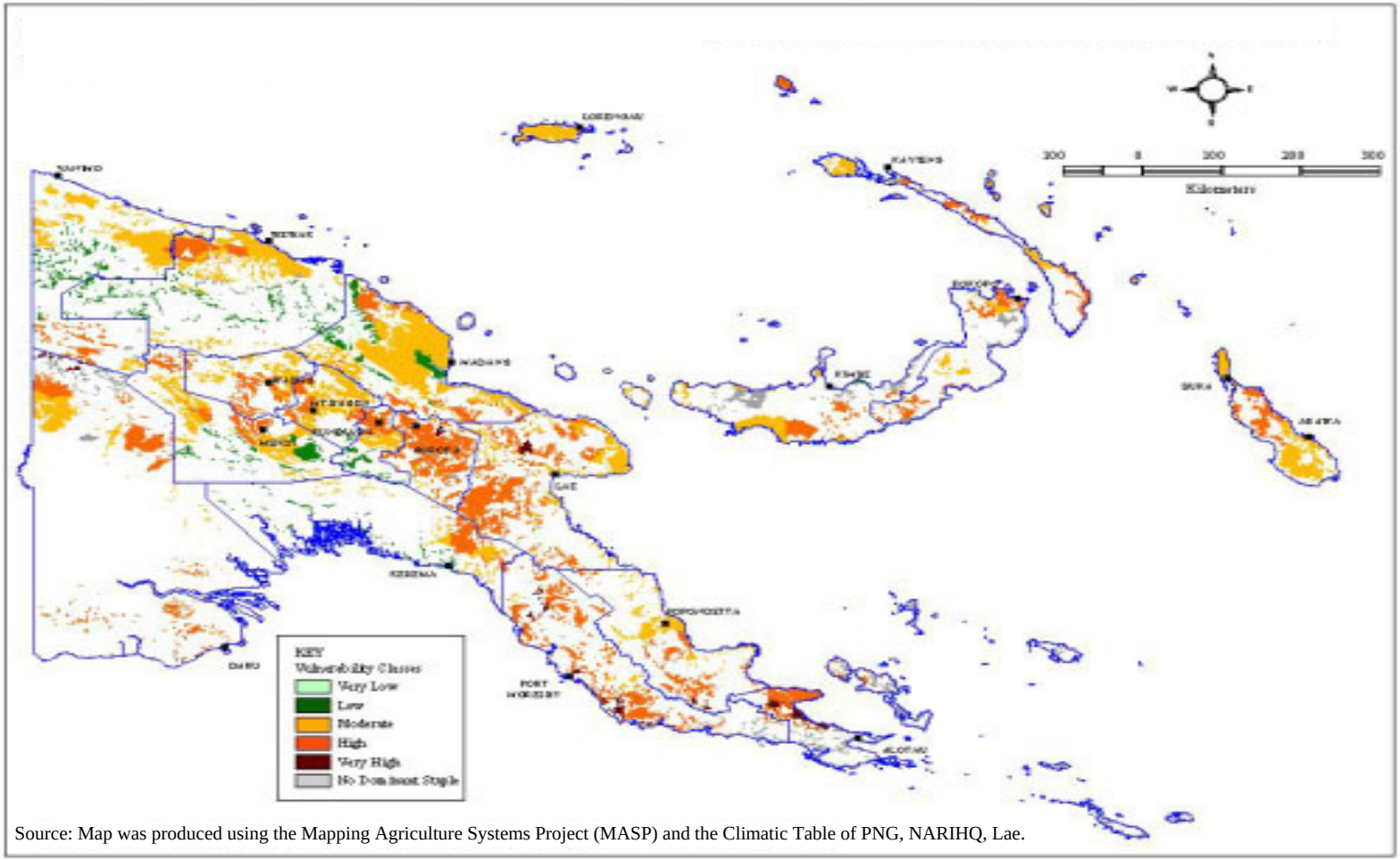
Figure 3.2 is a recently developed map showing drought vulnerable areas in PNG using four criteria. The criteria are: number of staples cultivated, intensity of land use, garden slope and variability in rainfall. The ranks used are 1-4 for land use and rainfall variability and 1-5 for staples and garden slope. The highest rank (4 or 5) indicates high vulnerability and the lowest rank (1) being low vulnerability. The following ranks were used to determine vulnerability classes:

Table 3.2 Data ranges used to determine the vulnerability classes

Summary code	Vulnerability description
5-6	Very low
7-8	Low
9-10	Moderate
11-14	High
15-18	Very high

Most areas highlighted as moderately, highly and very highly vulnerable to drought, were among the first to be affected during the mild El Nino of 2002.

Figure 3.2 Drought vulnerable areas of Papua New Guinea



Source: Map was produced using the Mapping Agriculture Systems Project (MASP) and the Climatic Table of PNG, NARIHQ, Lae.

4. Study Methods and Analysis of Impacts of the 1997 El Nino Induced Drought

4.1 Survey method

The major source of data was from information generated through Rapid Rural Appraisals in the districts. Subsistence family units in selected communities representing severely affected areas in the highlands and lowlands of Papua New Guinea were interviewed. Interviews were conducted using a questionnaire developed by the project units in each of the survey sites, giving a total of 96 respondents.

4.2 Analysis of the impact of the 1997 El Nino induced drought

The main areas of the questionnaire included:

- Respondent's personal details.
- Details of survey site.
- General drought and frost impacts.
- Agricultural production.
- Family income.
- Water supply for household use.
- Human health.
- Alternative or famine foods.
- Food aid/relief.
- Migration.
- Infrastructure and government services.

5. Criteria for Site Selection

The six sites selected were the worst affected, based on the 1997 drought impact assessment survey report. The sites had been among the worst affected (category 4 and 5) in the country (Allen *et al*., 1997 and Bang *et al*., 2003). In order to produce representative data, 2 sites were selected sharing a common altitude range. Furthermore, access to markets and presence of infrastructure was assessed to determine if these impacted the coping ability of people (Appendix 1 and 2).

5.1 Elevations

Two communities were selected from each of the three altitude zones.

Altitude	Districts	Province
• 0-500 masl	Raikos and Bogia	Madang
• 1,501-2,390 masl	Bena and Gumine	Eastern Highlands and Simbu
• 2,390 – 2,620 masl	Tambul and Kandep	Western Highlands and Enga

5.2 Types of sites or villages/communities

- A sample lowland site severely affected by drought with poor road infrastructure and limited market access - Raikos (Madang Province).
- A sample lowland site severely affected by drought but with good road infrastructure and access to markets - North Coast Road/ Bogia (Madang Province).
- A sample highland site which was severely affected by drought with good infrastructure and hence access to markets - Bena (EHP).
- A sample site in the Highlands severely affected by drought with poor road infrastructure and limited access to markets - Gumine (Simbu).
- A sample highland site which was severely affected by frost with a good road system and therefore access to markets - Tambul (WHP).
- A sample highland site severely affected by frost with poor road infrastructure and limited market access - Kandep (Enga Province).

Table 5.1 Description of the districts surveyed

District	Altitude (masl.)	Land use intensity (R-Value)	Types of staples	Road system	Market access	Comments
North coast (Bogia)	22 – 32	Low - Medium	Sweet potato, banana, cassava, taro, yam	Excellent sealed road	Good	-
Raikos	22 – 28	Low	Banana, cassava, sweet potato, taro, yam	Main bridge has been washed out	Bad	-
Bena	1,525 - 1,584	Low - High	Sweet potato, cassava, banana	Good	Fairly good	Distinct annual dry season (June - Oct)
Gumine	1,675 - 2,390	Low - Medium	Sweet potato, cassava	Not good	Not so good	Steep garden slopes
Tambul	2,388 - 2,624	Medium - High	Sweet potato	Good	Fairly Good	Frosts also experienced
Kandep	1,768 - 2,400	High	Sweet potato	Not good	Not so good	Frosts also experienced

The R- Value is as follows;

$$\text{R Value} = \frac{\text{Cropping Period x 100}}{\text{Cropping Period + Long Fallow Period}}$$

KEY: 1-27 = Low, 28-50 = Medium and 51-100 = High

6. Profile of the Study Sites

The six districts selected for the study were Raikos, Bogia, Bena, Gumine, Tambul and Kandep. Furthermore, assessment of frost risks was undertaken in Tambul and Kandep, both at high altitude. The profiles of these districts are given in Appendix 1.

The districts of Bogia, Bena and Tambul were better positioned to deal with drought because of good roads and therefore access to markets (Table 6.1). In the Bogia and Raikos, coconut and fish sustained people well and they were able to sell betel nut. The main weakness in the Raikos and Gumine was the poor road conditions.

In Tambul and Kandep, there is limited diversity of energy food crops and frosts kill all crops (except brassica under mild frost conditions). Opportunities for wage earning employment exist in Bena and Bogia districts as they are situated close to provincial centres. In the high altitude districts of Tambul and Kandep, the opportunity exists for the introduction of frost tolerant crops and alternate cash crops (wheat and pyrethrum).

Of the six districts, only 2 (Bogia and Bena) had a high capacity to manage under drought conditions. Bogia has a wider energy food diversity (both cropped and wild), good road access for marketing and the educated residents have the opportunity of wage earning employment in nearby Madang town to support their rural relatives. Similarly, people of Bena had a good road for market access and wage employment in nearby Goroka town. Furthermore, people there have a long history of adapting with suitable cultural practices as the area experiences a 6 month dry season every year. The main energy food crops there are cassava and Kalapua banana (both drought tolerant).

Table 6.1 The strengths, weaknesses, opportunities and risk management capacity of the six districts

Area	Strengths	Weaknesses	Opportunities	Risk management capacity	Remarks
Madang Bogia (Lowlands)	Good sealed road reliable well water, coconut and fish as fall back. Betel nut sales provide income.		Access to wage employment.	High	High level of education / literacy.
Madang Raikos (Lowlands)	Coconut and fish as fall back food.	Road is unusable in the wet season as rivers are unbridged.		Low-Moderate	Limited access to market and services.
Eastern Highlands (Bena)	Road access is fairly good.		Access to some wage employment.	Moderate – High	It has a distinct dry season. People have adapted.
Simbu Highlands (Gumine)		Road access is often bad. Sweet potato and cassava are the only staples.		Low	Garden on steep slopes.
Western Highlands (Tambul)	Good market for vegetables in Mt Hagen.	Crops affected by frost. Sweet potato is the only staple.	To introduce frost tolerant starch crops.	Low	Vegetables are main source of cash income.
Enga Highlands (Kandep)		Crops affected by frost. Sweet potato is the only staple. Vegetable market is not accessible.	To introduce frost tolerant starch crops. Wheat has been introduced as a food and cash crop. The pyrethrum* industry has been revived.	Low	Wheat has been introduced as a food and cash crop. Traditionally, people have migrated during the droughts (frosts).

* The pyrethrum industry produces pyrethrins used to produce insect repellents.

7. Assessment of Farm Performance During Drought

Crop yields declined by up to 80 per cent in the 1997 drought (Allen *et al*., 1997). The CGPRT survey revealed farm yield was significantly reduced for all crop types. The crop types analyzed were staples, perennial crops and cash crops.

Almost 100 per cent of respondents in all 6 districts stipulated the yield of sweet potato was significantly reduced. Furthermore, available tubers were rendered unpalatable, and therefore inedible, by the sweet potato weevil (*Cylas Formicarius).* Sweet potato is the main staple in all 6 districts surveyed. Banana and yam are staples in Gumine/Bena and Raikos/Bogia. While the majority of respondents mentioned yield decline, 13 and 19 per cent reported no yield decline in banana and yam respectively. It is possible this represents varieties that are tolerant to drought conditions. Kalapua bananas (ABB triploid) are drought tolerant (Kambuou, in Kapal, *et al*., 2002).

The respondents from Bogia/Raikos reported that the yield of sago was not affected or only reduced slightly during the 1997 drought suggesting that lives could be sustained with sago if there are sufficient palms and if there is water available for processing. On the contrary, the majority of interviewees in Tambul/Kandep mentioned a significant decline in the yield of karuka nut (*Pandanus Julianettii*).

The majority of respondents in all districts reported a significant decline in the yield of cash crops. These relate specifically to cocoa and coconut in Bogia / Raikos, coffee in Bena / Gumine and pyrethrum in Kandep.

Figure 7.1 Pyrethrum *(Chrysanthemum cinera-riaefolium)* in Kandep, Papua New Guinea

8. Assessment of Coping Strategies and the Preparedness of Affected Communities

Data on income sources, domestic water supply, methods of plant material preservation, famine foods eaten and migration will be presented. Among the total of 96, three from Bena/Gumine and from Tambul/Kandep are omitted due to incompleteness of the data, reduced to depth survey. The comparisons presented are between 3 groups according to altitude range. The groups are Bogia/Raikos, Bena/Gumine and Tambul/Kandep.

8.1 Analysis of income sources

The bulk of the respondents at all 3 altitudes earned money from the sale of food, cash crops and livestock (Table 8.1). Savings and royalty payments* were used as well. The sale of betel nut in Bogia and Raikos districts in Madang Province was important for 59 per cent of respondents there. Fresh fish were also important there. The retail of betel nut provided for 16 per cent of respondents at high altitude (Tambul/Kandep).

Table 8.1 The main income sources during the drought

Source	District							
	Bena/Gumine (29)		Bogia/Raikos (32)		Tambul/Kandep (31)		Total	
	Respondents	%	Respondents	%	Respondents	%	Respondents	%
Food crops	23	79	22	69	26	84	71	77
Cash crops	23	79	29	91	7	22	59	64
Livestock	22	76	18	56	23	74	63	68
Assets	1	3	0	0	0	0	1	1
Savings	4	14	2	6	1	3	7	8
Royalties	1	3	1	3	0	0	2	2
Betel nut	1	3	19	59	5	16	25	27
Fresh fish	0	0	20	62	1	3	21	23
Other	2	7	5	16	3	9	10	11

Note: Some mentioned more than one source of income.

In Table 8.2 it can be seen that there was no difference in income earning ability from food crops or livestock regardless of whether districts had good or poor market access. However, 11 more respondents in districts with poor market access sold cash crops for income. Cocoa and coconut were sold out of Raikos and Bogia, coffee from Gumine and Bena and pyrethrum from Kandep. This was because cash crops are sold dry and worth more per kg (compared to fresh food), so rural farmers were prepared to carry them to distant town markets. On the other hand, while some garden foods in rural areas were sold, most were generally shared or exchanged for other foods with surrounding households.

More respondents from Gumine earned income from food crops than Bena. In the Bogia and Raikos districts of Madang Province, equal numbers of respondents could sell food crops. At high altitude, all 16 respondents interviewed in Tambul sold food crops in nearby Mt Hagen city due to a reliable road system.

* Royalties are payments made to resource or land-owners by developers of logging and mining projects.

Table 8.2 Number of respondents reporting income from various sources

Income source	Bena (13) (G)	Gumine (16) (P)	Bogia (16) (G)	Raikos (16) (P)	Tambul (16) (G)	Kandep (15) (P)	Market access (G)	Market access (P)
Food crops	9	14	11	11	16	10	36	35
Cash crops	11	12	13	16	0	7	24	35
Livestock	10	12	11	7	11	12	32	31
Betel nut	0	1	12	7	3	2	15	10
Fresh fish	0	0	9	11	1	0	10	11

Note: G = Good market access and P = Poor market access.

8.2 Coping with domestic water requirements

Three per cent of total respondents settled near rivers (Bogia/Raikos and Bena/Gumine) (Table 8.3). Bamboo piping and wells were observed in Bogia and Raikos only, therefore reduced carting was reported. The respondents of the Highlands districts of Bena/Gumine and Tambul/Kandep mainly carted water from distant rivers. Coconut water provided an invaluable source of drinking water in the two Madang districts.

Table 8.3 Reported methods of obtaining household water during the drought

Methods	Bena/Gumine (29)		Bogia/Raikos (32)		Tambul/Kandep (31)		Total	
	Respondents	%	Respondents	%	Respondents	%	Respondents	%
Settle near streams and rivers	2	6	1	3	0	0	3	3
Carted water	21	72	16	50	23	74	60	65
Bamboo piping	0	0	4	12	0	0	4	4
Wells	0	0	9	28	0	0	9	10
Coconut	0	0	10	31	0	0	10	11
Others	8	27	3	9	5	16	16	17

Note: The numbers of respondents who did not indicate any way of coping with the water shortage were: Bena/Gumine (5), Bogia/Raikos (9) and Tambul/Kandep (5).

8.3 Plant material preservation

The majority of respondents in Bena/Gumine and Bogia/Raikos saved planting materials for rehabilitation (Table 8.4). However, the majority of Tambul and Kandep respondents did not save planting materials.

There were several methods used to preserve planting materials. It should be noted that in Table 8.5 the majority of respondents at high altitude (Tambul/Kandep) did not save seeds (presumably consumed), in contrast to the respondents of the mid-altitude and lowlands, who did. The majority of respondents saved seeds of annual crops. The respondents of Bogia/Raikos and Bena/Gumine also saved vegetative plant parts in water or swamp areas. The respondents of Tambul/Kandep did not save vegetative plant parts.

Table 8.4 Did you store planting materials during the drought?

	District		
	Bena/Gumine (29)	Bogia/Raikos (32)	Tambul/Kandep (31)
Yes	20	31	8
No	9	1	22
Total	29	32	30

Note: The numbers in brackets show the numbers of people surveyed in each district. One respondent from Tambul/Kandep did not answer.

Table 8.5 Methods of storing planting material by district

Method	Bena/Gumine (29)	Bogia/Raikos (32)	Tambul/Kandep (31)
Store sun dried seeds	10	26	2
Dig ground and bury	2	6	0
Plant in swamp or marsh	5	14	0
Store seeds over fire place	15	23	6
Vegetative parts in water	2	10	0
Low lying areas	3	0	0
Others	0	5	0
Total	37	**84**	**8**

Note: Some used more than one method of storing material

8.4 Famine foods

Respondents from mid to high altitude districts consumed more bush vegetables (Ficus, Ferns and Rungia) than the lowland people surveyed (Table 8.6). Lowland respondents reported consumption of wild energy foods such as taro and yams as well as bush vegetables. The respondents from Bena/Gumine obtained some wild yam but those from Tambul/Kandep did not as the plant does not grow at high altitude. Corms of banana (cultivars Kalapua and Yawa) were consumed as energy food in Bena.

Table 8.6 Main bush/famine foods eaten during the drought

	Bena/Gumine (29)	Bogia/Raikos (32)	Tambul/Kandep (31)
Ficus *Ficus wassa* *Ficus damaropsis*	10	0	8
Ferns	16	1	10
Rungia	2	0	2
Wild taro *Colacasia spp*	0	2	0
Tulip	0	19	0
Kumu mosong	3	13	0
Wild yam *Dioscorea spp*	6	26	0
Kang kong	0	2	0
Others	22	23	17

Note: The number of respondents who did not indicate any bush or famine foods were: Bena/Gumine (3), Bogia/Raikos (1) and Tambul/Kandep (7).

Figure 8.1 *Ficus Damaropsis* tree and fruit in Bena, Papua New Guinea

8.5 Migration

There was more migration (39 per cent) of respondents at high altitude (Tambul/Kandep) than those from lower altitudes (Table 8.7). Only 10 per cent and 16 per cent of respondents reported migration in Bena/Gumine and Bogia/Raikos respectively. People settled at lower altitudes, near towns or district head quarters or in other villages where food could be obtained. Those who migrated to towns sought jobs opportunities there.

Table 8.7 Migration and destination

	District		
	Bena/Gumine (29)	Bogia/Raikos (32)	Tambul/Kandep (31)
Migrate out of area?			
Yes	3	5	12
No	26	27	19
Total	29	32	31
Where to?			
Lower altitude	1	0	8
Near a river	1	3	0
District HQ	1	1	6
Towns/villages	2	0	3
Other villages	3	2	5
Bush	0	4	0
Others	0	0	3

Note: Some respondents nominated more than one location they migrated to.

8.6 The condition of infrastructure and availability of services in 1997 and 2002

The condition of physical infrastructure (roads and bridges) varies widely depending on its location. Half of the respondents recognized it was worse in 1997 than in 2002, while 30 to 40 per cent though the opposite (Table 8.8). The majority of respondents mentioned communication was non-existent then and it is doubtful whether the situation has improved. Social services (health and education) appear to have been better in 1997. About 50 per cent of respondents had no formal or clean water supply and the situation has not improved either. Government administration was considered to be worse or non-existent in 1997 compared to 2002, by the majority of respondents.

Table 8.8 Comparison of infrastructure and services available in 1997 with the 2002 situation

Facility/service	Same	Better	Worse	Non-existent	Total
Roads	9	36	45	0	90
Bridges	10	30	43	5	88
Communication*	3	13	17	49	82
Market facility	23	21	30	13	87
Health	13	44	26	4	87
Education	17	53	18	1	89
Water	12	13	12	43	80
Administration	8	13	23	30	74

* Radio and telephone.

8.7 Food aid received

Respondents in all 6 districts confirmed receipt of food aid. The amount of rice reportedly received did not differ between districts. Between 19–28 kg of rice was distributed to each family during the drought and frosts of 1997 (Table 8.9). It appears a little more flour and

cooking oil was received in Tambul/Kandep and Gumine/Bena respectively. On average, Bogia/Raikos received food once while in Tambul/Kandep up to 3 deliveries were made. Almost 80 per cent of those interviewed expressed that food aid was the most needed commodity during the drought of 1997, followed by water (29 per cent), water containers (23 per cent) and medical supplies (21 per cent).

Table 8.9 Food aid received by respondents in the six districts

Commodity, number of times and quantity delivered	Tambul	Kandep	Bena	Gumine	Raikos	Bogia
Rice						
Average times delivered	2	3.1	1.1	2.4	1.2	1.3
Average quantity (kg)	25	19.4	23.3	22.3	28.5	24
Flour						
Average times delivered	2.6	2.1	1.5	2	1	1
Average quantity (kg)	5.4	8.3	5	5	5	2.5
Cooking oil						
Average times delivered	2.4	2.6	1	1.8	1	1
Average quantity (ml)	268	250	250	397	250	250

8.8 Human health

During the 1997 drought and frosts, respondents in all districts reported sickness but could obtain medicine from health centres (Table 8.10). The majority of those interviewed were affected with stomach aches and dysentery. The reported number of deaths was highest for villages studied in Tambul/Kandep (6). However, it is hard to prove these deaths were caused entirely by the drought and frosts of 1997. While this serves as an indication, the differences between districts surveyed are probably not significant as the numbers of interviewees were so small.

Table 8.10 Reported availability of medicine and gastro-illnesses by respondents

Question response	Tambul (16)	Kandep (16)	Bena (16)	Gumine (16)	Raikos (16)	Bogia (16)
Medicine available in health centres	10	9	12	9	12	13
Respondents who suffered from dysentery	10	9	9	12	14	13
Respondents who suffered from stomach aches	11	9	9	12	15	14
Number of reported deaths	3	3	3	0	2	1

8.9 Discussion

The survey showed that the production of all crop types was reduced significantly during the drought. The coping strategies discussed here are, reliance on various income sources (to buy food and other needs), use of alternate domestic water sources, consumption of bush or famine foods, migration to more favourable environments, supply of food aid and preservation of planting materials (for post drought rehabilitation). The coping strategies documented in this study were consistent with those reported during the Drought Assessments in 1997 (Allen *et al*., 1997 and Bang *et al*., 2003).

The survey showed that of the 6 districts studied, dwellers of high altitude districts (Tambul and Kandep) are most at risk. This is due to the following reasons; the occurrence of frosts, non-availability of energy foods in the wild and limited storage of planting materials for rehabilitation. No preservation of vegetative plant parts was mentioned, probably because frosts would kill them anyway. The post drought period can be a desperate time when people await the harvest of their crops.

At high altitude, sweet potato production is especially vulnerable since drought is usually accompanied by frosts. Frosts destroy planting materials for future crops. The impact of frost on sweet potato production depends on the stage of crop growth when frost occurs and the number of times it occurs (Scoullar, 1972). If frost occurs when the crop is mature, tubers can be consumed right away. If frost occurs when the crop is not yet mature, development of tubers will be delayed. If frosts occur repeatedly the delay in regrowth will be much longer.

This partly explains why a greater percentage (39 per cent) of respondents from Tambul and Kandep migrated during 1997 (Table 8.7). People at high altitude were prioritised to receive food aid more than once and receive planting materials distributed by AusAID during the post drought in 1997-98. Similar support had been given during previous droughts.

The districts least at risk are Bogia and Raikos in Madang Province. The respondents there have energy foods in the wild (Table 9.6), have access to fish and coconut, access to betel nut for sale (Tables 8.1 and 8.2) and are able to store both seeds and vegetative plant parts for rehabilitation (Tables 8.4 and 8.5). In Bogia, one village surveyed has a water well.

While the distinct dry season in Bena and sloping gardens in Gumine are serious vulnerability factors, the respondents there obtained wild yam and were able to store seeds and vegetative plant parts for recovery.

Rural infrastructure (roads, bridges, communication facilities, water supply, etc.) are the basis of coping strategies not only against El Nino-induced drought but also any other natural disaster. Thus, the maintenance and improvement of rural infrastructures is vitually important to enhance the capability of the population.

Food aid such as rice, flour and cooking oil was received in all districts surveyed. The high altitude districts of Tambul/Kandep received rations up to 3 times (Table 8.9), which was more times than the lowland districts. Stomach aches and dysentery were the main health problems experienced due to the lack of food and contaminated water consumed. Although the sample size in each district was too small to draw a reliable conclusion, the number of deaths reported was higher in the high altitude districts (Table 8.10).

So did market access improve the coping ability of people in affected districts? The study showed market access did not influence the sale of food crops, livestock and fresh fish but it influenced the sale of cash crops and betel nut (Table 8.2). Respondents from poor market access districts also sold cash crops to obtain money to pay for their needs because the price per kg obtained for cash crops carted to town was higher than for food crops. Most cash crops, except betel nut, are sold dry whereas most food crops are sold fresh. Food was in demand in both rural and urban areas. Furthermore, due to tribal obligations, people with surplus food shared with the needy, so not all surplus food was sold for cash. This was the case in rural communities where people had very little money.

More respondents of Bogia sold betel nut than Raikos due to road accessibility (Table 9.2). Market access was determined by road or bridge conditions (Table 5.1). Sale of food and livestock did not depend on market access as food was so scarce during the 1997-98 El Nino period. However, comparing Tambul to Kandep, all of the people interviewed from Tambul sold food crops for cash, presumably in nearby Mt Hagen city. In Tambul, broccoli and potato are treated as cash crops. No respondents from Tambul obtained cash from the sale of pyrethrum, whereas seven respondents (44 per cent) from Kandep did.

Table 8.11 presents a summary of the difficulties drought imposed on people in the affected areas in terms of money, water and food.

Table 8.11 Differences in ways of obtaining money, water and food during drought and non-drought times

Item	Non-drought periods	Drought periods
Income	More income earned from food and cash crops. Used fewer savings to purchase food.	Reduced income from sales of food and cash crops. Savings spent on food purchases. Cash support from relatives also spent on foods.
Water	From secluded (uncontaminated) streams, from tanks or village water supply.	Walk long distances to fetch water from swamps or forests. Settle near rivers and boil water to drink.
Food	Consume garden foods and occasional bush foods.	Limited garden food and bush or famine foods. Working relatives send food (rice and flour). Migrate to areas with food.

According to Allen and Bourke (1997), some areas in Papua New Guinea were more vulnerable to food shortages than others. The following points are made about "vulnerable areas":

- The severity of the impact of the 1997 event increased with distance from the equator. Rainfall deficits were worst below 5 degrees south.
- Areas above around 1,800 masl are altitude prone to frost, but the dangers of frost are greatest in the valleys and basins into which cold air can drain and settle. Areas that are regularly frosted are well known locally.
- People with cash savings from the marketing of crops or other cash earning activities, or with relatives with cash, were best able to reduce the impact of the drought.
- People with little or no savings, with few or no relatives in employment, or with no political representation, suffered disproportionately.
- The places where these people live have poor access to services and markets. They are commonly located away from roads, along provincial borders, inland between the highlands and the lowlands, or inland on the larger islands and on most of the small islands. Even in normal times, living conditions in these places are poor and government services minimal.

These descriptions above are true for Raikos, Gumine and Kandep districts surveyed in this study.

9. The Preparedness of Affected Communities for Future El Nino Droughts

The people in the 6 districts surveyed have not had any significant positive changes in their socio-economic or agricultural systems in the past 5 years since 1997. What the people can do is to adopt technologies into their production systems, which would improve their ability to feed themselves. These technologies are presented in the On-Farm Drought Contingency Plans developed by the National Agricultural Research Institute (NARI). The document titled "Drought Response; On-Farm Coping Strategies by Kapal *et al*. (2002)' is available.

Some form of preparedness would help minimize problems like those experienced during the 1997/98 drought that saw 40 per cent of the rural population (1.2 million people) starving.

9.1 Opportunities for managing droughts

Particular characteristics of PNG's climate, environment and food production systems offer opportunities for managing droughts:

- The climate is largely influenced by El Nino Southern Oscillation (ENSO) events. The duration of droughts is usually short and the wet season does not fail to bring rain towards the end of the year.
- There is usually substantial rainfall even during dry years.
- PNG agricultural systems have a large diversity of genetic resources.
- Surface and sub-surface water resources are widespread – the larger rivers do not dry up even if smaller streams do.

The dependence on food aid is neither desirable nor sustainable. Hence, coping strategies to manage droughts are essential. The question to be asked now is whether it is possible to mitigate the impacts of droughts on food supplies in PNG.

9.1.1 Stages of a drought

A drought can be categorized for the purposes of discussion into three stages:

Pre drought:	Period from early warning to the appearance of adverse impacts on crop production.
Mid drought:	Period of complete crop failure.
Post drought:	Period from occurrence of drought breaking rains to first harvest.

These stages should not been seen as fixed and nor will they occur all over PNG at the same time.

9.1.2 Indicators

Internationally, indicators based on rainfall are used to define the stages of a drought. In PNG however, the stages of a drought should be more broadly based, using the following indicators:

Pre-drought:	
Start:	Evidence of strong ENSO event in the Pacific, below average rainfall during the early part of the year, and frosts at high altitudes in the first part of the year.
End:	Crops start to face severe water deficits and further frosts occur.
Mid-drought:	
Start:	Food production is severely restricted by the lack of rain, as confirmed by garden assessments in local areas.
End:	Return of good rains and the cessation of further frosts.
Post-drought:	
Start:	People are replanting large areas of food crops. Rain is falling regularly.
End:	Harvest of the first crops planted after the drought.

Since the stages are not clearly defined, activities should be undertaken to prepare for the drought event. These activities should be more of food supply securing and general health for basic survival. Other necessary actions would include fire, water and livestock management throughout the event.

Preparations should be ongoing activities that are adapted for strategic preparedness and are encouraged given the general attitude of the population.

Strategies compiled are aimed at getting Papua New Guineans to prepare themselves for the drought, coping during the drought and recovering after the event.

9.2 On-farm contingency plans

There are 2 methods of agricultural drought mitigation. One is short-term and the other is long-term.

9.2.1 Short-term

Once a drought has been predicted, contingency plans have to be grouped into the 3 stages in vulnerable areas. Strategies need to be adopted to prepare for the drought and to cope during and after the event (during the onset of rain). Technologies developed by the NARI World Bank Drought Response Project are listed below. Certain activities are recommended for each stage of the drought.

a) Pre-Drought

- Mulching of gardens.
- Maintenance of planting materials.
- Indigenous coping strategies under drought and frost conditions.
- Frost reduction.

b) Mid-Drought

- Tuber storage.
- Livestock management.
- Water management.
- Fire management.
- Sweet potato weevil management.
- Harvesting strategies for tuber crops during drought.

c) Post-Drought

- Plant early maturing sweet potato.

9.2.2 Long-term (strategic preparedness)

There are ongoing technologies that farmers should adopt as El Nino risks become more common. Although the adoption of the technologies would change the subsistence production system, they would improve the food security position of farmers in vulnerable areas. Rural people need to add other crops to their collections that can withstand drought conditions including cassava and drought tolerant cooking banana (Kalapua and Yawa). They should also adopt relevant technologies into their farming systems like growing, processing and the storage of crops like cassava, maize and beans and simple irrigation systems. The long-term strategies recommended for adoption include:

- Drought tolerant sweet potato varieties for the lowlands.
- Drought tolerant sweet potato varieties for the highlands.
- Drought tolerant banana.
- Recommended lowland cassava varieties.
- Recommended highland cassava varieties.
- Processing of cassava.
- Storage and preparation of maize and beans.
- Storage and preparation of corn and other legumes.
- Preservative storage of rice.
- Simple irrigation systems for Papua New Guinea.

The NARI World Bank Drought Response Project selected drought tolerant and early maturing varieties of sweet potato for lowland and highland farming systems. The project has also selected high yielding cassava varieties with low cyanide for both lowlands and highlands. Crop germ plasms at NARI research stations contain drought tolerant varieties of banana. Simple irrigation systems have been imported and tested under the project. A trial on mulching showed an increase in sweet potato yield.

NARI will start research on technologies for frost mitigation in 2003 under a project funded by the European Union.

10. Relevant National Plans of Action for Future El Nino Induced Drought

In PNG, the Director General of the National Disaster and Monitoring Office, based on advice from the National Weather Service, issues the warning of a drought. Following that, a National Agricultural Drought Response Committee implements short and long term On-Farm Contingency Plans developed by agricultural institutions such as the National Agricultural Research Institute.

As part of the national strategy, rainfall monitoring would reveal which provinces or districts are most vulnerable and therefore, receive attention first. Agricultural Drought Mitigation would be administered through the Provincial Food Security Committees or the Provincial Disaster Committees. Activities would include work-shopping contingency plans, demonstrating food processing and storage, and irrigation systems.

What is important is that people at all levels (district, provincial and national) of the country operate in cohesion as they move through the stages of drought.

Listed below are activities that would be undertaken once a drought warning has been issued and until the drought is over.

Pre-Drought

1. Drought Warning issued by the National Disaster and Monitoring Office (NDMO) on advice from the National Weather Service (NWS).
2. Identification of vulnerable areas by the National Agricultural Drought Response Committee (NADRC) with assistance from NWS and NDMO.
3. Initiate Drought Awareness Programs by the National Agricultural Drought Response Committee (NADRC). Distribute information (farmer pidgin bulletins) regarding on-farm coping strategies.
4. Distribute drought tolerant varieties of crops and set up simple water pumps and food processing by NADRC through the Provincial Food Security (or Disaster) Committees.

Mid-Drought

5. Identify food shortages in vulnerable areas by NADRC.
6. Send out food assessment teams from NADRC and NDMO to areas where food shortages are life threatening. Assistance will be sought for affected provinces. (Training of assessment teams is a necessary pre-requisite)
7. Decide on the vulnerability of food shortages in assessed areas and provide food aid only where absolutely necessary.

Post-Drought

8. NADRC to distribute early maturing crop varieties during post drought through Provincial Food Security (or Disaster) Committees.
9. Monitor rainfall received throughout the country and collate information on recovery.

11. Conclusions and Recommendations

11.1 Conclusions

The study concluded that the people of Tambul and Kandep districts were most vulnerable, which suggests people in high altitude areas of PNG are more at risk during and after a drought, during which time frosts also occur. The natural endowments in these areas do not provide the inhabitants the necessary requirements to sustain life when traditional food gardening is not possible. The lack of suitable agricultural technologies is another concern.The National Agricultural Research Institute (NARI), with support from the World Bank, has completed a project aimed at the development and adaptation of technologies to manage drought impacts and frosts in PNG. Both short and long term coping strategies developed by this project and contributions from others are contained in the document entitled " Drought Response; On-Farm Coping Strategies" by Kapal, Bang, Askin and Allen (2002).

While food aid programs provide short-term relief, they cannot be the long-term solution. The long-term solution lies in developing coping strategies and adaptive mechanisms aimed at loss reduction and better preparedness.

11.2 Recommendations

An ongoing implementation program of long-term on-farm coping strategies in vulnerable areas is necessary, especially in high altitude highland areas (2000–2800 metres above sea level), as droughts (and frosts) become more frequent. This should include the introduction of suitable agricultural technologies. Frost mitigation strategies are necessary and all weather roads are essential to access markets and for the delivery of food aid. The drought (and frost) response mechanism should be clearly defined for implementation in these vulnerable areas.

The following are other recommendations by Bang, Poloma and Allen (2002) based on the assessment of the 1997 drought in Papua New Guinea.

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 needs to be funded adequately so that it does not have to charge exorbitant prices for its data.

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.

Recommendation 3

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

Accessibility to market is crucial as people would have cash to purchase food 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.

Recommendation 4

It is recommended that the National Agricultural Research Institute 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 (frost) 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.

Recommendation 5

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

High value-to-weight products such as chillies should be investigated. Cash earnings proved to be the best possible drought mitigation measure in 1997.

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 and wheat can be used.

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

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Appendix

Appendix 1. Information on the Districts Surveyed

Information on the districts surveyed was obtained from the book by Hanson, L.W, B.J, Allen, , R.M, Bourke and T.J, McCarthy, (2001) titled “Papua New Guinea Rural Development Handbook”.

1.1 Tambul-Nebilyer district

Tambul-Nebilyer district is in the southwest of the Western Highlands Province and covers the Kaugel and Nebilyer valleys, the northern slopes of Mt Giluwe and the southern extent of the Kubor Range. Average annual rainfall ranges between 2,300 and 4,000 mm, increasing from northwest to southeast. Altitude varies from 800 m in the lower Kaugel Valley, to over 4,000 m on the upper slopes of Mt. Giluwe. Most people live between 1,200 and 2,800 metres.

1.1.1 Population

The estimated rural population in the year 2000 was 59,000. The highest population density is in the upper Nebilyer Valley with 170 persons/km^2. The upper Kaugel Valley around Tambul has a density of 115 persons per km^2, while the lower Nebilyer Valley has 90 persons per km^2. Most of the Kubor Range is unoccupied. The Kaugel Valley has significant in-migration as people seek better access to services and more productive environments. The population of the Tambul Census Division increased by 4.2 per cent per year between 1980 and 1990.

1.1.2 Access to services

People in the upper Nebilyer Valley require less than one hour's travel to reach Mt Hagen, while those in the lower Nebilyer and Kaugel valleys require up to four hours travel. A branch road of the Highlands Highway runs from Togoba to Wabag. Other roads extend to Tambul and south into Southern Highlands Province.

1.1.3 Income

Incomes are high in the Nebilyer Valley and are derived from the sale of coffee and fresh food. Coffee plantations provide some wage employment. People in the high altitude areas of the Kaugel Valley earn moderate incomes from the sale of potato, other fresh food and firewood.

1.1.4 Subsistence agriculture and nutrition

Agriculture in the Kaugel Valley is characterized by high intensity sweet potato cultivation. Crop production is maintained through the use of composting, tillage and mounding. In the Nebilyer Valley, people cultivate moderate intensity sweet potato gardens with 6-14 consecutive plantings before a fallow period of 5-15 years. Land improvement practices consist of peanut rotations, drainage and bedding. In the 1982-83 National Nutrition Survey, malnutrition in children under five years was assessed as relatively low; 35 per cent of children were stunted and four per cent were seriously under weight.

1.1.5 Land potentials

Land potential in the Nebilyer Valley is very high and the land in this area is among the most productive in PNG. Land improvement practices such as drainage, bedding and peanut rotations maintain production. The flatter land of the Kaugel Valley has very high potential constrained by low temperatures, while the upper slopes have low to moderate potential due to steep slopes, frequent cloud cover, low temperatures and frost. The Kubor Range has low potential because of steep slopes, frequent cloud cover and high rainfall.

1.1.6 Agricultural pressure and potential

There is strong agricultural pressure on the upper slopes of the Kaugel Valley, south of Tambul, as a result of very high intensity agriculture being practiced in a low potential environment. Soil erosion and soil fertility decline result in declining crop yields. Severe frost damage also disrupts food supply. There is moderate agricultural pressure in other upper slope areas of the Kaugel Valley and marginal pressure near Siapangi. There is potential for further agricultural development in the Nebilyer Valley given the very high land potential, lack of agricultural pressure and good access to markets. Coffee and fresh food are established smallholder cash-earning activities in this area.

1.1.7 Disadvantaged people

The most disadvantaged people in the district are those on the upper slopes of the Kaugel Valley, south of Tambul, where there are very high population densities and strong agricultural pressure. People are vulnerable to the effects of land shortages, land degradation; declining crop yields, frost damage and food shortages. All other upper slope areas of the Kaugel Valley have very high population densities and moderate agricultural pressure. Overall, people in Tambul-Nebilyer district are not disadvantaged relative to people in other districts of PNG. There is some agricultural pressure, land potential is very high, access to services is good and cash incomes are moderate.

1.2 Kandep district

Kandep district is in the south of the province and covers the Wage Valley, high altitude swamps and plains of the Kandep Basin and surrounding mountains. Average annual rainfall ranges between 2,200 and 2,800 millimetres. Attitude varies from 2,000 m near Winja in the south of the district, to over 3,500 m on the mountain peaks. This is the only district in the country where all areas are over 2,000 m in altitude.

1.2.1 Population

The estimated rural population in the year 2000 was 66,000. The fringe areas of the Kandep Basin have the highest population density with 175 persons/km^2. Areas in the Wage Valley have 85 persons/km^2. Unoccupied mountains cover much of the western half of the district.

1.2.2 Access to services

All people in the district require 4-8 hours travel to Wabag. There is a good road network in the Kandep Basin, connecting to Laiagam in the north and Margarima and Mendi in Southern Highlands Province.

Income

Incomes are low in the entire district and are derived from minor sales of fresh food, particularly potato.

1.2.4 Subsistence agriculture and nutrition

Agriculture in the Kandep Basin and Wage Valley is characterized by high intensity sweet potato production. Potato is also an important crop. Cultivation is continuous and production is maintained through the use of land improvement practices such as drainage, composting and mounding. Small amounts of inorganic fertilizer are used on some commercial potato gardens. The high attitude and low temperatures limit crop diversity, slow plant growth and rates of production. In the 1982-83 National Nutrition Survey, malnutrition in children under five years was assessed as poor; 46 per cent of children were stunted and four per cent were seriously under weight.

1.2.5 Land potential

The land potential is very low to low throughout the entire district because of long-term inundation in swamp areas, poor soils, frequent cloud cover, low temperatures and frost. In some agricultural areas north of Kandep and in the Wage Valley, the land potential increases to very high where swamps have been drained, making fertile organic soils usable. However, in most agricultural areas, production is maintained through the use of land improvement practices such as drainage, composting and mounding.

1.2.6 Agricultural pressure and potential

Most areas in the district have strong agricultural pressure resulting from intensive agriculture being practiced in low potential environments. Land degradation of various forms and reduced crop yields are common problems. Some fringe areas in the Kandep Basin have moderate agricultural pressure. There is little potential for agricultural development in the district.

1.2.7 Disadvantaged people

The most disadvantaged people in the district are those in the fringe areas of the Kandep Basin and Wage Valley, where population densities are high to very high, agricultural pressure is strong and incomes are low. Large numbers of people are vulnerable to the effects of land degradation, reduced crop yields, frost and food shortages, and have limited cash to purchase supplementary food. The impact of the drought and frosts of 1997 was severe in the district. Possible solutions could focus on improving subsistence production and resilience through the extension of frost-tolerant crop varieties, and raising cash incomes. Potato is an established smallholder cash-earning activity and pyrethrum has been important in the past. Overall, people in Kandep district are extremely disadvantaged relative to people in other districts of PNG. There is strong agricultural pressure, land potential is low, access to services is moderate and cash incomes are low.

1.3 Gumine district

Gumine district is in the central west of the province and covers the Wahgi, Maril and Mon valleys in the north and the mountains of the Oima-Maril Divide in the south. Average annual rainfall ranges between 2,400 and 3,700 mm, increasing from north to south. Altitude ranges from 700 m in the lower Oima Valley, to over 4,000 m on Mr Kubor. Most people live between 1,400 and 2,000 metres.

1.3.1 Population

The estimated rural population in the year 2000 was 31,000. The highest population densities are in the Wahgi, Mon and Maril valleys with 111 persons/km^2. The mountains of the Oima-Maril Divide have a low population density of 14 persons/km^2. The mountains in the northwest and southwest of the district are unoccupied. There are areas of significant out-

migration such as the Wikauma Census Division where the population decreased by 3.6 per cent per annum between 1980 and 1990.

1.3.2 Access to services

People in the Wahgi, Mon and Maril valleys require less than four hours travel to reach Gumine or Kundiawa. People in the Oima-Maril Divide require 4-8 hours travel to the nearest service centre. An all-weather road links Gumine to Kundiawa. There is a poor quality road that runs up the Mon Valley and another that runs southeast towards Kilau and Nomane.

1.3.3 Income

Incomes are low in the Wahgi, Mon and Maril valleys and are derived from the sale of coffee and fresh food. People in the Oima-Maril Divide have very low incomes.

1.3.4 Subsistence agriculture and nutrition

Agriculture in the Waghi, Mon and Maril valleys is characterized by moderate intensity sweet potato production. There are 3-5 consecutive plantings before a fallow period of 10-15 years. Production is maintained through the planting of Casuarina trees in fallows, and the use of soil retention barriers and small mounds in gardens. People in the Oima-Maril Divide cultivate low intensity sweet potato gardens with only one planting before a fallow period of 15 years. Small mounds are widely used. In the 1982-83 National Nutrition Survey, malnutrition in children under five years was assessed as fair; 44 per cent of children were stunted and less than one per cent were seriously under weight.

1.3.5 Land potential

The land potential in the Mon and Maril valleys is high, but some areas are constrained by steep slopes and frequent cloud cover. There are some isolated areas of very high potential land in the Wahgi Valley on the northern border of the district. Otherwise, most of the Wahgi Valley has moderate potential constrained by steep slopes and frequent cloud cover. The Oima-Maril Divide has very low to low potential because of steep slopes, frequent cloud cover and low temperatures at higher attitudes.

1.3.6 Agricultural pressure and potential

There is moderate agricultural pressure on the upper slopes of the Mari Valley south of Gumine as a result of moderate intensity agriculture being practiced in a low potential environment. In other parts of the Maril Valley, there is marginal pressure, but this will only be of concern if agriculture continues to intensify without the adoption of suitable management practices. There is potential for agricultural development in most parts of the Wahgi, Mon and Maril valleys where there is moderate to very high land potential, little agricultural pressure and good access to markets. Coffee and fresh food production are established smallholder cash-earning activities in these areas, but land shortages caused by high population densities may limit further development.

1.3.7 Disadvantaged people

The most disadvantaged people in the district are those in the Oima-Maril Divide, where people live in low potential environments and earn very low incomes. However, population densities are low and the number of people affected is small. The area of moderate agricultural pressure south of Gumine also has very high population densities and people there are vulnerable to the effects of land degradation and declining crop yields. Overall, people in Gumine are moderately disadvantaged relative to people in other districts of PNG. There is some agricultural pressure, land potential is moderate, access to services is good and cash incomes are low.

1.4 Unggai-Bena district

Unggai-Bena district is centred on the Bena Bena Valley with the Bismarck Range in the north and the Unggai Range in the southwest. Average annual rainfall varies between 1,800 and 2,800 mm, with moderate dry seasons. The Bena Bena Valley lies within an altitudinal range of 1,400-1,600 m, with Mt Unggai rising to 2,400 m in the southwest and Mt Helwig rising to 2,700 m in the north.

1.4.1 Population

The estimated rural population in the year 2000 was 31,000. The highest population density of 62 persons/km^2 is found in the Bena Bena Valley, while the lowest of 13 persons/km^2 is found on the slopes of Mt Helwig. The Unggai Range has a population density of 52 person/km^2.

1.4.2 Access to services

The Highlands Highway runs through the centre of the district and roads run from the highway to most of the occupied areas of the district. Other than the remote northern villages near Mt Helwig where people require 4-8 hours travel to reach the nearest service centre, most people are within four hours travel of Goroka.

1.4.3 Income

Incomes are high in the Bena Bena Valley and are derived from the sale of coffee and fresh food. People in the Unggai Range area have moderate incomes, while people in the remainder of the district earn very low incomes, particularly those in the Mt Helwig area.

1.4.4 Subsistence agriculture and nutrition

Agriculture in the Bena Bena Valley is intensive and is dominated by the production of sweet potato. There are 3-5 consecutive plantings before a fallow period of 1-4 years. Production is maintained through the use of peanut rotational tillage, small mounds and drainage. People in the Unggai and Bismarck ranges cultivate low intensity sweet potato gardens, supported by small mounds, tillage and drains. In the 1982-83 National Nutrition Survey, malnutrition in children under five years was assessed as relatively low; 35 per cent of children were stunted and less than two per cent were seriously under weight.

1.4.5 Agricultural pressure and potential

There are minor areas of strong agricultural pressure on the steep slopes of the Bena Bena Valley where moderate intensity agriculture is practiced in a very low potential environment. Various forms of land degradation and reduced crop yields are common. There are significant areas of marginal agricultural pressure on the lower slopes of the Bena Bena Valley, however, these areas will be of concern only if agriculture continues to intensify without the adoption of suitable management practices. There is potential for agricultural development in parts of the Bena Bena Valley where there is very high potential land, no agricultural pressure and good access to markets.

1.4.6 Disadvantaged people

The most disadvantaged people in the district are those on the slopes of Mt Helwig where a very small number of people live in a low potential environment and earn very low incomes. These people have few opportunities to improve their livelihoods. People in the strong agricultural pressure areas of the Bena Bena Valley are vulnerable to the effects of land degradation, reduced crop yields and food shortages. However, incomes are high enough for people to purchase supplementary food. People in the Unggai Range live in a low potential environment. Overall, people in Unggai-Bena district are not disadvantaged relative to people in

other districts of PNG. There is limited agricultural pressure, land potential is moderate, access to services is good and cash incomes are high.

1.4.7 Land potential

The land potential on the plains and hills of the Bena Bena and the lower Asaro valleys is very high. There are also isolated pockets of very high potential land west of Mt Unggai. Land in the remainder of the district ranges from very low to moderate potential. Common limitations in the mountains are steep slopes, poor soils, frequent cloud cover and low temperatures. Common limitations in the valleys are poor soils and seasonal flooding.

1.5 Rai Coast district

Rai Coast district covers Long Island, the Rai Coast, and the Finisterre Range. Long Island is an active volcano, which is thought to have erupted catastrophically about 350 years ago. Average annual rainfall ranges between 2,000 and 3,400 mm, and increases from east to west. There is a long dry season in the east of the district. Altitude varies from sea level to over 3,800 m at the top of the Finisterre Range. Agriculture is practiced up to 2,600 m near Teptep.

1.5.1 Population

The estimated rural population in the year 2000 was 44,000. The high valleys on the northern side of the Finisterre Range around Teptep, Gwarawon and Tariknam have population densities that average 50 persons/km^2. The Rai Coast and Long Island have average densities of 25 persons/km^2, while the valleys on the southern side of the Finisterre Range have 18 Persons/km^2.

1.5.2 Access to services

People on the Rai Coast require around four hours travel to reach Madang town, whereas those in the Finisterre Range require up to eight hours travel. During the wet season, travel times from the Rai Coast to Madang rise significantly because of flooded unbridged rivers. Long Island is 70 km from Saidor and 130 km from Madang. It is the most remote part of the district as small boat travel is expensive and dangerous from December to March. People in the Finisterre Range are very remote and must walk to roads on the Rai Coast and in the Ramu Valley.

1.5.3 Income

Incomes are very low in most of the district and are derived from minor sales of betel nut, cocoa and copra. Incomes are low on Long Island. Some coffee and tobacco is sold in the Teptep and Gwarawon areas.

1.5.4 Subsistence agriculture and nutrition

Agriculture on the Rai Coast is dominated by low intensity mixed crop cultivation. Chinese taro, banana, coconut, taro and yam are important crops. One planting is made before a fallow period of 5-15 years. People in the northern valleys of the Finisterre Range cultivate low intensity sweet potato gardens; where those around Teptep area cultivate moderate intensity sweet potato gardens in which composting, tillage and ridging are used to maintain production. People in the southern valleys of the Finisterre Range cultivate low intensity banana and sweet potato gardens; while those living on Long Island make low intensity taro and yam gardens. In the 1982-83 National Nutrition Survey, malnutrition in children under five years was assessed as serious; 62 per cent of children were stunted and five per cent were seriously under weight.

1.5.5 Land potential

The land potential on the coastal plains of Long Island is high in many areas but restricted by a long dry season and an active volcano. The Rai Coast has low to moderate potential due to poor soils, a long dry season and seasonal flooding. The lower valleys of the Finisterre Range, on both the northern and southern sides of the range, have low potential, while the upper valleys and slopes have very low potential. Common constraints are steep slopes, frequent cloud cover, low temperatures and poor soils.

1.5.6 Agricultural pressure and potential

The area around Teptep has strong agricultural pressure as a result of moderate intensity agriculture being practiced in a very low potential environment. There are some opportunities for agricultural development along the Rai Coast.

1.5.7 Disadvantaged people

The most disadvantaged people in the district are those around Teptep where small numbers of people experience strong agricultural pressure and earn very low incomes. People are vulnerable to the effects of land degradation, declining crop yields, frost and food shortages, and have limited cash to purchase supplementary food. Large numbers of people in the northern valleys of the Finisterre Range are constrained by low potential environments and very low incomes. People in the southern valleys of the Finisterre Range occupy very low potential environments. Overall, people on the Rai Coast are extremely disadvantaged relative to people in other districts of PNG. There is some agricultural pressure, land potential is low, access to services is moderate and cash incomes are very low. Child malnutrition is of concern.

1.6 Bogia district

Bogia district is dominated by the floodplains of the lower Ramu River, the hills of the Ruboni Range and the mountains of the Adelbert Range; raised coral limestone plains extend from Hansa Bay along the coast to the eastern border of the district. Manam Island, an active volcano, is 15 km off the coast, as is the smaller Boisa Island. Average annual rainfall ranges between 2,000 and 3,000 mm and decreases from north to south. There is a long dry season. Altitude in most of the district is below 300 m with a few peaks such as Mt Uvo exceeding 800 metres.

1.6.1 Population

The estimated rural population in the year 2000 was 46,000. Boisa Island has the highest population density with 230 persons/km^2. Manam Island also has a very high density of 120 persons/km^2. The remainder of the district averages 20 persons/km^2. The Ramu floodplain and Adelbert Range are largely unoccupied. The coastal plains east of Cape Gourdon have significant in-migration. The population of the Ulingan Census Division increased by four per cent per year between 1980 and 1990.

1.6.2 Access to services

Most people in the district are within 4-8 hours travel of Madang town. A good road links Bogia to Madang, while a more recent road runs south from Bogia to Josephstaal.

1.6.3 Income

Incomes are very low to low throughout the entire district and are derived from minor sales of fresh food, cocoa and copra.

1.6.4 Subsistence agriculture and nutrition

Agriculture in the Ruboni Range and in the valleys of the Adelbert Range is characterized by low intensity taro and yam cultivation. People on the Ramu floodplain depend on sago production, which is supplemented by coconut and low intensity mixed staple gardens on higher ground. Much of this land is flooded every year by the seasonal rise of the Ramu River. On Manam Island, people cultivate low intensity sweet potato and taro gardens. Agriculture on the coastal plains of the mainland is dominated by moderate intensity sweet potato and yam gardens. Here, there are 3-5 consecutive plantings before a fallow period of 5-15 years. Drainage, tillage and small mounds are used to improve land productivity. In the 1982-83 National Nutrition Survey, malnutrition in children under five years was assessed as poor; 27 per cent of children were stunted and nine per cent were seriously under weight.

1.6.5 Land potential

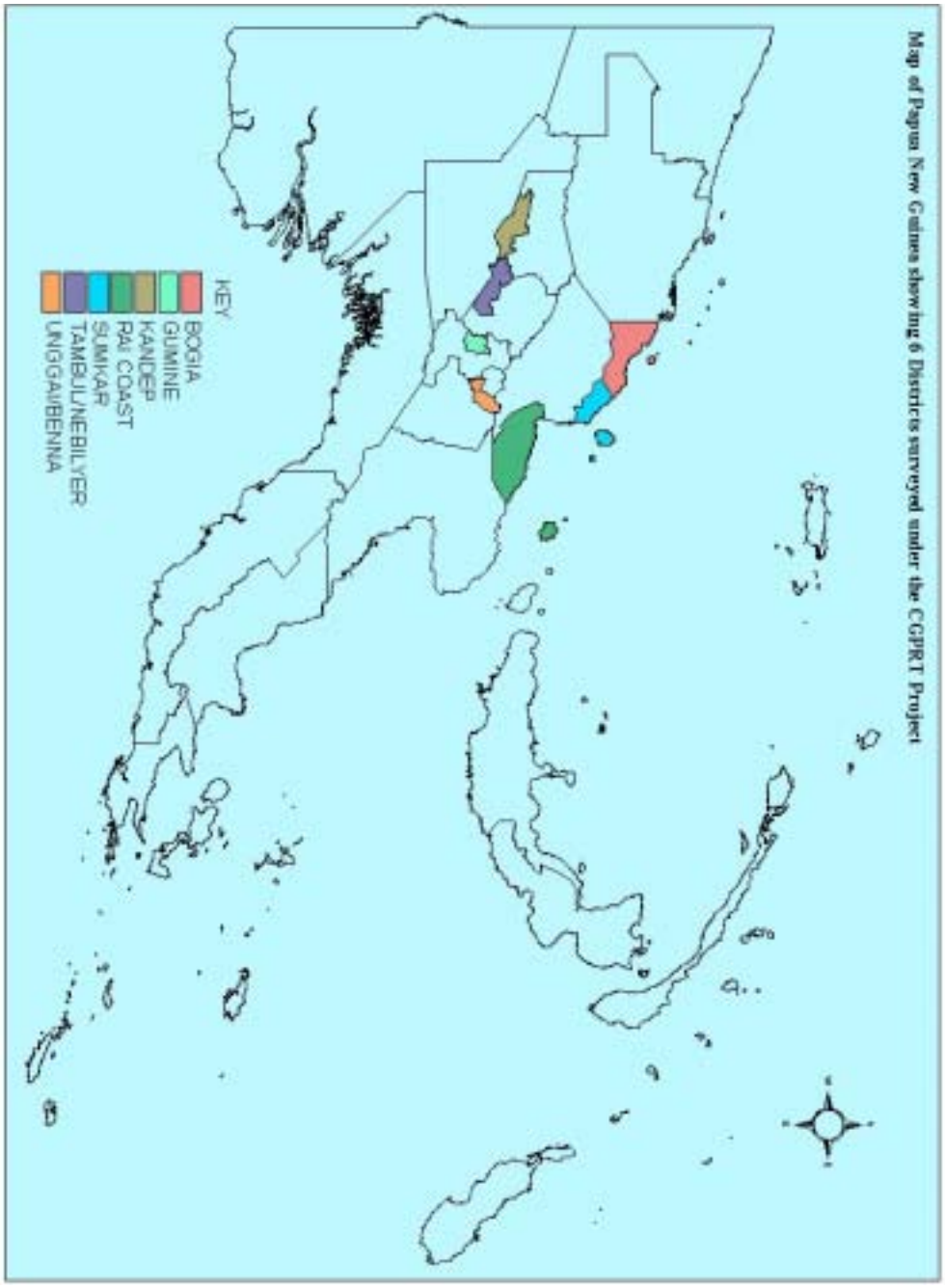
The land potential on Manam Island and in the Ruboni Range is moderate due to steep slopes and a long dry season. However, Manam is an active volcano and in the last 40 years people have twice been evacuated from the island during eruptions. The coastal plains have low to moderate potential, which could be significantly improved if drainage and soil fertility constraints are overcome. The Ramu floodplain has very low to low potential because of annual flooding and poor soils. However, isolated flood-free levees and terraces have good soils and high potential. The Adelbert Range has low potential due to steep slopes, frequent cloud cover and poor soils.

1.6.6 Agricultural pressure and potential

There is marginal agricultural pressure inland of Bogia and on Manam Island. These areas will be of more concern if agriculture continues to intensify in the absence of suitable management practices. The best opportunities for agricultural development are in the Ruboni Range and coastal plains, where there is moderate land potential and relatively good access to markets. The development of smallholder cocoa production is a strong possibility given that the cocoa industry is already established in the province and is supported by research and extension activities. Fresh food and betel nut are also established smallholder cash-earning activities in these areas.

1.6.7 Disadvantaged people

The most disadvantaged people in the district are those on the Ramu floodplain who are constrained by very low incomes and low potential environments. Overall, people in Bogia are moderately disadvantaged relative to people in other districts of PNG. There is little agricultural pressure, land potential is moderate, access to services is moderate and cash incomes are low.


Map of Papua New Guinea showing 6 Districts surveyed under the CGPRT Project
KEY
BOGIA
GUMINE
KANDEP
RAI COAST
SUMKAR
TAMBUL/NEBILYER
UNGGAI/BENNA

Appendix 3. Villages surveyed

3.1 Tambul district

Local level government	**Ward number**	**Village**
Giluwe	1	Maltaka
Giluwe	4	Maltaka Tekep 2
Giluwe		Malke
Giluwe	1	Laigam
Giluwe	2	Pulmong
Giluwe		Pukumung
Giluwe	3	Kerepia No. 3
Giluwe	2	Kerepia
Giluwe	3	Pakepena

3.2 Kandep district

Local level government	Ward number	Village
Kandep	**24**	**Lakis**
Kandep	**9**	**Longap**
Kandep	**17**	**Lauwe**
Kandep		**Palimai**
Upper Wage	**07**	**Mokale**
Upper Wage	**06**	**Taitans**

3.3 Gumine district

Local level government	Ward number	Village
Gumine	1	Tagla
Gumine	2	Omkolai
Gumine		Bonki
Gumine		Derimal
Gumine	8	Derima
Gumine	4	Gomgale
Gumine	13	Polma
Koma / Bomai	10	Boromil

3.4 Bena District

Local Level Government	Ward Number	Village
Ungai Bena	20	Kintinu
Ungai Bena	20	Lampo
Ungai Bena	3	Upegu
Unggai Bena	5	Bagaihinupa
Unggai Bena	4	Foii
Unggai Bena	4	Kapo Kamerigi
Bena Bena	20	Kinibonu

3.5 Raikos district

Local level government	Ward number	Village
Saidor	1	Kui
Saidor	30	Mindere
Saidor	11	Yaimas
Saidor	13	Biliau
Astrolobe Bay	1	Kumisangarl
Astrolobe Bay	2	Marakum
Astrolobe Bay	2	Rimba
Astrolobe Bay	2	Kumigangel

3.6 Bogia district

Local level government	Ward number	Village
Almami	34	Ulingan
Almami	22	Rarin
Almami	21	Susuwe
Almami		Wakormai
Almami	35	Toto
Almami	25	Aketa
Almami	36	Medebuk
Almami	8	Karem
Sumgilbar	1	Suwabun
Sumgilbar	8	Sarang # 1
Sumgilbar	8	Sarang # 2