



# **DROUGHT RESPONSE: ON-FARM COPING STRATEGIES**



**Compiled by Debbie Kapal, Sergie Bang, Dave Askin and  
Bryant Allen**

*May 2003*

*NARI INFORMATION BULLETIN No.6*

*ISBN 1980-932-26-0*



# Drought Response: On-farm coping strategies

## TABLE OF CONTENTS

Acknowledgements	v
Summary	1
1. Introduction	2
1.1 Food in Papua New Guinea (PNG)	2
1.2 PNG Food Production Systems	3
1.2.1 Shifting cultivation systems	3
1.2.2 Continuous production systems	3
1.2.3 Sago systems	4
1.3 Causes of Food Shortages	5
1.4 El Niño-Southern Oscillation (ENSO) and PNG	5
1.4.1 The Southern Oscillation Index (SOI)	7
1.4.2 How often do severe ENSO events occur and can their impact on PNG food production systems be predicted?	8
1.5 How Does a Severe ENSO Event Affect Food Production in PNG?	10
1.5.1 Shifting cultivation systems	10
1.5.2 Continuous cultivation systems	10
2. Identification and Assessment of Food Shortages	13
2.1 The Identification of Food Shortages	13
2.2 The Assessment of Food Shortages	14
2.3 Vulnerable Areas	15
3. Stages of Drought Response	17
3.1 Drought Response Stages	17
3.1.1 Opportunities for managing droughts	17
4. Short Term Coping Strategies	19
4.1 Pre-drought	19
4.1.1 Mulching of gardens	19
4.1.2 Maintenance of planting materials	20
4.1.3 Indigenous coping strategies under drought and frosts	23
4.1.4 Frost reduction	29
4.2 Mid-drought	31
4.2.1 Tuber storage	31
4.2.2 Livestock management	32
4.2.3 Water management	34
4.2.4 Fire management	36

4.2.5 Sago .....	37
4.2.6 Sweet potato weevil management.....	38
4.2.7 Harvesting strategies for tuber crops during drought.....	42
4.3 Post-drought.....	43
4.3.1 Early maturing sweet potato for the PNG lowlands .....	44
4.3.2 Early maturing sweet potato for the highlands of PNG .....	45
5. Long Term Strategies (Strategic Preparedness) .....	47
5.1 Drought Tolerant Crops .....	47
5.1.1 Drought tolerant sweet potato varieties for the lowlands of PNG .....	47
5.1.2 Drought tolerant sweet potato for the highlands of PNG.....	49
5.1.3 Drought tolerant banana .....	50
5.1.4 Recommended lowlands cassava varieties.....	52
5.1.5 Recommended highlands cassava varieties .....	54
5.2 Post harvest storage and use of various foods in PNG.....	57
5.2.1 Processing of cassava .....	57
5.2.2 Storage and preparation of maize and beans.....	59
5.2.3 Storage and preparation of corn and some legumes.....	61
5.2.4 Preservative storage of rice.....	62
5.3 Simple Irrigation Systems for Papua New Guinea .....	65
5.3.1 Introduction .....	65
5.3.2 Available systems .....	65
6. Technology Demonstrations .....	69
7. Contingency Planning: schedule of activities .....	70
Annex 1. Drought Assessment Map 1997 .....	71
Annex 2. World Bank Drought Response Project Report .....	72
Background.....	72
Objective .....	72
Achievements.....	72
Component 1 - Crops and cultivars tolerant to drought and frost: .....	72
Component 2 - Soil and water management technologies including simple irrigation systems:.....	77
Component 3 - Early warning and contingency plans:.....	77
Component 4 - On-farm trials:.....	78
Annex 3. CGPRT El Nino Project Annual Report 2002 .....	80
Objective .....	80

National impact assessment and mitigation measures of the 1997 drought in Papua New Guinea. ....	80
Indigenous drought coping strategies and risk management in Papua New Guinea. ....	80
Workshop paper submitted .....	80
Annex 4. List of Contributors .....	81

## TABLE OF TABLES

Table 1 Most important foods in PNG .....	2
Table 2: Impact of frost on sweet potato at high altitudes and of excessive rain ..	12
Table 3: Description of the districts surveyed.....	23
Table 4: Gardening practices adopted under drought conditions. ....	24
Table 5: Gardening practices adopted to minimise frost damage.....	24
Table 6: Methods used to preserve planting materials during drought. ....	25
Table 7: Practices adopted to cope with water shortage for domestic use .....	26
Table 8: Famine and alternative foods eaten to survive the drought and frost.....	27
Table 9: Socio-economic measures to cope with the impact of drought and frost .....	28
Table 10: The results of some experiments with cultural practices for Sweet Potato Weevil control.....	41
Table 11: Yield of early varieties at 13 weeks after planting.....	44
Table 12 Recommended early maturing sweet potato varieties for the lowlands ..	44
Table 13: Mean yield of early maturing highlands sweet potato varieties at 4 months after planting .....	45
Table 14: Recommended early maturing sweet potato varieties for the highlands .....	46
Table 15: Yield of the selected lowland sweet potato varieties under normal and dry soil conditions .....	47
Table 16: Recommended drought tolerant varieties for the lowlands .....	48
Table 17 Yield of these sweet potato varieties under dry soil conditions.....	49
Table 18: Recommended sweet potato varieties for the highlands .....	50
Table 19: Yield, protein and cyanide content of 4 selected Cassava varieties.....	53
Table 20: Recommended lowlands cassava varieties.....	54
Table 21 Selected highlands cassava varieties and their characteristics.....	55
Table 22 Recommended highlands cassava varieties.....	56
Table 23: Selected Highlands Sweet Potato Varieties and their Characteristics. ....	73
Table 24: Selected Lowlands Sweet Potato Varieties and their Characteristics ..	74
Table 25: Provisional Selected Highlands Cassava Varieties and their Characteristics.....	75

Table 26: Selected Cassava Varieties for the Lowlands and their Characteristics.	76
--	----

## TABLE OF FIGURES

Figure 1 Drought in Afore, Oro Province 1997.- Collecting water- a time to share and enjoy. Not everyone was lucky enough to have a vehicle to cart their water.	v
Figure 2 The “normal” circulation of air over the Pacific (the Walker Circulation) and circulation during an ENSO event.	7
Figure 3: Southern Oscillation Index 1997-2002	8
Figure 4 Afore District, Oro Province, during 1997 drought, fire caused long term damage to timber and also destroyed many gardens.	9
Figure 5: Effect of frost on sweet potato at high altitudes and rain at all altitudes	11
Figure 6 AusAid supplied helicopter delivering emergency food supplies during 1997 drought. Photo- D. Wissink.	14
Figure 7 Young people enjoying bush foods during drought, 1997. Are we making sure that these bush foods are planted and growing so that during a drought we also have options in terms of various kinds of food?	16
Figure 8 Containers to store seeds in	21
Figure 9 Keeping plant material alive, Tumolbil, Telefomin District, 1997.	25
Figure 10 Houses such as these in Tifalmin were very susceptible to fire during the 1997 drought.	26
Figure 11 Fire during drought destroys homes, gardens, forest, animals and plants. (Telefomin District, 1997, D.Askin)	36
Figure 12 Sweet potato weevil	38
Figure 13 Sweet potato weevil damage	40
Figure 14 April 1989, Mt Hagen – excess top growth in sweet potato after drought	43
Figure 15 Dwarf Kalapua	51
Figure 16 Kalapua plant	51
Figure 17 Cassava evaluation, NARI	55
Figure 18 Tinned fish can, used as a grater	57
Figure 19 Weevils destroy seeds	61
Figure 20 Dry corn is excellent food for use during droughts	62
Figure 21: Rope & washer pump for use in rivers	65
Figure 22 Rope & washer pump for use in wells	66
Figure 23 Drum Kit Drip Irrigation System	67
Figure 24 Evaluating Cassava, NARI.	75
Figure 25 Demonstrating a rope and washer pump, Markham	79



**Figure 1 Drought in Afore, Oro Province 1997.- Collecting water- a time to share and enjoy. Not everyone was lucky enough to have a vehicle to cart their water...**

## Acknowledgements

The development of an ENSO event in the Pacific early in 2002, less than average rainfall over much of PNG from May onwards, and frosts in high altitude areas in early October, gave rise to concerns in the Government of PNG (GOPNG) about food security in parts of rural PNG.

GOPNG thus requested AusAID for technical and financial support to assist the National Agricultural Research Institute (NARI) and the National Agricultural Drought Response Committee, to: carry out a rapid appraisal of the situation; to monitor the situation in the provinces in terms of rainfall, rice sales and market prices of staple crops; develop and publish a resource of coping strategies for use by extension agents and farmer families; travel to the provinces to conduct awareness programs and develop linkages for information dissemination; to produce and distribute appropriate

extension material on drought mitigation for farming families; and to provide AusAID and other agencies with a situation report and response strategy.

Funding for the drought mitigation project had been provided by AusAID though the project, Australian Contribution to National Agricultural Research Systems (ACNARS), which provides technical and financial support for NARI capacity development. The project would like to acknowledge this assistance.

This activity is based on work carried out by NARI with the support from the World Bank, initially under the leadership of Dr. K. P. C. Rao. The project aimed at development and adaptation of technologies to manage impacts of droughts and frosts in PNG. As part of this project and in response to rapid falls in the Southern Oscillation Index (SOI) between

April – June 2002, a drought contingency planning workshop was conducted in June 2002.

One of the biggest challenges in successful implementation of drought plans is identification and getting the right groups of people to communicate effectively on monitoring, risk assessment, and mitigation and response issues. The four important groups involved are climatologists, natural resource managers, decision makers and those with links to farming families. An appropriate mechanism is needed for coordination of various activities from monitoring early warning signals to the situation where basic human needs are threatened and providing the authorities concerned with plans that are appropriate to mitigate the negative impacts. Thus an important outcome of the contingency planning workshop was formation of an ad hoc committee - the National Agricultural Drought Response Committee (NADRC).

NADRC has representatives from NARI, NGOs, DPI and DAL (Highlands and Southern Region, Madang, Simbu, New Ireland and Milne Bay), the National Weather Service and the ACNARS project. The committee has, with support from NARI and the ACNARS project, taken responsibility for compiling the coping strategies document, identifying information and training needs of farmers and communication and coordination among different interested groups. The contribution of members of the committee, under the chairmanship of Dr. Sergie Bang, is acknowledged.

A team made up of experienced people from NARI (Dr. Sergie Bang), ACNARS (Mr. Martin Gunther) and the ANU (Dr. Bryant Allen) visited the Tabubil area including Telefomin and Oksapmin,

the high altitude areas in WHP, Enga and SHP, travelled by road from Mt Hagen to Lae via Kainantu and Aiyura. They made their own observations as well as collecting reports from others (e.g. Salvation Army Ag development project EHP). Allen, Gunther and Bang were accompanied for four days by two officers from the National Disasters Management Office, Michael Viula and Andrew laego.

In Lae the team attended the National Agricultural Drought Response Committee meeting - where they received further reports from EHP, Simbu, Morobe, Madang and Milne Bay.

Dr. Allen subsequently has worked with NARI staff (especially Ms. Debbie Kapal, Dr. Sergie Bang, Dr. Geoff Wiles) and ACNARS staff (Mr. Martin Gunther, Dr. David Askin and Mr. Rob Shelton) to compile this document. Sarah Luton provided desk top publishing input. Their contribution is gratefully acknowledged. A full list of contributors is included in Annex 4 on page 81.

**Ian Grant –**

**ATL**

**ACNARS Project**



# Drought Response: On-Farm Coping Strategies





## Summary



The National Agricultural Research Institute (NARI), with support from the World Bank, has been implementing a program aimed at development and adaptation of technologies to manage impacts of droughts and frosts in PNG. 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.



This document, compiled by NARI staff, with contributions from the ACNARS project and members of the National Drought Response Committee, provides a resource of information for extension providers. Topics covered include defining the common reasons for food shortages in PNG; the factors that determine how severe food shortages will be; how to assess the severity of food shortages; and identifies the sorts of things that farming families can do to strengthen food production systems in PNG. This in turn will reduce the likelihood of food shortages.

This plan will be the basis for preparation of a number of bulletins, in simple English and Tok Pisin, for extension workers and farmers.

Strategies are presented under three headings. (See page 18).

- ▶ [Pre-drought](#) - when there is a forecast of dry conditions and crops face severe water deficits;

- ▶ [Mid-drought](#) - when crops face severe water deficits and crops fail; and
- ▶ [Post-drought](#) - between when good rains fall and harvest of first sown/planted crop.

Examples of topics covered are:

- ▶ Planting drought tolerant crops;
- ▶ Simple water management techniques such as irrigation and mulching;
- ▶ Preserving domestic water supplies;
- ▶ Fire prevention;
- ▶ Preserving planting material and genetic diversity;
- ▶ Post-harvest processing and storage; and
- ▶ Control of pests and diseases.

Four annexes provide additional background information:

1. [Drought assessment Map from 1997](#); (Page 71)
2. [Final report on the World Bank Drought Response Project](#); (Page 72)
3. A copy of the [CGPRT El Nino Project Annual Report](#) - a 3 – year UNDP ESCAP funded Project aiming to stabilise upland Agriculture under (El Nino –Induced) Climatic Risks, through the documentation of the impacts of the 1997-8 Drought and recommendation of Mitigation Strategies, both indigenous and introduced; (Page 80)
4. [List of Contributors](#). (Page 81)



# 1. Introduction

In Papua New Guinea (PNG) the majority of people (about 85%), produce their own food. The great majority grow edible plants and manage animals in agricultural systems. A minority manufacture food from plants they do not cultivate, mainly sago, and hunt wild animals or catch fish. Food shortages occur in Papua New Guinea when for some reason, agricultural systems produce insufficient food to satisfy the nutritional requirements of people.

This document discusses:

- ▶ the most common reasons for the occurrence of food shortages in PNG;
- ▶ what determines how severe food shortages will be;
- ▶ how they can be identified and their severity assessed;
- ▶ what sort of things can be done to strengthen food production systems to reduce the likelihood of food shortages.

## 1.1 Food in Papua New Guinea (PNG)

PNG has a large number of agricultural systems that produce food. Table 1 lists the most important food crops in PNG in terms of the proportion of the population they support and the calories they provide.

**Table 1 Most important foods in PNG**

Crop	% Population most important food	% Total calories	Estimated PNG production (tonnes)
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 and fish, chicken not included.*

*Source: % population – Agricultural Systems of PNG; % calories and estimated PNG production – Gibson, John The economic and nutritional importance of household food production in PNG. 2001. In Food Security for Papua New Guinea 2000 Conference. ACIAR Proceedings No.99, 37-44*

A number of important points about PNG food production systems are:

- ▶ Sweet potato is the most important crop in PNG. It provides 30% of total calories consumed in PNG and on its own and supplemented by other crops, is the most important food for 61% of the total population, an estimated 3 million people in 2002.
- ▶ The proportion of 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% of 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.

## 1.2 PNG Food Production Systems

In simple terms, three main types of food production systems are used in PNG.

### 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 from trees or scrub or grasses and is planted in 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 in fallow. In these systems the time land is cultivated is normally much less than the time it is left in fallow.
- ▶ Crops are planted only once each year and food is produced throughout the year by using a large number of different crops that 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. Pitpit, sugar and many green leaves are also grown.
- ▶ Trees and palms are also planted for leaves, (notably coconuts) nuts and fruit.

### 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 the continuous 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 in 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 2800 meters above sea level (m). The main highlands valleys are between 1500 and 2000 m, but considerable numbers of people live above 2000 m.
- ▶ 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 full of water, or saturated. In

saturated soils sweet potato produces luxuriant top growth (leaves and vines) but very small tubers.

- ▶ In many of these systems domestic pigs are important. They eat up to half of the sweet potato produced, usually the smallest tubers that are thought to be not fit for humans to eat.

### 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 1100 m above sea level.
- ▶ 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 old) by cutting down the palm, chopping the trunk into fine chips and leaching out the starch contained in them 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. Many people who cultivate gardens also depend on sago as a supplementary food.

### 1.3 Causes of Food Shortages

The most common causes of widespread food shortages in PNG are too much rain, too little rain and, at higher altitudes, very low temperatures. Important points about PNG's climate and food shortages follow:

- ▶ Food shortages are the outcome of the climate, the way plants are affected by the climate, and the responses of people to the way plants behave. It is difficult to change the climate, but we can find plants that are better adapted to the climate and we can educate people about how to manage the plants better.
- ▶ A clear distinction must be made between dry seasons which occur every year in some places and periods of very low rainfall that occur over most of the country from time to time. They have different causes and different impacts on PNG food production.
- ▶ Where there is a regular dry season agriculture and food production is adapted to deal with the dry conditions that are expected to occur every year.
- ▶ Most of PNG does not have a dry season. Over much of PNG there is rainfall all year round. As a result, over most of PNG, soil-water deficits are rare.
- ▶ **Most PNG agriculture and food production systems are adapted to deal with too much soil-water. Plants are grown on slopes, and drains are commonly used to get rid of excess water from the soil.**
- ▶ However, from time to time PNG suffers from a serious lack of rain in many parts of the country, including those parts that do not normally have a dry season.
- ▶ From time to time parts of PNG have periods of excessive rain.
- ▶ These low rainfall and high rainfall period events are, almost without fail, associated with what is known as the El Niño-Southern Oscillation (ENSO) phenomenon.

### 1.4 El Niño-Southern Oscillation (ENSO) and PNG

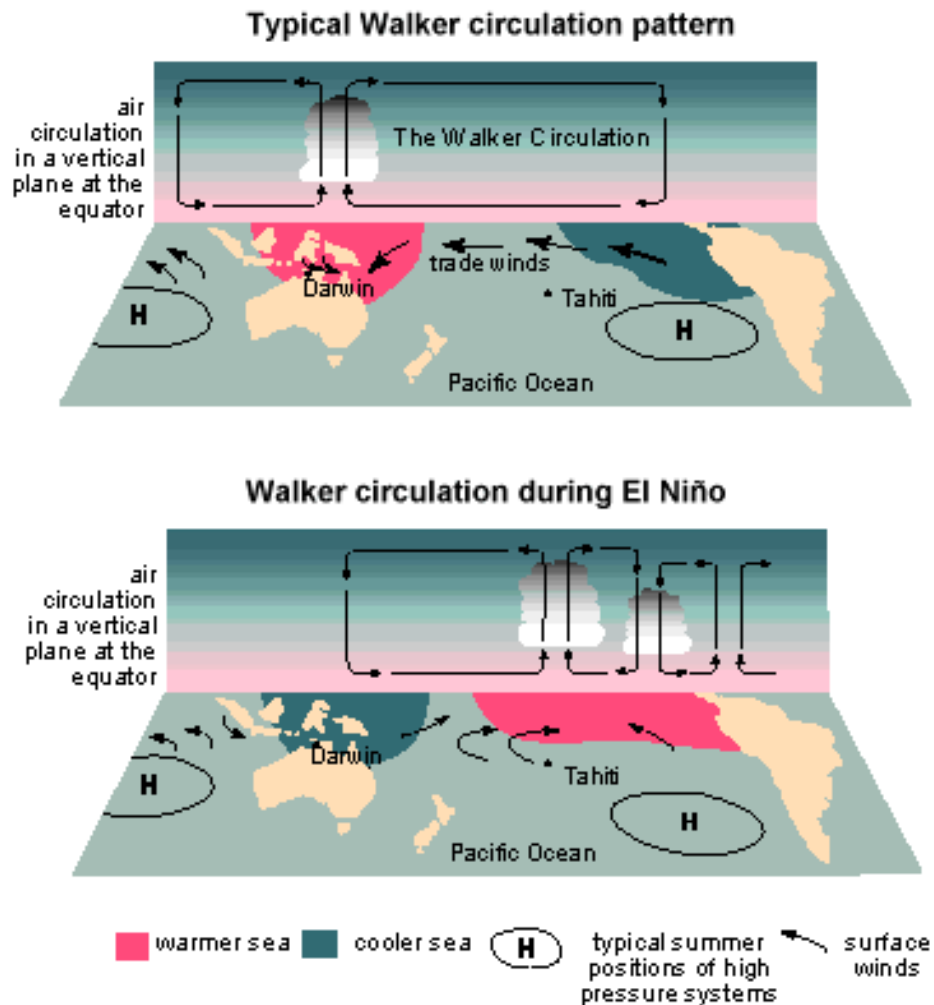
Extremes of rainfall in PNG are closely associated with the El Niño-Southern Oscillation (ENSO) phenomenon. Important points about the ENSO phenomenon are:

- ▶ The Southern Oscillation is the term given to a global phenomenon in which, in the Southern Hemisphere, the temperature of the sea, the air pressure over the sea and the circulation of air across the sea, move backwards and forwards from one extreme to another (To "oscillate" is to move backwards and forwards between two extremes).
- ▶ **ENSO can bring both flooding rain and drought to PNG.** During an ENSO event, excessively wet periods and dry periods often occur one after the other in a sequence.
- ▶ There is a pattern to the Southern Oscillation but it is

not a regular one and is therefore difficult to predict.

- ▶ 'Normally' the seas in the western Pacific (the PNG side) are warmer than the seas in the eastern Pacific (the South American side). 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 (Figure 2).
- ▶ When the sea is warmer and the air pressure is lower, large amounts of water are absorbed by the air and are carried over the land. When warm moist air rises the moisture is released as rain. PNG mountains are very high and the prevailing northwest and southeast winds are forced to go up over them. The outcome is very high rainfall over much of PNG much of the time.
- ▶ An ENSO event occurs when the sea in the eastern Pacific (near Chile) begins to warm up. As the ENSO develops, the sea in the western Pacific becomes cooler than the sea in the eastern Pacific and the circulation of air across the Pacific reverses and goes in the opposite direction to normal.
- ▶ 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.
- ▶ When night time skies are clear in the highlands, the heat from the ground is able radiate into the sky and it becomes very cold. On some nights the temperature can go below freezing. Temperatures below freezing will damage the leaves of most food plants and some trees. The lowest temperatures are experienced just before sunrise.





Source: <http://www.bom.gov.au/climate/glossary/elnino/elnino.shtml>

**Figure 2** The “normal” circulation of air over the Pacific (the Walker Circulation) and circulation during an ENSO event.

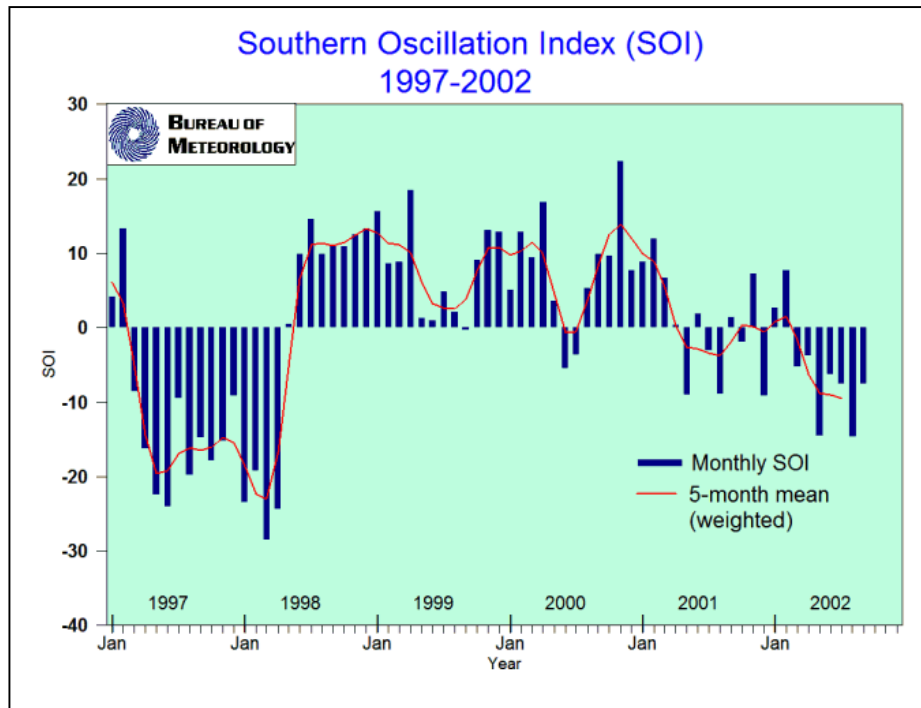
#### 1.4.1 The Southern Oscillation Index (SOI)

The SOI is a measure of the status of ENSO and an indicator of the strength of an ENSO event. Important points about the SOI are:

- ▶ Air pressure has been measured in the eastern Pacific, at Tahiti, and in the western Pacific at Darwin, since the 1870s.
- ▶ The differences between the pressure at Tahiti and at Darwin have been standardized into an index called the Southern Oscillation Index or SOI (Figure 2).
- ▶ When pressure at Tahiti (E. Pacific) is higher than pressure at Darwin (W. Pacific), the SOI is a positive number.
- ▶ When pressure at Darwin is higher than pressure at Tahiti, the SOI is negative number.

- Because the SOI can be calculated back to 1877 it provides a basic, long-term record of ENSO events, which

can be matched against information from historical reports about food shortages in PNG.



Source: <http://www.bom.gov.au/climate/glossary/elnino/>

**Figure 3: Southern Oscillation Index 1997-2002**

In Figure 3 it is possible to compare the SOI record in 1997 with 2002. In 1997 the SOI fell from a high of +12 in January to -25 in April and stayed below -20 well into 1998. In 2002 it fell from less than +10 to -15 in April and was mainly above -10 for most of 2002. The 2002 ENSO event was therefore much weaker than the 1997 event.

#### 1.4.2 How often do severe ENSO events occur and can their impact on PNG food production systems be predicted?

It would clearly be very useful to be able to predict when an ENSO event is going to occur and how seriously it will impact on PNG. The

record of ENSO events and impacts on PNG can be examined.

The main conclusions are:

- From 1877 to 1988 seven strong El Niño events can be identified in the historical records, namely: – 1877-78, 1914, 1940-41, 1972, 1982 and 1987. To this list we can add perhaps 1902, probably 1993-94 and certainly 1997.
- In the 125 years from 1877 to 2002, there have been 19 ENSO events, on average about one every 6 to 7 years. In the same time there have nine strong ENSO events or on an average one event every 14 years.

- ▶ ENSO events are associated in PNG with drought, frost, and excessive rain. These climatic events sometimes cause serious food shortages, bush fires and movements of people that are severe enough to be reported by administrators or the media.
- ▶ By examining government reports, newspapers and oral accounts, it is possible to count the years in which these events are reported to have occurred.
- ▶ In 11 of the 125 years between 1877 and 2002 some or all of these severe impacts occurred. This is a frequency of every 12 years, on average. If strong ENSO events occur around every 14 years, **this suggests that about 85% of all strong ENSO events have some impacts on PNG food production in PNG.**
- ▶ The impacts on food production in PNG of most of

these 11 events were not as severe as the impacts of the 1997 ENSO event. It is apparent that strong ENSO events do not always have a severe impact on PNG food production. Of the 11 years in which serious outcomes occurred in PNG, there are **only four that approached the severity of the 1997 event**, which is an average of once every 25 years.

- ▶ If we are trying to predict which ENSO events are likely to be as severe as 1997, the historical record suggests we will be right less than 50% of the time. Rather than trying to guess when the next severe ENSO event will impact on PNG food production, it would be better to adopt on-farm strategies that will reduce the severity of the impacts of most ENSO events whenever they happen.



**Figure 4 Afore District, Oro Province, during 1997 drought, fire caused long term damage to timber and also destroyed many gardens.**

## 1.5 How Does a Severe ENSO Event Affect Food Production in PNG?

A severe ENSO event has different impacts, depending on the type of food production system affected.

### 1.5.1 Shifting cultivation systems

- ▶ People who use shifting cultivation systems usually clear new land for planting towards the end of the dry season to ensure the new plants receive water from the rains which are expected to come. They commonly use fire to clear land for cultivation.
- ▶ During an ENSO event trees and tall grasses on land in fallow become very dry and fires used to clear land for planting can get out of control and destroy other gardens, animals, houses and kill people trapped by them. The destruction of vegetation on fallow land can extend the time it takes for land to be ready for cultivation again.
- ▶ If rain is delayed, crops already planted do not get established and have to be replanted again after rain has fallen. Seeds and planting material can become short if this happens.
- ▶ During a long drought people may be forced to eat crops they would normal reserve for planting and have little left to plant when rains falls.
- ▶ Heavy rain and long cloudy periods can also reduce production from shifting cultivation gardens, but the effects on of too much rain on many crops is not well understood.

### 1.5.2 Continuous cultivation systems

The continuous banana production systems of the PNG lowlands are resilient to most climatic upsets. Like all mono-cropping systems however, they can be disrupted by pests and diseases, which may be made worse by climatic conditions.

Sweet potato systems, however, are vulnerable to both excessive water and low temperatures. This sections concentrates on sweet potato systems.

Continuous production is achieved by planting continuously. If continuous planting is disrupted, or if the production of tubers is interfered with during the period the plant is maturing, then the production of food will be later interrupted. Commonly the interruption to the food supply and the cause are separated in time and are therefore misunderstood.

#### Drought and sweet potato production:

- ▶ Sweet potato is a drought resistant crop that can survive for long periods with little rain. Production may be reduced but vines will remain alive. Only very severe droughts will completely stop production from a sweet potato system.
- ▶ Sweet potato tubers can be stored in the soil during a drought. However severe damage can occur to the tubers if sweet potato weevil is present (as it is in most continuous sweet potato systems). For more information on the sweet potato weevil problem see page 38.

Excessive rain and sweet potato:

- ▶ Excessive rain which saturates the soil reduces sweet potato yields. Sweet potato plants initiate tuberisation in the first few weeks after planting. However tubers do not develop until the end of the cropping cycle, when they rapidly increase in size. Sweet potato yields are reduced when soils are saturated in the first two months after planting.
- ▶ Symptoms of saturated soils affecting tuberisation are a few, very small, thin tubers

surrounded by many fine, white, 'hairy' roots along the vine.

- ▶ Food shortages caused by saturated soils some months previously are usually blamed on some other more immediate cause.

Frost and sweet potato:

The effects of frost on continuous sweet potato production systems depend upon the time since planting of the sweet potato plant and the number of times it is frosted. Table 2 and Figure 5 illustrate what is thought to happen. More research is needed on this problem.

INTRODUCTION



Source: Scoullar, B. The effect of frost on sweet potato production at higher altitudes in the Highlands of Papua New Guinea. DASF, Laiagam, 4 August, 1972.

Figure 5: Effect of frost on sweet potato at high altitudes and rain at all altitudes

**Table 2: Impact of frost on sweet potato at high altitudes and of excessive rain**

Event	Outcome
No frost or excessive rain	Tubers attain maximum size at 12 months. Vine growth sufficient for replanting.
Frost 1 month after planting	Some vines retarded by 1 month, others by 3 months. Harvest delayed by 3 months and smaller quantity become available over 5 months
Frost 6 months after planting	Some vines delayed by 1 month, others by 5 months. Normal harvest delayed by 5 months and smaller quantity available over 7 months.
Frost 6-9 months after planting	Tubers stop growing and quickly rot. Most cannot be eaten and harvest may be a complete loss.
Frost 9-12 months after planting	Tubers stop growing, but depending on rainfall and severity of frost can be harvested and eaten. If weevil damage becomes severe, harvest will be lost.
Heavy rainfall 8 weeks after planting	Vine growth is luxuriant. Tubers will not develop properly. Yields will be significantly lower than normal.

The most important points about frost and sweet potato are:

- ▶ Every garden will contain sweet potato planted between 1 and 12 months ago. For this reason, one frost, or a number of frosts within a week or so, will **not** completely disrupt food supply.
- ▶ A frost will affect plants in the gardens differently, depending on how long before the frost occurred that they were planted. The greatest risk after frost is the loss of all sweet potato planted between 6 and 9 months previously and weevil damage on mature tubers still in the ground.
- ▶ Repeated frosts can cause a complete loss of production for some months because plants recovering from a previous frost are frosted again. Four or five frosts spaced about 6 weeks apart will destroy all

production for up to one year after the last frost.

- ▶ The most common response to repeated frosts in high altitude communities is to migrate to lower altitudes. Exchange and marriage relationships are maintained with communities there for this reason.
- ▶ If repeated frosts are accompanied by a severe drought then food will be short at lower altitudes too. Refugees from higher altitude will add to an already difficult situation there.
- ▶ The most important ways to reduce the impact of a single frost (or a number of frosts close together) is to plant a number of gardens at different places in the local area, including on slopes above valley floors. This is standard practice at higher altitudes.

## 2. Identification and Assessment of Food Shortages

It is possible to have food shortages without a climatic extreme and a climatic extreme that does not cause food shortages. Thus it is the **food shortages** and not the climatic extremes that are the problem and food shortages that should be the focus of concern.

This section will discuss:

- ▶ [The identification of food shortages](#)
- ▶ [The assessment of food shortages](#)
- ▶ [The idea of “vulnerability” to food shortages.](#)

### 2.1 The Identification of Food Shortages

Food shortages can be identified in a number of ways:

- ▶ The price of food being sold in local fresh food markets begins to increase.
- ▶ Staple fresh foods become scarce or disappear from local and regional markets.
- ▶ Rice and flour sales in local stores and shops increase and may be hard to get.
- ▶ People begin to express their anxiety about running out of food in the future.
- ▶ Written and oral reports are received from outstation officers complaining that it is becoming difficult to buy food in local markets, or in local trade stores.
- ▶ Letters are sent to newspapers about the food shortage.

The first response to these events should be to examine climatic records to see if a climatic cause can be identified:

- ▶ Monthly rainfall records should be compared with long-term monthly means and variations above and below the mean should be noted. It is especially important to note

excessively high rainfall, because the effects will not be felt for some time. A number of months of well below average rainfall with no reasonable falls on some days will be of interest.

- ▶ Temperatures below 5 degrees C in any of the main highlands towns almost certainly means there has been a frost somewhere in the high altitude areas. A single frost is not cause for anxiety, but a number of cold nights spaced well apart is.

A second response should be to check with the importers of rice and flour and to ask about the recent demand for imported food. They have a good knowledge of PNG and the market for imported food. Their contacts are listed below:

- ▶ Trukai Industries Ltd, Sales Manager 320 0733, 321 3530.
- ▶ Associated Mills 472 3555
- ▶ New Guinea Tablebirds (Flour millers) 472 1832, 472 6444

If these responses suggest the existence of a problem, an investigation in the local areas that the reports have originated from is justified.





## 2.2 The Assessment of Food Shortages

**The assessment of food shortages is a highly skilled task that demands a lot of experience and a steady nerve.** If the assessment is too harsh, many people will suffer and some may die. If it is too generous, there is a danger people will come to depend on outside assistance for relatively

mild shortages and lose their ability to cope with more serious events. The mere fact that an investigation is being made can raise local expectations and care must be taken not to promise any particular response during the assessment itself.



**Figure 6 AusAid supplied helicopter delivering emergency food supplies during 1997 drought. Photo- D. Wissink.**

Understandably, people are keen for “the government” or some other organisation, to provide them with food during a mild shortage. In the past in PNG there have been examples of attempts to exaggerate assessments so that food could be provided to serve political objectives.

Assessments have to achieve the following:

- ▶ Estimate how much food is available now, in gardens and

from other sources, and how much will become available in the future.

- ▶ Estimate the cash reserves of families and their ability to purchase food. This is probably the most difficult part of an assessment. After the shortage was over in 1997 it was found that many people were supported by relatives earning wages in towns. The assessment teams under-



estimated how much support was available from outside the affected areas.

- ▶ Estimate the nutritional status of people, in particular children and old people. Because very few records are kept, it is extremely difficult to assess whether people are losing weight.
- ▶ Similarly, the health of people must be assessed, but in many cases health centre records are not of a standard that allows before and during food shortages assessments.
- ▶ Estimate how much and what sort of food may need to be provided to help people maintain their health and basic nutritional needs. This requires the assistance of an expert in human nutrition.

Other factors that need to be considered include the existence and condition of roads into an area, the sale of cash crops, large-scale movements of people and the existence of large urban dwelling migrant communities from the

affected area who may be able to offer support.

Garden surveys are a critical part of an assessment but they need to be carried out in a systematic way, preferably by family, and all gardens being cultivated by a family need to be examined. This is often difficult because gardens may be widely scattered, people may be reluctant to show assessors good gardens with food available and time may be short. The food production systems of the affected area need to be understood (the PNG Agricultural Systems working papers have such information and should be consulted and taken into the field).

This is clearly an area that needs further attention. A cadre of skilled food shortage assessors needs to be created in PNG. The experiences of some of the assessment teams in 1997 are published in *Food Security for Papua New Guinea*, ACIAR Proceedings No. 99.

## 2.3 Vulnerable Areas

Past experience has shown that some areas are more “vulnerable” to food shortages than others. The following summary points can be made about “vulnerable areas” to food shortages:

- ▶ 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 1800 m altitude can be frosted, but the dangers of frost are greatest in 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 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.

Cash incomes are very low and child malnutrition rates are well above the PNG average.



**Figure 7** Young people enjoying bush foods during drought, 1997. Are we making sure that these bush foods are planted and growing so that during a drought we also have options in terms of various kinds of food?

### 3. Stages of Drought Response

This document was produced in response to a drought in 2002 and therefore focuses on food shortages caused by droughts and

frosts. It will eventually be extended to cover shortages from all causes.

#### 3.1 Drought Response Stages

##### 3.1.1 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. Duration of droughts is usually short and the wet season does not fail to bring some 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 cease running, 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.

▶ STAGES OF DROUGHT RESPONSE

##### Stages in a drought:

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

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

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

##### 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:

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

Since 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. Most preparations should be ongoing

activities that should be adapted for strategic preparedness, which should be 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.

## 4. Short Term Coping Strategies

It is important that farmers grow a wide variety of crops like sweet potato, inclusive of drought tolerant varieties at all times. It will almost always be too late to plant drought tolerant crops after a drought has begun. The main insurance against food shortages is to plant

as many varieties as possible and to plant a number of gardens in different places. A further insurance is to save cash from the sale of fresh foods, cash crops or firewood in good years and to use it to buy imported food during a food shortage.

### 4.1 Pre-drought

#### 4.1.1 Mulching of gardens<sup>1</sup>

Mulch is a layer of dead plants or grass, put on the ground between the plants that helps to reduce moisture loss from the soil. Mulch can be put on the garden after it has been dug and either before or after the crop has been planted. (Some crops can be planted through a mulch however with others it is best to spread the mulch around the crop after it has started growing). If a crop has been mulched it will be easier to plant a new crop in the same ground, after the original crop has been harvested, as the soil will be soft and few weeds will have grown. It is much better to put weeds, crop remains and other waste organic matter onto the soil as a mulch rather than burning them. The mulch layer must be thick enough to shade the soil and reduce airflow over the ground. It can be made from leaves, grasses or weeds but should be free of seeds if possible.

Droughts cause water stress and wilting of leaves that can lead to death of plants. The low humidity and big temperature changes cause problems for plant reproduction, leading to reduction

or complete failure of production. Frosts experienced in certain areas during droughts also kill plants by freezing the water inside plants and bursting open the plant cells.

During a drought the soil is exposed to heat and wind. Exposed soil gets hot, particularly during the day. A lack of water in the soils can cause hardening and cracking. Dry soils are hard to dig. Insects and very small animals in the soil can be destroyed and this slows the decomposition of organic matter. Surface soil can be blown away as dust. Soil water tables can also be lowered.

The effects of mulch include the following:

- ▶ Shades the soil, lowers soil temperatures, reduces the rate of water loss from the soil by evaporation and keeps the soil cool.
- ▶ Protects the soil from wind and therefore slows the evaporation of moisture from the soil. It also prevents soil being blown away as dust.
- ▶ Increases effective use of water by reducing evaporation caused by wind and high temperatures.
- ▶ As mulch decomposes some nutrients are added to the soil.

<sup>1</sup> Contributed by Rob Shelton

- ▶ Mulch reduces weed growth, particularly if the mulch layer is thick.
- ▶ Mulch should be left in place after the crop has been harvested, as the next crop will benefit from its protection also. Or it can be dug into the soil as compost. The presence of the mulch often means that less digging is necessary for planting the next crop. As a lot of moisture is lost from the soil each time it is disturbed, this is a way of making use of all the water that is available.
- ▶ Mulch reduces soil erosion by preventing excess water from running off the field quickly and acts as cover from heavy rain.



Moisture in the soil is precious to any plant growing in the soil in a drought and anything that will help the plant to be able to use it efficiently will make it easier for the farmer to grow food for his family for a longer time in a drought.

#### 4.1.2 Maintenance of planting materials<sup>2</sup>

Many plants dry up during a drought, which means that planting material is often in short supply. When the first rains come every attempt is made to get new gardens planted so that food supply will be back to normal as soon as possible. What happens if there are no follow-up rains? Many of the plants will die. Then when good rain does eventually come, planting material may not be enough to fully replant the garden. This will lead to further food shortage until after the second crop starts producing.

Reserves of planting material of the important crops should always be kept even if one planting fails. Certain criteria to be considered are:

- ▶ What are the important crops,
- ▶ What are the important varieties of those crops,
- ▶ Are these varieties available elsewhere, either, from neighbouring farmers, neighbouring villages, relatives, elsewhere in Papua New Guinea or stores.

Plants can be grown from seed, cuttings, suckers or tubers. The way that these materials can be preserved depends on the type of material, and the time that it can be stored and still grow.

<sup>2</sup> Contributed by Martin Gunther



### Seeds:

- ▶ Seeds are the easiest to store. Seeds can be stored in a small space; and for most seeds, they will still grow after one or two years.
- ▶ For good storage, seeds must be fully matured and dry when they are harvested. However, they should not be left on the plant too long as they may be damaged by rain or attacked by insects.
- ▶ When the seed is harvested it must be dried well. With some crops this can be done in the sun, but it is generally better to dry the seed out of the sun in a dry place where there is plenty of air movement.
- ▶ When seeds are dry and hard, small quantities can be stored under the roof of the house where the smoke from the fire helps to keep the insects away. Larger quantities should be stored in tins, jars or plastic containers that have tight fitting lids.
- ▶ Check the seeds about once a month to be sure that no insects have got in. If insects are found, remove any insects and damaged seeds and reseal the container.
- ▶ Seeds can also be stored in a cool, dry place as this will allow storage for a longer period. A corrugated iron shed gets too hot during the day and seed will not last as long.

Some seeds only have a short storage life. Use your own experience to determine how long you can store your seed, and how much you should store. It is a good idea to have at least two year's supply at all times, just in case you have to replant because of drought, flood, insect attack or disease.



**Figure 8 Containers to store seeds in**

There are many kinds of containers to store seed in. For example some people use bamboo segments to store seed, with the seeds kept in the smoke above a cooking fire. However the warmth from the fire will cause your small seeds to respire more than those kept cool and dry. This will mean lower germination rates when you plant them.

### Vegetatively propagated crops (tubers like yam, potato):

Yam is the main food crop in Papua New Guinea that is planted from a tuber. However, similar principles can be used for taro, sweet potato and English potato.

- ▶ The farmer has to know how much material will be needed for the next season. If a drought reduces the harvest in the current season, then a greater proportion of the total tubers harvested will be needed as seed tubers for the next crop to be planted.
- ▶ One way to make the available seed tubers go further is to use smaller planting pieces. This will generally mean lower yield of the new crop, but when food is short, this is the best way to ensure the next crop is planted.

- ▶ Better preparation of the soil for the new crop can help boost yields. Such things as adding mulch to the planting hole, or digging a deeper planting hole to help the yams grow bigger can be useful.
- ▶ Another way is to cut the tubers into small pieces or mini-setts. These may not produce large tubers in the first year, but are good for increasing planting material for later years.
- ▶ Taro, sweet potato and English potato can also be cut into small pieces as a way of increasing planting material. With these crops, it is important that there is an “eye” in the piece of tuber, otherwise there is nowhere from which the shoot can grow.

#### **Vegetative cuttings:**

Sweet potato, cassava, sugar cane, aibika, pitpit and some other vegetables are planted from cuttings.

- ▶ It is important to always have a reserve of the best varieties of these crops growing in a good area. This may be a damp area near a river or creek, near the edge of a swamp, or near the house where water can be applied to keep them growing even in

very dry periods, or even in a relative's garden in another village, or another province. In very dry periods it may be necessary to hand water this seed garden to keep it growing so that there will be material to plant later.

- ▶ Never plant all of your material at one time because you may lose it all if it does not rain enough. If there is not enough planting material to plant the whole garden, always keep some seed tubers in reserve to replant again, if the first planting does not get enough rain.
- ▶ Another way to preserve planting material is to plant smaller pieces, or fewer pieces in one planting hole. Such crops will probably not yield as well, but planting this way will mean that the material can go further. This is a choice that the farmer has to make.

The farmer is the person responsible for preserving the planting material for the garden. Government and other people can help, but they may not be able to provide the right varieties or the quantity that is needed at the time when it is needed. Losing planting material for the next season means that the effect of the drought will be experienced much longer.



### 4.1.3 Indigenous coping strategies under drought and frosts<sup>3</sup>

#### Introduction:

A survey was conducted in six of the worst affected districts following the 1997 drought (and frosts), primarily to document indigenous coping strategies. The districts were selected from three altitude ranges and with good or poor accessibility to markets (see Table 3). A secondary objective was to determine whether coping strategies differed between districts and at different altitudes.

There were sixteen randomly selected families surveyed in each district. The information collected is presented in the following tables. There are local gardening practices adopted during drought (Table 4) and frosts (Table 5), methods of preserving planting materials (Table 6), management strategies for household water requirements (Table 7), alternative or famine foods eaten (Table 8) and socio-economic support received during the famine period (Table 9).

**Table 3: Description of the districts surveyed**

District	Province	Altitude (m)	Market Access	Comments
North Coast (Bogia)	Madang	22 – 32	Good	Excellent sealed road.
Raikos	Madang	22 – 28	Bad	Main bridge has been washed out.
Bena	Eastern Highlands	1525 – 1584	Fairly good	Distinct annual dry season (June – Oct)
Gumine	Simbu	1675 – 2390	Bad	Steep garden slopes
Tambul	Western Highlands	2388 – 2624	Fairly good	Frosts were also experienced.
Kandep	Enga	1768 – 2400	Bad	Frosts were also experienced.

<sup>3</sup> Contributed by Kud Sitango

**Table 4: Gardening practices adopted under drought conditions.**

Practice	Description
Cultivation under canopy of trees	Crops under canopy were productive. This is probably due to reduced evapo-transpiration of crops under shade.
Cultivation on riverside plains	Families who had land near the river, planted the main crops like taro, sweet potato, banana and vegetables there. The gardens were also watered and planting materials were successfully maintained.
Gardening in wind sheltered areas/ pockets	Gardens were planted in gullies and at the foot of hills where soil was seen to be moist enough to support plant growth. Planting materials were also maintained.
Cultivate in the swamp or marsh areas	Families in areas where there are swamps cultivated food crops and preserved planting materials.

**Table 5: Gardening practices adopted to minimise frost damage.**

Practice	Description	Districts Where it is Practiced
Smoke smudges	Making fire near the garden or in the hut and directing the smoke through bamboo to the gardens nearby. The warm smoke disturbs cold air setting on the garden. However it has minimal impact and is seen to be effective only in small gardens.	Kandep and Tambul
Covering crops with dry grass or leaves	Crops growing in the field are covered with leaves and dry grasses to avoid direct contact with frost.	Kandep and Tambul
Cultivation on slopes	Frost moves down slopes to settle on the flat.	Kandep and Tambul
Plant trees across the slope	Trees disturb the flow of cold air down the slope.	Kandep and Tambul

**Table 6: Methods used to preserve planting materials during drought.**

Method	Description	Districts Where it is Practiced
Stored sun dried seeds	Seeds of annual crops like corn, bean, peanut, cucumber, watermelon, and pumpkin were sun-dried and stored in airtight containers.	Kandep, Tambul, Bena, Gumine, Raikos and North Coast
Under-ground preservation.	The corms of true taro and xanthosoma taro were buried in the ground as food and planting materials.	Raikos & North Coast
Planted in swamps or marsh areas	Crops were cultivated in swamp and marsh areas as food and for planting materials.	Kandep, Tambul, Bena, Gumine, Raikos and North Coast
Stored seeds over fire places	Seeds of annual crops such as corn, bean, peanut, cucumber, watermelon and pumpkin were dried over the fire and then stored in airtight bamboo containers and kept over the fireplace.	Kandep, Tambul, Bena, Gumine, Raikos, North Coast
Vegetative plant parts grown and watered in riverside gardens.	Cuttings, vines, suckers and tubers of clonally propagated crops like aibika, sweet potato, pitpit, sugarcane and banana etc. were planted in wet areas or at riversides and watered.	Bena, Gumine, Raikos & North Coast.
Sourced from low- lying areas post drought (& frost).	Low lying areas like the Waghi Valley or Wapenamanda areas were less affected by drought, so provided planting materials to severely affected areas.	Kandep, Tambul and Gumine



During the 1997 drought, farmers in Tumolbil, kept planting material alive in a normally swampy area.

**Figure 9 Keeping plant material alive, Tumolbil, Telefomin District, 1997.**

**Table 7: Practices adopted to cope with water shortage for domestic use**

Practices	Description	Districts Where it was Practiced
Carted water	The water for drinking and cooking was carried from large rivers using plastic containers, pots and bamboo.	Bena, Raikos, North Coast, Gumine
Bamboo piping	Water was channelled downhill to village or hamlet in bamboo pipes.	Gumine, Kandep, Tambul
Temporarily settled near rivers	Families who owned the land near rivers settled there temporarily until the rain returned.	Bena, Raikos, North Coast & Gumine
Wells	Where the water table was not too deep, wells were dug.	Raikos & North Coast.
Coconut Juice	In coconut growing areas, the juice from dry or fresh nuts was valuable. The nut flesh is also excellent food.	Raikos & North Coast
Tanks	Some villages had permanent water storage in the form of tanks, which were used for drinking water.	North Coast

**Figure 10 Houses such as these in Tifalmin were very susceptible to fire during the 1997 drought.**

**Table 8: Famine and alternative foods eaten to survive the drought and frost**

Type of food	Description	Districts Where it was Practiced
Lowland seasonal fruits & nuts.	These are bush foods only seasonally available. These include aila, breadfruit (artocarpus sp), and galip nuts (canarium sp). During the 1997 drought breadfruit was available. It was roasted on the fire or boiled in pots and consumed.	Raikos & North Coast.
Wild yam	Gathered from the bush, cooked or roasted on the fire and eaten.	Raikos & North Coast Road
Banana corm	Corms of Kalapua banana were sliced, dried, and cooked with ferns or other bush vegetables. In the lowland they were cooked with coconut milk.	Raikos, North Coast & Bena
Xanthosoma taro corm (Red or White flesh)	In the lowlands Xanthosoma taro corms were prepared in a number of ways for food; <ul style="list-style-type: none"> <li>▶ Dried in the sun, peeled and sliced then cooked with coconut milk and bush vegetables and served.</li> <li>▶ The fresh corm was grated, mixed with coconut oil, packed in bamboo and cooked over fire or wrapped in leaves and boiled.</li> <li>▶ The dried corm slices were boiled, mashed and mixed with coconut oil, then packed into a bamboo and cooked over the fire.</li> </ul>	Raikos & North Coast
Wild taro	In the lowlands, the taro corms were prepared in a number of ways for food; <ul style="list-style-type: none"> <li>▶ The fresh corm was grated, mixed with coconut oil, packed into bamboo and cooked over a fire or wrapped in leaves and boiled.</li> <li>▶ The dried corm slices were boiled then mashed and mixed with coconut oil, then packed into bamboo and cooked over the fire.</li> </ul>	Raikos & North Coast
Lowland vegetables Ficus and tulip	Tender leaves of Ficus spp and tulip ( <i>Gnetum gnemon</i> ) were boiled or cooked in mumu and eaten. Ficus fruits were also consumed.	Raikos & North Coast, Bena and Gumine.
Food from abandoned gardens	Some food crops available for use were cassava, taro kongkong, banana and taro.	Raikos, North Coast and Bena

**Table 9: Socio-economic measures to cope with the impact of drought and frost**

Activity	Description	Districts Where it was Practiced
Migration out of the affected area	<p>People from frost affected areas moved to less affected areas where there was food and water: e.g.</p> <ul style="list-style-type: none"> <li>▶ People from the higher altitudes of Kandep moved to Sirunki, Taluma, Laiagam, Wapenamanda, Mt. Hagen and Banz</li> <li>▶ People from higher altitudes of Tambul moved to Mt. Hagen and the Waghi Valley where they settled until end of frost period.</li> </ul>	Kandep and Tambul
Migration within the affected area	<p>In the lowland, families from drought affected areas moved to the bushes, riverside or beach to settle until the rains returned</p> <p>In the highlands, severely affected families, who owned land near rivers settled there or in gullies and mountain valleys until it rained.</p>	<p>Raikos , Almami, North Coast</p> <p>Gumine and Bena</p> <p>(There was less migration in Bena compared to Gumine)</p>
Use of cash and remittances from relatives and friends (wantoks)	Cash savings were used to purchase food. Wage earning relatives provided financial assistance or sent store foods to affected families.	Raikos, North Coast, Bena, Gumine, Tambul & Kandep.
Support from relatives and friends (wantoks).	Relatives and friends of affected families provided temporary accommodation for those migrating and / or shared foods.	<p>Raikos, North Coast, Gumine, Bena,</p> <p>Kandep and Tambul</p>
Postponement of social obligations	Cultural ceremonies such as compensations and bride price payments were deferred.	Raikos , North Coast, Gumine, Bena, Kandep and Tambul.
Sale of assets and artefacts	Household goods, utensils, furniture, string bags and carvings etc were sold to obtain cash to purchase food.	Raikos, North Coast, Gumine, Bena, Tambul and Kandep.



#### 4.1.4 Frost reduction<sup>4</sup>

##### Introduction:

Frost is the term used to describe the ice formed from dew when air temperature gets too low.

Frost can occur when cold air from the mountains settles into low-lying areas on clear nights when there is no wind. On the tops of high mountains, this can occur during the dry season, and normally only when the weather has been very dry for a long period. During such times, there are usually no clouds and wind in the night.

Clouds act like a blanket over the earth and stop it getting cold. So frost does not occur when the weather or sky is cloudy.

Wind mixes the air so that the cold air from the mountain does not settle into low places. Hence, frost does not occur when there is wind blowing.

##### Where frost is likely to occur:

Frost tends to occur more frequently on flat land or in valleys at the bottom of a mountain, especially in high altitude areas where the average minimum temperature is usually below 13°C. Higher up the mountain, while it is normally cooler, the cold air flows down to lower areas almost like water flowing down hill sides. It is only with severe frosts that there is much damage on the sides of hills. When this occurs, the damage is normally much less than at the bottom of the hill.

##### Reducing damage caused by frost:

Local experience over a number of years should show areas where frost tends to be worse, and where it tends to be less severe. Steps

should be taken to minimise damage by making sure susceptible areas are marked out.

- ▶ Some gardens should always be planted in the areas marked out as less subject to frost damages.
- ▶ Traditional practices of planting gardens in different areas of available land help to ensure some gardens will not be affected by frost.
- ▶ Gardens on good soil on the bottom of hills tend to produce more crops under normal conditions, but can be more subject to frost.
- ▶ Gardens at the top of hills near the bush may not produce as well normally, but are less likely to be affected by frost.
- ▶ Gardens on hillsides tend to be less affected than those at the bottom of the hill. Though they do not produce as well as those at the foot of hills, they may be better than those near the bush.
- ▶ Trees should be planted near gardens at the bottom of hills to help reduce the effect of frost.
- ▶ A row of trees planted across the hill above the garden can stop cold air coming down. Trees planted across the hill but below the garden will trap cold air causing more severe frost damage.
- ▶ Trees planted on a hill side should have plenty of space between them to increase air movement and circulation. This means the cold air flowing down will mix with warmer air and reduce frost occurrence.
- ▶ The practice of planting gardens between *yar* trees

<sup>4</sup> Contributed by Martin Gunther

that have had a lot of branches cut off to allow light in should be encouraged. This also helps reduce frost by increasing air circulation.

- ▶ Thin layers of pitpit should be laid on top of sweet potato mounds and kept there until the frost season ends for plant protection. A thick layer would be better though it will need to be removed during the day to allow the leaves exposure to the sun. The pitpit can be used in mounds for new gardens.
- ▶ Old corn stalks and bean stakes should be left in gardens to help protect sweet potato vines from being damaged by frost.
- ▶ Few small fires should be lit in gardens to help reduce frost damage. When smoke rises, air around the fire is drawn in, causing air movement that

disturbs the mass of cold air in the gardens.

- ▶ Any fires lit will need to be managed very carefully, as frost and drought and extreme fire hazard go hand in hand.

Such steps should be undertaken in preparation for frost occurrence once a drought warning is issued. Frosts are associated with droughts due to the fact that there is less cloud cover both day and night with temperature that are high during the day and very low during the night. Long term considerations would include planting trees round gardens at the foot of hills and above gardens on hill sides. Work on frost tolerant crops is being started at the National Agricultural Research Institute's High Altitude Programme in Tambul, which should identify certain crops for cultivation. Research will also be directed towards improving farming practices in existence today.



## 4.2 Mid-drought

This section deals with things that can be done during a drought, when it is still uncertain when rain will fall.

### 4.2.1 Tuber storage<sup>5</sup>

#### Strategies for sustaining food supply:

Diets of Papua New Guineans mainly consist of root crop staples like sweet potato (kaukau), yam, taro and cassava (tapiok). These, unlike grain crops, generally have poor storage qualities. Storage qualities depend on a range of things (including respiration, senescence (a period when plants 'sleep'), attack by fungi and other microbiological agents) that vary from one root crop to another, as well as biochemical and chemical processes that affect the concentrations of nutrients in the different species.

#### Sweet Potato Tuber Storage:

The common practice in Papua New Guinea of continuous planting and sequential harvesting (harvesting only a few mature tubers from under the growing plant and leaving other tubers to mature) decreases the need for long-term storage. But in 1997/98, sequential harvesting became impossible because the soil became very dry, and weevils destroyed tubers stored in the soil.

Traditional storage of tubers on platforms in the sun can extend storage for up to a month. Otherwise, not much is known on methods used for storage. Weevil control is very important and is discussed on page 38.

<sup>5</sup> Notes adapted from 'Chemistry of Tropical Root Crops: Significance for Nutrition and Agriculture in the Pacific' by Bradbury and Holloway, 1988

#### Storage of Taro:

##### ► True taro, *Colocasia*, and Singapore taro, *Xanthosoma*

Less is known about the storage of taro and Singapore taro compared to sweet potato, yam and cassava. Both taros can be harvested after maturity at 6 months and field stored for many months, which is the general practice in Papua New Guinea.

It is also known that taro can be stored in pits lined with coconut fibre or banana leaves, then covered with the same material and then sealed with a layer of soil. This enables unpeeled tubers to be stored for 2 – 3 months and peeled tubers for a month.

##### ► Giant taro, *A. macrorrhiza*, and Giant Swamp taro, *C. chamissonis*

These crops are mainly grown at sea level, especially among atoll communities. These are planted independently of season and harvested from about 9 months to 4 years or more, hence corms are not usually stored. However, giant taro may be stored in special houses with yams.

Submerging tubers in water or covering them with wet sand may help store giant swamp taro. Storage using methods similar to that of taro in lined pits covered with soil or stones is reported to allow storage of giant swamp taro for 2 – 3 months.

#### Storage of Yams:

Unlike the other root crops mentioned yam becomes senescent (dormant or asleep), and is storable for several months. Yams in many parts of PNG are traditionally harvested in May to July and may be stored till October/November before replanting. For

yams to be stored for a longer period, physical damage that occurs during harvesting and handling must be minimised. Traditional storage in yam houses or any dry shelter should be applied for successful storage. Shoots can be removed a number of times to extend the dormancy.

### **Storage of Cassava:**

Cassava's swollen roots unlike the other tuber crops roots that bud, act simply as carbohydrate stores that may be used by the plant, enabling it to survive during periods of drought (Bradbury and Holloway, 1988). Deterioration is extremely rapid once roots are detached from the plant. Cassava can be left attached to the plant in the ground for longer periods after it is ready for harvest.

Several ways by which storage properties of cassava can be improved have been listed below.

- ▶ To leave tubers in the ground until need arises. This is probably the best place to store cassava in a drought.
- ▶ Pruning all branches from the plant up to 3 weeks before harvest. This causes changes in the tubers that improve storage.
- ▶ Reduction of both exposure of roots to air and moisture loss improves storage for up to 2 months.

Sugar content increases during storage. Cassava tubers stored in the ground during a drought may become more fibrous but remain edible.

### **4.2.2 Livestock management<sup>6</sup>**

We must manage our livestock properly during droughts. If we do

not, animals will roam food gardens and water holes, causing destruction and contamination. Those that are left to fend for themselves can die of starvation.

There are various benefits of rearing livestock at home. First and by far the most important benefit is the protein that they provide, then money from sales, as forms of payment, and droppings as valuable organic manure for gardens. In some areas where dogs are eaten, they also provide security.

### **Managing pigs:**

Pigs form an integral part of livestock rearing in most parts of PNG. Although they are seen as wealth, they can be a pest in times of droughts. Under dry conditions, pigs will be more difficult to keep than other livestock like chickens.

Several steps should be taken to ensure that pigs do not put a strain on the food supply and destroy gardens, natural bushlands and water:

- ▶ Use most of the pigs to settle debts, and/or sell them for money.
- ▶ Give to relatives for safekeeping, in areas near rivers or places where drought will harm the animals less.
- ▶ Keep at least a healthy reproducing male and female in a fenced area or hut for monitoring and breeding after the drought.
- ▶ Kill, distribute and eat pork with *wantoks* if strain on food supply intensifies, especially the male pigs.
- ▶ Use waste matter as manure in backyard gardens, which should be kept going as best as possible for daily vegetable supplements.

<sup>6</sup> Contributed by Markus Muntwiler

- ▶ Fence in vital gardens and water sources if there are possibilities of pigs accessing those sites.
- ▶ Pigs should be given less priority when kaukau becomes scarce.

If pigs are managed wisely, they will assist in providing food during droughts.

### **Managing other livestock like sheep, goats, chickens, ducks and rabbits:**

In most villages throughout PNG, chickens and ducks are a normal sight. Sheep and goat rearing is also picking up pace, particularly in high mountain areas or where the Seventh Day Adventists are a large portion of the population. Rabbits are also being reared in small numbers. These minor livestock usually demand less attention and food.

Effective management of these livestock would mean a prolonged food source. Steps for managing livestock:

- ▶ Sell most and use money to buy and store livestock feed. Some of this money should be used to buy and store food like oil, flour and rice.
- ▶ Kill and eat as feed supply starts getting scarce. Most would feed on grass and leaves of vegetables that are not normally eaten by humans, thus animals like goats and rabbits should not be affected immediately.
- ▶ Chicken and duck populations should be reduced to a manageable size. Both could live on plants and insects but not for long.
- ▶ All livestock should be kept in fenced areas. In cases where goats are reared, ropes should be tied around the neck at

appropriate lengths to minimise destruction to gardens.

- ▶ There should always be at least a healthy reproducing male and female kept for breeding purposes after a drought.

Fencing in of all livestock ideally at all times should contribute a lot to good management. This will also ensure less damage is done to food gardens, bush and water sources. Most villages do not practise this and when dry periods are experienced, more needs to be done to erect fences and monitor gardens or water sources.

Livestock populations should be monitored and if necessary reduced by either being eaten or sold for money.

### **Animal manure:**

When animals are fenced in, waste can easily be collected and applied in backyard gardens, which are much easier to maintain. Dry leaves should be placed under livestock cages or inside fences or huts for collecting waste. The manure and leaf mixture can then be used to compost gardens by digging small drains and filling them with manure and soil on top. Vegetables can be grown on these sites. Waste can also be used in fishponds to provide microorganisms which become food for carp are farmed for building micro-organism populations.

For more information, contact the Salvation Army:

Salvation Army Agricultural Development Service Program,  
P.M.B 3, Kainantu, EHP

Tel/fax: (675) 737 1274,  
Email: salvo@datec.com.pg

### 4.2.3 Water management<sup>7</sup>

Water is most essential for survival. It is used in many different ways from household use to gardens and livestock. Household uses include cooking, drinking, washing and laundry.

During rainy periods, there is plenty of water and rivers continuously flow. This is the normal sight in Papua New Guinea, but during a drought, these sources dry up. Most have water flowing underneath the dried up riverbeds. In instances where the water source dries up completely, the little amount that can be found must be managed wisely. Wise management of water is something most Papua New Guineans do not possess given the general mentality that water can always be found.

Managing water involves [locating water](#), [using water carefully](#) so that the source's life is prolonged and [treating water](#) obtained for drinking and cooking.

#### Locating water:

Most depend on rivers and creeks as water sources. Such instances, people and animals alike use the source and most times, contamination occurs. In such areas where the river or creek dries up, water can still be found flowing under the dry bed. Wells should be dug in the middle of the dry bed and the water found be allowed to collect into a pool and left to clear. Leaves should be placed on the holes to prevent contamination from animals. As dirt settles, clear water can be collected with cups and brought home for use.

In cases where water is still running, animals and humans should not be allowed to bath in the river or creek. Water should be

drawn in a bucket or dish for laundry and washing. This should be done more than a metre away on sand or stone banks to minimise contamination.

Where the water source is underground and a well is used, the well should be fenced in. If in cases where the water dries up, the well should be dug deeper for water below the normal level. Care should be taken where wells are concerned as children and animals can fall into them.

In wet marsh or swamp areas, most often the greenest spots are those that have water underneath. These areas should be marked and shallow wells dug. Leaves should be used to cover these holes as water collects. It would be best to harvest all the water collected and cover the holes for future harvesting.

#### Treating water for use:

All water brought in for drinking or cooking should be left in clean containers for dirt to settle. Once dirt has settled, clear water on the top should be transferred into drinking bottles for boiling to kill harmful organisms.

Water for cooking should be the next lot that is transferred. This should be boiled before food is added into the pot. Water left in the base should be used to do dishes, washing or laundry.

#### Prolonging source and use of water:

Most natural sources of water have their limits and so they can dry up after a while. For those in tanks, water depends on how much is used. In many cases, when water is plentiful, wasting occurs. To prevent wasting of water, vital steps should be taken. Some have been listed below.

<sup>7</sup> Contributed by Markus Muntwiler

- ▶ Always collect enough for the household if more than one family uses the water source.
  - ▶ Strong fences should be built around water sources where possible.
  - ▶ Some of the water left after cooking and drinking portions are separated should be used for livestock.
  - ▶ Water used to wash vegetables etc, should be given to livestock or gardens.
  - ▶ Soapy water from laundry and dishes should be used to water gardens. This can help control some insects and pests. (Splashing soapy water on aphids helps to reduce aphid populations).
  - ▶ All water use should be restricted to buckets, dishes or other containers where used water can be recycled.
  - ▶ Those with water supplies or tanks and inbuilt showers should build temporary showers outside in gardens or in tubs to collect and recycle water.
  - ▶ Children should be encouraged to share showers or baths to minimise the use of water.
  - ▶ Plants should be deep watered once a week. This means making small drains around the base of plants and pouring water into those drains. Wells should be made on top of mounds to water plants that grow on them.
  - ▶ Water should be introduced slowly and a bit at a time for maximum soaking and preventing run off.
  - ▶ The use of sprinklers should be stopped with hoses being placed at the base of each plant to flood the area around it. This deep watering helps roots of plants to grow deep and away from the surface heat.
  - ▶ Houses with fencing around them, especially in towns should have beans growing onto them. Small patches of land should also be used for kitchen gardens. This is so that gardens can benefit from used water.
  - ▶ Gutters and down pipes should be fixed for maximum water collection during rains before a drought and dew during a drought.
  - ▶ Washers in leaking taps should be replaced.
- Make sure everyone in the family understands the importance of, and wise use of water.
- For more information, write to:  
 Salvation Army Agriculture and Development Services Program,  
 P.M.B. 3, **Kainantu**, E.H.P.  
 Tel/fax: (675) 737 1274, Email: [salvo@datec.com.pg](mailto:salvo@datec.com.pg)



#### 4.2.4 Fire management<sup>8</sup>

##### Fire and droughts:

Fires can cause lots of damage to gardens, houses and forest. People light fires to help make gardens. Some people think that smoke from fires will bring clouds. Other people light fire to burn rubbish, or for no good reason. During a drought, small fires can quickly grow into large bush fires that destroy gardens, timber trees, food trees, animals, and houses, and fill valleys with smoke.

Fire is a very big problem during a drought.



**Figure 11 Fire during drought destroys homes, gardens, forest, animals and plants.** (Telefomin District, 1997, D.Askin)

---

<sup>8</sup> Contributed by David Askin

### How can villages be protected from bush fires?

Cut long grass, weeds or small bushes that can bring a fire right up to houses. Cut these dry plants down and drag the dry leaves and branches well away from houses.

Discuss the danger of lighting fires. In many countries, during droughts, no one is allowed to light fires outside. People who light fires can be taken to court and fined.

To help protect your village:

- ▶ Don't let people light fires in gardens.
- ▶ Fill any large containers with water and keep them covered.
- ▶ Make ladders that are strong and can be used to allow people to get quickly onto a roof to put out a fire in the thatch.
- ▶ Make sure buckets are kept in the drum or nearby,
- ▶ Make beaters from green branches or have target plants ready for use to beat out fires while they are still small.

Any fire in the village, even a small cooking fire must be closely watched. Even small sparks that will normally not cause problems might start a big bush fire.

### Can smoke help to make clouds and rain?

The smoke from fires does not make clouds that bring rain. Rain clouds are different to smoke clouds. Do not light fires to try and bring rain. All that will happen is that the fires will burn gardens, houses and perhaps people.

### 4.2.5 Sago<sup>9</sup>

During a drought it is often difficult for people to reach their good stands of sago because the rivers and creeks go dry. Also, the lack of water due to the dry creeks means that some accessible sago cannot be washed.

Sago is an important food crop. In some areas, it is the main source of food, while in many others, it is an important secondary food to yams, taro, sweet potato and banana.

How can we make sure that there will be sago available when a drought occurs?

1. Sago will survive long periods of drought where other crops may not grow, or die.
2. Use your experience. Know where your sago grows. Know what areas are accessible even in very dry years. Know also where there is permanent water to wash the sago even in very dry years, whether this is from rivers and creeks, or swampy areas, springs or wells that can be dug into the ground for water.
3. Make sure there are always sago trees near the permanent water and accessible areas so that there will be trees that can be cut down and processed even in very dry times.
4. Fire destroys many areas of sago during droughts, when the normally swampy areas dry out. Removing the dry leaves from the trees and rubbish from the ground can help reduce the effect of fire if it burns the stand. A fire break around the stand can

<sup>9</sup> Contributed by M. Gunther.

- help stop a fire entering the stand. This can be made by cutting grass and bush from the edges, or burning the edges early in the dry season before the sago dries up.
5. Washing sago and storing it helps ensure that there will be food available if the sago is difficult to access. What is the experience in your area? What have the old people done in the past? The most important thing for good storage is to wash and strain the sago well so that there is no fibre left in the washed sago. When this is done, drying will allow it to be stored for long periods in good condition. The sago can be spread out and dried in the sun. When it is well dried, it can be stored in the house, where it is often kept above the fire so that the smoke will help preserve it.
  6. In some areas people sometimes roast pieces of the sago in the fire straight from the tree. Some sago has less fibre and is easier to eat this way. But if it becomes impossible to process the sago because of shortage of water, this can be a way of ensuring there is some food available, even if it is not very palatable.
  7. As a long term measure, if there is a shortage of sago growing in accessible areas with a good permanent water supply, think about planting trees in good areas so that in the future the problem of shortage will not be so bad. In some areas of Papua New Guinea people plant all of their sago trees, in other areas, it grows wild

and none is planted, but if you have experienced shortages in the past, this may be a useful way to improve your supply. After planting, a tree may take fifteen years or more before it matures, but it is an investment to make life easier in the future, or for your children.

#### 4.2.6 Sweet potato weevil management<sup>10</sup>

##### Introduction:

During a drought or after a frost, sweet potato tubers still in the soil are commonly attacked by a small weevil. The Sweet Potato Weevil (*Cylas formicarius*) is the worst insect pest of sweet potato. The weevil bores holes in the tubers, causes them to taste bad and to rot quickly.

This insect pest is very difficult to control, even using insecticides. Weevils can cause the loss of up to half of the sweet potato produced and sometimes the total loss of the crop, especially **during the dry season**.



**Figure 12 Sweet potato weevil**

##### Description:

- ▶ The adult sweet potato weevil is about 6 mm long with a long nose and has a reddish body.

<sup>10</sup> Contributed by Roy Masamdu, Johnny Wemin and Pus Wesis



- ▶ It may look like an ant but it is a true weevil. It falls and pretends to be dead when disturbed.

### Life cycle:

- ▶ The insect undergoes four different stages in its life cycle (i.e. egg, larva, pupa, adult).
- ▶ It takes about 33 days to complete the life cycle.
- ▶ The time it takes to complete each stage depends mainly on temperature, i.e. the higher the temperature, the faster the development of the life cycle.
- ▶ Hot and dry weather is highly favourable to weevil development because the tubers are more easily reached through cracks in the soil.
- ▶ The adult weevils live up to 94 days being highly productive in the first 50 days. Most eggs (50-250) are laid during this period.

### Behaviour and damage:

- ▶ During the day, the weevils rest under the sweet potato plants or in cracks in the soil.
- ▶ Male weevils are active at night while female feed and lay eggs during the day.
- ▶ The females prefer tubers for feeding and laying eggs. This means that tuber initiation and formation stages of the sweet potato plant influence the egg laying behaviour of the female weevils.
- ▶ Adults and larvae cause serious damage to the crop because they spend their entire life cycles on the host.
- ▶ Both the feeding and egg laying punctures degrade eating and marketing quality of tubers. Tubers stored with egg

punctures will serve as a source of infestation for clean tubers stored beside them.

- ▶ Hatched larvae bore into sweet potato vines or tubers and start feeding and growing within the tissues. These cause most of the damage in tubers.
- ▶ Obvious signs of weevil damage are thickening or malformation in tubers, feeding marks and frass (insect excreta) accumulation in the tunnels that show as dark coloured patches on the surface.
- ▶ The sweet potato tubers react to the damage by producing a poisonous substance with a bad smell that spoils the flavour. This poison is harmful to the lungs and heart of human beings and livestock. For this reason, weevil damaged tubers should not be used as human or animal food.
- ▶ The weevil-damaged tubers are also susceptible to Black Rot, a fungal disease that causes tuber rotting.
- ▶ The sources of weevil attack are contaminated tubers, vines and residues from previous crops. Other host plants include kangkong (*Ipomea aquatica*).



### Figure 13 Sweet potato weevil damage

Be aware that sweet potato tubers may be poisonous following weevil damage.

#### Management:

Sweet Potato Weevil is difficult to control effectively. However, farmers can prevent or minimise the damage by following the advice below.

#### Cultural Methods:



**Crop Rotation:** Rotate sweet potato with other unrelated crops to reduce weevil population build up.

**Variety Selection:** In highly infested areas, farmers are urged to select deep rooting and early maturing varieties so that the tubers are formed deep under the ground, making weevil access difficult. Early maturing varieties reduce weevil contact time and ensure early harvesting of good tubers.

**Clean Planting Material:** Always select clean planting material from weevil-free plants or a weevil-free field often obtaining about 20-30cm vine cuttings from the growing tips.

**Earthing up:** Always cover the exposed tubers and soil cracks to prevent weevil entry.

**Sanitation:** Always remove and destroy all crop residues to prevent weevil infestation in a new field or new planting. Remove other host plants like kangkong from the sweet potato field.

**Mulching:** Cover the soil with mulch (e.g. grass) as it helps to keep the soil moist and prevent soil cracks. Mulch also provides a more favourable place for natural enemies.

**Fallow:** Allow bush to grow in the weevil-infested field and return later. This helps to break the life cycle and reduce weevil population.



**Table 10: The results of some experiments with cultural practices for Sweet Potato Weevil control**

Cultural Method	Site Tested	Result
Hilling up (Earthing up)	Taiwan, India, Philippines, Vietnam, America, East Africa, Cuba, Indonesia	Works well. Should be done before the adult weevil reaches the tubers to lay eggs.
Early Harvesting	Philippines, East Africa, Vietnam, America, Cuba	In Vietnam, harvesting two weeks earlier reduced loss due to weevil damage from >30% to <5%. Good results in other locations too.
Intercropping	Philippines, India	AVRDC (Asian Vegetable Research & Development Centre) tested 103 different crops as intercrops for weevil control and found that coriander produced best results.
Routine Irrigation	Taiwan, Philippines, Vietnam, America, Indonesia	Effective because it prevents soil cracks. Suitable for farmers with reliable water supply.
Field Sanitation	Taiwan, Philippines	Field sanitation can help reduce weevil infestation if it is practiced in a larger ecosystem area. Bury infested tubers to >15cm depth of soil.
Flooding of Field	Indonesia	Flooding of fields for at least 48hrs can kill the larvae of weevils present in roots that have been left in the field.
Mulching	Taiwan, India, East Africa, America	Mulch has shown a reduction in weevil damage. The soil surface should be covered soon after planting and maintained until harvest. The mulch not only helps to retain soil moisture but also prevents the weevils from gaining access to roots through soil cracks.

**Natural enemies (Biological control):**

Protecting and allowing natural enemies to control the pest is very important in effective pest management.

***Predators:*** Other organisms killing and eating the weevils. These organisms include earwigs, ants, ground beetles and spiders. Ants' nests can be moved to the sweet potato field to allow the ants to kill the weevils.

***Parasites:*** Other organisms living on the weevils and killing them.

***Pathogens*** (things that kill weevils): A fungus known as *Beauveria bassiana* has proven to be fairly effective in killing the weevils. This pathogen lives in the soil and it can easily be cultivated on coffee residue, wheat and rice straw. The planting material and the soil can be treated with *Beauveria bassiana* mixture to reduce the weevil population.

### **Chemical control**

The behaviour of the adults makes chemical control very difficult because they rest under sweet potato plants and in soil cracks during the day and are active at night. Hence, it is not only inconvenient but also not practical for farmers to spray insecticides at night. This is also an expensive option.

### **Pheromone traps**

Using sex pheromone traps (attractive chemicals) attracts adult male weevils in large numbers that can be collected and killed, thus helping to reduce the male population. Sex pheromone traps are not available in PNG at present.

## **4.2.7 Harvesting strategies for tuber crops during drought<sup>11</sup>**

During drought, soil is dry and the growth of plants is very slow because of the shortage of water. Plant roots can grow deep into the soil to find what little moisture is available. However, damage to roots reduces the amount of water that a plant can obtain. Plants lose water because of evaporation from the leaves. There is more evaporation from the bottom side of the leaf than from the top. The less damage caused to the leaves and roots, the longer the crop will be able to keep growing.

When a drought occurs, nobody can be sure how long it will last. It is important to let a garden continue producing as long as possible to provide food for the family. During such times, old gardens that may have been abandoned may still be able to

provide some food to help. Protect these gardens from damage by pigs and fire because, while they may not produce a lot of food, the little extra may be very useful.

### **Crops that are harvested over time such as Sweet Potato:**

#### **Minimise Leaf Disturbance**

- ▶ Reduce visits to gardens. Disturbance to leaves causes exposure of underside of leaves to the sun, which will increase the evapo-transpiration and put plants under more stress. This is particularly so with sweet potato, but occurs to some extent with all crops. When you have to walk through the garden, cause as little disturbance to the leaves as possible.
- ▶ Harvest the crop from only one area of the garden at the same time, selecting tubers that are ready from that section only. The next time you harvest, start from where you finished and start from there rather than going to a different section of the garden, as this will cause disturbance to a lot more plants and reduce their growth.

#### **Minimise Root Disturbance**

- ▶ Reduce disturbance to the soil and surrounding plants. When tubers are harvested, the remaining roots of the plant are damaged. This reduces its ability to get water out of the soil. The roots of neighbouring plants are also disturbed. As the ground is dry, the plants will not be able to grow more roots quickly to help recovery.
- ▶ When the plant is harvested, fill in the hole with any loose soil. This will help protect the roots still feeding the plant.

<sup>11</sup> Contributed by Martin Gunther

### Crops where the whole plant is harvested (taro):

- ▶ When taro is harvested, the whole plant is removed. When the leaves dry and the corms are harvested as required, the garden should be protected from pigs and rats as much as possible.
- ▶ In other areas where the taro leaves do not dry off, it is best

to take out individual plants throughout the garden. This will reduce the competition between plants and allow the remaining ones to have better access to the water in the soil. When doing this, it is important to cause as little disturbance to surrounding plants as possible.

## 4.3 Post-drought

After a drought when normal rains return, food production must begin again as soon as possible. Planting of quick maturing crops after the drought is the obvious solution. The use of early maturing varieties to provide food in the post-drought period is recommended. In order to do this planting material must be available and should have been preserved though the drought period (see page 20). Information on early maturing varieties of sweet potato is presented overleaf. Other important crops that will produce rapidly after drought are maize, beans, peanuts and potato.

Another reason not to plant just sweet potato after a drought is that during a drought nitrogen levels rise in the soil, partly through death and decay of plants, animals and micro-organisms. Quick growing

leafy vegetable crops can use the extra nitrogen to grow quickly and yield well, but sweet potato tends to grow lots of leaves, while tuber production is disappointing. It is better to plant a crop of maize first, followed by a crop of early maturing sweet potato.



**Figure 14 April 1989, Mt Hagen – excess top growth in sweet potato after drought**

### 4.3.1 Early maturing sweet potato for the PNG lowlands

Three early maturing sweet potato varieties (B11 PT, NUG 5 and SI 278) have been listed. These have also shown tolerance to drought. One other variety, SI 85, is an excellent variety for early harvest, but lacks the drought tolerance as the other three varieties. All these varieties yielded from 113 to 209% of mean yield when harvested 13 weeks after planting in a Sogeri trial.

**Table 11: Yield of early varieties at 13 weeks after planting**

Variety	% of trial mean	g/plant
SI 85	209	983
I 278	172	809
B11 PT	126	590
NUG 5	113	534

#### Recommended varieties

All these varieties were selected for trial as a result of past research done by the Pacific Regional Agricultural Program (PRAP) under the Department of Agriculture and Livestock (DAL).

**Table 12 Recommended early maturing sweet potato varieties for the lowlands**

NARI name		Variety	Origin	Characteristics
English	Tok Pisin			
NLSP 1	NARI nambis kaukau 1	B11 PT	Bubia, Morobe	Tuber skin and flesh are both white in colour
NLSP 2	NARI nambis kaukau 2	SI 278	Solomon Islands	Tuber skin and flesh are both white in colour
NLSP 3	NARI nambis kaukau 3	NUG 5	Nuguria Islands, Bougainville, PNG	Tuber skin and flesh are both white in colour
NLSP 5	NARI nambis kaukau 5	SI 85	Solomon Islands	Tuber skin and flesh are both white in colour

*Note: NLSP stands for NARI Lowlands Sweet Potato.*

These sweet potato varieties must be planted as soon as normal rains return after a drought. Supply should be available by the third month. Requests for foundation planting materials should be addressed to NARI Laloki using the contact details below.

Research Program Leader, NARI  
Dry Lowlands Program, Laloki  
P O Box 1828, PORT MORESBY,  
NCD  
Telephone: 328 1015 or 328 1068,  
Fax: 328 1075, E-mail:  
[dlplaloki@datec.com.pg](mailto:dlplaloki@datec.com.pg)

### 4.3.2 Early maturing sweet potato for the highlands of PNG

The National Agricultural Research Institute's Main Highlands Programme at Aiyura has selected 9 Sweet potato varieties, which have produced acceptable yields at 4 and 5 months after planting. The selection was based on results from 2 trials. The selected varieties yielded between 4 and 7 tonnes/ha at 4 months after planting. The varieties are 469, WBS 010, SSYK 026, WHCK 007, 123, SKK 010, 559, 714 and WHCK 005. Five of these varieties (WHCK 005, SKK 010, PRAP 469, WBS 010 & PRAP 714) are also tolerant to drought conditions.

**Table 13: Mean yield of early maturing highlands sweet potato varieties at 4 months after planting**

Variety	Yield at 4 Months (tonnes/ha)	Remarks
PRAP 469	6.98	Drought tolerant and Early Maturing. Good yield. Acceptable tuber shape and taste.
WBS 010	6.69	Drought tolerant and Early Maturing. Yields well with acceptable tuber shape and taste.
SSYK 026	6.42	Early Maturing only. Popular in Simbu Province
WHCK 007	5.77	Very early maturing
PRAP 123	5.73	Early Maturing only.
SKK 010	5.70	Drought tolerant and Early Maturing. Yields well, good tuber shape and taste.
PRAP 559	5.51	Early Maturing only.
WHCK 005	5.33	Drought tolerant and Early Maturing. Good yield with good tuber shape, size and taste.
PRAP 714	4.86	Drought tolerant and Early Maturing. Good yield, acceptable tuber shape and taste.

#### Recommended varieties:

Of the 9 varieties, 5 were collected from farmers' fields and 4 from varieties held by NARI from previous research conducted by Pacific Regional Agricultural Program (PRAP) under the Department of Agriculture & Livestock (DAL). Details of the selected varieties with the NARI names have been provided in Table 14.



**Table 14: Recommended early maturing sweet potato varieties for the highlands**

NARI name		Variety	Origin	Local name
English	Tok Pisin			
NHSP 1	NARI hailans kaukau 1	WHCK 005	Keltiga, Hagen Central, WHP	Flawa
NHSP 2	NARI hailans kaukau 2	SKK 010	Kerowagi, Simbu, PNG	Okome
NHSP 3	NARI hailans kaukau 3	WBS 010	Sipil, Banz, WHP, PNG	Tiki amb
NHSP 4	NARI hailans kaukau 4	PRAP 469	Karel, SHP	-
NHSP 5	NARI hailans kaukau 5	PRAP 714	Tokiroko, Tari District, SHP	Tapura
NHSP 6	NARI hailans kaukau 6	SSYK 026	Sinasina, Yogamuk, Simbu, PNG	
NHSP 7	NARI hailans kaukau 7	WHCK 007	Keltiga, Hagen Central, WHP	-
NHSP 8	NARI hailans kaukau 8	PRAP 123	U.S.A.	Kani
NHSP 9	NARI hailans kaukau 9	PRAP 559	Komea, SHP, PNG	Wannega

*Note: NHSP stands for NARI Highlands Sweet Potato.*

#### **When to plant:**

Farmers are encouraged to plant these early maturing sweet potato varieties after a drought to provide food during the recovery period. They should be planted as soon as the rains return. Trials at Aiyura have shown that acceptable yields can be obtained after 4 months, though tubers will continue to bulk up after this. They can provide edible tubers sooner than most varieties, which take longer to mature.

#### **Planting materials:**

Foundation planting materials can be obtained from the National Agricultural Research Institute's Main Highlands Programme in Aiyura:-

Research Program Leader, NARI  
Main Highlands Programme,  
Aiyura

PO Box 384, UKARUMPA, EHP

Telephone: 737 3500 or 737  
3561, Fax: 737 3516,

E-mail: [narimh@global.net.pg](mailto:narimh@global.net.pg)



## 5. Long Term Strategies (Strategic Preparedness)

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 storage of crops like cassava, maize and beans, and simple irrigation systems.

### 5.1 Drought Tolerant Crops

It is very important that over the long term, people are encouraged to plant a wide variety of staple foods, some that mature quickly

and some that are tolerant to low soil water conditions. This section begins with drought tolerant sweet potato varieties.

#### 5.1.1 Drought tolerant sweet potato varieties for the lowlands of PNG

##### Varieties:

The National Agricultural Research Institute (NARI) at Laloki Dry Lowlands Program has selected four sweet potato varieties, which have shown promise for drought tolerance in the lowlands of PNG.

The selection was based on results from one trial. The selected varieties showed a yield reduction of up to 30 % under dry conditions. They are B 11 PT, SI 278, NUG 5 and K 9.

**Table 15: Yield of the selected lowland sweet potato varieties under normal and dry soil conditions**

Variety	Yield under sufficient soil moisture (tonnes/ha)	Yield under dry soil conditions (tonnes/ha)	Yield reduction under dry conditions (Percent)	Remarks
B 11 PT	23.78	16.74	-30	Good yield, tuber shape, size and taste. Also early maturing.
SI 278	14.54	10.57	-27	Yields well with good tuber shape and taste. Early maturing.
NUG 5	12.81	10.71	-16	Good yield, good tuber shape and taste, also early maturing.
K 9	10.14	11.65	+15	Moderate yield, good tuber shape and taste. Yield less affected by drought.

**Recommended varieties:**

The four varieties were collected from the National Germplasm collection held by NARI from previous research conducted by the Pacific Regional Agricultural

Program (PRAP) under the Department of Agriculture & Livestock (DAL). See below for details

**Table 16: Recommended drought tolerant varieties for the lowlands**

NARI name		Variety	Origin	Local name	Characteristics
English	Tok Pisin				
NLSP 1	NARI nambis kaukau 1	B11 PT	Bubia, Morobe	Not recorded	Tuber skin and flesh are both white in colour
NLSP 2	NARI nambis kaukau 2	SI 278	Solomon Islands	Not recorded	Tuber skin and flesh are both white in colour
NLSP 3	NARI nambis kaukau 3	NUG 5	Nuguria Islands, Bougainville	-	Tuber skin and flesh are both white in colour
NLSP 4	NARI nambis kaukau 4	K 9	Keravat, East New Britain	-	Not provided

*Note: NLSP stands for NARI Lowlands Sweet Potato.*

Three of the sweet potato varieties are also early maturing; they should be planted as soon as the rains return at the end of a drought. Trials in Central Province have shown that acceptable yields will be obtained after about 3 months. They can provide food sooner than most varieties, which take longer to mature.

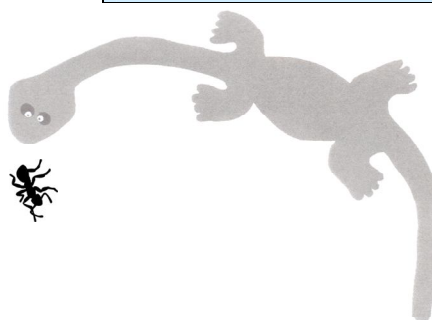
**Planting Materials:**

Requests for foundation plant materials should be forwarded to this address →

Research Program Leader, NARI  
Dry Lowlands Program, Laloki  
P O Box 1828, PORT MORESBY,  
NCD

Telephone: 328 1015 or 328 1068,  
Fax: 328 1075,

E-mail: [dlplaloki@datec.com.pg](mailto:dlplaloki@datec.com.pg)



### 5.1.2 Drought tolerant sweet potato for the highlands of PNG

#### Varieties:

The National Agricultural Research Institute (NARI) at the Aiyura Main Highlands Program has selected 5 sweet potato varieties which have shown promise for drought tolerance in the highlands of PNG (see Table 18). The selection was based on results from 3 trials.

The selected varieties showed a yield reduction not exceeding 25% under dry conditions (See below).

**Table 17 Yield of these sweet potato varieties under dry soil conditions**

Variety	Yield under sufficient soil Moisture (tonnes/ha)	Yield Under Dry Soil Conditions (tonnes/ha)	Yield Reduction under dry conditions (Percent)	Remarks
WHCK 005	26.1	21.9	-16	Good yield with good tuber shape, size and taste. Also early maturing (4 months).
PRAP 469	16.7	16.4	-2	Good yield. Acceptable tuber shape and taste. Early maturing (4 months).
SKK 010	20.5	15.5	-24	Good tuber shape and taste. Early maturing and yields well.
WBS 010	18.1	15.3	-15	Yields well with acceptable tuber shape and taste; also early maturing.
PRAP 714	15.1	12.6	-16	Good yield, acceptable tuber shape and taste; also early maturing.

#### Recommended varieties:

Of the 5 varieties, 3 were collected from farmers' fields and 2 from varieties held by NARI from previous research conducted by Pacific Regional Agricultural Program (PRAP) under the Department of Agriculture & Livestock (DAL).

**Table 18: Recommended sweet potato varieties for the highlands**

NARI name		Variety	Origin	Local name
English	Tok Pisin			
NHSP 1	NARI hailans kaukau 1	WHCK 005	Keltiga, Hagen Central, WHP	Flawa
NHSP 2	NARI hailans kaukau 2	SKK 010	Kerowagi, Simbu	Okome
NHSP 3	NARI hailans kaukau 3	WBS 010	Sipil, Banz, WHP	Tiki amb
NHSP 4	NARI hailans kaukau 4	PRAP 469	Karel, SHP	-
NHSP 5	NARI hailans kaukau 5	PRAP 714	Tokiroko, Tari District, SHP	Tapura

Note: NHSP stands for NARI Highlands Sweet Potato.

### When to plant:

Farmers are encouraged to plant these drought tolerant sweet potato varieties **all the time**. It is too late to plant these varieties after a drought has begun. Cultivation of other drought tolerant crops such as cassava and bananas (Kalapua and Yawa) are strongly recommended as well. More than one staple crop should be cultivated where possible, in case some crops fail. If available, mulch should be used on all crops grown under dry condition (see page 19).

Given these 5 sweet potato varieties are also early maturing, they should be planted as soon as the rains return. Trials in Aiyura have shown that acceptable yields will be obtained after 4 months. They would provide food sooner than most varieties, which take longer to mature.

### Planting materials:

Requests for foundation plant materials should be forwarded to:-

Research Program Leader, NARI  
Main Highlands Programme,  
Aiyura

PO Box 384, UKARUMPA, EHP

Telephone: 737 3500 or 737  
3561, Fax: 737 3516,

E-mail: [narimh@global.net.pg](mailto:narimh@global.net.pg)

### 5.1.3 Drought tolerant banana<sup>12</sup>

The banana varieties that survived the 1997 drought were mainly from the Kalapua, Yawa and Cavendish groups. Cavendish were introduced into PNG for their commercial possibilities. The other groups of banana did not do well during the drought.

Although there were no trials done to select for drought tolerance, recommendations of these three varieties have been made based on observations from collections done after the 1997/98 drought. Observations on performance of these varieties held at the Papua New Guinea Banana Germplasm

<sup>12</sup> Contributed by Rosa Kambuou and Janet Paofa

Collection site in Laloki were also incorporated. Varieties from these three banana groups are hardy and can withstand prolonged dry periods and bear good fruits. The Yawa and Cavendish are known dessert bananas while the Kalapuas are mostly cooking bananas, but can be eaten when ripe.

The detailed descriptions of the three groups of bananas are given below.

#### **Kalapua (dwarf, small and large varieties):**

This group of banana has more than 10 varieties and belongs to the ABB genome. They are triploids and have large, thick pseudostems that store a lot of water to keep them alive in long dry periods. Their leaves are very waxy, meaning less water is lost through evapo-transpiration. These characteristics help Kalapua varieties to survive droughts.



**Figure 15 Dwarf Kalapua**

There are two types of Kalapuas. The tall type that grows to an average height of five metres and the dwarf type that grows to about 2.5 metres.



**Figure 16 Kalapua plant**

Methods of cooking include unripe fruits normally being roasted on open fires, boiled, baked in earth oven (mumu) and fried in oil. Firm ripe Kalapua is known to be best when cooked in coconut cream.

#### **Yawa:**

Yawa varieties also belong to the ABB genome. Unlike the Kalapuas that have single stands (few suckers), the Yawas have very thick stands and can become very weedy especially in wet areas. Their rate of multiplication is fast and they tend to spread quite quickly, choking out other plants growing nearby.

They are tall plants with heights ranging from three to five meters that bear fruit after 18 to 19 months. They have large fruit bunches and matured fruits have

soft flesh, which are sticky when peeled. The fruits are ripened and eaten as dessert bananas or can also be eaten when cooked. Yawa is commonly known in the Asian region as *Pisang Awak*.

Yawa has been recommended as best in sago dishes.

### **Cavendish (dwarf, medium and tall varieties):**

The Cavendish varieties are introduced dessert bananas that also survived the drought. Many people had eaten cooked unripe fruits as food became scarce.

Cavendish varieties have a tendency to grow well in almost any type of soil, which make them ideal varieties to have growing during droughts. It is known that unripe Cavendish fruits, once ready, can be peeled and boiled briefly before being fried with salt to enhance taste. This method removes the bitter taste that is usually associated with cooked, unripe Cavendish. The ripe fruits, when still firm, can be coated with flour or breadcrumb and deep-fried. Fully ripe fruits can be mashed, mixed with flour and fried as pancakes. These various methods of preparing Cavendish diversify its uses and make it more than a dessert banana.

There is still confusion with the naming of the Kalapua and Yawa varieties. What is known as Yawa in the lowlands is mostly known as Kalapua banana in the highlands. Kalapuas are very robust plants, with few stems in a stand and have large fruit bunches. The matured fruits are dried and firm when peeled and are always cooked. Few varieties can be eaten as dessert bananas.

Yawa plants however, are not as robust but have very dense stands. They also have large fruit bunches like Kalapuas but matured fruits are

sticky when peeled. The fruits are most often ripened and eaten as dessert bananas.

We advise farmers to plant these banana varieties around gardens, homes and land not normally used for gardens for security in cases of future droughts. Planting materials should be easily accessible from old gardens, relatives and friends throughout the country.

Planting materials of Dwarf Kalapua, Yawa and Cavendish varieties are being multiplied for distribution by NARI Laloki. Varieties of other bananas of interest can be obtained also from the national banana germplasm collection:

Research Program Leader, NARI  
Dry Lowlands Program, Laloki

P O Box 1828, PORT MORESBY,  
NCD

Telephone: 328 1015 or 328 1068,  
Fax: 328 1075,

E-mail: [dlplaloki@datec.com.pg](mailto:dlplaloki@datec.com.pg)

### **5.1.4 Recommended lowlands cassava varieties**

#### **Introduction:**

Cassava is a drought tolerant crop that can survive extended periods of low rainfall. In the lowlands it takes 8 – 10 months from planting to harvest. Harvesting can be delayed for some weeks after maturity, but if left too long roots become fibrous and unpalatable. Cassava roots contain cyanide, which is a poison that can be destroyed by cooking; however the varieties we have selected are low in cyanide and can be safely consumed after boiling.



**Varieties:**

The National Agricultural Research Institute (NARI) at Laloki Dry Lowlands Program has selected 4 Cassava varieties, which have shown promising yields, with low cyanide content for the lowland conditions of PNG. Table 19

provides details of the selected varieties based on a trial conducted by the project at Laloki. Varieties included in this trial had already performed well in previous Laloki trials.

**Table 19: Yield, protein and cyanide content of 4 selected Cassava varieties.**

Variety	Total Yield (tonnes/ha)	Protein (%DM)	Total Cyanide content (mg/100 g)	Tuber Flesh Colour	Remarks
L86	20.1	0.74	1.33	White	Acceptable yield. Good tuber shape, size. Very good taste.
L51	29.2	0.63	1.20	Yellow	Good yield. Good tuber shape and size. Very good taste.
L6	28.7	0.76	1.17	Yellow	Good yield. Tuber shape and size ok. Very good taste.
L92	28.6	0.65	1.50	Yellow	Yields well with acceptable tuber shape and size. Good taste.

Note: Cyanide in cassava for fresh tuber:

<5.0 mg cyanide/100 g of fresh tuber is safe/harmless

5.0 – 10.0 mg cyanide/100 g is moderately poisonous

> 10.0 mg cyanide/100 g is highly poisonous

**Recommended varieties:**

All of the selected varieties were collected from the existing collections held by NARI from previous research conducted under the Department of Agriculture and Livestock. Table 20 lists the details:





**Table 20: Recommended lowlands cassava varieties**

NARI name		Variety	Origin	Local name
English	Tok Pisin			
NLC 1	NARI nambis tapiok 1	L 6	Central Province	Yellow cassava
NLC 2	NARI nambis tapiok 2	L 51	Central Province	Manihota
NLC 3	NARI nambis tapiok 3	L 86	Keravat, East New Britain	Not recorded
NLC 4	NARI nambis tapiok 4	L 92	Keravat, East New Britain	Not recorded

*Note: NLC stands for NARI Lowlands Cassava.*

### When to plant:

Cassava is a drought tolerant root crop. Farmers are encouraged to plant these recommended cassava varieties all the time to ensure that food is available should a drought occur. Cassava can survive a prolonged dry spell of 2 to 3 months and recover to produce edible roots soon after the drought. Cultivation of other drought tolerant crops such as cooking bananas (Kalapua and Yawa) and sweet potato is strongly recommended as well. More than one staple crop should be cultivated where possible, in case some crops fail. If available, mulch should be used on all crops grown under dry conditions.

### Planting materials:

Research Program Leader, NARI  
Dry Lowlands Program, Laloki  
P O Box 1828, PORT MORESBY,  
NCD  
Telephone: 328 1015 or 328 1068,  
Fax: 328 1075,  
E-mail: [dlplaloki@datec.com.pg](mailto:dlplaloki@datec.com.pg)

## 5.1.5 Recommended highlands cassava varieties

### Introduction:

Cassava is the major root crop in Fiji and Tonga, whereas in Papua New Guinea and most other countries it is still less important than sweet potato, taro and yam.

But in recent years, the importance of cassava has increased due to it being a hardy drought-resistant crop that gives acceptable yields on low fertility soil. Furthermore its popularity in the highlands of Papua New Guinea has increased since the recent drought in 1997/98. Unlike its important role as a staple food in the dry coastal villages of Central Province, cassava was generally seen as a pig food, especially in the highlands.

Recommended cassava varieties have acceptable cyanide levels, most of which is destroyed in post harvest treatments and cooking.

### Research done:

A total of 34 cultivars were collected during the post-drought survey carried out from 7 July to 4 August 1999 and maintained at

Aiyura. Out of the 34 cultivars maintained at Aiyura, nine distinct cultivars have been identified with the rest being duplicates.

#### Selection of varieties:

These seven accessions were compared in a trial at Aiyura with five of the best varieties from Laloki. Based on the results of this trial, four varieties were selected

using three main selection criteria: high marketable and total yield, and low cyanide content. Protein content was not seen as important at this stage for selection. The selected varieties are shown in Table 21. Yields obtained ranged from 26.0 to 36.0 t/ha, increasing cyanide levels from 1.75 – 2.50 mg HCN/100 g fresh weight.

**Table 21 Selected highlands cassava varieties and their characteristics**

Variety	Average tuber no. per plant	Total yield (t/ha)	Tuber flesh cyanide at harvest (mg/100 g)	Tuber flesh protein at harvest (%)	Tuber flesh colour	Taste
AIYME 003	10	35.96	1.75	1.78	White	Acceptable
AIYME 002	8	30.23	2.25	1.52	White/Cream	Acceptable
AIYME 007	8	27.49	2.50	1.49	White/Cream	Excellent (soft & pasty)
AIYME 001	7	25.96	2.50	1.84	White/Cream	Acceptable

Note: Cyanide in cassava for fresh tuber:

<5.0 mg cyanide/100 g of fresh tuber is safe/harmless

5.0 – 10.0 mg cyanide/100 g is moderately poisonous

➤ 10.0 mg cyanide/100 g is highly poisonous



**Figure 17 Cassava evaluation, NARI.**

**Recommended varieties:**

Information on the origin of the four recommended cultivars is given below:

**Table 22 Recommended highlands cassava varieties**

NARI name		Variety	Origin(s) of collection
English	Tok Pisin		
NHC 1	NARI hailans tapiok 1	AIYME 003	Daulo, Henganofi and Lufa (EHP), Keltiga (WHP) and Gumine and Sinasina/Yogomugl (Simbu)
NHC 2	NARI hailans tapiok 2	AIYME 002	Henganofi and Daulo, EHP
NHC 3	NARI hailans tapiok 3	AIYME 007	Banz and Jimi, WHP
NHC 4	NARI hailans tapiok 5	AIYME 001	Daulo, Henganofi and Lufa (EHP), Banz and Jimi (WHP) and Gumine (Simbu)

*Note: NHC stands for NARI Highlands Cassava.*

Cassava can be grown all year round and the excess tubers can be processed into various products that can store for longer periods than fresh tubers. Increased planting of the crop in the drier parts of available land is encouraged during the pre-drought period, though it is better if cassava crops are included in gardens in all seasons.

The recommended varieties are suitable for most highlands areas and are safe for consumption.

Foundation planting materials can be obtained from National Agricultural Research Institute, Aiyura using the contact detailed below:

Research Program Leader, NARI  
Main Highlands Programme,  
Aiyura

PO Box 384, UKARUMPA, EHP

Telephone: 737 3500 or 737  
3561, Fax: 737 3516,

E-mail: [narimh@global.net.pg](mailto:narimh@global.net.pg)

## 5.2 Post harvest storage and use of various foods in PNG

### 5.2.1 Processing of cassava<sup>13</sup>

#### Introduction:

Cassava is grown and consumed in most parts of the tropics. It survives droughts or floods and is easy to cultivate, harvest and prepare for eating. Papua New Guineans know about roasting cassava in fire, boiling and mumu. This paper presents three other methods of preparing cassava:

#### Fufu:

- ▶ Boil your cassava well: it should not be over boiled or half boiled.
- ▶ Use a mortar and pestle to pound without adding water until it is well pounded.

NB: Training in this area is strongly recommended. Also, hands must be well washed before pounding cassava to avoid contamination of the *fufu* with bacteria.

#### Preparation of soup to accompany fufu:

- ▶ Chicken, pork, fish, goat, mutton and any other meat can be included in the soup. Cut meat into pieces, wash it clean and put meat into the cooking pot before adding vegetables. Add water according to the number of people and bring to the boil.
- ▶ Cut tomatoes, onions/spring onions into the boiling water with the tinned fish or meat that is already there. Add salt to taste.
- ▶ Cover, place on the fire and steam for some time, and add salt if more is requested.

When well steamed, add extra water if required- according to number of people to be served.

- ▶ Add the pounded cassava to the boiling soup and let it all boil well for at least 20 minutes, turning each ball of fufu while it boils.
- ▶ Serve fufu to eat once ready. This dish is delicious if well prepared.

Training is recommended for preparation of *fufu* and its soup.

#### Gari:

This second method is the one that lasts for ages and is called *gari*.

- ▶ Fresh cassava roots should be used the same day they are dug. Peel off the skin (peel can be given to pigs, sheep etc).
- ▶ Grate with nailed fish tin, milk tin or pieces of roofing iron.



**Figure 18 Tinned fish can, used as a grater**

- ▶ When enough cassava has been grated, place into clean rice or coffee bags. These bags should be tied well, placed on a flat stone or piece of wood with a series of heavy stones arranged on top. These

<sup>13</sup> Contributed by Fr Joseph Sakite

then should be supported with sticks tied with rope so that the stones do not fall off. This is a traditional press that will allow moisture to get out.

- ▶ Allow this to stay under stones for three full days. For instance, if you put grated cassava under stones on Monday, it should be ready by Thursday.
- ▶ After the three full days, remove the stones and take the dough out of the bag, place in a dish and strain.
- ▶ While some people are straining the dough, others should also start the next stage of toasting in a cast iron boiler.
- ▶ The dry gari must be stored in a cool dry place (tin) where rats and insects cannot damage it.

NB: Training in this area is also strongly recommended.

### **Serving processed gari:**

- ▶ Put processed gari into a cup of water, add milk, sugar and drink.
- ▶ Put a little onto a plate, open tin fish, mix and eat as a heavy meal.
- ▶ Prepare vegetable soup, add to gari, mix and eat.

This processed cassava will last for up to six years or more.

### **Flour from cassava:**

The third method is called *lapiawa* or *kokonte*.

- ▶ Pieces of cassava not to be used for fufu or gari should be dried in the sun for a long period daily. When well dried, pound in a mortar and strain to get flour.

Cassava flour also has a longer storage life like *gari*.

### **Ginger sauce:**

- ▶ Dry ginger well or grate ginger and dry, before pounding into powder.
- ▶ Get mince meat or dry pounded fish, boil with fresh tomatoes in cooking oil.
- ▶ Next, put about 5 litres of cooking oil in a big boiler. Hot oil is dangerous. Take special care not to splash hot oil onto the skin. It will cause severe burns.

NB: This requires training.

In order to achieve quality results for Papua New Guinea to become self sufficient in processing cassava, skills are needed. Training is available from Fr. Sakite and his team either on site when requested, or at the Goglime Human Development Centre in Simbu.

For more information, the contact details provided below can be used.  
 Contact: Fr. Joseph Sakite, SVD,  
 Human Development Centre,  
 Catholic Church, P.O. Box 167,  
 Kundiawa, Simbu Province,  
 Telephone: 735 1245, Fax: 735 1245.

### 5.2.2 Storage and preparation of maize and beans<sup>14</sup>

The staple diets in Papua New Guinea are dominated by root crops like sweet potatoes, taro and yam. Other crops that significantly contribute to the food basket are Irish potatoes, cassava and bananas. Unlike the grains and pulses, these foods cannot be stored for a long time due to their high moisture content. Yams can be stored for four months without sprouting while potato tubers start sprouting in five weeks. Sweet potato weevils, rodents and nematodes, hamper storage of root crops in the garden.

It is therefore very important that farmers should consider alternative food sources particularly during droughts. During the 1997 drought, many lives were saved by importing huge quantities of rice. Rice can be carried long distances and kept for a long period. Farmers are trying to learn to grow rice and wheat for obvious reasons.

Papua New Guinea farmers already grow and eat maize and beans. But they do not recognise dry maize (corn) and beans as food simply because they do not know how to prepare and cook them. This paper makes an attempt to explain the process of storing and preparing dry maize and beans into human food.

#### Maize (*Zea mays* L.)

Maize is a versatile tropical crop with tremendous genetic variability, which enables it to thrive well under lowland tropical, subtropical, and temperate climates. It grows from sea level to over 3000 meters elevation, in cool and hot climates,

and with growing cycles ranging from 3 to 13 months. It is the third most important cereal in the world, after rice and wheat.

When grown for human food, maize is an important source of calories. Subsistence farmers grow the crop widely in mixed cropping systems.

#### Harvesting:

- ▶ Maize is picked by hand in most countries. However, in large-scale agriculture, it is usually harvested mechanically using special machines, which shell the cobs at the same time. Harvesting is done when the moisture content is about 19 – 20% for safe storage.

#### Utilisation:

- ▶ “Green maize”, i.e. maize which is not fully dried out, is roasted or boiled and eaten on the cob.
- ▶ The dried grains are cooked whole; they may be eaten with beans cooked in the same way or may be incorporated into boiled and mashed potatoes and bananas.
- ▶ Dried grains can be made into pellets or flour by pounding with a mortar and pestle. The pellets are cooked like rice by boiling, while the flour is made into porridge.
- ▶ In many countries, most of the maize produced is dried and ground into flour for making various food dishes and drinks including porridge.

#### Cooking dry maize:

- ▶ Boil seeds for two minutes and soak in water for one hour.
- ▶ Drain the soak water and boil again until cooked – takes approximately one hour.

<sup>14</sup> Contributed by Jacob and Florence Kiara



- ▶ Alternatively, soak the seed overnight in cold water and boil until cooked.
- ▶ Add salt and seasoning according to your taste.

### **Beans (*Phaseolus vulgaris*):**

Phaseolus bean, or common bean, is the world's most important food legume. Farmers eat common beans in two forms, as dry beans and as snap beans (the green pods are consumed as a vegetable).

Beans are an attractive crop for farmers, because of their adaptability to different cropping systems and short growing cycle. They are however, susceptible to many diseases and climatic stresses.

Beans are nutritionally rich in protein and iron, in addition to being a good source of dietary fibre and carbohydrates. They make an important contribution to human nutrition, especially for poor consumers.

### **Harvesting:**

Smallholders usually harvest beans by uprooting whole plants. The uprooted plants may be dried in the field or taken to the homestead where they are dried on bare earth, mats, sacks, tarpaulins or iron sheets. The drying period may take up to a week depending on the weather and amount of drying in the field before harvesting. The dry beans are beaten with sticks, either directly or after putting them into sacks. The haulms and pods are later removed by hand and by winnowing.

### **Utilisation:**

- ▶ Green bean leaves are eaten as vegetables.
- ▶ Pods harvested before they dry may be cooked whole (as in a mumu) or opened so that the seed is cooked and eaten

either alone or mixed with vegetables, potatoes or bananas.

- ▶ Dry beans are boiled alone or with maize seeds until both are soft; the mixture is eaten alone or with green vegetables.
- ▶ Alternatively, potatoes, bananas and green vegetables are added towards the end of boiling period; the mixture is then pounded into a paste.
- ▶ Beans are boiled alone and then ground into a paste, after removing the seed coats. This paste may be eaten immediately or fried. In both cases the paste is usually eaten with other foods as stew.

### **Cooking of dry beans:**

- ▶ Put one (1) measure of dry beans into four (4) measures of water and boil for two minutes. Let it soak for one hour and boil until soft.
- ▶ Alternatively, soak dry beans in cold water overnight. Then boil until soft.
- ▶ Add salt and flavourings to your taste.

### **Storage**

Storage losses may be due to a number of factors. The main losses are caused by insects and rodent damage, fungus growth and rotting. It is therefore imperative that grain foods are properly dried and stored in both air and water-tight containers. Cereals are safely stored at 12 – 14% moisture contents while beans and other pulses are stored at between 13 and 15% moisture content.

Storage containers vary from earthen pots to baskets, to big metal or cement silos. The storage



containers chosen for each circumstance will depend purely on financial capabilities, available materials and prevailing climatic conditions. However, whatever container is used, it must keep the product dry and cool, and protect it against insects, fungi, rodents, domestic animals and thieves.

#### **Other storage methods:**

- ▶ Mixing grain with wood ash, burned cow-dung, fine sand and lime. The material used should fill the spaces between the grains, thereby restricting insect movement and emergence.
- ▶ Earthen pots sealed with mud can store grains for about one year.
- ▶ Baskets smeared with mud, clay or cow-dung on the outside can protect grains for a period of 6 – 9 months.



**Figure 19 Weevils destroy seeds**

Protect your seeds from weevils, by using tins, jars or earthen pots.

#### **Drying:**

Drying of the grains and pulses is absolutely crucial for safe storage. It is very harmful for a product to become wet during drying. The product should be dried in thin layers to allow air to circulate freely. Where drying in open air is not adequate, drying above the fireplace may be appropriate.

### **5.2.3 Storage and preparation of corn and some legumes<sup>15</sup>**

Drought in PNG is a golden opportunity for Papua New Guineans to develop food crops already cultivated here such as cassava and cereals. The country would then save a lot of money by reducing importation of food such as rice, flour and noodles.

This paper will present ways of processing corn or maize and some legumes like peanuts. These food crops are already being cultivated in PNG and eaten in simple forms such as boiling, roasting and *mumu*.

Corn or maize is cultivated in both the lowlands and highlands, and depending on the variety, the crop matures as early as three to four months from planting.

In the **pre-drought period** a lot of corn should be cultivated and allowed to dry on the stalk before harvesting. However if there is hunger it could be harvested fresh green and boiled for food.

#### **Sun drying:**

First the corn should be allowed to dry on the stalk before being harvested with the cob. This should be further dried in the sun without removing the husk. When the corn is well dried, pine can be strung above the fire in the cooking house to store the cobs. (Tie them in pairs using some of the husks).

<sup>15</sup> Contributed by Fr Joseph Sakite



**Figure 20 Dry corn is excellent food for use during droughts**

The smoke and the heat of the fire can preserve corn for the period of the drought. This corn can also be used as seeds for planting during the post-drought period.

Another way of sun drying is to allow the corn to dry on the stalk before harvesting. The husks are then removed from the harvested cobs along with the grains one by one and the grains are further dried until well dried. This could take days or weeks. The grains can be stored in rice bags, coffee bags or copper dishes with chillies to ward off weevils.

#### **Preparation of dried corn for food:**

- ▶ The dried corn is then milled into flour to be prepared in various dishes such as *banku*, *kenkey*, *akple* or porridge for breakfast.
- ▶ Another way is to roast the dried corn first before milling. In this case it could be eaten as corn flakes with water, sugar and milk.
- ▶ The roasted milled flour could also be prepared for eating as solid food.

#### **Some legumes:**

Peanuts should be very well dried, roasted, then pounded or milled into butter. Pigeon peas and soybeans should also be well dried in the sun for storage. Peanuts and soybean are also rich sources of cooking oil. Dried pigeon pea should be soaked in water

overnight then boiled and eaten with other food.

All these need training. Other training in smoking fish and meat, or salting of fish and meat for storage purposes can also be arranged. It is recommended that prospective trainees go to the Centre at Goglime for training, especially for areas nearby like the highlands provinces, Lae and Madang.

For more details, contact: Fr. Joseph Sakite, SVD, Human Development Centre, Catholic Church, P.O. Box 167, KUNDIAWA, Simbu Province, Telephone/fax: (675) 735 1245

### **5.2.4 Preservative storage of rice<sup>16</sup>**

#### **Introduction**

In Papua New Guinea, drying of seed grains, for either storage for food or seed material, using natural sunlight is the most important operation practised by farmers. In some instances, initial sun-drying is subsequently followed by shade or even heated air supplemented with heat treatment. This is mainly to reduce the moisture content to very low levels for safe storage. These simple technologies, still prevalent today, have evolved from ancestral trial and error experiments passed down through generations. The major limitation, however, is the absence of appropriate storage practices and facilities to complement these drying efforts. Food and seed grade materials therefore cannot be stored for a long period of time.

Many farmers throughout the country are growing rice as a smallholder crop. Most supplement

<sup>16</sup> Contributed by Joel Waramboi

daily diets with the rice produced. As rice cultivation picks up pace, simple preservation and storage methods need to be adapted to sustain food and quality seed supply.

### Drying

During a drought, farmers are presented with the ideal low humidity conditions for drying seeds. Drying basically reduces the moisture content to very low levels, thereby increasing seed longevity, viability and germination power. Ultimately, physiological and microbiological activities are suppressed. Farmers should be advised to continue drying seeds. This method of preservative treatment is old, easy and most popular.

Smoke drying is quite common in places like Mape, Kote and Hube in Finschafen, where rice has been cultivated for over 100 years since its introduction by early missionaries. This involves previously sun-dried unmilled rice, stored in bags, being placed on raised platforms just above the fireplace in houses. Smoke and heat from the fire below keeps the rice dry. The formation of phenolic (bitter) compounds on the kernels, caused by smoke, deters pests and micro-organisms from damaging the rice.

### Parboiling

Another treatment that can be used to preserve rice is known as parboiling. This involves the boiling of unmilled rice for 30 minutes, steaming and drying to 12% moisture content. **Grains only intended for eating should be treated this way and not those intended for seed material.** Parboiling causes compounds like vitamins, especially thiamine, and minerals to migrate from the husk into the endosperm, making them more nutritious.

Though not as popular as plain sun-drying, parboiling has a few advantages:

- ▶ The exposure to heat treatment during boiling and drying loosens hulls. These can then be easily removed to get brown rice for cooking, which would greatly benefit farmers with limited access to milling facilities.
- ▶ Parboiled rice is more nutritious than raw milled rice and can be used as an alternative source of nutrients obtained from vegetables, fruits and nuts.
- ▶ Parboiled rice is more resistant to breakage during milling, resulting in higher head rice recovery rates. Most farmers discard grains that are broken so this method would greatly decrease that amount.
- ▶ Parboiled rice is also less affected by pests and insects, increasing storage life.
- ▶ Parboiled rice keeps better than milled rice because it is more resistant to rancidity (bad smell and taste).

The only constraint to parboiling rice is the acceptance by farmers, who are so used to milled raw rice. Parboiling treatment usually changes the appearance (colour), sensory (flavour) and textural (consistency) qualities of rice.

### Storage

Traditionally, immediate consumption or processing of all rice after harvest is impossible. Almost all the rice is stored in houses where it will eventually be used for food and as seed material.

Seeds cannot be stored for very long in areas affected by frost, as the humidity in the atmosphere will cause some seeds to germinate.

Hence, controlling humidity would be the major issue.

The following points should be considered when storing rice for food and seed material.

- ▶ Properly dried rice can be stored for up to three years or more, hence the drying process should be treated with utmost importance.
- ▶ Rice should not be milled until needed. This is because milled rice does not store as long as unmilled rice.
- ▶ Furthermore, milled rice tends to be more affected by weevils so mill the rice only when necessary. If weevils are observed, grains should be rubbed with cooking oil, sun-dried then stored.
- ▶ Storage bins, metal bins, polythene silos and gunny bags can be used as short to

medium term rice storage. These can provide some protection from moisture, insect pests, and rats.

- ▶ Enclosed hollow bamboos, mud plastered bamboo bins, or other effective traditional storage equipment can be also used for storage purposes.
- ▶ All containers should be cleaned before use to minimise any attack from pests, especially weevils.
- ▶ Airtight containers are ideal for seed storage. Polythene film and jars can protect seeds for 3-4 years.
- ▶ Regular checks should be made to ensure quality of the grain is maintained.

Rice and maize are great crops to grow as they have a much longer storage life than other staples.

## 5.3 Simple Irrigation Systems for Papua New Guinea

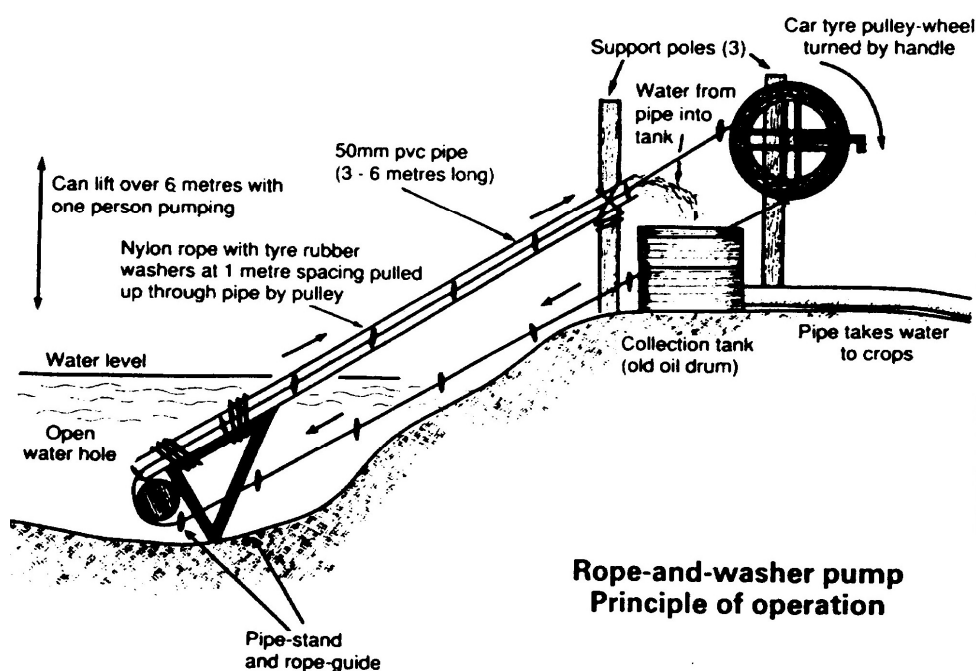


Figure 21: Rope & washer pump for use in rivers

### 5.3.1 Introduction

Irrigation simply means the supplying of water to land and crops, especially by means of specially constructed channels or pipes. Many countries practise irrigation whereas in Papua New Guinea most areas have enough rain all year round to make irrigation unnecessary. In a few places of PNG traditional irrigation systems are used.

The focus in this section is on systems that can use ground water through shallow wells and tapping surface flows from streams and rivers, without relying on engine-powered pumps that are costly and hard to run and maintain, especially for smallholder farmers. The adaptation of such intermediate technology pumps that deliver more water than simple hand pumps would prove more

economical and reliable for delivering irrigation water. Such simple technologies are more likely to be accepted and adopted by small-scale farmers.

Several such systems were presented at the Drought Contingencies Planning Workshop in June 2002 organised by NARI.

### 5.3.2 Available systems

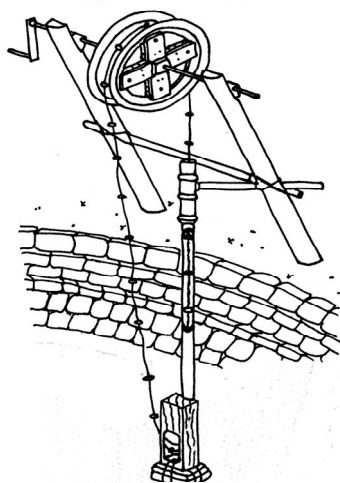
#### Water withdrawal systems:

Water withdrawal refers to the removal and transportation of water from a groundwater or surface water source to a place of use, commonly referred to as "water lifting" because most systems lift water from streams, ponds or wells.

#### Gravity-Flow Systems

This is the channelling of water through ditches or pipes from a source by gravity flow, similar to

some traditional practices already in use. Such systems would be costly for areas where water has to be channelled a great distance if plastic or metal pipes are used along with reservoir tanks, or labour costs are incurred to make ditches to point of irrigation. However where the topography is suitable, such systems are attractive as they only involve construction of diversion weirs and channels from the upslope water source to the area to be irrigated.



**Figure 22 Rope & washer pump for use in wells**

#### **Rope and Washer Pump**

A nylon rope, washers, a pipe and a pulley are used to make this pump. As the pulley is rotated the nylon rope is pulled up through the pipe. The washers attached to the rope push the water up to the surface. This device can lift water 20m high and costs around K500. It is most suitable for pond, rivers or underground sources of water.

This pump can be manufactured using local materials, so costs of acquiring and maintaining it would be low.

#### **Treadle (Pressure) Pump**

A foot-operated device, it can be made totally from bamboo. The

current prototype is a modification of a 90 mm (3.5 inch) bamboo treadle pump, which has a suction depth of 8-10m. It has the capacity to lift water up to a height of 10 metres or even 20 metres in a pond or river. It discharges 2000 litres per hour. This pump can be used to irrigate small plots in regions that have a high water table.

The pump costs about K40 and can be manufactured in PNG.

#### **Hydraulic Ram Pump**

A ram pump lifts and discharges a smaller amount of water by using the force of a larger amount of water to do the work. The large water intake 1m above the pump will cause the smaller amount of water to be lifted up to 10m. Two sizes of ram pump were observed: one that could lift 5-10 litres per second and another that could lift 10-20 litres per second.

The pump can be manufactured in PNG with the water inlet being filtered and the valve being replaced regularly due to rusting.

Costing around K600 it would be appropriate for areas where there is a suitable flow available that can be used as the input. A ram pump requires water to be dammed and drawn into the inlet pipe.

#### **Coil Pump**

Water is delivered when a coil of tubes is rotated. The open end of a tube lets in both water and air, and water is lifted by pressure differences created by the two. It can lift to 10 metres. This pump can also be made with local materials.

#### **Water distribution systems:**

##### **Gravity Flow (Flood) System**

This system involves the distribution of water through flooding of fields or furrows made in gardens. Though cheap, it delivers



far more water than needed for crop growth, with only 50-60% of the water reaching crops because of evaporation, seepage and runoff (Miller, 1994). Furthermore, such over-watering without adequate drainage also causes waterlogging and salt build-up in the soil.

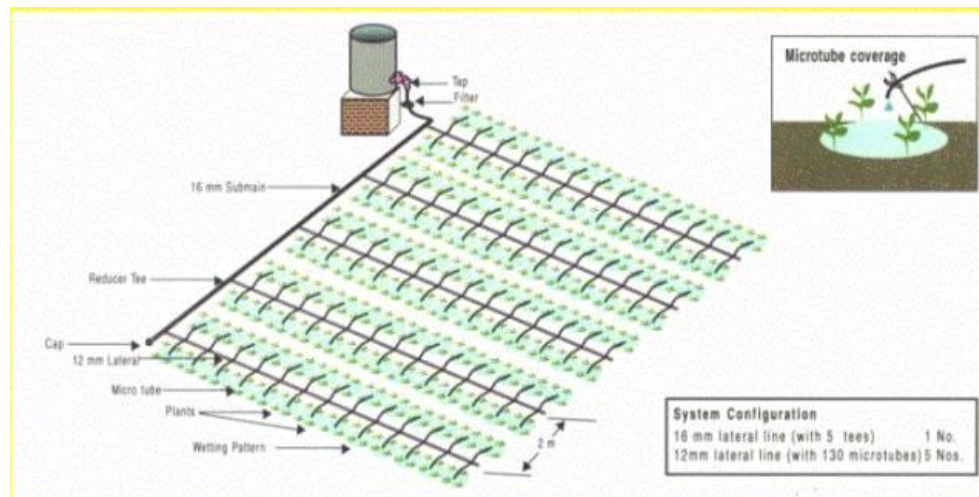
#### **Micro Tube (Drip) System**

A drip or trickle system is a network of perforated piping, installed at or below the ground surface, releasing a trickle of water close to the plant roots. This minimises evaporation and seepage, and brings 80-90% of the water to crops (Miller, 1994).

Similar to the drip or trickle concept already in use, the micro-tube

system is being promoted as simple bucket and drum kits. The bucket kit consists of a bucket placed at 50cm with a lateral line (hose) fitted with micro tubes, ideally suitable for kitchen gardens. The drum kit differs by the inclusion of a sub-main pipe to which several lateral lines with micro tubes are connected, and seen ideal for small commercial farmers. It is not only cost effective but also water efficient. The drum and bucket kits cost around K221 and K24 respectively.

Figure 23 illustrates the drum kit drip irrigation system that is being promoted in the country by NARI.



**Figure 23 Drum Kit Drip Irrigation System**

#### **Micro Sprinkler (Spray) System**

The most commonly used system where water is sprayed from nozzles is the centre-pivot system which delivers water to areas in a circular pattern. 70-80% of the water in such overhead sprinkler systems reaches crops (Miller, 1994).

The micro-sprinkler kit is also a sprinkler system and is suitable for farmers with access to pressurised water. A micro-sprinkler kit consists

of a set of micro-sprinklers connected to pipes that are fed by a main pipe that is connected to running tap water or a small domestic water pump. Such a system would cost about K85 and is seen ideal for nurseries or mixed vegetable gardens.

#### **Systems recommended**

Of the systems available, two water lifting and one water distribution system have been selected for on-farm demonstration. These are the



**Rope and Washer Pump**, the **Treadle Pump** and **Micro Tube Drip Irrigation system**. The rope and washer pump is already being demonstrated at the National Agricultural Research Institute's Main Highlands Programme in Aiyura. Demonstrations in other centres are also being organised. This pump can be ordered from the Appropriate Technology and Community Development Institute<sup>17</sup>. Also, the **Gravity Flow System** as both a water lifting and distribution system is recommended where feasible.

Selection criteria used were:

1. The system should be cheap to set up and maintain; meaning most parts should be able to be made locally.
2. Operation of the system should be easily understood and managed by almost anyone.
3. System suitability should not be restricted to only one type of water source.
4. Water volumes lifted should be sufficiently large with pump use being reasonably efficient.
5. Less labour required for set-up and use.
6. The system should be portable.

The systems chosen were seen to match the criteria satisfactorily.

## Water sources

Water sources need to be easily accessed for these systems to be useful. In most cases, many of the sources would have dried up during a drought period, so others will have to be found. Wells can be dug in dry river or swamp beds and water can be drawn and supplied to gardens using the portable systems recommended. Areas with green grass may also indicate the presence of water. When these spots are marked, holes are dug to the depth at which water is found and left covered with leaves and branches for dirt to settle. Once water is clear, a water lifting system can be set up, or if the well is too shallow, buckets can be used to draw water to feed the irrigation system.

The systems chosen are suitable for most water sources except bore water. The water distribution system is adaptable to any source, even if the drum needs to be filled manually.

It is also suggested that traditional irrigation systems, along with water conservation practices, should be documented for adaptation elsewhere in Papua New Guinea. Most of these employ gravity-flow and flood irrigation concepts.

<sup>17</sup> Appropriate Technology and Community Development Institute, PNG University of Technology, Private Mail Bag, LAE, Morobe Province. Phone: (675) 473 4776 Fax: (675) 473 4303.

## 6. Technology Demonstrations

The two technologies being promoted are the Simple Irrigation System and Food Processing for Storage. Farmers are encouraged to adopt these as Adaptive Strategies in order to cope with food famines associated with droughts.

Information on simple irrigation pumps, including the Rope & Washer Pump can be obtained from NARI Aiyura and Laloki. For demonstration, a pump has already been set up in Markham (Morobe Province) and one will be set up at Bena (EHP), Kondiu (Simbu Province) and Laloki (Central Province) respectively.

The Appropriate Technology Department of the University of Technology can produce the Rope and Washer Pump as well as other

pump types. They can be contacted on phone 473 4776 or fax 473 4303. In the Highlands, the Appropriate Technology NGO group in Goroka is interested in producing the Rope & Washer Pump.

Information on Food Processing can be obtained from Father Joseph Sakite, who trains farmers on cassava -based recipes. He can be contacted at Human Development Centre, Goglime Catholic Church, P O Box 167, Kundiawa, Simbu Province. The Food Processing Preservation Unit at Unitech has also developed useful technologies and can provide training. Their phone contact is 473 4562 or fax 475 7868.

## 7. Contingency Planning: schedule of activities

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. The three stages of drought are the pre, mid and post. These stages are defined on page 17.

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 National Disaster and Monitoring Office (NDMO) on advice from 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 National Agricultural Drought Response Committee (NADRC). Distribute information (farmer pidgin bulletins) on on-farm coping strategies.
4. Distribute Drought Tolerant Varieties of Crop Varieties and information/set up of simple water pumps and

food processing by NADRC through the Provincial Food Security (or Disaster) Committees.

### Mid-Drought

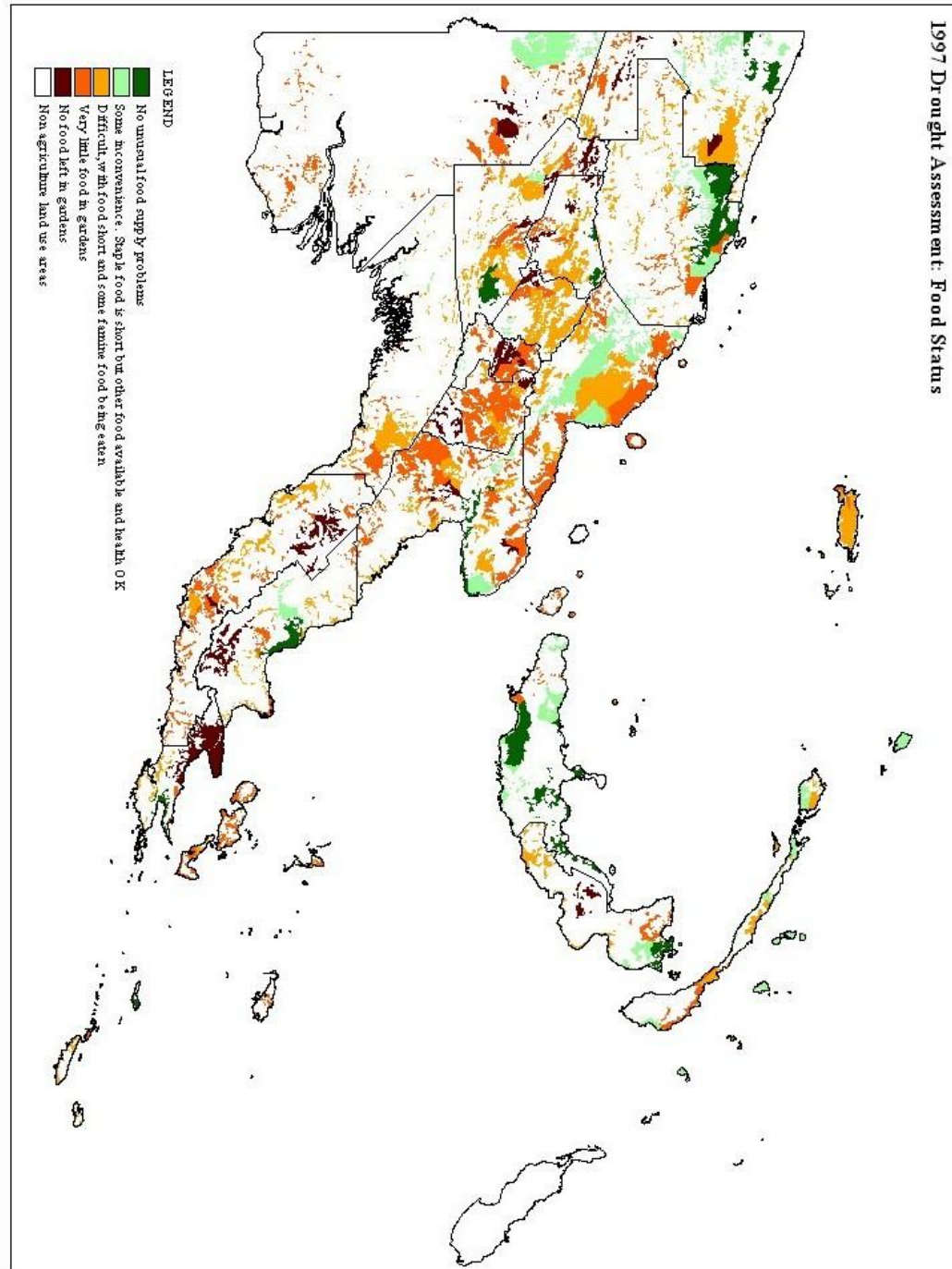
5. Identify Food Shortage in vulnerable areas by NADRC.
6. Send out Food Assessment Teams by NADRC and NDMO to areas where food shortage is life threatening. Assistance will be sought from affected Provinces. (Training of Assessment Teams is a necessary prerequisite)
7. Decide on the vulnerability of Food Shortage in assessed areas and Provide Food Aid only where absolutely necessary.

### Post-Drought

8. NADRC will 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.

## Annex 1. Drought Assessment Map 1997

Map of 1997 Drought Assessment: Food Status in PNG



## Annex 2. World Bank Drought Response Project Report

### Background

In 1997 Papua New Guinea experienced a severe drought associated with frosts. Crop yields were reduced by as much as 80 % in some areas, resulting in severe food shortages (AUSAID Report). Towards the end of 1997, 40 % of the rural population (1.2 million) was starving (Allen & Bourke, 2000).

The PNG Department of Agriculture & Livestock and NARI jointly proposed a project to improve PNG's ability to cope with future El Nino related weather fluctuations. The World Bank accepted and funded the project in 1998. The project ended in June 2002.

### Objective

The agriculture research component of the World Bank El Nino Drought Response Project (P7213-PNG) was aimed at developing strategies to reduce the impact of droughts and frosts on food supplies from subsistence gardens, which are the major food source for more than 85 % of the population.

The four components of this project were:

1. Collection, selection and multiplication of crop and

cultivars that were tolerant to drought.

2. Identification and adaptation of simple soil and water management technologies including irrigation techniques.
3. Development of an early warning system with contingency plans.
4. Demonstration and extension of appropriate technologies through on-farm operational work.

### Achievements

#### Component 1 - Crops and cultivars tolerant to drought and frost:

##### Surveys and Collection Trips

Ten provinces where more than 50 % of the people experienced severe food shortages during 1997 were targeted. The collection trips assembled 46 varieties of sweet potato, 47 banana varieties, 34 cassava varieties and 14 yam

varieties which farmers identified as being drought tolerant. These varieties have been characterized and tested for their tolerance to drought.

##### Trials to identify varieties with tolerance to Drought.

Five drought tolerant sweet potato varieties have been selected and recommended for the highlands farming systems and four drought tolerant varieties for the lowlands.

Foundation planting materials are available from Aiyura and Laloki Research Stations.

In the highlands, drought conditions were simulated using clear plastics as rainout shelters. The plastic sheets were removed each morning and rolled over the plots each night or if rain threatened during the day. If it looked like raining during the day the sheets were kept in place. In

the lowlands, the trial was planted to coincide with the normal dry season. The control plants were irrigated.

Table 23 and Table 24 show selections for the highlands and lowlands. They yielded well under drought conditions and have good tuber quality.

**Table 23: Selected Highlands Sweet Potato Varieties and their Characteristics.**

Variety	Yield under sufficient soil Moisture (Tonnes/ha)	Yield Under Dry Soil Conditions (Tonnes/ha)	Yield Reduction under dry conditions (Percent)	Remarks
WHCK 005	26.1	21.9	-16	Good yield under dry conditions with good tuber shape, size and taste. Also early maturing (4 months).
469	16.7	16.4	-2	Good yield. Acceptable tuber shape and taste. Early maturing (4 months).
SKK 010	20.5	15.5	-24	Good tuber shape and taste. Early maturing and yields well.
WBS 010	18.1	15.3	-15	Yields well with acceptable tuber shape and taste; also early maturing.
714	15.1	12.6	-16	Good yield, acceptable tuber shape and taste; also early maturing.

**Table 24: Selected Lowlands Sweet Potato Varieties and their Characteristics**

Variety	Yield under sufficient Soil Moisture (tonnes/ha)	Yield under Dry Soil Conditions (tonnes/ha)	Yield change under dry conditions (Percent)	Remarks
B 11 PT	23.78	16.74	-30	Good yield, tuber shape, size and taste. Also early maturing.
SI 278	14.54	10.57	-27	Yields well with good tuber shape and taste. Early maturing.
NUG 5	12.81	10.71	-16	Good yield, good tuber shape and taste, also early maturing.
K 9	10.14	11.65	+15	Moderate yield, tuber shape and taste. Yield not affected by drought.

### Early Maturing Sweet Potato Varieties

Trials on early maturing varieties were carried out to select varieties to plant after the drought. It is a critical period during which people have to secure foods quickly. The five drought tolerant highland varieties are early maturing, that is, sizeable tubers can be harvested in 4 months (see Table 23). Three of the four drought tolerant varieties selected for the lowlands are also early maturing (see Table 24). Good yields can be obtained in 3½ months.

Information on these selected varieties has gone out to all Provinces. Planting materials have been sent to DAL Goroka and the Salvation Army in Kainantu for multiplication. Cuttings have also been sent to Minyama in Morobe Province. All recommended varieties are currently being multiplied. Requests for cuttings

are expected once the document on 'Drought Response: On-Farm Coping Strategies' and the Pidgin Extension Bulletins have been distributed. These documents contain information on the recommendations.

The drought tolerant sweet potato varieties need to be planted 1 or 2 months before the onset of the drought. The early maturing varieties should be planted at the onset of rain post drought.

### Cassava Varieties

Cassava is a drought tolerant crop. NARI selected high yielding varieties, which also have low cyanide (less than 3.0 mg per 100g). Five varieties have been selected for the highlands and four varieties for the lowlands. Information on selected Cassava varieties for the highlands is presented in Table 25 and for lowlands in Table 26.



**Table 25: Provisional Selected Highlands Cassava Varieties and their Characteristics.**

Variety	Average Tuber No. per Plant	Total Yield (Tonnes/ha)	Tuber Flesh Cyanide at Harvest (mg/100 g)	Tuber Flesh Protein at Harvest (%)	Tuber Flesh Color	Taste
EHS 010	10	36.0	1.75	1.78	Yellow	Acceptable
EHK 012	8	30.2	2.25	1.52	White/Cream	Acceptable
WBS 007	8	27.5	2.50	1.49	White/Cream	Excellent (soft & pasty)
WBD 011	7	26.9	2.50	1.52	Yellow	Good
EDK 007	7	26.0	2.50	1.84	White/Cream	Acceptable

WORLD BANK DROUGHT PROJECT

*Note: For Cyanide in cassava of fresh tuber, amounts less than 5.0 mg/100 g of fresh tuber is safe for humans, amounts between 5.0 and 10.0 mg/100 g is moderately poisonous and more than 10.0 mg/100 g is highly poisonous*



Figure 24 Evaluating Cassava, NARI.

**Table 26: Selected Cassava Varieties for the Lowlands and their Characteristics.**

Variety	Total Yield (Tonnes/ha)	Protein (%DM)	Total Cyanide content (mg/100 g)	Tuber Flesh Color	Remarks
L86	20.1	0.74	1.33	White	Acceptable yield. Good tuber shape, size. Very good taste.
L51	29.2	0.63	1.20	Yellow	Good yield. Good tuber shape and size. Very good taste.
L6	28.7	0.76	1.17	Yellow	Good yield. Tuber shape and size ok. Very good taste.
L92	28.6	0.65	1.50	Yellow	Yields well with acceptable tuber shape and size. Good taste.

*Note: For Cyanide in cassava of fresh tuber, amounts less than 5.0 mg/100 g of fresh tuber is safe for humans, between 5.0 and 10.0 mg/100 g is moderately poisonous and amounts more than 10.0 mg/100 g is highly poisonous.*

Planting materials have already been distributed to farmers in Aiyura and multiplication is underway. Interest has been expressed by Provincial DPLs. Cuttings are expected once the document on 'Drought Response; On-Farm Coping Strategies' and the Pidgin Extension Bulletins are distributed.

Cassava is recommended to farmers as an adaptive (long term) strategy as it can tolerate both dry and wet conditions. That is, it should be grown continuously as a buffer crop in case other foods become short due to either too dry or wet growing conditions. Information on processing for storage and recipes of cassava are also contained in the Drought Response Document.

### **Drought Tolerant Bananas**

NARI collections in Aiyura, Bubia and Laloki have cultivars of *Kalapua* and *Yawa* bananas reputed by farmers to be drought tolerant during 1997.

### **Database with description of Crops and Varieties tolerant to Drought.**

#### **Sweet potato**

A report has been completed on 46 varieties collected in the highlands. There were 36 distinct varieties and 10 duplicates.

#### **Cassava**

A report has been completed on 34 accessions collected and there are only 8 distinct varieties.

### **Banana**

Characterisation of Banana has been completed. The accessions mainly include Yawa, Kalapua and 2 types of Cavendish.

### **Program for multiplication and distribution of planting materials**

Selected highlands sweet potato and cassava varieties are being multiplied in Aiyura.

Likewise, selected lowlands sweet potato and cassava varieties are being multiplied at Laloki.

### **Component 2 - Soil and water management technologies including simple irrigation systems:**

#### **Assessing the effectiveness of soil and water management practices**

The second trial using Leucaena and vetiver hedgerows and mulching of the same to assess moisture retention in soil will be harvested in December 2002.

#### **Installation and demonstration of low cost irrigation systems to farmers**

Two types of simple irrigation systems have been identified in India and ordered. The Rope & Washer pump has arrived and has been demonstrated with a drip irrigation system. The treadle pump is yet to arrive.

#### **Rope & Washer (CART) Pump**

Adopted from India by NARI and recommended for irrigation in PNG, the pump can draw water from 20 m. It is cheap and very easy to build and maintain. The demand for it is growing and we need some persons to lead the way in manufacturing them.

The pump draws water by pushing water up through a pipe using washers. The washers are attached to a nylon rope, which is rotated using a pulley. As the nylon rope moves through the pipe, the washers bring water up. The pump can be manufactured using all local materials. The main maintenance is the replacement of the washers.

The device can lift water 20 m high and costs 1, 000 Rupees (K106). As head increases, the amount of water lifted will decrease. When using a 2.5 – 5 cm pipe diameter, the discharge at 20 m would be 25 litres per min. At 5m the discharge would be 5 times more.

This pump can lift water from open water sources like lakes, open wells and streams or rivers. Water can be pumped for gardening or for household use. The pump has been demonstrated in Aiyura to DPI officers and a unit set up on a farm in Markham Valley, where field days have been organized for farmers. Another unit will be set up this month in Bena (EHP) and a field day will be conducted at Laloki (NARI) on December 09, 2002.

### **Component 3 - Early warning and contingency plans:**

#### **Assessment of suitability of PNG rainfall data for drought prediction**

The project correlated PNG Rainfall data with the Southern Oscillation Index (SOI) and sea surface temperature (SST) data using the Rainman Program to see whether this can be used to predict drought in PNG. Analysis does indicate there is a strong relationship in PNG between droughts and a "Consistently Negative" SOI phase or value. This model will be developed further with other factors

to obtain a reasonably adequate drought warning system.

The current model, when considered with other factors, is adequate to predict a drought. Potential 'droughts' or periods of below median rainfall can be predicted using a combination of historical rainfall data and SOI phases and averages (International Rainman). Other factors to consider are the rainfall season to date in vulnerable areas, information on areas that are becoming high risk (i.e. food shortages) and the global climate outlook.

Specific rainfall probabilities for key locations in PNG can be obtained using International Rainman. By combining these detailed rainfall probabilities with information on what has happened to date throughout PNG, staff will be able to highlight areas of potential high risk.

It would take 2-3 years to ensure this system of warning is operational.

#### **Developing contingency plans for vulnerable areas**

The Contingency Plans are contained in this document: Drought Response - On-Farm Coping Strategies. It is a handbook to all Didiman / Didimeri at National, Provincial and District level for advice to stakeholders. Pidgin extension bulletins are also being produced for farmers. The

document contains information on how the occurrences of droughts (ENSO phenomenon) affect subsistence food supply and Drought Coping Strategies. The coping strategies recommended are both short and long term. Crop variety diversification is encouraged as a buffer against both extreme dry and wet conditions.

### **Component 4 - On-farm trials:**

#### **Multiplication and distribution of planting material of recommended varieties**

This activity has started in Aiyura and Laloki for selected crop varieties (sweet potato, cassava and banana). A list of recommended varieties for both highlands and lowlands farming systems is given in the Drought Response document.

#### **Distribution of African yam**

African yam production technology and the use of mini-setts for rapid multiplication have been widely disseminated in PNG.

#### **Multi-location testing of sweet potato cultivars**

The Sogeri trial of 15 lowland Drought Tolerant Sweet Potato varieties was harvested in April 2002. A similar trial was harvested in Kondiu in October 2002 for highland drought tolerant varieties.

### Demonstration of low cost irrigation systems

Demonstration at Aiyura and on-farm in Markham has commenced in 2002. Below is the Rope & Washer Pump at Markham being used for both home use and irrigation.<sup>18</sup>



► WORLD BANK DROUGHT PROJECT

**Figure 25 Demonstrating a rope and washer pump, Markham**

<sup>18</sup> Further improvements would include connecting the unit to a bicycle so that a person uses leg muscles rather than arms to do the turning.



## Annex 3. CGPRT El Nino Project Annual Report 2002

This is a three year UNDP ESCAP funded Project, which will terminate in March 2003. Countries

participating in this project are Indonesia, Malaysia, PNG, Philippines and Thailand.

### Objective

To stabilize upland Agriculture under (El Nino – Induced) Climatic Risks, through the documentation of the impacts of the 1997-8 Drought and recommendation of Mitigation Strategies, both indigenous and introduced.

#### **National impact assessment and mitigation measures of the 1997 drought in Papua New Guinea.**

This report documents impact of drought on agricultural production, human health, and urban drift, on institutions, the economy and social obligations. Local coping strategies are documented as well as aid provided by both government and donors. Long-term mitigation strategies are recommended for authorities.

#### **Indigenous drought coping strategies and risk management in Papua New Guinea.**

Six of the worst affected districts in the 1997 drought were surveyed to document indigenous coping strategies and to determine if people in some districts were coping better than others. They were Bogia and Raikos districts in Madang Province, Bena in Eastern Highlands Province, Gumine in Simbu Province, Tambul in Western Highlands Province and Kandep in Enga Province.

The main parameters assessed were agricultural production, family income, and water supply for household use, bush/famine foods eaten, migration, food aid received, human health and infrastructure and government services during the drought period.

The study suggests the inhabitants of Tambul/Kandep (high altitudes) are more at risk, followed by those at Bena/Gumine districts. (mid - altitude). The inhabitants of Bogia/Raikos districts (lowlands) are least at risk. The outlook for the vulnerable districts is not good, unless on-farm coping strategies (contingency plans), both short & long term, are adopted.

#### **Workshop paper submitted**

A paper was submitted at an El Nino Workshop organized by CGPRT in September in the Philippines.

It is titled; Bang, S.K. and Sitango K, (2002), **Indigenous Drought Coping Strategies and Risk Management in Papua New Guinea**. Presented at CGPRT El Nino Workshop in Philippines, September, 2002.

## Annex 4. List of Contributors

### Askin, David

ACNARS Project  
C/-NARI Head Office  
PO Box 4415, LAE  
Morobe Province  
Phone: (675) 472 0608  
or +64 3325 2138  
Fax: (675) 472 0879  
or +64 3325 2165  
E-mail: [dave@kilu.org.nz](mailto:dave@kilu.org.nz)  
[www.kilu.org.nz](http://www.kilu.org.nz)

### Bang, Sergie

NARI High Altitude Programme  
PO Box 120,  
MT HAGEN  
Western Highlands Province  
pH (675) 542 3443  
Fax: (675) 542 2779  
Email [wbdffrost@global.net.pg](mailto:wbdffrost@global.net.pg)

### Demerua, John

NARI Dry Lowlands Programme  
Laloki  
PO Box 1828  
PORT MORESBY  
National Capital District  
Phone: (675) 328 1068, 328 1015  
Fax: (675) 328 1075  
E-mail: [wbdlaloki@global.net.pg](mailto:wbdlaloki@global.net.pg)  
Or [dlplaloki@datec.com.pg](mailto:dlplaloki@datec.com.pg)

### Gunther, Martin

ACNARS Project  
C/-NARI High Altitude Programme  
PO Box  
MT HAGEN

Western Highlands Province

Phone/Fax: (675) 542 2779  
E-mail: [martin.gunther@global.net.pg](mailto:martin.gunther@global.net.pg)

### Kambuou, Rosa

NARI Dry Lowlands Programme  
Laloki  
PO Box 1828  
PORT MORESBY  
National Capital District  
Phone: (675) 328 1068, 328 1015  
Fax: (675) 328 1075  
E-mail: [dlplaloki@datec.com.pg](mailto:dlplaloki@datec.com.pg)

### Kiara, Jacob and Florence

C/-NARI Main Highlands Programme  
Aiyura  
PO Box 384  
KAINANTU  
Eastern Highlands Province  
Phone: (675) 737 3561, 737 3500  
Fax: (675) 737 3516  
E-mail: [narimh@global.net.pg](mailto:narimh@global.net.pg)

### Masamdu, Roy

Wet Lowlands Mainlands Program  
Bubia  
PO Box 1639  
LAE  
Morobe Province  
Phone: (675) 475 1189  
Fax: (675) 475 1034  
E-mail: [nariwll@datec.com.pg](mailto:nariwll@datec.com.pg)



**Muntwiler, Markus**

The Salvation Army  
Agricultural Development Services  
Private Mail Bag 3  
KAINANTU  
Eastern Highlands Province  
Phone: (675) 737 1297  
Fax: (675) 737  
E-mail: [salvo@datec.com.pg](mailto:salvo@datec.com.pg)

**Paofa, Janet**

NARI Dry Lowlands Programme  
Laloki  
PO Box 1828  
PORT MORESBY  
National Capital District  
Phone: (675) 328 1068, 328 1015  
Fax: (675) 328 1075  
E-mail: [dlplaloki@datec.com.pg](mailto:dlplaloki@datec.com.pg)

**KPC Rao,**

ICRISAT- Nairobi,  
C/- ICRAF, UN Avenue, Gigiri,  
PO Box 39063, Nairobi, Kenya,  
Phone (254-2-524552 IVDN +1-650833-6645 ext 4552  
Fax 254-2-524001 IVDN: +1 650 833-6646

**Sakite, Fr Joseph**

Human Development Centre  
Golgme Catholic Church  
PO Box 167  
KUNDIAWA  
Simbu Province  
Phone/Fax: (675) 735 1245

**Shelton, Rob**

ACNARS Project  
C/-NARI Main Highlands Programme

Aiyura  
PO Box 384  
KAINANTU  
Eastern Highlands Province  
Phone: (675) 737 3579  
Fax: (675) 737 3516  
E-mail: [rshelton@global.net.pg](mailto:rshelton@global.net.pg)

**Sitango, Kud**

NARI High Altitude Programme  
Tambul  
PO Box  
MT HAGEN  
Western Highlands Province  
Phone/Fax: (675) 542 2779

**Waramboi, Joel**

NARI Rice & Grains Programme  
Bubia  
PO Box 1639  
LAE  
Morobe Province  
Phone: (675) 475 1189  
Fax: (675) 475 1034  
E-mail: [nariwll@datec.com.pg](mailto:nariwll@datec.com.pg)

**Wemin, Johnny**

NARI Main Highlands Programme  
Aiyura  
PO Box 384  
KAINANTU  
Eastern Highlands Province  
Phone: (675) 737 3561, 737 3500  
Fax: (675) 737 3516  
E-mail: [ipm.aiyura@global.net.pg](mailto:ipm.aiyura@global.net.pg)  
Or [narimh@global.net.pg](mailto:narimh@global.net.pg)

**Wesis, Pus**

C/-NARI Main Highlands Programme

Aiyura

PO Box 384

KAINANTU

Eastern Highlands Province

Phone: (675) 737 3561, 737 3500

Fax: (675) 737 3516

E-mail: [ipm.aiyura@global.net.pg](mailto:ipm.aiyura@global.net.pg)

Or [narimh@global.net.pg](mailto:narimh@global.net.pg)