# The World Bank El Niño Drought and Frost Impact Management Project

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*Abstract*

The PNG El Niño Emergency Drought Response World Bank Project is an agricultural research project aimed at decreasing the impacts of future El Niño-related weather fluctuations. It originated from a joint proposal by the Department of Agriculture and Livestock and the National Agricultural Research Institute (NARI) following the severe effects of the unusual weather in 1997; it is funded by the World Bank and implemented by NARI. The project aims to identify drought-tolerant crops and cultivars, introduce appropriate irrigation technologies, develop an early-warning system and farm-based contingency plans, and carry out onfarm operational research and demonstration projects. Progress on the drought-related activities is nearly on target. Progress in the frost-related activities has been hampered by our failure to identify practical solutions. The project is about half finished, with ongoing work in all areas.

FOLLOWING the 1997 drought and frosts, the PNG Department of Agriculture and Livestock (DAL) and the National Agricultural Research Institute (NARI) jointly proposed a project to improve PNG's ability to cope with future El Niño-related weather fluctuations. The proposal was accepted in 1998 and was given the name 'PNG El Niño Emergency Drought Response World Bank Project (P7213-PNG) Agriculture Research Component: Development and Adaptation of Technologies to Manage Impacts of Droughts and Frosts in PNG'. NARI was given the responsibility of implementing the project. The project consists of four components:

- selection of drought-tolerant crops and cultivars;
- identification of better soil and water management techniques;
- development of advanced warning and contingency plans; and
- onfarm operational research.

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In October 1998, the project scientist Dr K.P.C. Rao began duties. He was assisted by NARI scientist Anton Varvaliu and experimentalist Timothy Geob of the Highlands Agricultural Experiment Station (HAES) at Aiyura, and later by scientist Peter Gendua and experimentalist Paul Osilis. Anton Varvaliu left NARI in May 1999 and was replaced by John Demerua. Dr Rao lead the project until October 1999, when he returned to the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and was replaced by Bill Humphrey as project scientist at Aiyura. At that time, James Ernest was also assigned to the project. Although the World Bank has funded the project under emergency arrangements, NARI sees it as the beginning of long-term work in the area of food security.

## Selection of Drought-Tolerant Crops and Cultivars

Initially the project obtained information about the impact of the drought and frosts in the worst-hit provinces of PNG. Table 1 shows the percentage of the population in categories 4 and 5 (severely affected by

the drought) in October 1997 and December 1997. The next step was to compile a database describing existing germplasm collections and collect information from farmers about drought-tolerant crops and cultivars. This information is summarised in Tables 2 and 3, respectively. Project personnel are also producing digital databases describing the national collections of cassava and drought-tolerant sweet potato and yam. The collected cultivars of these crops have been added to the national collections for ongoing evaluation. Finally, screening trials have been conducted at Laloki Research Station, in Central Province, and at HAES. When the evaluations have been completed, the selected materials will be distributed to appropriate agencies and departments.

The 1997 drought survey collected much data about the use of famine foods in the worst-hit areas. The project team will review the survey data and carry out follow-up collection and identification trips. In addition, a trial to evaluate 10 selected cassava cultivars is under way at Laloki. This trial will assess yield, cyanide content and protein in irrigated and unirrigated treatments.

**Table 1.** Summary of drought and frost impact in the worst-hit provinces.

| Province | Percentage of population in drought-affected categories 4 and 5[a] | |
|---|---|---|
| | October 1997 | December 1997 |
| Western | 50 | 74 |
| Gulf | 11 | 58 |
| Central | 24 | 50 |
| Milne Bay | 29 | 60 |
| Western Highlands | 9 | 21 |
| Simbu | 0 | 100 |
| Eastern Highlands | 10 | 74 |
| Morobe | 12 | 55 |
| Madang | 3 | 42 |
| New Ireland | 0 | 19 |

[a] The most severe impact categories of food supply at the time of the survey during the 1997 drought/frost period: 4 = severely affected; 5 = critically affected.
Source: Allen and Bourke (1997ab)

## Lowlands (Laloki) screening trial

A sweet potato drought-tolerance screening trial was conducted at Laloki Research Station using 20 cultivars selected through predrought screening done at Keravat. The trial relied on the natural dry season to impose drought stress where desired and irrigation was used where stress was not desired. Planting was carried out on 31 July 1999. The stress treatments were:

1. continuous irrigation;
2. irrigation to day 35 followed by no irrigation to day 95; and
3. irrigation to day 95 followed by no irrigation to day 155.

Planting was poorly timed and the seasonal rains began just as the stress period was starting for treatment 3. This effectively made treatment 3 the same as treatment 1. No significant differences were found in the cultivar responses to drought conditions. A second trial will be conducted in 2000 to screen about 30 varieties, including the best 15 from the first trial as well as other recommended varieties not yet tested and one cultivar identified by farmers as having drought tolerance.

## Highlands (Aiyura) screening trial

A sweet potato drought-tolerance screening trial was conducted at the HAES using 20 cultivars selected through predrought screening at Aiyura and Tambul. The dry season at Aiyura is less reliable than at Laloki, so the trial employed rain-out shelters to ensure that rain was excluded from the plots when necessary. Irrigation was applied when soil moisture conditions suggested it was necessary. The moisture stress treatments were:

1. continuous irrigation when needed;
2. irrigation when needed to day 45, followed by irrigation and rain excluded to day 107; and
3. irrigation when needed to day 117, followed by irrigation and rain excluded to day 188.

As in Laloki, no significant differences were found in the cultivar responses to drought conditions.

Two more screening trials are scheduled for Aiyura. The first will involve about 60 cultivars originating from the national highlands plant germplasm collection as well as farmer-identified drought-tolerant cultivars. Before the trial, some cultivars will be eliminated if they perform poorly or duplicate the recommended varieties from the national collections of cassava and drought-tolerant sweet potato. The trial will rely on the natural dry season because of practical

**Table 2.** Overview of PNG's national germplasm collections.

| Crop | Number of accessions | | | | |
|---|---|---|---|---|---|
| | Keravat | Laloki | Aiyura | Bubia | Tambul |
| Sweet potato | 737 | – | 1200 | – | 58 |
| Banana | 70 | 303 | – | 19 | – |
| Taro | 4 | – | – | 586 | – |
| Cassava | 38 | 78 | – | 7 | – |
| Yams | 13 | – | – | 63 | – |
| Aibika | 43 | 46 | – | – | – |

– = not in the collection

**Table 3.** Summary of farmer-identified drought-tolerant accessions collected following farmer surveys.

| Source province | Number of accessions by crop | | | |
|---|---|---|---|---|
| | Sweet potato | Cassava | Banana | Yam |
| Western Highlands | 16 | 11 | 9 | 5 |
| Simbu | 28 | 9 | 9 | 7 |
| Eastern Highlands | 3 | 12 | 13 | 4 |
| Madang | 1 | 12 | 13 | SPYN |
| Morobe | – | 10 | 6 | SPYN |
| Central | – | 2 | 10 | 20 |
| Milne Bay | 1 | 2 | – | 9 |

– = not in the collection
SPYN = South Pacific Yam Network

problems in evaluating more than 20 cultivars under rain-out shelters. The dry season at Aiyura is not as distinct as at Laloki, so there is a risk that results will only be indicative and further work may be necessary.

A second screening trial under rain-out shelters will also be carried out. This will use mainly farmer-identified drought-tolerant cultivars. Of the 47 collected, 18 will be selected from observations of performance in multiplication plots and after elimination of duplicates. Two cultivars from the first trial will be included as a check.

## Soil and Water Management Techniques

The aims of this component of the study are to:

- identify appropriate irrigation systems;
- identify appropriate soil and water conservation technologies;
- test the technologies on farmers' fields; and
- document and disseminate information to extension agencies.

To date, we have identified people with expertise in irrigation in PNG, held a one-day workshop and set up a working group to identify the most appropriate technologies to supply water to farmers' fields during droughts. We have tentatively identified some sites for installation of irrigation equipment.

We are evaluating irrigation equipment. Any pump used must be inexpensive and easy to maintain. After considering ram pumps, pressure coil pumps and shallow-well hand pumps, we believe it will be difficult to find a pump that will be inexpensive, yet have sufficient capacity for a food garden and be topographically appropriate for our target population. We have not yet decided what pumps to use for demonstration sites, but one possibility is a simple lined well from which water would be drawn by hand. Only a limited amount of water could be applied with this method, which would probably be limited to preserving planting materials rather than actually producing food

during drought. However, it would allow much quicker recovery from drought and be within the budget of smallholder farmers.

Work has not yet begun on identifying appropriate soil and water conservation technologies. We will begin by carrying out a literature review and demonstrating contour mounding, mulching and other water conserving practices.

Eventually, we will demonstrate and document chosen technologies by selecting demonstration sites for the construction of pumps, irrigation equipment and agronomic practices. This has not yet been done.

## Advanced Warning System and Farm-Based Contingency Plans

This component of the project is aimed at providing a warning period prior to impending drought. This would allow farmers to adopt avoidance or adaptation strategies. The project will also develop contingency plans that will provide practical advice to farmers to increase their awareness of alternative cropping strategies to lessen the impact of drought.

### Advanced warning system

The advanced warning system concept is based on using the Southern Oscillation Index (SOI) to predict the onset of El Niño-induced drought. The SOI is a measure of changes in the atmospheric pressure between Darwin and Tahiti. The SOI changes at the start of an El Niño event and the subsequent changes in rainfall patterns take a few months to develop, so the SOI can provide a warning of impending drought. It is the world's most widely used index for seasonal weather predictions.

The challenge in PNG is to determine, from historical rainfall data, the strength of the association between the SOI and subsequent seasonal drought. Historical PNG rainfall data have been collected and a software package has been used to evaluate the association between the data and the historical SOI. The project is currently evaluating the data quality and usefulness on a station-by-station basis. This is a complex task because the network of rainfall observation stations in PNG is less formal than in some other countries. In order to augment the existing network, the project has purchased eight automatic weather stations. These have been commissioned at various locations in PNG, including five NARI sites and three other sites, all in the highlands. As the project proceeds, we will develop a protocol for monitoring the SOI with a view to deciding when drought warnings should be given.

### Farm-based contingency plans

This component of the project is intended to provide farmers with information on how they should respond to impending drought or an increased likelihood of frost as indicated by the advance-warning system that is being developed. Ideally, the contingency plans will reflect local conditions and will be linked to the resources necessary to implement them. The work on contingency plans will not begin until the results of the other components of the study are known.

## Onfarm Operational Research

The onfarm operational research component of the study will extend the results of agronomic trials to farmer management and further test technologies that seem promising in research trials. Current activities include yam technology demonstrations in three locations. As yam is a drought-adapted crop, and stores well after harvest, it is well-suited for promotion in drought-prone areas. The African yam, *Dioscerea rotundata*, is the test crop in this case. The technologies under evaluation are miniset propagation, continuous planting at two-month intervals, and alternative plant spacings. The test locations are in Central, Morobe and East Sepik provinces.

## Acknowledgments

Most of the work was initiated by Dr K.P.C. Rao, who worked for one year in PNG while still maintaining his position at ICRISAT in India. The World Bank and the government of PNG, through NARI, provided funding for the work. The difficult task of implementing the fieldwork has been carried out by many staff within NARI and collaborating organisations, primarily the provincial Divisions of Primary Industry. These people and institutes are gratefully acknowledged.

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