



PAPUA NEW GUINEA  
NATIONAL AGRICULTURAL RESEARCH INSTITUTE

# ANNUAL REPORT 2021



**CORPORATE DOCUMENT No.5/2022**

**Promoting Excellence in Agricultural Research for Sustainable Development**



# 2021

# Annual

# Report

National Agricultural Research Institute  
Lae, Papua New Guinea

**Corporate Document 5 / 2022**

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# Acronyms and Abbreviations

ACIAR	Australian Centre for International Agricultural Research
AIP	Annual Implementation Plan
AR4D	Agricultural Research For Development
BCS	Bogia Coconut Syndrome
CCR	Climate Change Resilience
CSA	Climate Smart Agriculture
CIP	International Potato Centre
CPL	City Pharmacy Limited
DAL	Department of Agriculture and Livestock
ENB	East New Britain
EU	European Union
EUCCR	European Union funded action for climate change resilience
FAW	Fall Army Worm
FPDA	Fresh Produce Development Agency
HAHRC	Highlands High Altitude Regional Centre
HRC	Highlands Regional Centre
IAEA	International Atomic Energy Agency
ICDF	Taiwan International Cooperation and Development Fund (TTM Taiwan)
IPM	Integrated Pest Management
IRC	Islands Regional Centre
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
LAES	Lowlands Agricultural Experiment Station
LLG	Local Level Government
MRC	Momase Regional Centre
NAIC	National Agricultural Insect Collection
NARI	National Agricultural Research Institute
NAQIA	National Agricultural Quarantine Inspection Authority
NGO	Non-Government Organisation
NIP	Nut in Pulp
NIS	Nut in Shell
NISIT	National Institute of Standards and Industrial Technology
PGR	Plant Genetic Resources
PIP	Public Investment Program
PNGIF	Papua New Guinea Incentive Fund
PPP	Public Private Partnership
PPAP	Productive Partnership in Agriculture Project
PT	Pathogen Tested
R4D	Research for Development
SIP	Strategic Implementation Plan
SP	Sweetpotato
SRC	Southern Regional Centre
SRF	Strategy and Results Framework
SSS	Storage, Seed, Sprouting
TADEP	Transformative Agriculture & Enterprise Development Program
TOT	Training of Trainers
TTM	Taiwan Technical Mission to PNG (ICDF Taiwan)

## Foreword

Greetings to you all from the NARI Council and Management. It gives us great pleasure to share NARI's progress during 2021 with you.

2021 was a very challenging year which truly tested most organisations and NARI was no exception. The Covid19 pandemic continued into 2021 and expanded its challenges. With concern for the risks, NARI took a proactive approach of in-house testing, mandated "niupela pasin" and encouragement of vaccination. These measures have minimised the impact of Covid19, protecting our staff and families, and minimising risk to our stakeholders, particularly in more remote areas.

Work continued on development of the new ten year NARI Corporate Plan for 2022-2031. The key documents, the Strategy and Results Framework (2022-2031) and Strategic Implementation Plan for the next five years, 2022-2026, have been completed, laying the ground work for finalisation of the Institute Annual Implementation Plan for 2022. While adequate finance and staffing continues to be a challenge, the Strategic Implementation Plan provides the resourcing and organisational structure adjustments needed to ensure an effective Agricultural Research for Development environment.

The key research outcomes revolved around climate change adaptation, pest management, and biodiversity management with our development partners, particularly from the European Union and the Australian Centre for International Agricultural Research. NARI also continues to contribute to the African Swine Fever and Fall Army Worm responses as they have developed into major biosecurity concerns.

Scaling out research generated innovations has been a strong focus through both international partner projects and the GoPNG PIP implementation. These are serving to strengthen provincial partnerships while equipping and building capacity in targeted Districts. This will be further expanded and strengthened in 2022 as we take on additional partnerships with the Food and Agriculture Organisation of the United Nations (FAO).

While finance remains tight, with inadequate funding allocations and irregular cash flows from GoPNG providing a challenge to deliver our mandated functions, NARI continues an outstanding record in financial management, confirmed by an Unqualified Audit Report, certified by the Auditor General's Office, for the 2020 financial year. Our thanks and congratulations to the Financial Controller and team. The financial audit for 2021 is awaiting final certification.

The Council and Management express their appreciation to all NARI staff, and to our partners for their commitment and contributions which underpins the organisation's expanding achievements. We look forward to your continued support in 2022.



Warea Orapa  
a/Director General



Nimo Walter Kama  
Chairman



## The Institute

The **National Agricultural Research Institute (NARI)** was established by an *Act of the National Parliament of Papua New Guinea (PNG)* in July 1996 as a public funded, statutory research organisation to conduct and foster applied and adaptive research into:

- I. any branch of biological, physical and natural sciences related to agriculture;
- II. cultural and socio-economic aspects of the agricultural sector, especially of the smallholder agriculture; and
- III. matters relating to rural development and of relevance to Papua New Guinea.

Under the NARI ACT (1996), the Institute was given responsibility for the following functions:

- to generate and adapt agricultural technologies and resource management practices appropriate to the needs, circumstances and goals of smallholders.
- to promote and facilitate applied and adaptive research in food crops, livestock, alternative cash crops, and resource management.
- to promote the use of appropriate technologies and provide essential technical services to improve the productivity, income, nutritional status and food security, resource base and quality of life of rural households and communities.
- to develop and promote ways of improving the output, quality, harvesting, post-harvesting, handling and processing and marketing of food crops, livestock produce and alternative crops.
- to maintain and conserve the diversity of genetic resources for food and agriculture, act as custodian for these resources, and promote the effective utilisation of these resources in the country; and to update and maintain the national inventory on soil resources.
- to develop, promote and maintain sustainable practices in agriculture.
- to provide agricultural information services, extension service support and other such assistance packages to the agricultural sector.
- to provide liaison and access to international agencies that promote agricultural development
- to formulate national agricultural research policies, define sectoral research priorities and allocate funds and advise the Minister and the National Executive Council on these matters.

The Institute was initially under the Ministry for Agriculture and Livestock but was brought under the umbrella of Research, Science and Technology, in the Ministry of Higher Education, Research, Science and Technology in 2002.



## Governance

The *National Agricultural Research Institute Act, 1996*, sets forward the roles and responsibilities of the NARI Council in providing governance for the organisation. This ensures the separation of governance from the management. It is the Council's role to approve strategic directions and structures for control and accountability. The Council safeguards and supports the implementation of the mission of the organisation, integrates organisational interests and stakeholder interests, and serves as a link to NARI's constituencies. The Director General manages the affairs of the organisation to deliver the objectives and targets according to NARI's strategic directions as determined by the Council, and in compliance with the NARI Act and Council approved policies and procedures.

The Council is the final authority of NARI and it reports to the Minister for *Higher Education, Research, Science and Technology*. The membership is made up of nominated representatives from the agricultural sector, Higher Education, and *Ex-Officio* representatives of key Government Departments.

The terms for all *non-Ex-Officio* Council members expired in January 2021, requiring a new interim NARI Council to be appointed in the first Quarter of 2021. The interim Council convened on two occasions in 2021.

**Table 1: Composition of the Interim Council, 2021**

Name	Constituency Represented
Professor Topul Rali, Chairman	University of Papua New Guinea Nominee
Mr Yala Yatu, Deputy Chairman	Smallholder Farmers
Mr Albert Veratau	Smallholder Farmers
Mr Nimo Walter Kama	Smallholder Farmers
Mrs Maria Linibi	Women Smallholder Farmers
Mr Ronnie Ilam	Growers' Association
Dr Ora Renagi	PNG University of Technology – Vice Chancellor
Mr Francis Daink	Department of Agriculture and Livestock – Secretary's Nominee
Mr Dominic Ira	Department of Finance – Secretary's Nominee
Mr Warea Orapa	NARI Management – a/Director General

NARI is guided by five core values:

## Our Core Values

The five Core values provide the foundation for an organisational culture in NARI that is focused on leading in agricultural research for development and delivering innovative solutions to its stakeholders in agricultural and rural development.

**Leadership** is a key value for the future of the Institute. NARI needs leaders who are visionary, apply systemic thinking and serve as inspiring role models at different levels of the operation. Leaders should wish to serve, help others to see beyond the obvious and look forward to the new possibilities of shaping the future. This leadership aspiration extends to the aim for NARI to be a leading agricultural research organisation in PNG and the Pacific.

**Innovativeness** is a leading principle for the Institute as a leader in Agricultural Research for Development (AR4D). This encompasses catalysing, facilitating and incentivising creativity in all facets of organisational behaviour to ensure responsiveness to the changing external environment and encouragement of innovation as an on-going process in agricultural development.

**Integrity** at all levels of the organisation is the basic moral fabric that guides our behaviour and conduct. We uphold high transparency and accountability standards and believe in consistency between words and deeds, trust, unity and honesty within the organisation, with our valued partners and engagement with rural communities and other stakeholders.

**Communication** is a foundational value for NARI to reach all stakeholders. Communication needs to be clear, intentional, and effective and incorporate feedback as essential part in on-going organisational learning.

**Organisational Excellence and Relevance** is applied at all levels of the Institute. With a strong client focus, we plan and strive to be systematic and efficient and promote scientific rigour in research for development at high standards.

## Our Strategy

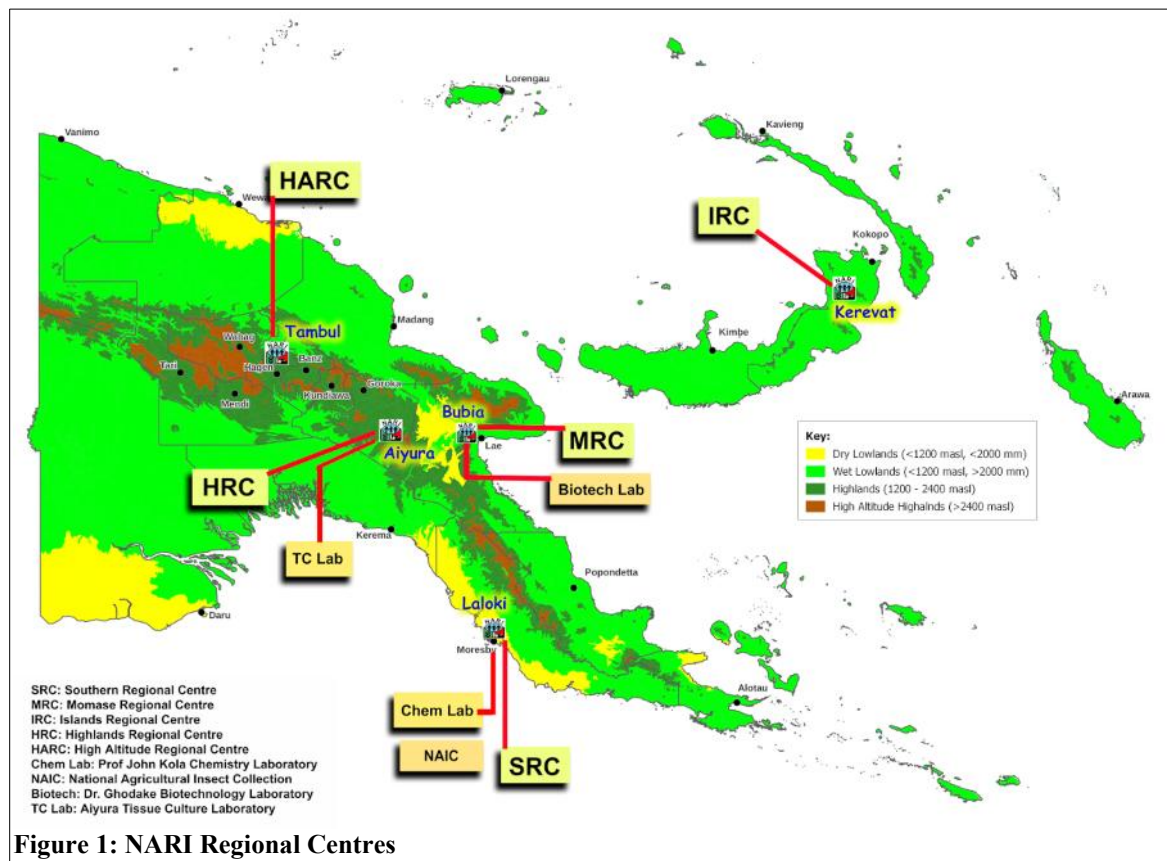
In its Vision for PNG, NARI sees:

“Prosperous PNG Agricultural Communities” through its Mission of promoting innovative agricultural development in PNG through scientific research, knowledge creation and information exchange. This is to be accomplished through the Institute’s Purpose (Strategic Objective) of enhanced productivity, efficiency, stability and sustainability of the smallholder agriculture sector in the country so as to contribute to the improved welfare of farming and rural communities who depend wholly or partly on agriculture for their livelihoods.

Our strategy aligns and contributes directly to the achievement of the GoPNG Development Goals, which also cascade from the UN Sustainable Development Goals (SDGs), the PNG Vision 2050, and PNG’s DSP 2030, PNG Medium-Term Implementation Plan (MTDP3) 2018-2022, and the Agriculture Medium Term Development Plan (AMTDP), 2020-2022. The medium-term strategies and priorities are documented in the NARI Strategy and Results Framework 2011-2020 and NARI

Strategic Program Implementation Plan (SPIP) 2012-2020, and have guided the NARI research directions for 2021.

To deliver on its research mandate, NARI has its head office situated in Bubia, Lae, Morobe Province with regional centres established according to agro-ecological areas covering the dry lowlands, wet lowlands, highlands and high altitude highlands (Fig 1). See Annex 5 for more details on the NARI regional centres.



## Research for Development



*NARI research studies (Annex 2) are funded under major projects supported by our international development partners and the PNG Public Investment Program (PIP). (Annex 1).*

## Projects

Supporting commercial sweetpotato production and marketing in the PNG highlands (TADEP)	HORT/2014/097 Completed: June 2021
<i>An ACIAR funded project led by CQU in partnership with NARI, FPDA, ANU and QDAFF. Project to sustainably increase the contribution of the sweetpotato crop to cash income and food security, via transformative improvements in selected sweetpotato value chains</i>	
Developing improved crop protection options in support of intensification of sweetpotato production in Papua New Guinea	HORT/2014/083 Completed: June 2021
<i>An ACIAR funded project led by Charles Sturt University in partnership between NARI, FPDA, UOT in PNG and USQ in Australia. Project developing, testing and promoting the adoption of sustainable solutions to protect sweetpotato crop production</i>	
On-farm diversity root, tuber, and banana crops	Bioversity Int./Crop trust Completed: September 2021
Pacific regional integrated food and security initiative to COVID19 (PRISCO19) program	EU / SPC Completed Dec 2021
<i>EU Initiative to Address National Priority Needs Around COVID19</i>	
<b>Ongoing 2022</b>	
Strengthening food production capacity and resilience to drought of vulnerable communities (EUCCR)	FED/2016/382-604 Completion: April 2022
<i>A European Union funded action to contribute to achieving a greater resilience of smallholder farming and rural communities in Papua New Guinea to abiotic stresses arising from seasonal weather patterns, climate change or natural disasters and impacting on their livelihood.</i>	
Sustaining soil fertility in support of intensification of sweetpotato cropping systems	SMCN/2012/105 Completion: April 2023
<i>An ACIAR funded project led by UQ in partnership with NARI. Project providing farmers with a range of nutrient supply options to underpin the sustainable intensification of the PNG Highland sweetpotato cropping system.</i>	

<p>Responding to emerging pest and disease threats to horticulture in the Pacific islands</p>	<p>HORT/2016/185 Completion: September 2023</p>
<p><i>An ACIAR funded project led by UQ with partners from NARI, Fiji, Samoa, Tonga, Solomon Islands, and SPC. Project aims to develop integrated pest and disease management strategies for the sustainable intensification of fruit and vegetable crop production, addressing the threats posed by the inappropriate use of pesticides, emerging pests and diseases and climate change.</i></p>	
<p>In situ Conservation and Utilisation of Sweetpotato (Ipomoea batatas) for Climate Smart Agriculture Vulnerable Farmers in Papua New Guinea</p>	<p>ITPGRFA BSF Completion: June 2023</p>
<p><i>International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) - Benefit Sharing Fund</i></p>	
<p>Climate Smart Agriculture opportunities for enhanced food production in PNG (CSA)</p>	<p>ASEM/2017/026 Completion: June 2024</p>
<p><i>An ACIAR funded project led by ANU with partners in PNG (NARI, CCDA, DAL, FPDA, NWS, UOG) and in Australia (ANU, Phloem 3 Pty Ltd, Sustineo Pty Ltd). Project facilitating the use of seasonal climate information in farming communities to inform food production decisions and by doing so improve food security outcomes for rural communities.</i></p>	
<p>PIP – Research and Development</p>	<p>PNG Government PIP 05020 - Research and Development Completion: December 2023</p>
<p><i>Component 1: Preparedness to cope with climate induced stress (drought, frost, excess moisture and salinity)</i></p> <p><i>Component 2: Sustainable poultry, aquaculture and goat farming for economic and nutritional well being of rural communities in Morobe and Madang Provinces</i></p>	
<p>Enhancing private sector-led development of the Canarium industry in Papua New Guinea – phase 2</p>	<p>FST/2017/038 NARI, Griffith University and the University of Adelaide Completion: December 2022</p>
<p><i>Project targets barriers to private sector investment in the Canarium industry by improving supply, further enhancing efficiencies in the production and processing systems and further developing both domestic and export markets for processed galip nuts</i></p>	



## Research completed in 2021

The 2021 Agricultural Research for Development portfolio comprised a total of twenty one (21) key research studies with twelve (12) studies continuing and nine (9) studies completed. See Annex 2 for a full list of completed and ongoing studies.

### Identification and distribution of sweetpotato viruses and their vectors



Figure 2: Sweetpotato virus survey

Surveys of farmer sweetpotato fields at selected project sites in Eastern Highlands, Jiwaka and Western Highlands Provinces showed prevalence of sweetpotato viruses across the three provinces.

Most prevalent viruses were the Sweetpotato feathery mottle virus and Sweetpotato virus G. There was no significant difference in the virus inoculation intensity

between the old and new gardens. There is diversity of alternative hosts distributed throughout the sweetpotato growing areas. The survey recorded 6 widespread wild *Ipomoea* species: *Ipomoea coccinea* (Mexican scarlet morning glory); *Ipomoea purpurea* (Pink Morning Glory); *Ipomoea indica* (Purple Morning Glory); *Ipomoea palmate*; *Ipomoea quamoclit*; and *Ipomoea alba*. There was significantly less incidence of sweetpotato virus detected in the alternative host plants compared to sweetpotato gardens.

The aphid and whitefly virus vectors are widely distributed and transmission of viruses is considered to be intense throughout the areas surveyed. Aphids (*Myzus persicae*, *Aphis gossypii*, *Macrosiphum euphorbiaea*) and, whiteflies (*Bemisia tabaci*) were found in all sites.

The survey showed that virus re-infection in sweetpotato gardens is high and confirmed the ongoing need for commercial farmers to use clean pathogen tested planting material.

*The survey was conducted with support from ACIAR, under a project, **Supporting commercial sweetpotato production and marketing in the PNG highlands**, which aims to sustainably increase the contribution of the sweetpotato crop to cash income and food security, via transformative improvements in selected sweetpotato value chains (TADEP)*



## Efficiency and profitability in local honey production



Figure 3: Checking beehives in EHP

There has been much interest in beekeeping from farmers in recent years due to its economic potential. While it is a growing industry in PNG with good prospects, local honey remains relatively expensive compared to imported honey and not many producers have progressed to larger scale production.

This study was designed to understand the basic costs for beekeeping and the average returns from honey production at different scales of operation, and determine the economic feasibility of the local honey businesses. Preliminary data indicates good potential

for honey as an industry and some areas where change is needed to realise the potential. The report and recommendations will be available in 2022.

*The study was conducted by NARI under the ACIAR supported project **Efficiency and profitability in local honey production by smallholder farmers in Eastern Highlands Province***

## Improved goat and sheep husbandry and health practices



Figure 4: Sample goat poster

As small ruminants, goats and sheep are well suited for village meat production. Providing farmers with reliable information on best husbandry practices and cost of farming will contribute to improved smallholder goat and sheep meat production, increase consumption, and provide nutritional benefits.

The study used the goat and sheep herd at the NARI Momase Regional Centre (MRC) to determine improved husbandry practices, and generate baseline data for goat and sheep production.

The key management lessons derived from this study are shared via two posters to guide farmers.

## Addressing priority needs for COVID 19

The *European Union funded PRISCO19* initiative aimed to reduce the impact of Covid19 on food security. It added to NARI's collaboration with stakeholders to:

- Reduce pig losses through improved African Swine Fever (ASF) detection with rapid test kits supplied to project sites at risk in Western Highlands, Jiwaka and Simbu Provinces.
- Boost food security by vegetable planting material availability through seed kits from the World Vegetable Centre and tissue culture planting materials from the Centre for Pacific Crops and Trees (CePaCT) for distribution and observation at project sites in Gulf, Western, Milne Bay, Oro, Central, Madang, Morobe and East Sepik Provinces.
- Increase chicken breeding stock supply through support for foundation breeding stock supply and small scale hatchery units to boost adapted village chicken production at selected sites.



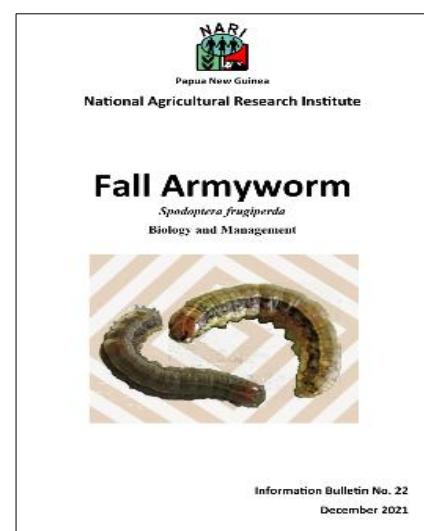
**Figure 5: Incubator for small scale hatchery**

## Fall Army Worm (FAW) biology and management

This information bulletin suggests options and strategies that are being used around the world to manage FAW at both the small plot and commercial levels of crop production.

The underlying literature study indicated the need to evaluate the effectiveness of low risk insecticides and methods for targeted application, to survey and identify natural enemies and pathogens of FAW in PNG, to identify opportunities to benefit from use of biological agents from around the world, and to evaluate various cultural techniques for FAW management.

The bulletin was compiled by NARI entomology colleagues, Dr Sim Sar and Mr Robert Geno.



**Figure 6: FAW information bulletin**

## Diversity of banana, root, and tuber crops

Starting in 2019, an in-depth diversity assessment of banana, yams and sweetpotato crops and their wild relatives was made in Bogia District, Maprik District and at the NARI Laloki Centre. Tissue samples of wild and cultivated diversity of banana, yam and sweetpotato were collected for DNA analysis. The geno typing is in progress, and results will be available in the scientific report to be written collectively by the partners over the next year. The other aspect of the study involved determining how farmer’s management practices impact the diversity of wild and cultivated diversity of crops in their locality.

Maprik District was the final site to be assessed in 2021. It was important as it is known as one of the yam diversity hot spots in PNG. There is also a good diversity of bananas present in the district. It was noted that Maprik would be a prime site for future collections for PGR conservation.



Figure 7: Collecting leaf tissue samples from diseased leaves



Figure 8: Capturing yam descriptors from community

*The collection was conducted by a team from NARI and the Centre for International Agricultural Research for Development (CIRAD) under the **On-farm diversity of root tuber crops in PNG** project, in collaboration with Bioversity International.*



## Rearing black soldier fly as a protein source for livestock

The potential use of the Black Soldier Fly larvae (*Hermetia illucens*) for bio-conversion of organic matter into pre-pupae larvae as a source of protein in livestock feed gave the motivation for this study. The process was tested on 2 organic media, sweetpotato silage and fermented household waste.



Figure 9: Black soldier fly larvae

We were able to achieve a pre-pupae wet weight production of 14-23 grams per square metre in a single day under favourable conditions for household waste and sweetpotato silage respectively.

The results are lower than expected in comparison to detailed experiments elsewhere, but it is evident that bio-conversion of otherwise unused organic wastes by Black Soldier Fly larvae has potential as a high protein feed source for smallholder farmers.

*The study Rearing Black Soldier Fly larvae (Hermetia illucens) as an alternative source of high protein from regenerating organic farm wastes into feed for fish and chickens<sup>1</sup>*

## Validation of the SSS method for sweetpotato tuber storage during drought conditions in PNG



Figure 10: Poster describing the SSS method

The study<sup>1</sup> to validate the Storage, Sand, Sprouting (SSS) method for sweetpotato root storage during drought conditions in PNG was a success.

The results for two seasons at two highland sites (Tambul, Aiyura) and one lowland site (Laloki) confirmed that the sand and sawdust treatment provided the best storage media, extending sweetpotato root storage life for up to six months. All local sweetpotato cultivars gave a sprouting rate of around 60% to 80%.

The ability to save and protect storage roots during predicted drought and frost periods, for later sprouting as new planting material, is a key technique in the arsenal for farm resilience to climate change.

<sup>1</sup>Conducted under the European Union funded project “Strengthening food production capacity and resilience to drought of vulnerable communities”

## Ongoing research

### Rice for climate change resilience

Rice is a key commodity in the PNG diet. It is also valuable in building community resilience through its ability to be stored for use in times of food shortage. It would be an added advantage if we have varieties which are better adapted to dry conditions.

In the search for varieties with improved climate resilience, the ongoing assessment of selected varieties from the New Rice for Africa (NERICA)

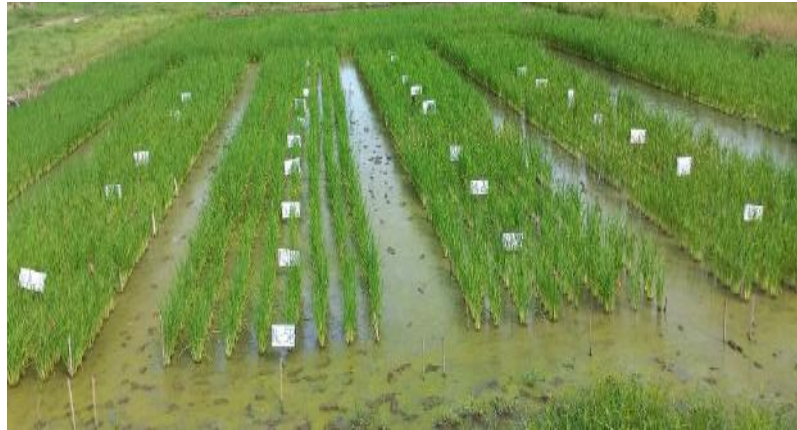


Figure 11: NERICA rice trial at Laloki

program has shown promise with selections showing good yields and acceptability. Further assessment on stress and pest resilience is needed with the selections. Performance comparison to the current NARI released varieties is to be conducted in 2022.



Figure 12: Climate resilience variety assessment (supported by the European Union)

*The Evaluation of Promising NERICA rice Lines under Upland and irrigated Environmental Conditions in PNG has been supported under the European Union funded project "Strengthening food production capacity and resilience to drought of vulnerable communities"*

## Supporting a quality Galip nut industry

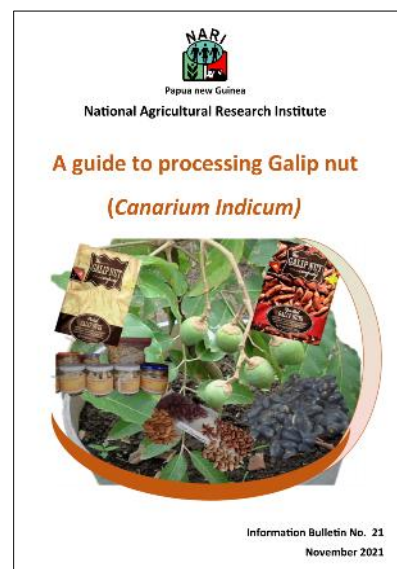
The galip nut industry is in its infancy and there is growing interest in both the supply chain from farmers and unfilled demand by consumers. We have continued our work targeting barriers to private sector investment in the Canarium industry by improving supply, further enhancing efficiencies in the production and processing systems and further developing both domestic and export markets for processed galip nuts

There is huge potential for processors to be involved in this growing industry. Best practice harvesting and post-harvest handling of Canarium nuts is essential for quality control and food safety. A guide for processors has been developed, based on overseas experience and local research conducted by a team from NARI and Australia, led by Griffith University in Australia, and funded by the Australian Centre for International Agricultural Research,

“A guide to processing galip gut (*Canarium Indicum*)” is now available as NARI Information Bulletin No.21.

As part of the ongoing work on the processing aspects of the galip nut value chain, a prototype de-pulper (*Fig 14*) was successfully developed by the Appropriate Technology and Community Development Institute at the PNG University of Technology in cooperation with NARI. This development is encouraging to a fledgling industry as it provides a machine at a much reduced cost to alternative commercial machines produced overseas.

The availability of the processors guide manual and new developments such as this machine has potential to both grow the market supply and greatly improve the throughput and quality of galip nuts.



**Figure 13: Galip processors guide manual**



**Figure 14: Prototype galip de-pulper**

*Collaborative research between NARI and Australian based researchers under the project **Enhancing private sector-led development of the Canarium industry in Papua New Guinea – phase 2** supported by the Australian Centre for International Agricultural Research.*



## Banana Wilt Associated Phytoplasma in the Markham Valley

Banana Wilt Associated Phytoplasma (BWAP) continues to cause losses to farmers of the Markham Valley in Morobe Province. Similarly to bacterial wilt in potato, there is not as yet any chemical or other treatment available for infected plants requiring farmers to rely on preventative measures. As a key measure, we have been successful in producing BWAP free planting material through tissue culture in our Biotechnology Centre at the NARI MOMASE Regional Centre.

We have also confirmed the ongoing presence of insect vectors (*Derbidae* family, *Taparella spp* and *Colgaroides spp.*) which spread BWAP between plants. The work in 2021 focused on improving the tissue culture technique, confirming activity of insect vectors, and



Figure 15: BWAP re-infection trial at Manzarang Umi

assessing the re-infection of tissue culture material in three Markham Valley locations.

Tissue culture propagated plants (Blugoe-ABB genome) were planted for assessment of re-infection at three locations in the Markham Valley. Visual assessment after 12 months showed BWAP re-infection on the tissue cultured plants. Fruit from these plants did not appear to be affected at the first harvest. Taro planted in between the bananas appeared very healthy, not showing any symptoms of BWAP or virus infection.



Figure 16: Taro intercrop unaffected by BWAP

Work to date has successfully identified the cause and mechanism of spread, and has developed the technique for producing disease free planting material. More research is needed on management of the insect vectors to successfully scale these research outcomes.

The *Investigation into Banana Wilt Associated Phytoplasma in the Markham Valley* has been conducted under the NARI Research and Development Public Investment Program (PIP)



## Breeding for resilience to climate change

While NARI supports on-going breeding programs using conventional breeding techniques to develop crop varieties to address the issues of low yield, poor quality and declining productivity of subsistence food crop production, these take many years to deliver a result. Mutation breeding by invitro mutagenesis can provide a faster way to achieve results.

NARI's previous experience using mutation breeding in aibika and sweetpotato provided a platform to further develop our capacity in mutagenesis work. The current research activities aim to provide reliable and reproducible tissue culture protocols for material for mutagenesis. Further research effort targeting other abiotic stresses (drought, salinity) is ready to be optimised in 2022.

The major challenge we are facing is in establishing the protocols and bulking up sufficient tissue culture materials. Despite the technical challenges, PNG is expected to send the first batch of tissue culture plants later in 2022 for radiation at International Atomic Energy Agency (IAEA) laboratories in Europe. Another issue here will be the significant logistical challenge, with



Figure 17: IAEA lab in Vienna - Joel Pilon from NARI

Covid19, in ensuring timely transport back to PNG for further sub-culturing and screening following radiation.

Preliminary results have been achieved for the following research studies in developing the methods and protocols for successful tissue culture mutagenesis.

- Effect of Bleach on invitro contamination level of Kerua and Saina-mau banana
- Effect of BAP on invitro shoot induction of Kerua and Saina-mau banana
- Qualitative and Quantitative Toxicity Assessment of Sodium Hypochlorite on banana leaf disc
- Lemon influenced corm sprouts in Saina-mau banana
- Potential Hydrogen and Temperature Relationship in Plant Tissue Culture Medium Preparation
- Investigating Sweetpotato Direct Organogenesis Part-way for EMS mutagenesis in PNG

*Work conducted under the project **Improving crops Resilience to Climate Change through Mutation Breeding in Pacific Islands**, supported by the International Atomic Energy Agency (IAEA)*

## Conserving sweetpotato diversity

Many rural farming communities in Papua New Guinea are vulnerable to the effects of climate change and face serious food security issues. Agro-biodiversity supports resilience and its loss due to droughts and other natural events aggravates the food security situation. Sweetpotato, as a key widespread staple food crop in PNG with high diversity, was selected for a community based diversity conservation trial.

NARI established of a working collection of 170 sweetpotato accessions from various sources, including 116 from NARI maintained germplasm, thirty eight from international partners (CePACT/CIP-Peru), and 16 from local farmers, to increase the available diversity. The accessions were evaluated and final selections made, 16 for the highlands and 23 for the lowlands, for participatory varietal selection and poly cross breeding within communities.



**Figure 18: Community participation at ITPGRFA site at Teptep**

The Family Farm Team (FFT) approach has been successfully applied to strengthen the family unit and community participation. There has been strong community interest and acceptance of the diversity objective in the lead up to the trial work in the coming year.

*This work is conducted with support of the International Treaty for Plant Genetic Resources for Food and Agriculture (ITPGRFA) Benefit Sharing Fund for the project: **In situ Conservation and Utilization of Sweetpotato (*Ipomoea batatas*) for Climate Smart Agriculture Vulnerable Farmers in Papua New Guinea***

## Aligning farmer advisories to climate forecasts



Figure 19: Farmer field trial for CSA

Over the past two years, trials have been conducted, with potato, sweetpotato, taro, bulb onions, and cabbage, to contribute to building a matrix of management practices suited to varying rainfall scenarios, which will in turn assist extension providers to develop localised farm advisories to inform food production decisions and by doing so improve food security outcomes for rural communities.

The “Climate Smart Agriculture” (CSA) research is a collaboration of scientists from Australia and PNG, with support from the Australian Centre for International Agricultural Research. The PNG National Weather Service is a key partner, collaborating with its Australian counterparts in developing three and five month rainfall scenarios for which agricultural management advisories will be developed.

To ensure an AR4D approach, the work has used stakeholder involvement and analysis tools, including farm based trials, social network analysis, “Family Farm Team” workshops, focus group discussions and farmer surveys. A “rainfall management matrix”, summarising management responses to different climate forecast scenarios, is a key output and will be finalised and introduced to farmer and extension provider stakeholders in the coming year, with training on its use with climate forecasts and probability risk.



Figure 20: CSA potato treatments trial

Related field trials in progress:

- Influence of inflow water and fertiliser levels on growth and yield qualities of Irish potato at Aiyura.
- Effect of inflow water and fertiliser levels on bulb onion growth and yield component along different growth stages at Aiyura.
- Comparing sweetpotato growth and yield under split fertiliser application, rain-fed, and irrigation conditions at Bubia, Lae

*The CSA research is part of a collaborative project, **Climate Smart Agriculture opportunities for enhanced food production in PNG**, facilitating the use of seasonal climate information in farming communities to inform food production decisions and by doing so improve food security outcomes for rural communities.*



## Rice foundation seed program

The program has focused on the assessment of new introductions and rejuvenation through field selection of the current NARI variety releases. The work has confirmed the recommended NR1 and NR15 as the primary varieties for warmer regions and NR2 and NR3 where cold tolerance is needed. NR1 has stood out with good yields (6-7 tonnes/ha) and resistance to brown plant hopper.



**Figure 22: Bubia NR1 rice harvest and straw mulch collection**



**Figure 21: Irrigated taro mulched with rice straw**



**Figure 23: Taiwan ICDF TCS-10 variety at Bubia**

The rice foundation seed multiplication program has been a collaborative effort between NARI and the Bubia and Laloki based Taiwan Technical Mission (Taiwan ICDF). Apart from technical contributions, Taiwan ICDF continues to multiply and supply seed of its popular Taichung Sen 10 (TCS-10) variety. This collaboration has strengthened NARI, assisting in development of facilities, providing training to second stage seed growers, assisting NARI in exploring utilisation of field wastes, and developing more mechanised production techniques. These aspects will be further strengthened in the coming year.

## Technical Services



*Technical services conduct and support NARI research as well as providing services to the wider agricultural community through:*

- *Professor John Kola Chemistry laboratory*
- *MRC Biotechnology Centre*
- *Aiyura Tissue Culture Laboratory*
- *Information and Knowledge services*
- *National Agricultural Insect Collection*
- *Regional Centre Genetic Resources Management*

## Chemistry Laboratory Testing Services

The **Professor John Kola Chemistry Laboratory** is a national chemical testing laboratory, accredited under the PNG Laboratory Accreditation Scheme. It is an ISO/IEC 17025 registered laboratory and offers a wide range of chemical (trace and heavy metals), physio-chemical parameters (ions and anions) and bacteriological (anaerobic coliform).

The laboratory has state of the art equipment, including Inductive Coupled Plasma Optical Emission Spectroscopy, Atomic Absorption Spectrophotometers, Graphite Furnace Tube Analyser, ultra-High Pressure Liquid Chromatography, UV Spectrophotometer, Bomb Calorimeter, and bench top DO/pH/EC meter allowing quality analytical and diagnostic services covering:

- soil fertility tests,
- plant leaf nutritional analysis,
- water testing on chemical, physio-chemical and bacteriological qualities/pollutants from different ground water and saline water bodies including environmental samples, and
- proximate analysis in natural products (stock feeds and food) to determine their chemical composition.



Figure 24: Water analysis

The Laboratory has a total of 17 staff consisting of nine technical and eight support staff. The laboratory received 1,553 samples and conducted 9,161 tests for 321 clients with an estimated revenue earning of K423,443.00.

Core Business: as presented in Table 2 is a summary of the total number of frequencies of samples received, the number of samples and analysis/ tests carried out as requested by clients for the year. Also presented in Table 3 is the cash earning against expenditure up to 31 December 2021.

**Table 2: Summary of analyses for 2021.**

Sample Types	Water	Soil	Plant	Nat Prod/Food	Total
No of Batches	271	31	3	16	321
No of Samples	1,221	103	112	117	1,553
<b>No of Tests</b>	<b>7,470</b>	<b>748</b>	<b>603</b>	<b>313</b>	<b>9,161</b>



**Table 3: Summary of expenditure and cost recovery for 2021.**

	Q1	Q2	Q3	Q4	Total
Cash earning PGK	59,636.00	95,086.00	164,387.00	104,334.00	423,443.00
Expenditure (Goods, services, casual labour)	95,580.00	69,007.00	85,149.00	137,963.00	387,699.00

Under the International Atomic Energy Agency, IAEA – RAS5078 TC Project, the Project recognised NARI and NAQIA as project counterparts. The project continues to supply instrument accessories, chemical reagents and chemical standards, and standard operating procedures. Support is being provided to develop technical analytical data on residues of principal veterinary drugs in commonly consumed food items, and chemical residues and aflatoxin in dried agricultural products for exports. Plans are in place through IAEA for supply of laboratory consumables and short term work attachments for two chemists in Pakistan in 2022.

## Biotechnology Services

NARI has two operating tissue culture laboratories. The smaller laboratory at the Bubia Momase Regional Centre Biotechnology Laboratory has focused on research. The larger facility at Aiyura is a shared facility between NARI and Coffee Industry Corporation (CIC).

NARI has been the manager and main user of the Aiyura Tissue Culture Laboratory (TCL) over recent years, primarily to supply foundation material for the National seed potato program and for producers of virus free sweetpotato planting cuttings from NARI Pathogen Tested (PT) planting material.

The Aiyura TCL maintains tissue culture of crop species for germplasm conservation, virus cleaning (PT) and mass micro-propagation for commercial purposes. The commercial aspects generate sufficient income to cover the cost of consumables and electricity, but is not yet commercially viable.

The main challenges for 2021 remain the frequent power disruptions. A replacement generator has been acquired.



**Figure 25: Tissue culture growth room at Aiyura**



The other challenge has been wastage through the oversupply of potato tissue culture plantlets due to client insufficient screen house capacity to utilise the supply. This is a concern to NARI on wasted tissue culture output as well as possible impact on seed potato supply to farmers.



Figure 26: Sprouting PT sweetpotato

The MRC Biotechnology Laboratory is conducting molecular research and invitro mutagenesis. The laboratory has identified the Banana Wilt Associated Phytoplasma (BWAP) causing decline in bananas in the Markham Valley, its insect vectors, and developed the tissue culture technique for providing clean planting material for the *Kalapua* and *Yawa* varieties affected. The work on mutation breeding is done with support of the International Atomic Energy Agency (IAEA) which involves preparing tissue culture material for mutation through radiation by the IAEA. Invitro mutagenesis of vegetatively propagated crops relies on reproducible tissue culture protocols. The laboratory is currently working on the following protocols:



Figure 27: Banana multiplication and rooting

- Optimised surface sterilisation
- Optimised banana initiation and shoot induction using single growth regulators or in combination.
- Optimised banana shoot multiplication
- Optimised banana rooting
- Optimised sweetpotato multiplication using callus culture
- Optimise disease (BSD) screening procedures in the screen house and under nursery conditions for detached leaf methods and invitro plantlets.

## National Agricultural Insect Collection

The **National Agricultural Insect Collection** (NAIC) is the key service activity. The collection holds more than 200,000 insect specimens. Adding specimens to the NAIC database

continues to be the main task. This is designed to be a photographic database and will have web access.

Development of the NAIC database began in 2018 with recording of 24,035 specimens belonging to 2,183 species from four orders: *Lepidoptera*, *Hemiptera*, *Hymenoptera*, and *Orthoptera*. Work has been ongoing since then. This has now grown to 96,744 specimens over 16 Orders.

We should note though that the virtual database collection is primarily for ease of searching and cannot replace the need for a physical collection.



Figure 28: Display from NAIC

The maintenance requirements for the NAIC facility have become a key area of concern with a need for urgent funding support to upgrade the facility and allow it to continue to serve the wider agricultural research and development community.

## Information and Knowledge Services

The institute continues to support the sector at large with various information on agricultural research, innovative practices and technologies as well as documenting traditional and adaptive knowledge to stimulate discussion and further research and development.

Various formats are used to package information targeting the diverse stakeholders in the sector but focusing on smallholder farmers.

The **NARI Nius** was produced quarterly as light informative reading for our multi stakeholders. In this reporting period, the newsletter underwent minor changes in formatting for ease of reading electronic formats.



Due to the Covid 19 Pandemic, the Agricultural Innovation Show and annual provincials shows were not held. However, NARI publications were still displayed and distributed whenever possible. Information was also made available to staff on project activities to display to farmers during their meetings.

We continue to maintain an effective networking with the mainstream media to create increased awareness on NARI AR4D activities. Articles are published with the two daily newspapers (Post Courier and the National), radio, NBC and EMTV.

A list of new professional publications is included in Annex 3.

## Corporate Services



*Corporate Services provide the necessary administrative support to the NARI research and scaling programs, with responsibility in the following areas:.*

- *Corporate Plan*
- *Finance management*
- *Human Talent management*
- *Assets management*
- *Information Technology and Communications infrastructure*



## Corporate Plan development

2021 was a year of achievement in development of the new NARI Corporate Plan. In July, we finalised the draft of the second NARI Strategy and Results Framework (SRF) 2022-2031. This represented a major milestone in the Institute's ambition to continue effectively contributing to improving PNG's welfare, especially of smallholder farmers and rural communities. The new SRF signals confidence in the Agricultural Research for Development (AR4D) paradigm adopted by NARI in 2011, and continues the emphasis on NARI as a results-oriented learning organisation.



**Figure 29: Staff and stakeholders collaborate to develop the new NARI Corporate Plan**

In the development of this SRF2, NARI has built on the principles of AR4D that informed the programs and activities under the past 10 year SRF. We have also examined our guiding principles and identified and introduced five Core Values. These provide the foundation for an organisational culture in NARI that is focused on taking the leadership in agricultural research for development and delivering innovative solutions to its primary clients the smallholder farmers and stakeholders in agricultural and rural development.

In this new ten year SRF 2022-2031, we have taken note of our internal challenges and aspirations, but we have also proactively sought and taken on board the views of our external partners and stakeholders. A major consultative review lead by CAPDEV Consultants was the key informant in the scoping process and development of the new SRF 2022-2031. The consultations and review provided many valuable insights and inputs, and identified adjustments needed for NARI to better play its key role and provide strategic inputs and guidance in the agriculture and rural development impact pathway. A second review targeting the external environment ensured the SRF was well aligned to GoPNG goals and policies.

The Institute links well with the GoPNG priorities arising from the targeted development impacts of reduction of poverty, assurance of food and nutritional security and health and

sustainable resources management as guided by the countries long-and medium-term development strategies. Three derived priorities of the Institute for the next 10 years for which the Institute will contribute to are:

Priority 1: Contribution to economic resilience and development by enhancing agricultural markets, value chains and trade;

Priority 2: Contribution to enhanced resilience of rural communities and systems in light of climate, economic and demographic changes and associated threats to livelihoods and the environment;

Priority 3: Contribution to the enhanced consumption of healthy and sustainable diets by rural and urban households

While the SRF aligns with the National Development Goals and provides the overall direction for the Institute, it was important to carefully map out the different steps it will need to take to achieve this and deliver tangible outputs and outcomes to impact on lives of rural communities in the country. This is provided through development of a Strategic Implementation Plan (SIP), a second tier corporate planning document which provides NARI managers, researchers, donors and partners a guide to AR4D implementation for the first five years of the SRF. Key in development of the SIP was a consultation and prioritisation exercise to inform both its development and a subsidiary Annual Implementation Plan for 2022.



**Figure 30: Stakeholder workshop in development of the NARI SIP**

We take this opportunity to express appreciation to our stakeholders for their contributions and effort in developing the NARI corporate plan.

## Finance

### Funds sources and trends

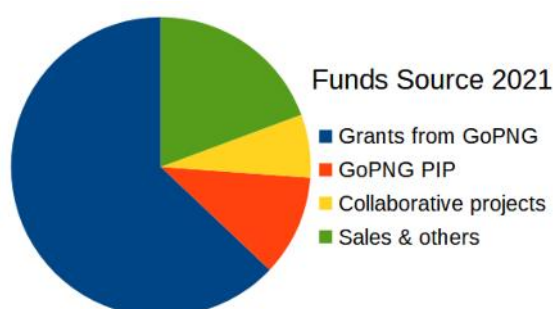
The GoPNG recurrent budget allocated to NARI for 2021 increased from K11.06m allocated in 2020 to K11.55m, but was still far short of the budget estimate of K27m requested.

The GoPNG funded Research and Development Project received K2m under the 2021 Public Investment Program (PIP) allocations for ongoing work in *“Preparedness to cope with climate induced stress”* and a new component for *“Sustainable poultry, aquaculture and goat farming for economic and nutritional well being of rural communities in Morobe and Madang Provinces”*.

Internal revenue, generated from sales of produce and services, consultancy, tenders, and acquittals contributed K3.55m. Grants received for collaborative Donor Projects were transferred to the respective projects account for spending on planned project activities with cost recovery as appropriate. Table 4 shows the changes in funding allocations by source for 2019 to 2021.

**Table 4: Sources of Funds (millions): 2019-2021**

Funding Source	2019	2020	2021
Grants from GoPNG – Recurrent	9.56	11.06	11.55
Grants from GoPNG – Public Investment Program	1.70	1.00	2.00
Collaborative projects	0.01	0.09	1.25
Sales of produce & others (tenders, consultancy, GST, acquittals etc)	2.31	1.46	3.55
<b>Total Funds Available</b>	<b>13.58</b>	<b>13.61</b>	<b>18.34</b>



**Figure 31: Funds by source**

The Institute’s detailed funding and expenditure statement for the year ending December 2021 is given in Table 5. This provides actual for both Recurrent and PIP funds for 2021.

**Table 5: Funds Inflow and Expenditure**

Descriptions	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total 2021
<b>Funds Inflow</b>					
GoPNG - Recurrent	3,594,737.00	1,175,450.00	3,809,342.00	2,965,738.00	11,545,267.00
GoPNG - PIP	500,000.00	250,000.00	500,000.00	750,000.00	2,000,000.00
Sales of Produce and Services	159,770.25	211,729.69	414,110.71	187,964.70	973,575.35
Assets Disposal	69,376.70	206,016.15	370,854.00	240,291.82	886,538.67
Collaborative Projects - HR and Admin Contributions	315,868.67	897,798.06	-	31,591.62	1,245,258.35
Acquittal Reconciliations	1,014,874.14	182,962.26	309,841.70	116,211.65	1,623,889.75
Bank Interest	-	-	59,495.97	-	59,495.97
<b>Total Funds Available</b>	<b>5,654,626.76</b>	<b>2,923,956.16</b>	<b>5,463,644.38</b>	<b>4,291,797.79</b>	<b>18,334,025.09</b>
<b>Expenditure</b>					
Salaries & Allowances	3,674,972.06	2,365,477.55	2,757,996.97	2,632,856.18	11,431,302.76
Travel Expenses	73,257.04	95,649.35	132,892.03	33,225.90	335,024.32
Office Materials & Supplies	35,994.40	22,503.55	27,026.27	41,359.82	126,884.04
Operational Materials & Supplies	657,244.90	1,144,431.14	408,757.53	528,184.74	2,738,618.31
Transport & Fuel	36,452.99	41,295.00	66,650.08	51,987.31	196,385.38
Council	16,620.69	64,807.96	-	14,243.30	95,671.95
Legal	41,000.00	170,500.00	176,300.00	117,095.00	504,895.00
Security Contracted	128,427.20	128,053.10	176,985.44	183,924.14	617,389.88
Electricity and Water	89,048.26	108,820.59	95,124.27	89,144.02	382,137.14
Information and Communications Technology	74,860.18	75,665.58	192,920.04	63,047.59	406,493.39
Repairs & Maintenance	119,751.39	159,213.18	100,295.85	185,602.33	564,862.75
Furniture & Office Equipment	10,214.98	40,380.26	62,943.79	24,139.13	137,678.16
Vehicles, Equipment & Machinery	9,945.00	393,034.97	222,058.45	107,843.39	732,881.81
<b>Total Expenditure</b>	<b>4,967,789.09</b>	<b>4,809,832.23</b>	<b>4,419,950.72</b>	<b>4,072,652.85</b>	<b>18,270,224.89</b>
<b>Net Surplus (Deficit)</b>	<b>686,837.67</b>	<b>(1,885,876.07)</b>	<b>1,043,693.66</b>	<b>219,144.94</b>	<b>63,800.20</b>



## Expenditure

Expenditure by category is shown in Table 6 and Figure 32. While salaries and wages continue to take more than sixty percent (60%) of the total GoPNG grant, this remains far short of the amount required to recruit the staff needed and unfortunately limits delivery of impacts from research. A more realistic staffing scenario has been presented as part of our Strategic Implementation Plan for 2022 – 2026.

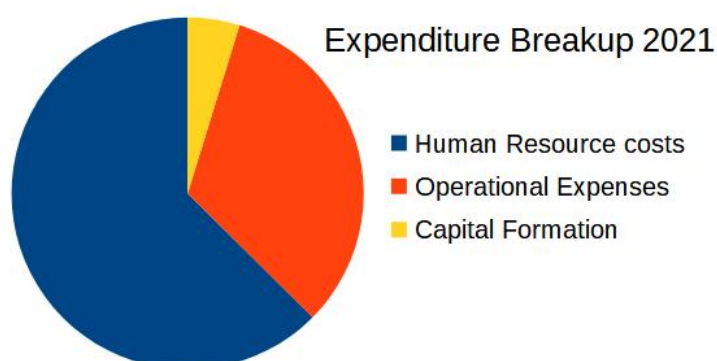


Figure 32: Expenditure by Category

Operational expenses showed a marked decrease with down-scaling of operational activities reduced government budget to NARI and unforeseeable low cash flow experienced with GoPNG during 2021. The Management has focused on regular and routine costs such as personnel emoluments and other basic operational activities required for the daily upkeep when faced with very tight cash flow during 2021.

Table 6: Expenditure by Category: 2019-2021 (million Kina: % in brackets)

Expenditure Category	2019	2020	2021
Salaries and wages	10.17 (56)	9.84 (61)	11.43 (62)
Operational Expenses	7.29(40)	3.95(24)	5.97(33)
Capital Formation	0.63(3)	2.50(15)	0.87(2)
<b>Total Expenditure</b>	<b>18.09</b>	<b>16.29</b>	<b>18.27</b>

The Institute continues to manage its expenditure under strict financial management procedures and protocols. All financial transactions in NARI are subject to annual audit by the Auditor General's Office. The Institute has a clean record of unqualified audit reports since its establishment in 1997. The financial report for the 2020 fiscal year has received an unqualified audit report. The latest audited Balance Sheet extracted from the 2020 audit report is provided as Figure 33. The 2021 accounts have been audited, awaiting certification. The interim balance sheet, 2021 is shown in Table 7.

## NATIONAL AGRICULTURAL RESEARCH INSTITUTE

## BALANCE SHEET

AS AT 31 DECEMBER 2020

	Notes	2020 Kina	2019 Kina
<b>ASSETS EMPLOYED:-</b>			
<b>FIXED ASSETS</b>	3	296,264,193.99	295,564,908.98
<b>Work-In-Progress (Buildings)</b>	4	-	-
<b>CURRENT ASSETS</b>	5		
Debtors and Prepayments		582,022.06	320,100.17
Stock		0.00	-
Petty Cash		516.70	462.05
Cash at Bank		2,301,423.68	6,942,365.61
Biological Assets		214,766.90	224,056.50
Interest Bearing Deposit		7,136,433.55	6,000,000.00
		<u>10,235,162.89</u>	<u>13,486,984.33</u>
<b>CURRENT LIABILITIES</b>			
Creditors and Accrued charges	6	949,982.93	1,228,496.37
Provision for Employee Benefits - Gratuity		1,520,568.81	864,859.77
		<u>2,470,551.74</u>	<u>2,093,356.14</u>
<b>NON CURRENT LIABILITIES</b>			
Deferred Income		2,700,000.00	2,700,000.00
Provision for Employee Benefits - LSL		500,545.46	481,844.04
		<u>3,200,545.46</u>	<u>3,181,844.04</u>
<b>NET ASSETS</b>		<u>300,828,259.68</u>	<u>303,776,693.13</u>
<b>Representing :</b>			
<b>Capital Grant</b>	2 (e)	1,229,570.94	1,927,044.62
<b>Assets Revaluation Reserve</b>	2 (d)	373,354.86	373,354.86
<b>Assets Revaluation Reserve - Land</b>	2 (d)	273,370,000.00	273,370,000.00
<b>Government Equity and Reserves</b>			
Government Grant (Revaluation of Assets)	2 (d)	12,581,579.85	12,581,579.85
Government Contributions		344,829.80	344,829.80
Surplus/(Deficit) from Income and Expenditure		12,928,924.22	15,179,884.00
		<u>300,828,259.68</u>	<u>303,776,693.13</u>

The accompanying notes form an integral part of the above financial statements.



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Figure 33: Balance Sheet, 2020 (Audited)

Table 7: Interim Balance Sheet 2021

<b>NATIONAL AGRICULTURAL RESEARCH INSTITUTE</b>		
<b>BALANCE SHEET (Interim)</b>		
<b>AS AT 31 DECEMBER 2021</b>		
	<b>Notes</b>	<b>2021</b>
		<b>Kina</b>
<b>ASSETS EMPLOYED:-</b>		
<b>FIXED ASSETS</b>	3	294,987,945.02
Work-In-Progress (Buildings)	4	-
<b>CURRENT ASSETS</b>	5	
Debtors and Prepayments		663,203.92
Stock		0.00
Petty Cash		402.30
Cash at Bank		4,183,331.73
Biological Assets		150,454.00
Interest Bearing Deposit		5,280,163.48
		10,277,555.43
<b>CURRENT LIABILITIES</b>		
Creditors and Accrued charges	6	566,364.19
Provision for Employee Benefits - Gratuity		943,355.67
		1,509,719.86
<b>NON CURRENT LIABILITIES</b>		
Deferred Income		2,998,197.03
Provision for Employee Benefits - LSL		544,737.67
		3,542,934.70
<b>NET ASSETS</b>		300,212,845.88
Representing :		
Capital Grant	2 (e)	868,522.25
Assets Revaluation Reserve	2 (d)	373,354.86
Assets Revaluation Reserve - Land	2 (d)	273,370,000.00
Retained Earnings	2 (d)	25,600,968.77
		300,212,845.88

## Human Talent Status

The Government recurrent funding in 2021 for personnel emolument costs enabled the recruitment for the critical scientific and technical staff only. Staff numbers dropped from 129 staff in 2020 to 112 staff at the close of 2021. Those who left NARI in 2021, did so either through volunteer resignation, termination on disciplinary grounds, medical retirement and contract conclusion for lapses in performance. No one was terminated or removed due to COVID-19. Six (6) new contract staff were engaged during the year 2021. More information on various categories of staff is presented in Table 8 below.

**Table 8: Staff categories, 31st December 2021**

LOCATION	CONTRACT	CADETS	ANCILLARY	TOTAL	PERCENT (%)
Head Office	30	0	37	67	16.8%
Aiyura	16	0	42	58	14.5%
Tambul	7	0	30	37	9.25%
Laloki	8	0	33	41	10.25%
Bubia	25	0	64	89	22.25%
Kerevat	15	0	74	89	22.25%
Kilakila	11	0	8	19	4.75%
<b>TOTAL</b>	<b>112</b>	<b>0</b>	<b>288</b>	<b>400</b>	<b>100%</b>



**Figure 34: NARI a/DG and a/HRM with winners for 2021 NASFUND Employer's Award.**



Sixty-three percent (63%) of current contract staff are engaged in science and research activities. Thirty seven percent (37%) provided management and technical support as shown in table 9.

**Table 9: Contract staff roles, 31st December 2021**

Distribution of Contract Staff as Per Various Categories													
Staff/Category	Grades	Non-PNG Citizen	PNG Citizen	Sub Total	HQ	HRC Aiyura	HRC Tambul	SRC Laloki	SRC Kilakila	MRC Bubia	IRC Keravat	Total	%
Executive	Ex 4	0	1	1	1	0	0	0	0	0	0	1	0.9%
Director/Manager	10 - 12	2	5	7	6	0	0	0	1	0	0	7	6.3%
Research Coordinator	5 - 10	0	6	6	0	1	1	1	1	1	1	6	5.3%
Research staff	4 - 9	0	59	59	5	11	4	2	5	23	9	59	52.7%
Management Support Staff	2 - 9	0	39	39	21	2	3	2	3	4	4	39	34.8%
Cadets	3	0	0	0	0	0	0	0	0	0	0	0	0%
<b>Total Staff</b>		<b>2</b>	<b>110</b>	<b>112</b>	<b>33</b>	<b>14</b>	<b>8</b>	<b>5</b>	<b>10</b>	<b>28</b>	<b>14</b>	<b>112</b>	<b>100%</b>
Male				66								66	59%
Female				46								46	41%

Gender balance amongst contract staff in employment shows on-going improvement with Table 9 showing fifty nine percent (59%) male contract staff with forty one percent (41%) female. NARI continues to provide a gender sensitive, safe and conducive working environment for all.

The planned retirement of long serving ancillary staff was on hold in 2021 due to lack of funding. Fifty three (53) permanent ancillary staff have retired to date. Fourteen (14) Contract Staff and twenty (20) Ancillary Staff have been provisionally identified for retirement as funds become available.

Emphasis on staff training and development continued in 2021 with a total of thirteen (13) staff members engaged in doing or have completed their Diploma or Post Graduate training programs. This represents 11.6% of current contract staff released for concentrated training. There are eight (8) staff on Masters programs, two (2) staff doing Bachelor degrees, two (2) staff on Diploma courses, and one (1) on a certificate course.

**Table 10: Staff post graduate training, 2021**

Name	Work Location	Training	Institute	Completion Status
Boney Wera	Aiyura	Masters in Plant Breeding	Massey University, New Zealand	Completed 2021
William Sirabis	Aiyura	Masters in Soil Science	University of Hawaii, Manoa Campus	Completed 2021
Winnie Maso	Aiyura	Masters in Agricultural Science	University of Queensland, Australia.	Completed 2021
Stanley Amben	Tambul	Masters on Animal Science	James Cook University, Australia	Completed 2021
Karo Gebo	Head Office	Masters in Telecommunications	On-line program, Atlantic International University, USA	In Progress
Anna Boyope	Tambul	Bachelor in Public Administration	University of PNG, Waigani Campus	Completed 2021
Arthur Roberts	Bubia	Masters in Aquaculture	Flinders University, Australia	Completed 2021
Elly Solomon	Bubia	Masters in Animal Sciences	Massey University, New Zealand	Study ongoing
Jeremiah Ahizo	Tambul	Masters in Agriculture Science	University of Melbourne, Australia	Completed 2021
Benny Wasika	Kerevat	Certificate in Agriculture	OSICA, Kokopo	Completed 2021
Gloria Wingawe	Bubia	Diploma in Office Administration	HTC, Lae	Completed 2021
Martina Gengkawa	Bubia	Diploma in Accounting	ITI, Lae	Completed 2021
Cresencia Mathew	Head Office	Bachelor in Accounting	University of Technology	Study ongoing

In recognition of the Institute's effort to ensure its staff members are served well in the payment and timely remittance of staff retirement benefits to NASFUND, NARI was considered amongst 61 other qualified organisations and awarded three (3) awards for 2021 NASFUND Employers Awards. The three awards were for Category C for being the 2021 Employer of the Year, Best Employer Voluntary Contribution and Best Member Voluntary Contribution. The awards are a testament of Institute's dedicated efforts, commitments and team work through its Human Resources and Finance departments.

The institute also acknowledge the changes in the working environment and its need to improve its HR Management Services. An electronic human resources database information system is in development with the first phase due for implementation in the latter half of 2022.

## Assets Management

The Institute's asset register was updated for HQ and regional centres. We have progressed development of an asset management manual as an Institute Management Standard and initiated a move to an online asset database.

A number of livestock research buildings and plant nurseries at centres were renovated. The HARC generator at Tambul was replaced as a high priority. The renovation of the Western Pacific Training Guest House was completed, giving improved support to workshops and training events. This was a major refit, upgrading 12 guest rooms, office and kitchen.

A new field facility building was constructed in cooperation with Taiwan International Cooperation Development Fund (Taiwan ICDF) to support the ongoing rice foundation seed improvement program.



Figure 35: Guest house room renovation



Figure 36: Rice field facility building at Bubia

During this period the Institute completed valuation and surveying of its land, registering its remaining portions of land. Work has continued securing the NARI boundaries at our six locations through increases to the number of intermediate boundary markers and establishing permanent and live fences. There are two current court cases related to unauthorised encroachment on NARI land.

A proposal for infrastructure development has been submitted for funding to upgrade research facilities over the period 2022-2027.

## Information Technology and Communications

IT infrastructure upgrades have been implemented to improve communications and reduce costs. Video conferencing equipment was installed across all NARI regional research centres, primarily to reduce the impacts of Covid19 related travel restrictions, and ensure research could be progressed with minimal disruption. They have also served to allow more participatory management and team building.



**Figure 37: New VoIP PABX in operation at HQ Reception**

A central “Voice over Internet Protocol” (VoIP) PABX server was installed, and a limited number of handsets for HQ and regional research centres are under preparation for installation.

The primary Internet backbone link at HQ was upgraded from 10Mbps to 20Mbps by DataCo at no additional ongoing cost, in exchange for providing access for a DataCo switch to serve surrounding customers. This will increase available internet bandwidth, which will be particularly useful for our extended use of video conferencing.



# Appendix

## Annex 1: Major Projects

<p>Supporting commercial sweetpotato production and marketing in the PNG highlands (TADEP)</p> <p><i>An ACIAR funded project led by CQU in partnership with NARI, FPDA, ANU and QDAFF. Project to sustainably increase the contribution of the sweetpotato crop to cash income and food security, via transformative improvements in selected sweetpotato value chains</i></p>	<p>HORT/2014/097</p> <p>Completed: June 2021</p>
<p>Developing improved crop protection options in support of intensification of sweetpotato production in Papua New Guinea</p> <p><i>An ACIAR funded project led by Charles Sturt University in partnership between NARI, FPDA, UOT in PNG and USQ in Australia. Project developing, testing and promoting the adoption of sustainable solutions to protect sweetpotato crop production</i></p>	<p>HORT/2014/083</p> <p>Completed: June 2021</p>
<p>On-farm diversity root, tuber, and banana crops</p>	<p>Bioversity Int./Crop trust</p> <p>Completed: September 2021</p>
<p>Pacific regional integrated food and security initiative to COVID19 (PRISCO19) program</p> <p><i>EU Initiative to Address National Priority Needs Around COVID19</i></p>	<p>EU / SPC</p> <p>Completed Dec 2021</p>
<p>Ongoing 2022</p>	
<p>Strengthening food production capacity and resilience to drought of vulnerable communities (EUCCR)</p> <p><i>A European Union funded action to contribute to achieving a greater resilience of smallholder farming and rural communities in Papua New Guinea to abiotic stresses arising from seasonal weather patterns, climate change or natural disasters and impacting on their livelihood.</i></p>	<p>FED/2016/382-604</p> <p>Completion: April 2022</p>
<p>Sustaining soil fertility in support of intensification of sweetpotato cropping systems</p> <p><i>An ACIAR funded project led by UQ in partnership with NARI. Project providing farmers with a range of nutrient supply options to underpin the sustainable intensification of the PNG</i></p>	<p>SMCN/2012/105</p> <p>Completion: April 2023</p>

<i>Highland sweetpotato cropping system.</i>	
<p>Responding to emerging pest and disease threats to horticulture in the Pacific islands</p> <p><i>An ACIAR funded project led by UQ with partners from NARI, Fiji, Samoa, Tonga, Solomon Islands, and SPC. Project aims to develop integrated pest and disease management strategies for the sustainable intensification of fruit and vegetable crop production, addressing the threats posed by the inappropriate use of pesticides, emerging pests and diseases and climate change.</i></p>	<p>HORT/2016/185</p> <p>Completion: September 2023</p>
<p>In situ Conservation and Utilisation of Sweetpotato (Ipomoea batatas) for Climate Smart Agriculture Vulnerable Farmers in Papua New Guinea</p>	<p>ITPGRFA BSF</p> <p>Completion: June 2023</p>
<p>Climate Smart Agriculture opportunities for enhanced food production in PNG (CSA)</p> <p><i>An ACIAR funded project led by ANU with partners in PNG (NARI, CCDA, DAL, FPDA, NWS, UOG) and in Australia (ANU, Phloem 3 Pty Ltd, Sustineo Pty Ltd). Project facilitating the use of seasonal climate information in farming communities to inform food production decisions and by doing so improve food security outcomes for rural communities.</i></p>	<p>ASEM/2017/026</p> <p>Completion: June 2024</p>
<p>PIP – Research and Development</p> <p><i>Component 1: Preparedness to cope with climate induced stress (drought, frost, excess moisture and salinity)</i></p> <p><i>Component 2: Sustainable poultry, aquaculture and goat farming for economic and nutritional well being of rural communities in Morobe and Madang Provinces</i></p>	<p>PNG Government PIP 05020 - Research and Development</p> <p>Completion: December 2023</p>
<p>Enhancing private sector-led development of the Canarium industry in Papua New Guinea – phase 2</p> <p><i>Project targets barriers to private sector investment in the Canarium industry by improving supply, further enhancing efficiencies in the production and processing systems and further developing both domestic and export markets for processed galip nuts</i></p>	<p>FST/2017/038</p> <p>NARI, Griffith University and the University of Adelaide</p> <p>Completion: December 2022</p>

## Annex 2: Research Studies

Research Study	Fund source	Status
In Vitro Evaluation of Fungicides against Phytophthora infestans of potato ( <i>Solanum tuberosum</i> )	NARI Research Fund	Completed Report pending
Investigating Soil Water Dynamics under different sweetpotato cultivation techniques	PIP R&D	Completed Report pending
Identification and distribution of sweetpotato viruses and their vectors in the PNG Highlands	ACIAR TADEP	Completed Report pending
Sweetpotato viruses – second season trial – single and dual infection with viruses.	ACIAR TADEP	Completed Report pending
Evaluating economical feeding regimes for weaner and grower pigs when fed grain-based diets or blended diets of sweetpotato or cassava with universal protein concentrate	PIP R&D	Completed Nov 2021
Efficiency and profitability in local honey production by smallholder farmers in Eastern Highlands Province	ACIAR	Completed June 2021
Economic evaluation of introduced sweetpotato cultivars in strengthening climate change resilience of vulnerable households' food security in Misima and Selepet	EUCCR project	Completed June 2021
Validation of the SSS method for sweetpotato tuber storage during drought conditions in PNG	EUCCR project	Completed July 2021
Baseline information on Labu goat and sheep generated and utilised to improve husbandry and health practices	NARI Research Fund	Completed Dec 2021
<b>Ongoing 2022</b>		
Influence of inflow water and fertiliser levels on growth and yield qualities of Irish potato at Aiyura.	ACIAR CSA Project	Active
Effect of inflow water and fertiliser levels on bulb onion growth and yield component along different growth stages at Aiyura.	ACIAR CSA Project	Active



Comparing sweetpotato growth and yield under split fertiliser application, rainfed and irrigation condition at Bubia, Lae	ACIAR CSA Project	Active
Rearing Black Soldier Fly larvae (BSFL; <i>Hermetia illucens</i> ) as an alternative source of high protein from regenerating organic farm wastes into feed for fish and chickens	EUCCR project	Active
Evaluation of Promising NERICA rice Lines under Upland and irrigated Environmental Conditions in PNG (Laloki)	EUCCR project	Active
Documentation of Indigenous knowledge in managing prolonged dry weather situations: The case of Teptep, Rigo and Pobuma communities of Papua New Guinea	EUCCR project	Active
Banana ( <i>Musa</i> sp) and Sweetpotato in vitro mutagenesis in Papua New Guinea	IAEA, NARI	Active
Preliminary evaluation of wheat varieties in the High Altitude Highlands of Papua New Guinea	PIP R&D	Active
Investigation into Banana Wilt Associated Phytoplasma in the Markham valley	PIP R&D	Active
Assessment of variation in the relationship and genetic diversity between and within <i>Amaranthus</i> from Papua New Guinea by ISSR DNA fingerprinting	ARSFII/ACIAR	Active
A reliable loop-mediated isothermal amplification (LAMP) technique for detection of Sweetpotato virus G (SPVG)	ARSFII/ACIAR	Active
Screening for potato ( <i>Solanum tuberosum</i> ) viruses in introduced varieties using DAS-ELISA and Loop-Mediated Isothermal Amplification (LAMP)	ARSFII/ACIAR	Active

## Annex 3: Professional Publications

Bai, S.H., Trueman, S.J., Nevenimo, T., Hannet, G., Bapiwai, P., Poienou, M., and Wallace, H.M. (2021a). Effects of shade-tree species and spacing on soil and leaf nutrient concentrations in cocoa plantations at 8 years after establishment. *Agric. Ecosyst. Environ.* 246, 134–143 <https://doi.org/10.1016/j.agee.2017.06.003>.

Eyland D, Breton C, Sardos J, et al. (2021) Filling the gaps in gene banks:Collecting, characterizing, and phenotyping wildbanana relatives of Papua New Guinea. *CropScience*. 2021;61:137–149.<https://doi.org/10.1002/csc2.20320>

Hannet, G., Singh, K., Fidelis, C., Farrar, B. M., Muqaddas, B., Bai, H. S., (2021) Effects of biochar, compost, and biochar-compost on soil total nitrogen and available phosphorus concentrations in a corn field in Papua New Guinea

Jeffrey Y, Sirabis W, Atung C, Weh, B, Menzies N, and Kirchhof G (2021). Soil fertility management techniques for increased sweetpotato root yield in Papua New Guinea (PNG) highlands. Poster presentation at the Soil Science Australia and the New Zealand Society of Soil Science Joint Conference, Cairns, QLD Australia, 27 June - 2 July 2021.

Jeffrey Y, Sirabis W, Atung C, Weh, B, Menzies N, and Kirchhof G (2021). Sweetpotato yield comparison from pathogen tested and non-pathogen tested vines with coffee pulp in the PNG Highlands. Poster presentation at the Soil Science Australia and the New Zealand Society of Soil Science Joint Conference, Cairns, QLD Australia, 27 June - 2 July 2021.

Kallow, Simon, Kevin Longin, Natalia F. Sleziak, Steven B. Janssens, Filip Vandeloock, John Dickie, Rony Swennen, Janet Paofa, Sebastien Carpentier, and Bart Panis. 2020. "Challenges for Ex Situ Conservation of Wild Bananas: Seeds Collected in Papua New Guinea Have Variable Levels of Desiccation Tolerance" *Plants* 9, no. 9: 1243. <https://doi.org/10.3390/plants9091243>

Kohun PJ and Mazi M (2021). Liveweight change in mature female sheep and goats at Labu Research Centre grazing semi-improved pastures supplemented with millrun. *UOG Journal of Popular Science in Papua New Guinea*, Volume 1, Number 2, pages 74-89

Mottl, Yombai J et al. (2021). Inter-specific aggression generates ant mosaics in canopies of primary tropical rainforest, *Oikos*.

NARI (2021) Annual Report 2020, Corporate Document 1/2021, National Agricultural Research Institute, Lae, PNG.

NARI (2021) Fall Armyworm (*Spodoptera frugiperda*) Biology and Management, Information Bulletin No.22, National Agricultural Research Institute, Lae, PNG.

NARI (2021), 2020 Baseline survey in the East and West Sepik Provinces for the EU-STREIT PNG Program, National Agricultural Research Institute, Lae, PNG.

Randall B, Jones K, Hodges B, Hannel D, Nevenimo T, Hosseini Bai S, Wallace H (2021) A guide to processing galip gut (*Canarium Indicum*), Information Bulletin No.21, National Agricultural Research Institute, Lae, PNG.

Sachter-Smith, G.; Paofa, J.; Sardos, J. (2021) Bananas of West New Britain - Papua New Guinea. Rome (Italy): Alliance of Bioversity International and CIAT, 127 p.

Wau W, Komolong B (2021) Virus Vectors (Aphids and Whiteflies) Epidemiology in Virus-free Fields of Beauregard Sweetpotato Variety. *J Plant Physiol Pathol* 9:6.

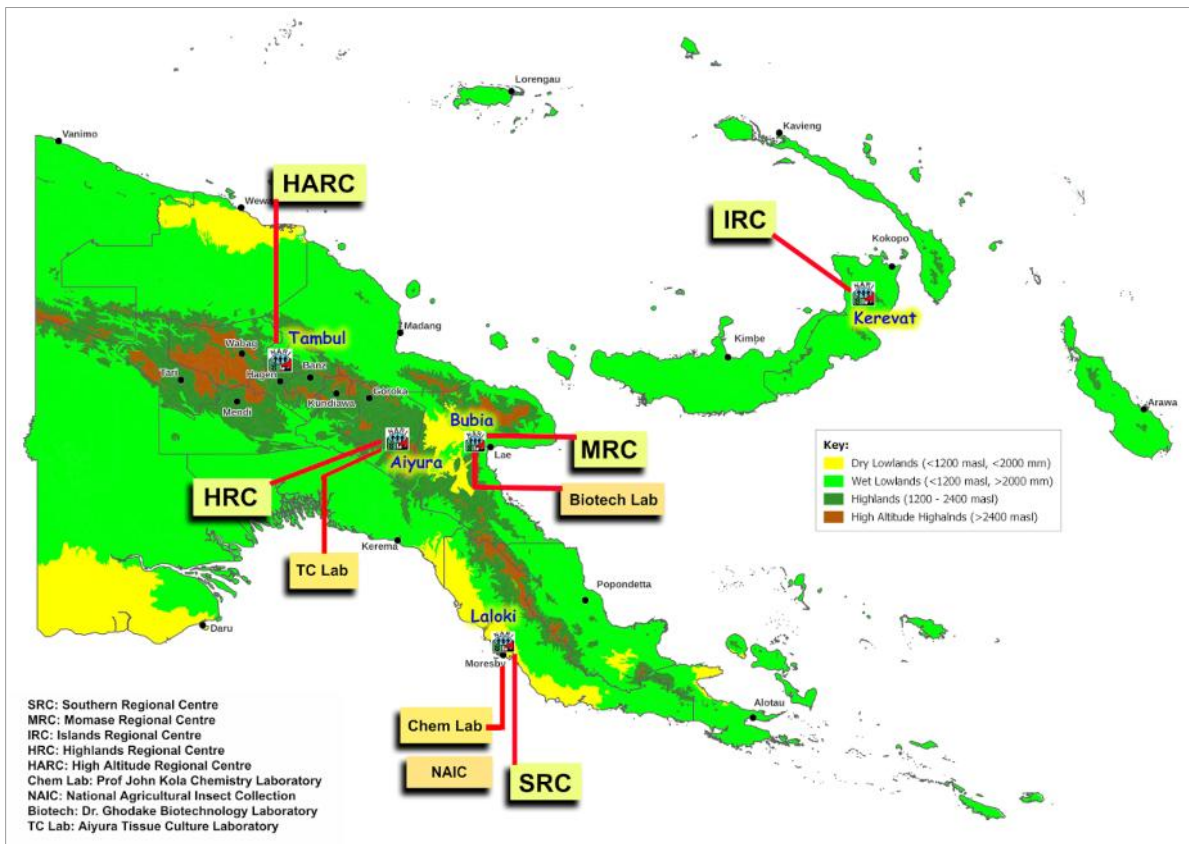
Yombai J, Klimes et al. (2021). Ant species diversity, distribution, and community composition in different forest types in Papua New Guinea, CSE.

## Annex 4: NARI Regional Centres

NARI Head Office is located outside Lae, at Bubia in the Morobe Province. There are five regional centres and tree technical facilities. The regional centres are distributed throughout the country to enable adaptive research specific to the respective agro-ecological zone where they are located. While the centres primarily serve the region where they are located with research, information, and genetic resources, the location allows the centre to conduct research which can then be applied to similar agro-ecological zones anywhere in PNG. All centres have recently been equipped with automatic weather stations which are networked with the NARI website, and will supplement the national climate data collated by the National Weather Service.

### Highlands Regional Centre

The Highlands Regional Centre (HRC) is in the Aiyura valley, close to the township of Kainantu, Eastern Highlands province. HRC Aiyura is situated at an altitude of 1664 metres above sea level (masl). The centre supplies the demand for foundation planting material for improved crop varieties and other planting materials for both commercial production and building of resilience to climate change and other natural disasters. HRC is the centre for





several research studies in soil management and pest management, particularly in relation to the sweetpotato value chain.

### **High Altitude Regional Centre**

Tambul in the Western Highlands province at 2200masl focuses on locations in the higher altitude range, from 1,800 to 2,850 masl.

The centre maintains planting material to supply foundation stock for adapted village chickens and high altitude adapted crop varieties for both commercial production and building of resilience to climate change and other natural disasters. Key focus crops have been potato, sweetpotato, wheat, and pyrethrum.

### **Islands Regional Centre**

The agro ecological zone for the Islands Regional Centre (IRC) is the wet lowland and islands including atolls. Formerly known as Lowland Agriculture Experimental Station (LAES), the IRC is based at Keravat in the Gazelle Peninsula of the East New Britain Province. It services the agricultural research needs of the five island provinces of East New Britain, West New Britain, New Ireland, Manus and the Autonomous Region of Bougainville.

Galip research and development piloting value chains of quality Galip primary and secondary product (kernel, oil), has been a key focus for the Islands Regional Centre. Apart from Galip, maintenance of germplasm collections of food and cash crops of the region and implementation of the EUCCR and CSA projects have been key activities.

### **Momase Regional Centre**

The Momase Regional Centre (MRC) research and development activities are coordinated from Bubia, Lae, Morobe province. Research and development initiatives at MRC is focused on both livestock and food crop improvement; germplasm maintenance; pest and disease management; post harvest and food technology; lowlands food crop screening, evaluation and multiplication; integrated farming systems, and marketing systems.

The main focus of livestock research for development is on the delivery of appropriate technologies to make smallholder livestock production more effective and sustainable, especially on developing low cost feeding options through enhanced utilisation of local feed resources for priority small livestock such as pigs, chickens, ducks, goats, sheep and rabbits.

MRC also hosts a biotechnology research laboratory. The current focus has been on disease diagnosis using molecular tools, development of tissue culture protocols for the response to BWAP, and development of protocols for preparation of materials for invitro mutagenesis.

### **Southern Regional Centre**

The Southern Regional Centre (SRC) is located at Laloki in the Central Province, about 30 km outside the capital, Port Moresby. Research and development activities of the Centre are

focused on dry-lowland areas of the country. The Southern Region includes the Western Province through to Gulf and Central to Milne Bay and Oro Provinces.

Most of the current research and development activities are related to building climate change resilience under a European Union funded action, and multiplication of quality foundation seed with assistance from the Taiwan Technical Mission (Taiwan ICDF). The Centre also conducts conservation, characterisation, evaluation, maintenance and documentation of the national plant genetic resources (PGR) ex-situ collections of banana, yam, cassava and aibika.

### **National Agricultural Insect Collection**

The National Agricultural Insect Collection (NAIC) located at Kilakila, Port Moresby. NAIC provides an insect identification service and holds more than 200,000 insect specimens.

### **Prof John Kola Chemistry Laboratory**

The John Kola Chemistry Laboratory located at Kilakila, Port Moresby. It is an ISO/IEC 17025 registered laboratory and offers a wide range of services including chemical (trace and heavy metals), physio-chemical parameters (ions and anions) and bacteriological testing.

### **Aiyura Tissue Culture Laboratory**

The tissue culture laboratory in HRC Aiyura is a shared facility with the Coffee Industry Corporation (CIC). NARI manages the facility and has been able to consistently provide pathogen free potato plantlets to the Fresh Produce Development Agency (FPDA) as foundation material for the national seed potato scheme. Supply of foundation planting material of potato late blight (PLB) resistant potato varieties continues as a key contribution to the commercial potato industry, reducing the need for chemical fungicides. The laboratory also provides pathogen free (PT) sweetpotato cuttings of commercial varieties.



**NARI Logo** - The letters NARI are the initials of the National Agricultural Research Institute. The PEOPLE symbolise those included in the mandate of NARI such as farmers, researchers, extension agents, partners, NGOs etc., backed with **BLUE** to encompass the sky and the macro environment. The LEAF symbolises crops, backed with **GREEN** to depict the crop environment. The PIG and CHICKEN heads symbolise livestock. The **RED** background portrays the toil and sweat of the people.

***Our international development partners play a key role in enabling the National Agricultural Research Institute to achieve its development objectives. The Institute gratefully acknowledges the generous support of our international partners.***



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