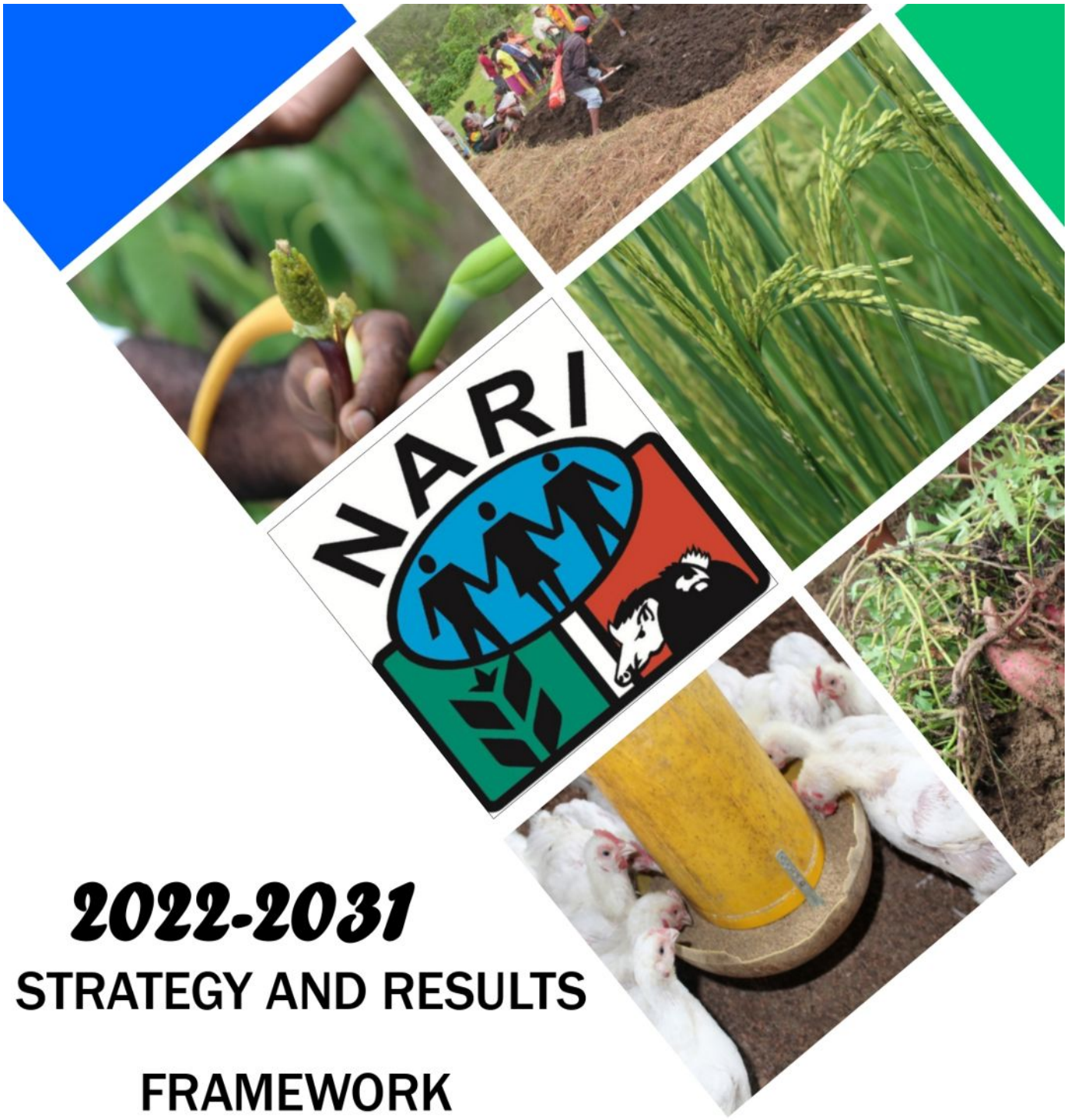


2022-2031

STRATEGY AND RESULTS FRAMEWORK

NARI's Contibution to Realising
PNG Vision 2050

Promoting Excellence in Agricultural Research for Sustainable Development

Strategy and Results Framework 2022-2031

National Agricultural Research Institute

Lae, Papua New Guinea

Corporate Plan No. 1/2022

Recommended Citation: National Agricultural Research Institute, 2022. Strategy and Results Framework 2022-2031, Corporate Plan 1/2022, National Agricultural Research Institute, Lae, Papua New Guinea.

Table of Contents

List of Tables

Table of Figures

External stakeholder participants at NARI Prioritisation workshop

Foreword

NARI is proud to present its second ten year Strategy and Results Framework (SRF). Our strategy aligns and will contribute directly to the achievement of the GoPNG Development Goals, in particular to promote economic activity and reduce poverty, to improve food and nutrition security, to promote sustainable resource management, and respond to climate change challenges. These also cascade from the UN Sustainable Development Goals (SDGs) the PNG Vision 2050 and PNG's DSP 2030, which share a common 2030 target date with our framework.

PNG still ranks poorly on social indicators, showing last in the Pacific on the HDI, with agriculture related nutrition issues, particularly showing in malnutrition with higher than acceptable levels of poor early development and deaths of children under five. Women and youth remain particularly disadvantaged. We cannot simply follow familiar paths in response to these needs. We must extend our focus on women and young people, focus to provide economic opportunities and improved diets and nutrition, particularly among mothers and young children, and intensify our work on climate-smart agriculture. These are all given new focus in our research agenda, along with continuing research efforts to improve the productivity of new and traditional staple food crops, livestock and fish, and the sustainability of our natural resources and environment.

In the development of this SRF, NARI has built on the principles of Agricultural Research for Development that informed the past ten year SRF, Programs and Activities. 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.

We greatly appreciate all contributions, as together, these consultations and approaches have greatly strengthened and focused NARI's Strategy to better serve the people and government of PNG. The new priority areas clearly articulate the research strategies, which with the supporting technical services and institutional structure provides a firm foundation for the research and partnerships needed to deliver on PNG's National development goals, across the diverse Agricultural Development Domains, over these next ten years from 2022-2031.

Effective agricultural research for development is key to PNG's development aspirations and the 85% of the population who are rural based and depend on productive agriculture to escape the poverty trap of the rudimentary subsistence agriculture systems. While this Strategy and Results Framework provides a clear platform and pathway for the future, NARI cannot do it alone. We call on our partners and stakeholders to work with us to share in achieving our common aspirations in fulfilling our national development plans and objectives.

Warea Orapa
a/Director General

Executive Summary

NARI Vision, Goal and Purpose

In its Vision for PNG, NARI sees "Prosperous PNG Agricultural Communities" supported by the NARI Mission of promoting innovative agricultural development in PNG through scientific research, knowledge creation and information exchange. This is intended 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 rural families and communities who depend wholly or partly on agriculture for their livelihoods.

PNG Development Challenges

Papua New Guinea (PNG) is by far the largest country in the Pacific in terms of the size of the economy, land mass as well as population size. However, while the nominal it has the largest gross GDP among the 22 Pacific Island Countries and Territories, the country ranks last in the region in the Human Development Index (HDI) and other social and demographic indicators. This is against a backdrop of abundance of natural resources including minerals, oil, gas and timber, fish and agricultural produce for export and domestic consumption. A burgeoning population will put increasingly pressure on natural resources, an already fragile agri-food system, necessitating creative strategies to empower the growing population with innovative ways to increase income earning and employment opportunities.

Agriculture Research for Development

NARI as the premier agricultural research institute in the country is well positioned to make significant contributions in applying science and strategic research to address major challenges and realise opportunities in agricultural development. The Institute has realised that it needs to go beyond its traditional role of research and supplier of technology and information, to be a more active change agent in driving innovation, with people at the centre of the innovation rather than a focus on technology. In order to do so, NARI adopted the Agricultural Research for Development (AR4D) paradigm in 2010. AR4D is embedded within the Agricultural Innovations System (AIS) framework. This approach is now widely accepted and principles applied by agricultural research organisations and donor funding programs across the world. It is used in emerging approaches to enhance development outcomes, bringing an expanded role of research to integrate different types of research and learning approaches, active participation in scaling pathways, responsiveness to peoples needs, and a strong emphasis on research and innovation around the social, institutional and policy dimensions in impact pathways.

Agriculture, Forestry and Fisheries have been identified in the country's medium to long-term strategies as the key drivers in economic and social development with more than 85% of the population living in rural areas and relying on those sectors for their livelihoods. While Agriculture is often referred to as the back-bone of the country, it is yet to reach its full potential to support a rapidly growing population towards improved welfare and living standards. Agricultural Research for Development interventions can make a significant contribution to the achievement of targets in social and economic development set out in the medium-and long-term strategies and policies of the PNG Government, addressing major impact areas of poverty reduction, increased food and nutritional security, and a healthy and

sustainable natural resource base. The major policy directions and initiatives from the Government of PNG guiding social and economic development over the next 10-years, and necessary contribution from agricultural development include the following:

Reduction of poverty

The DSP 2030 targets an additional two million jobs by 2030. The SME policy 2016 is a key instrument in the Government's long-term strategy to achieve this aim. With 85% of population living in rural areas and engaged and depending on agriculture, forestry and fisheries for their livelihood, most of the anticipated creation of SMEs and associated jobs will have to be in those sectors. Opportunities need to broaden to cover on-farm as well as off-farm employment to slow down the urban drift and make it attractive for young people to seek employment and build their livelihoods in rural areas. This approach calls for the strengthening of research for development and innovation along priority value and supply chains with a strong focus on inclusiveness to lift the country's performance and benefits from improved gender equality.

Food and nutritional security and health

All facets of food and nutritional security, covering food availability, food access, utilisation of food, and stability of food availability and access need to significantly increase to meet the demands of the growing population and meet the targets set out by the Government in DSP 2030 and MTDP III 2017-2022 and other key policies including the National Nutrition Policy 2016-2025 and Draft National Food Security Policy 2018-2027.

Sustainable resource management and use of agri-ecosystem services

PNG's rich natural resources, including it's unique biodiversity, are under threat from over-exploitation, use of unsustainable agricultural production practices and global Climate Change, unless a major shift using a whole system approach is instituted. The ongoing reliance of the national economy on mineral resource development and logging for revenue generation will continue to damage the environment, degrade the landscape, and accelerate loss of biodiversity requiring effective responses in policy, monitoring and rehabilitation efforts to sustain agri-ecosystems. Innovation system approaches are needed to ensure that agricultural development is holistic and inclusive, ensuring that agri-ecosystem services are extracted in a sustainable manner.

Agricultural Research for Development - A Strategy and Results Framework

The new Strategy and Results Framework (SRF) 2022-2031 builds on the first SRF 2011-2020 which is grounded in the Agriculture Research for Development (AR4D) paradigm. AR4D is embedded within the Agricultural Innovations System framework, a widely accepted framework used to guide agricultural research, donors and development practitioners across the world. As part of the development of the new SRF, the Institute commissioned a review of the implementation progress of the previous SRF that included stakeholder assessments, sought further comments from Senior Managers and Scientists. The new SRF development was built on the insights and lessons learnt from the past.

The NARI Goal and Strategic Objectives as stated in the NARI Act 1996 have been reaffirmed during the strategic planning process:

Goal: *Improved welfare of rural families and communities who depend wholly or partly on agriculture for their livelihoods*

Strategic Objective: *Enhanced productivity, efficiency, stability and sustainability of the smallholder agriculture sector*

While the NARI Goal is aspirational and links into the country's long-term vision as articulated in Vision 2050, the NARI Strategic objective expresses the Institute commitment to actively contribute in all aspects of the agricultural development process with relevant research outputs and outcomes. Contributions will be made to the following development outcomes:

- Increased incomes and employment in rural areas arising from increased economic activities and business development
- Enhanced stability and resilience of livelihood systems of rural households and communities
- Production, productivity and efficiency of crop and livestock products increased and producers better linked through efficient value chains to profitable markets at scale
- Rural and urban households consuming healthy balanced and nutritious diets
- Improved standards in Food and Feed safety in agricultural production and food/feed use are applied
- Enhanced and equitable benefits from agri-ecosystem goods and services
- Agricultural production systems are sustainably managed under changing climates and macroeconomic drivers
- Enhanced equity and inclusion achieved

Targeting for Impact and major beneficiaries

NARI used geographic information system (GIS) methods to classify the country into Agricultural Development Domain (ADD) Clusters. ADD clusters will help guide the Institute in targeting AR4D activities and ensure that they are responsive to the needs of the beneficiaries and at the same time provide a guide on further scaling of successful interventions for achieving wider outcomes and impacts. The primary beneficiaries of NARI's Agricultural Research for Development agenda are the more than 80% of men and women smallholder farmers that live in rural areas in PNG and rely on agriculture, forestry and fisheries for their livelihoods. Other beneficiaries include consumers in general as well as off-farm actors such as traders, processors, transport operators, and other service providers.

Agriculture Research for Development Priorities and Strategies

Over the next 10 years, NARI will focus on the following priorities and strategies:

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

Markets, value chains and trade are not well developed in PNG and much of the agricultural produce for local consumption is traded in informal markets. But there is a strong drive by the PNG Government for a transition from the traditional subsistence and semi-commercial production system to an agribusiness oriented Micro-Small to Medium Enterprises (MSMEs) and Small to Medium Enterprise (SME) model of agriculture farming. NARI and partners will use a whole value-chain approach to address the constraints in selected priority value-chains. Other AR4D strategies will explore opportunities in enhancing value-addition or advancing

other forms of down-stream processing of crop and livestock products and research interventions.

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*

Rural communities and households have a high vulnerability to food insecurity and disruption of income generating activities due to their low adaptive capacity to manage those threats and risks to their livelihood. Other economic pressures, high population growth and demographic changes with migration of people closer to roads and markets is putting increasing pressure on natural resources including soils, water and biodiversity. With an aim to increase resilience of communities and agriculture systems changes need to target technology, social and institutional changes. NARI's strategies will focus on three areas, viz. management and use of PNG's rich agri-biodiversity, adaptation strategies to global Climate Change and the broader application of technological, social and policy innovations in a system wide approach to strengthen agricultural production systems in a sustainable manner.

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

PNG is facing a severe nutritional crisis with a triple burden of malnutrition, i.e. under nutrition, micro-nutrient deficiencies, and overweight/obesity. The threat of a lost generation that is impaired in contributing gainfully to economic and social development and to sustain their own livelihoods is a major threat to the nations future. Changes are required in all aspects of food and nutritional security, i.e. availability, access and use of nutrient dense food at all times including food safety considering the prevalence and impact of food borne diseases, malnutrition and mortality of children. There are important linkages between agriculture and nutrition, and AR4D has a major role to play in with nutrition-specific interventions to the multi-sector approach of the Government. The major areas of intervention include enhancing the availability of nutrient dense crops and crop varieties by strengthening seed systems and diversifying production systems, increase of livestock production and consumption in both rural as well as urban setting, and increasing the awareness, education and changing attitudes, habits and perceptions of rural and urban dwellers towards food, diets, preparation and consumption of food.

Acronyms and Abbreviations

ADD	Agricultural Development Domains
AR4D	Agricultural Research for Development
ASTI	Agricultural Science and Technology Indicators
CBD	Convention on Biological Diversity
CSA	Climate Smart Agriculture
DAL	Department of Agriculture and Livestock
DSP	Development Strategic Plan
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Product
GHG	Green House Gases
GII	Gender Inequality Index
GIS	Geographic Information Systems
GoPNG	Government of PNG
GRFA	Genetic Resources for Food and Agriculture
HDI	Human Development Index
HT	Human Talents
ICT	Information and Communication Technology
ME&L	Monitoring and Evaluation and Learning
M&SME	Micro and Small to Medium Enterprises
MTDP	Medium-term Development Plan
MTIP	Medium-term Implementation Plan
NAIS	National Agricultural Information System
NARI	National Agricultural Research Institute
NARS	National Agricultural Research System
NAIC	National Agricultural Insect Collection
NCD	National Capital District
NSO	National Statistical Office
PGRFA	Plant Genetic Resources for Food and Agriculture
PKCL	Prof. Kola Chemistry Laboratory
PM&E	Planning, Monitoring and Evaluation
PNG	Papua New Guinea
SDG	Sustainable Development Goals
SME	Small to Medium Enterprises
SO	Strategic Objective
SPC	Secretariat of the Pacific Community
SRF	Strategic Results Framework
StARS	National Strategy for responsible sustainable development
TOT	Training of Trainers
UNDP	United Nations Development Program
UNFCC	United Nations Framework Convention on Climate Change

NARI, a lead partner in facilitating innovative solutions for sustainable agricultural development and improved livelihoods in PNG:
Strategy and Results Framework

1. The Institute

The National Agricultural Research Institute (NARI) was established by an Act of 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:

(a) any branch of biological, physical and natural sciences related to agriculture; and

(b) cultural and socioeconomic aspects of the agricultural sector, especially of the smallholder agriculture; and

(c) matters relating to rural development of relevance to Papua New Guinea.

NARI is also responsible for providing technical, analytical, diagnostic and advisory services and up-to-date information to the agriculture sector in PNG.

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. NARI is guided by five core values, as below.

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.

2. PNG Development Challenges

Papua New Guinea (PNG) is by far the largest country in the community of the Pacific Island Countries in terms of the size of the economy, land mass as well as population size. However, while the nominal gross GDP is more than twice the size of New Caledonia as the second largest economy among the 22 Pacific Island Countries and Territories, the GDP per capita is third last with only US$2854 compared to US$37,448 in New Caledonia (Pacific Community (SPC) 2020). PNG also continues to rate poorly in the Human Development Index (HDI) ranking 155 out 189 countries/territories which has been stagnant at this position for many years. This is similar for other social and demographic indicators, e.g. it ranks 155 out of 182 countries for the Gender Inequality Index II (UNDP 2019). The performance in those social and economic indicators point to major underlying challenges that the country is facing in progressing towards the Vision of a "Smart, Wise, Fair and Happy Society" by 2050 that is set out in the country's long-term development plan "PNG Vision 2050" (Government of PNG 2009). This is against a backdrop of abundance of natural resources including minerals, oil, gas and timber, fish and agricultural produce for export and domestic consumption.

Despite the richness in natural resources, the challenges the country has to overcome on its development path are formidable as outlined in the recently published "Voluntary National Review of Progress in implementing the Sustainable Development Goals" (DNPM 2020). The high population growth rate of 3.1% (NSO 2013) which is beyond the carrying capacity of the national economy is one of the major national issues the Government has identified. The burgeoning population will put increasingly pressure on natural resources and an already fragile subsistence agri-food system. Creative strategies and innovative solutions are required to harness the growing population in gainful economic activity to ensure increased income earning and employment opportunities and ensure food and nutritional security.

3. Agriculture Research for Development

NARI as the premier agricultural research institute in the country is well positioned to make significant contributions in applying science and strategic research to address major challenges and realise opportunities in agricultural development. Over the past 24 years since its establishment, NARI has been a major provider of new and improved agriculture technologies, practices and information to the agriculture sector, for both smallholder farmers and small to medium agriculture enterprises (SMEs). NARI is very actively involved in the technology transfer to stakeholders and productive partnerships with development partners. But questions were being raised on its role, relevance and effectiveness in contributing to development outcomes and impacts at the community level and at the national level. The realisation that the Institute needs to go beyond its traditional role of research and supplier of technology and information, to be a more active change agent in driving innovation, with people at the centre of the innovation rather than a focus on technology, NARI adopted the Agricultural Research for Development (AR4D) paradigm in 2010. This over-arching approach was captured in the first 10-year Strategy and Result Framework (SRF, 2011-2020) (NARI, 2011) and guided the planning and annual implementation processes to in aligning the Institute to serve its mandate in enhancing the agricultural development pathways.

AR4D is embedded within the agricultural innovations system (AIS) framework (Mbabu and Ochieng 2006; Rajalahti et al. 2008; Anandajayasekeram and Gebremedhin 2009). The paradigm is widely accepted now and principles applied across agricultural research organisations in the world, donor funding programs[1] and in emerging approaches to enhance

1 https://www.ifad.org/en/agricultural-research-for-development; https://ypard.net/news/changing-paradigm-agricultural-research-and-innovation; https://blog.gfar.net/2017/01/14/the-changing-paradigm-of-

development outcomes (Hall et al. 2016; Maru et al. 2017, 2018; Thornton et al. 2017; Woltering et al. 2019).

The role of research as part of an agricultural innovation system (AIS) is not only about the generation of technology and knowledge but has to assume an expanded role which involves the following actions:

- Expands scope of research and learning that integrates different types of research and learning approaches;
- Facilitates and brokers partnerships and innovations as an essential pathway for scaling where interaction between the range of actors and interest groups results in joint analysis, planning, and hence collective action and shared achievements and learning;
- Designs systems (biophysical and social) that enable innovation and responsiveness to peoples needs;
- Places a strong emphasis on research and innovations around the social, institutional and policy dimensions in impact pathways

As part of an AIS, different system agents interact to generate the tangible outputs and contributions to system and development outcomes and impacts. Research is an essential part of the interacting system. Responding to the needs of the people and the sector, research agencies deliver relevant outputs addressing prevailing constraints and enhance opportunities in agricultural development but also have a responsibility in engaging with other system agents to form partnerships and continue to resolve emerging issues along the development pathway.

3.1 Agriculture as key to development:

Agriculture, Forestry and Fisheries have been identified in the country's medium to long-term strategies including the PNG Vision 2050, the Development Strategic Plan 2010-2030 and the MTIP 2017-2022 as the key drivers in economic and social development with more than 85% of the population living in rural areas and relying on those sectors for their livelihoods. The sector employs currently over 25% of the formal work force and generates approximately 18% of foreign exchange earnings. The contribution of the sector to the national GDP declined from 36.7% in 1977 to around 23.5% in 2012 and has stagnated ever since (DAL 2020). Overall total factor productivity and efficiency is still extremely low compared to other low- and middle-income countries in Asia and even compare to the small Pacific Island Countries. Future acceleration of agricultural growth will be highly dependent on technical change (Omot et al. 2019). The steady decline of the per capita agricultural production index (Figure 1) (FAOSTAT 2021) and increases in food imports over the past 10 years of about 40% (https://oec.world) is another indicator that domestic food production is not keeping up with population growth and demand.

agricultural-research-and-innovation/ ;
https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/630358/EPRS_BRI(2019)630358_EN.pdf

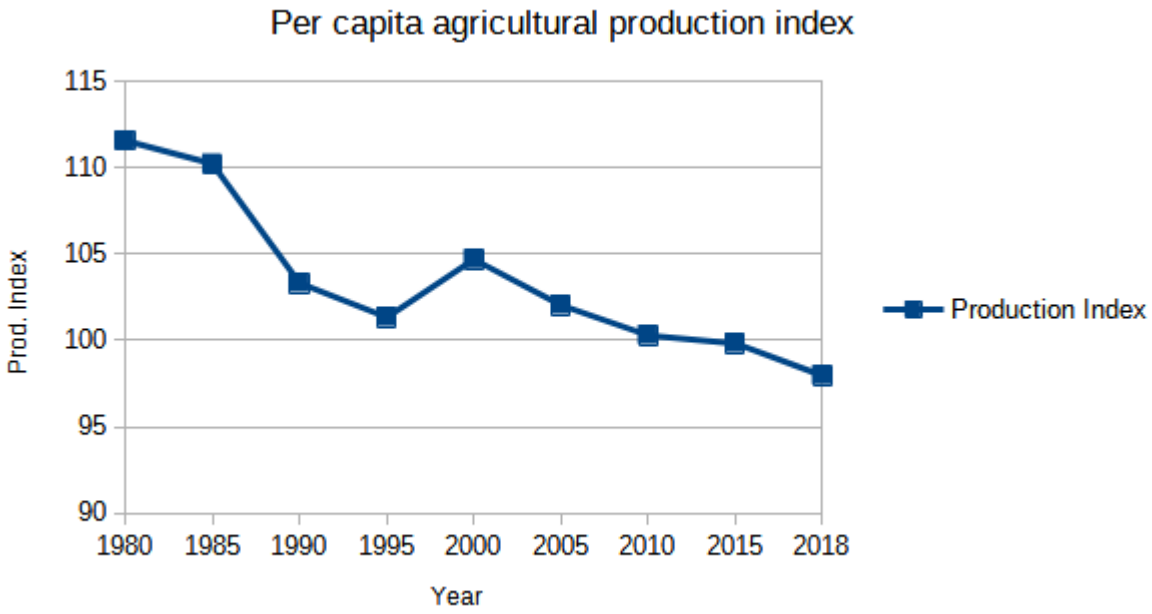


Figure 1: Per capita agricultural production index in PNG, 1980-2018 based on FAO statistics (2014-2016 = 100)

Agricultural development and integrated agricultural research offers however, great promise to make a major contribution towards economic growth, poverty reduction, and increasing environmental services. Growth in agriculture GDP can be twice as effective in reducing poverty compared to GDP growth in other sectors, especially for agriculture-based countries such as PNG (The World Bank 2007). The agriculture sector in PNG has still a large untapped potential to assure food security, increase incomes and absorb much of the incoming labour force in gainful productive employment with major investments in agriculture production, manufacturing and value-addition. It will make a significant contribution to the achievement of targets in social and economic development set out in the medium-and long-term strategies and policies of the PNG Government and support a rapidly growing population for improved welfare and living standards.

3.2 Contribution of Agricultural Research for Development to PNG Development Targets

The major impact areas for social and economic development that are influenced by agricultural development and associated research include the reduction of poverty, increase of food and nutritional security and health, and establishing a sustainable natural resource base. The following sections highlight the major policy directions and development targets for the next 10 years for those impact areas and the necessary contribution coming from agricultural research for development.

Reduction of poverty:

With projections of a total population of almost 11 Million by 2030, the DSP 2030 (DNPM 2010) is targeting to create an additional 2 million jobs to ensure that about 20% of the population is in formal employment. The SME policy 2016 (DoTCI 2016) is a key instrument in the Government's long-term strategy to achieve this aim. Table 1 shows the national targets for job creation and employment by 2030. With 85% of the population living in rural areas

and depending on agriculture, forestry and fisheries for their livelihoods, the bulk of the anticipated creation of SMEs and associated jobs will have to be in those sectors.

Table 1: National targets for job creation and employment for 2030

Outcome	**Target (2030)**
Number of SMEs	500,000[1] 70% of subsistence farmers will expand into small and medium primary agricultural enterprises[1]
Job creation	2,000,000[2]
People living below the poverty line	<30%[2]
Improve and increase education and skills training and personal development programs that meets job market needs and for self--employment.	60% youth employed[1] 200,000 M&SME operated by youth[3]
Increase women's access to economic opportunities and awareness of their economic rights.	60,000 M&SME operated by women[3]
Reduction in Gender Inequality Index	0.4 [3]

[1]Development Strategic Plan 2030; [2]SME Policy 2016 (DoTCI 2016); [3]Medium-term Development Plan 2017 - 2022

Opportunities need to cover on-farm as well as off-farm employment to address the urban drift and make it attractive for young people to seek employment and build their livelihoods in rural areas. Participation of rural communities in economic activities can be increased with a strong focus on linking them with agricultural value chains that supply either local, regional, national or international markets. There is an urgent need for the strengthening of research for development and innovation along priority agricultural value and supply chains with a strong focus on inclusiveness in relation to increase opportunities for both women and men in earning income and employment in rural areas.

Food and nutritional security and health

Population growth and changing diets are among the factors that affect the demand for food. PNG's population is growing by 3.1 percent and it is expected to reach 30 million in 2050 but growth in the agriculture sector is only about 2 percent (DAL 2020). Protein-energy malnutrition serves as a proxy indicator for demand for food. The measurement of the level of malnutrition especially that of infants and children, is the key indicator (DNPM 2014a). The country is facing already a food and nutrition crisis due to declining net food production and the triple burden of malnutrition, e.g. stunting rates of children below 5 are estimated at 48% which is twice the global average (NSO 2011; FAOSTAT 2020). Malnutrition is a major cause of child mortality, it impairs cognitive development and increases cost of health care. The human and economic cost of malnutrition are estimated at PGK1.7 billion per year to the PNG economy at present (Hurney 2017). The National Nutrition Policy 2016-2025 (DAL et al. 2016) and National Food Security Policy (NFSP) 2018-2027 (DAL 2018) have defined a range of strategies to address food and nutritional security issues to meet the targets set out by the Government (Table 2) in DSP 2030 and MTDP III 2017-2022 (DNPM 2018). Agricultural research for development initiatives are an integral part of those strategies to address all facets of food and nutritional security i.e. food availability, food access, utilisation of food and stability of food availability and access (FAO 2006) and action is called into development of more nutritious crops, changes in consumption patterns, and relevant policies to harness inclusion, equitable outcomes, economic returns, protection of the environment, and productivity in food systems.

Table 2: Food security, nutrition and health strategies and targets from GoPNG policies

Strategy	Targets (2030)
Enhanced nutrient content and balance of food products consumed by nutritionally vulnerable households and individuals.	*Prevalence of stunting in children reduced to <5 (%): <30%*[1] *Prevalence of wasting in children reduced to <5 (%): <2%*[1]
Productivity and farm output growth of the main food staples, horticulture, (small) livestock and fish farming and increasing efficiencies along the entire food value chain	*Composite staple food production index (million tonnes): 7.9*[2] *18,000t domestically produced fruits and vegetables*[1] *20,000 t of meat*[1] *60% improvement in agr productivity*[3]
WaSH program to provide safe water and improved sanitation services to all rural households and business houses	*Proportion (%) of rural population using an improved drinking water source: 75%*[1] *Proportion (%) of rural population using improved sanitation facilities: 75%*[1]

[1]Medium-term Development Plan 2017-2022**;** [2]National Food Security Policy 2018-2027; [3]Development Strategic Plan 2030

Sustainable resource management and use of agri-ecosystem services

PNG is one of the world's biodiversity rich countries. It has the richest diversity of island flora with a very high level of endemism (Cámara-Leret et al. 2020) and one of the world's largest remaining areas of tropical forest. However, this is rapidly changing with estimated losses of 1.1-3.4%/year with increasing trends which is attributed mostly to logging and subsistence agriculture (Shearman et al. 2009; Mitchell and Aruga 2017). Already in areas with higher population densities there is evidence of degradation of the environment through waste disposal and poor cropping practices that deplete soil of nutrients. The high population growth rates will put even more pressure on limited arable land resources and expansion into fragile landscapes unless a major shift in using more productive and sustainable agricultural production practices is instituted. The ongoing reliance of the national economy on mineral resource development and logging for revenue generation will continue to damage the environment, degrade the landscape and accelerate loss of biodiversity. This requires effective responses in policy, monitoring and rehabilitation efforts to counter the negative consequences and sustain productive agri-ecosystems.

The PNG Vision 2050 identified global Climate change as the greatest challenge that will impact the economy, environment and people's livelihood in PNG. Immediate actions need to be taken to manage such impacts based on the unique cultures and traditions to ensure that future generations can enjoy the environmental benefits from PNG's diverse environmental resource base. Those sentiments are further translated into the National Strategy for responsible sustainable development for PNG (StARS) (DNPM 2014b) which introduces the Sustainable Development Framework that forms the basis of the economic development on the strength of the country's strategic assets focusing on innovative green growth, inclusive growth and the integration of economic, social and environmental objectives. The Green Growth Measurement Framework of StARS is shown in Table 3.

Table 3: StARS Green Growth Measurement Framework

Strategies/Outcomes	Indicators
Environmental and resource productivity of the economy	•Carbon and energy productivity •Resource productivity: materials, nutrients, water •Multi-factor productivity
Natural asset base	•Renewable stocks: water, forest, fish resources •non-renewable stocks •Biodiversity and ecosystems
The environmental dimension of quality of life	•Environmental health and risks •Environmental services and amenities
Economic opportunities and policy responses	•Technology and Innovations •Environmental Goods and Services •Prices and transfer •skills and training •Regulations and Management approaches
Socioeconomic context and characteristics of growth	•Economic growth and structures •Productivity and trade •Labour markets, education and income •Socio-demographic patterns

DNPM (2014b)

Relevant sustainability targets on natural resource management are further reflected across sector strategies in the MTDP III 2017-2022 (DNPM 2018). With the right incentives, strategies and technologies, agriculture has much more to offer rural communities. Innovative approaches to create healthy agricultural environments will help in adapting to and mitigating climate change, improving water and soil quality and increasing biodiversity and in turn increase communities' resilience and generate livelihood opportunities for youth, women and men.

3.3 Major threats, constraints and opportunities in agricultural development

Among the major constraints and threats that can impact the agriculture and food systems are:

- Overall low productivity, efficiency and insufficient volumes of food crops and livestock production considering population growth rates;
- Climate change and its effects on agricultural productivity and the inadequate ability of communities to manage the adverse and unpredictable impacts of global climate change;
- Degradation of the environment through uncontrolled waste disposal and poor cropping practices that depletes soil of nutrients,
- Increased risks to erosion because of sloping land and deforestation;
- Ongoing reliance on extractive industries and logging for revenue generation is causing damages to the environment, degradation of the landscape and loss of biodiversity
- Long-term effects of malnutrition and under-nutrition on cognitive development and health impacting on labour availability and productivity

- Lack or inadequate implementation of supporting policies, strategies, agenda and priorities in the agricultural sector
- Poor hygiene and sanitary conditions and access to water supplies impacting on food safety and overall health of rural communities
- Prevailing inequalities in opportunities for social and economic empowerment between genders, accessing benefits and participation in decision-making processes
- High degree of drudgery in agricultural production and poor access to markets, low income prospects and general lack of opportunities in rural areas increase urban drift;
- Weak, uncoordinated and fragmented agricultural innovation systems are attributed to lack of exploitation where synergies and networking among Government, research and training institutions, industry, financial sector and professional groups;
- Inadequate funding for agricultural research;
- Absence of skills inventory and inadequate alignment of the planning of human resource to development needs;

On the other hand, there are considerable opportunities to be realised from the development of the Sector including:

- Increase biological productivity of crops and livestock, enhance efficiency and profitability of production and marketing of crops and livestock products;
- Enhancing supply of agricultural commodities to rural, urban and export markets;
- Exploring value-addition and product diversification of crops and livestock
- Agriculture sector as the primary source for expansion of future productive employment for the large number of youths entering the workforce

4. Agricultural Research for Development - A Strategy and Results Framework

4.1 Development of the Strategy and Result Framework

NARI commissioned an independent review of the implementation and achievement of the first SRF 2011-2020 in October 2019. The independent review team confirmed the overall approach by the Institute was well aligned with its major strategies for generating relevant research outputs along the development impact pathways. The major areas that were identified to consider and incorporate into the next SRF include:

- the need to build capacity in a range of socio-economic competences (agricultural economics, rural sociology, anthropology, GIS, policy analysis and advocacy);
- increase engagement with strategic partnerships and institutionalisation of partnership management skills
- the need to build up competences and systems for Monitoring, Evaluation and Learning (MEL)
- better articulation of the impact pathway using tools such as the Theory of Change approach in the design of programs and projects;
- allocation of resources in fore-sighting and being at the forefront of research and policy

- stronger engagement with donors to align funding with research for development priorities as articulated in the SRF and implementation plans
- stronger efforts to ensure that key concepts including cascading logic, results-based organisational structure, Agricultural Development Domain clusters are entrenched into the organisational culture
- assemble a team of competent and experienced Senior Managers and capable leadership to facilitate necessary change management to institutionalise AR4D

The management sought further comments from Senior Managers and Scientists for their views on the reviewers' recommendations and their own views on areas of improvement in effecting the paradigm shift, including the relevance of underlying concepts and approaches, the long-term Vision, Mission, Goal, and the Institute's Strategic Objective and *modus-operandi* in implementing the SRF. The Institute's Core Values were adopted using a participatory process and a methodology based on the Value of Values Game[2] involving a total of 111 staff of the Institute from Council members to field personnel. All comments and responses were considered and incorporated in the development of the new SRF II 2022-2031.

4.2 NARI Goal and Strategic Objective

The review process undertaken before the development of the new SRF reaffirmed the validity and relevance of the NARI Goal and Strategic Objectives as stated in the NARI Act 1996. They are translating the NARI Vision and Mission into results that the Institute would be held accountable against.

NARI Goal and Strategic Objective

Goal: Improved welfare of rural families and communities who depend wholly or partly on agriculture for their livelihood

Strategic Objective: Enhanced productivity, efficiency, stability and sustainability of the smallholder agriculture sector

While the NARI Goal is aspirational and linking into the country's long-term vision as articulated in the PNG Vision 2050, the NARI Strategic Objective expresses the Institute's commitment to actively contribute in all aspects of the agricultural development process with relevant research outputs and outcomes that address the most pressing issues and opportunities in agricultural development. The Institute links up 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 (Figure 2). The Institute endeavours to contribute to them by generating necessary AR4D results in technology development and adaptation, improving production, marketing and consumption systems, innovations in institutional arrangements, policy and stakeholder engagement, using the strategies described in the following sections. Collaboration with other partners and networks in the sector and beyond will be a key success factor. A generalised pathway to development impact is depicted in Figure 3.

2 The value setting approach was developed by Dr Phillip Harrell based on the DOLAN Triaxial Model of Values by Professor Simon Dolan (www.learningaboutvalues.com);

The priorities of the Institute for the next 10 years and targeted development outcomes (Table 4) that the Institute will endeavour to contribute to are as follows:

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

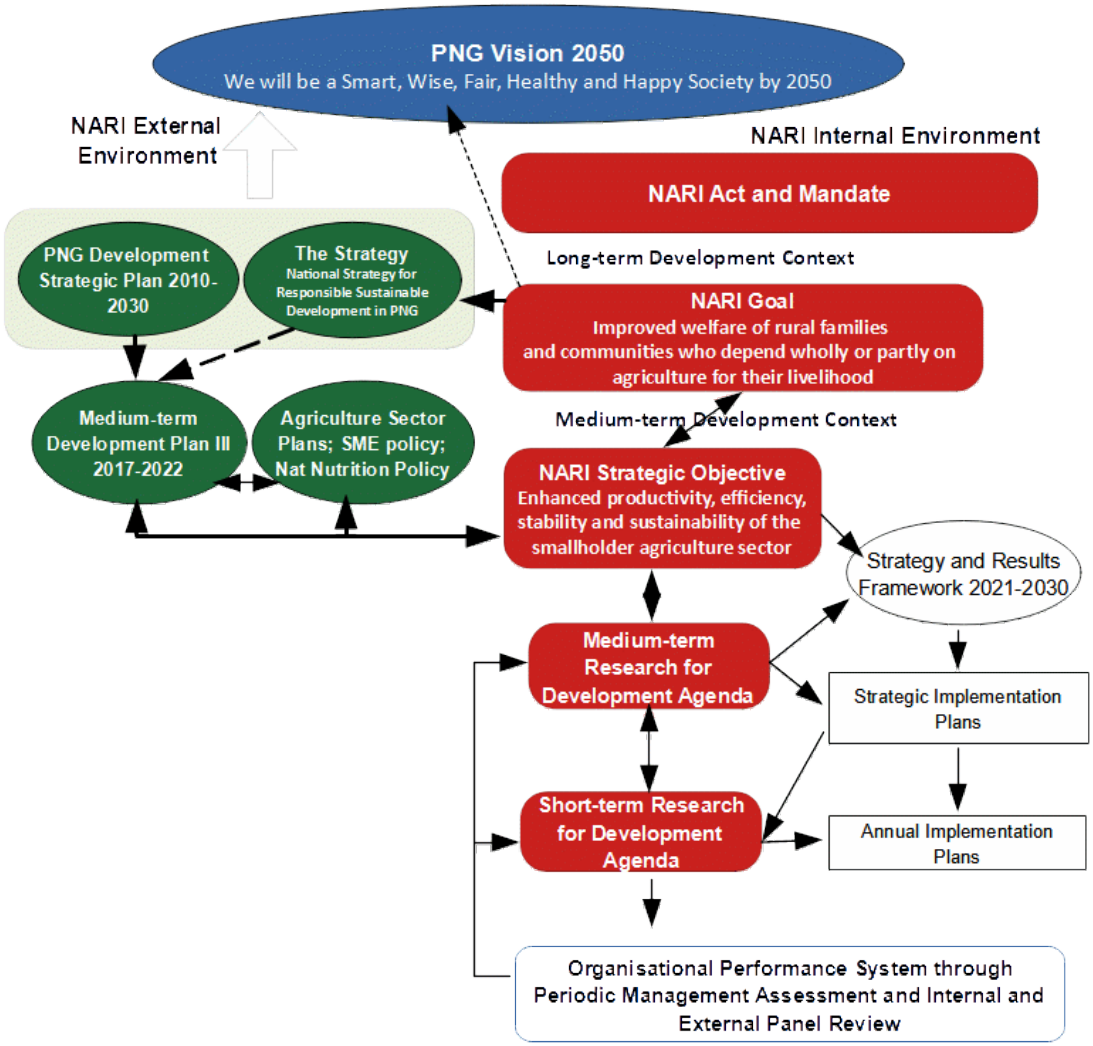


Figure 2: NARI contribution to agriculture sector and national development

Table 4: Targeted Development outcomes

- Increased incomes and employment in rural areas arising from increased economic activities and business development
- Enhanced stability and resilience of livelihood systems of rural households and communities
- Production, productivity and efficiency of crop and livestock products increased and producers better linked to profitable markets at scale
- Rural and urban households consuming healthy balanced and nutritious diets
- Improved standards in Food and Feed safety in agricultural production and food/feed use are applied
- Enhanced and equitable benefits from agri-ecosystem goods and services
- Agricultural production systems are sustainably managed under changing climates and macroeconomic drivers

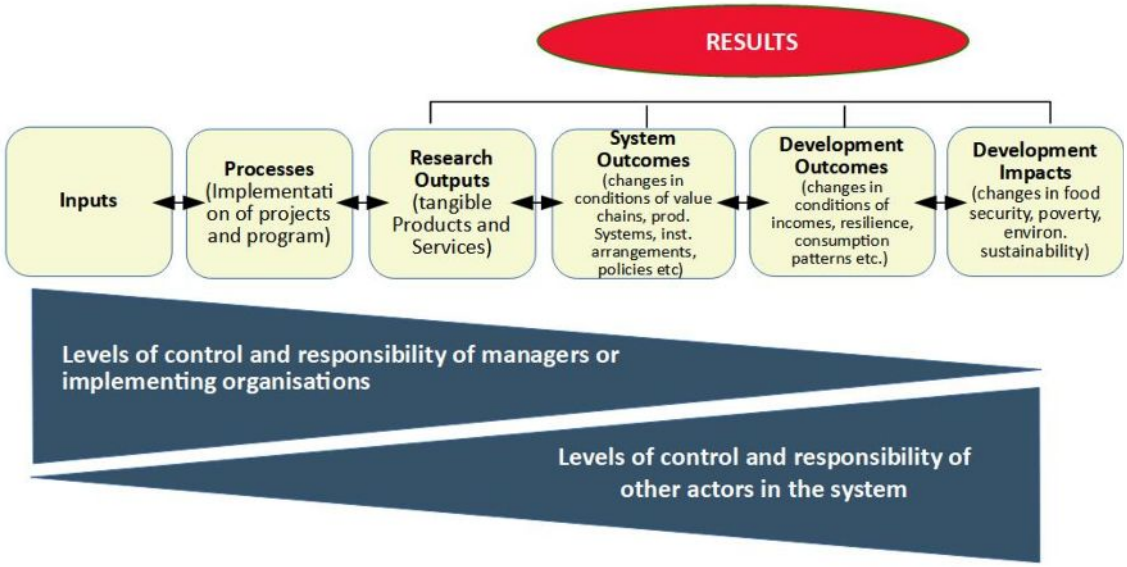


Figure 3: Pathway to development impact

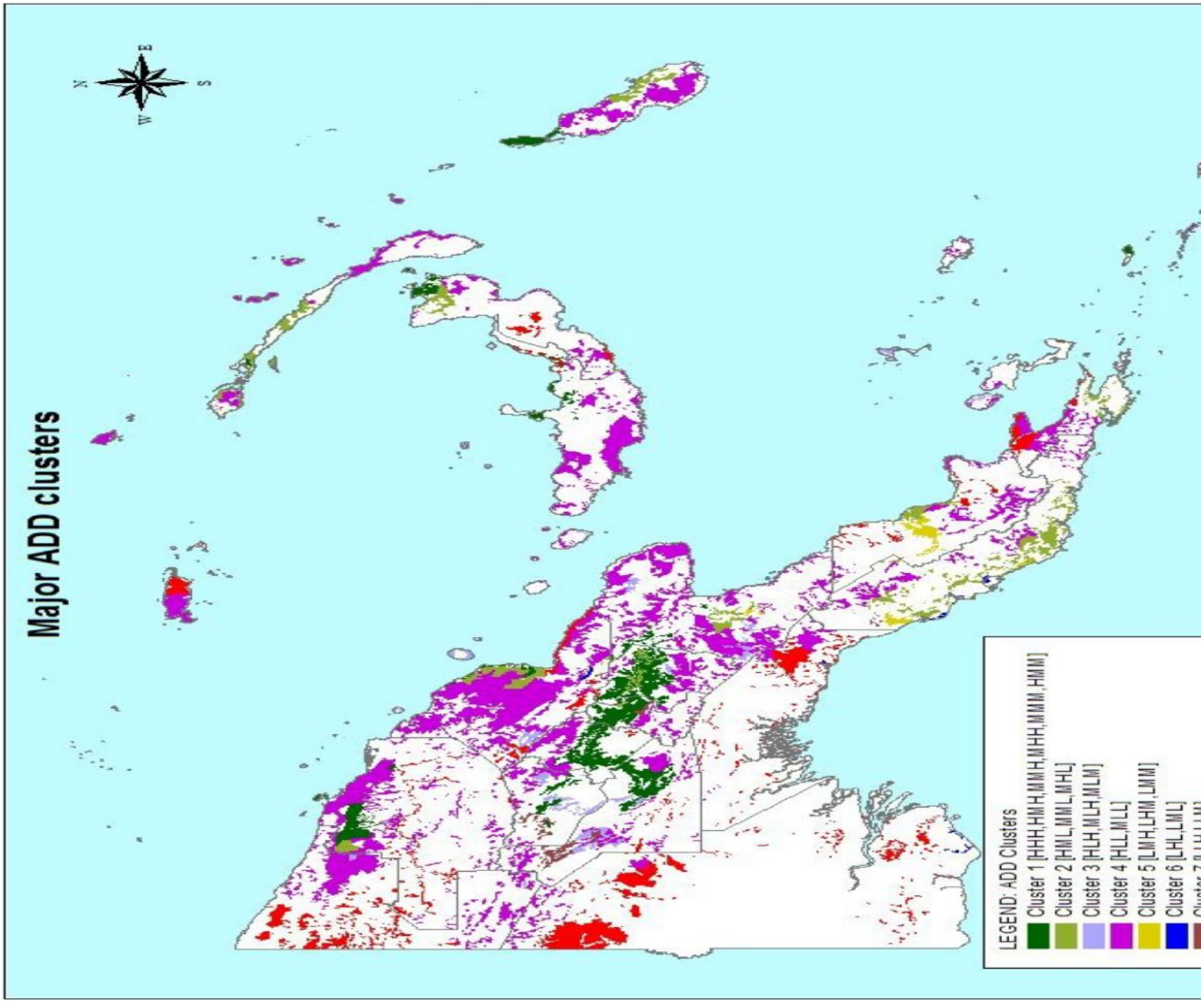
4.3 Targeting for Impact

Challenges and opportunities of farming communities are much influenced by their bio-physical and socioeconomic environment, which is highly complex in the diverse PNG traditional society. As part of the development of the first SRF in 2010, NARI used geographic information system (GIS) methods to classify the country into Agricultural Development Domain (ADD) clusters (Figure 4, Annex 1) to depict spatial similarities and differences in agricultural development and livelihood constraints and opportunities (Omamo et al. 2006; Komolong et al. 2012). ADD clusters serve as an approximation of the constraints and opportunities experienced by smallholder farmers in the different parts of the country and reflect the absolute and comparative advantage specific to a certain geographical locations in agricultural production. NARI will use this framework to derive targeted AR4D innovations and interventions that are responsive to the needs of the people and communities in particular ADD clusters. These interventions are context-specific and arise from the specific bio-physical and socio-economic environment. The underlying assumption is that successful

piloted interventions in one part of an ADD cluster, have relevance and application for the whole ADD cluster. Proven interventions can then be out-scaled or up-scaled to achieve wider outcomes and impacts nationwide.

The identified priorities relate to issues of national importance. The broad issues identified, the changes needed and strategies used in each priority however may differ in relevance, feasibility, extent or importance between ADD clusters.

Figure 4: Agricultural Development Domain Clusters in PNG



Major beneficiaries:

The primary beneficiaries of NARI's Agricultural Research for Development agenda are the more than 85% of men and women smallholder farmers and families that live in rural areas in PNG and rely on agriculture, forestry and fisheries for their livelihoods. Smallholder farmers are in this context defined as using 1-2 ha of their land for agricultural purposes. They will be enabled to improve their skills, abilities, aspirations and knowledge and sustain the livelihood of their family and the wider communities. This includes innovative ways in linking smallholder farmers with large scale investment initiatives by the Government of PNG or other investors. Other beneficiaries include:

- Consumers in general will benefit from more nutritious, better quality crop and livestock products at affordable prices;
- Social groups including women, youth and other groups that are socially disadvantaged or marginalised from economic and social development;
- Off-farm value-chain actors-traders, processors, transporters and other service providers will benefit from opportunities arising from better organised and diversified supply and value-chains.

4.4 Agriculture Research for Development Priorities and Strategies

The Institute has identified three priorities derived from development priorities by the PNG Government that require investment in AR4D interventions in order to ensure a significant contribution to the targeted development outcomes and impacts (Section 5.2). For each of the priorities, a number of results referred to as system outcomes[3] have been identified with relevant strategies to achieve them. The identified system outcomes will guide the development of programs and project portfolios that will deliver the necessary results for the achievement of the system outcomes. Delivery pathway of research innovations into the AR4D system towards development outcomes at scale is summarised in Figure 5.

4.4.1 Priority 1 Markets, Value chains and Trade

Challenges and Opportunities:

Markets, value chains and trade are not well developed in PNG and much of the agricultural produce for local consumption is traded in informal markets. The Department of Agriculture and Livestock reports that domestic fresh produce movement along value chains almost doubled between 2014 and 2017, however, there is still a significant deficit of up to 9000t of fresh produce annually in major towns and cities. There is also significant scope in reducing the huge food import bill of $230 million US for fresh produce, wheat, rice and meat (sheep/goats and poultry) which constitutes about 1/3 of total agri-food imports in 2019 (https://oec.world/).

There are numerous issues to be addressed that are contributing to the low productivity. Among them are:

- low skill levels and knowledge on improved production practices,
- access to and cost of inputs;
- the low level of mechanisation in all aspects of agricultural production, postharvest and processing

3 Changes in the conditions of value chains, markets, household and system resilience, consumption patterns etc. as well as changes in the attitudes, aspirations, skills and knowledge of the targeted beneficiaries

- linking supply to demand.
- inconsistency of supply,
- poor product quality due to lack of improved post-harvest management issues.
- Lack of incentives and reward for producing quality,
- lack of marketing infrastructure and cool-chain systems for product consolidation and long-distance marketing
- Lack clear policies and institutions that enable equitable and an efficient value chain at different scales.

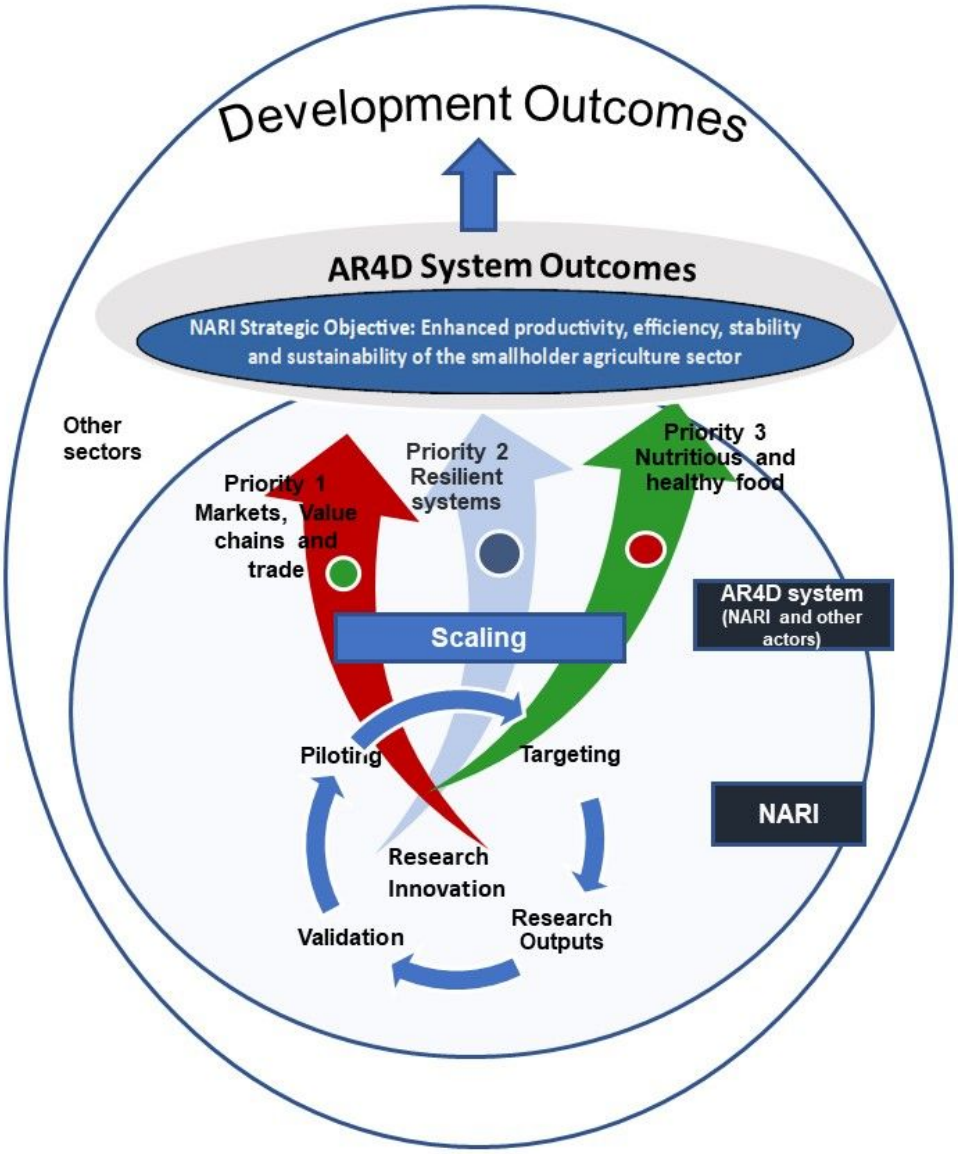


Figure 5: Delivery pathway of AR4D system and development outcomes at scale

There are opportunities in enhancing value-addition or advancing other forms of down-stream processing of crop and livestock products and creating markets for industrial or non-food products exploring and using PNG's rich agro-biodiversity and research interventions are necessary to ensure that such opportunities are realised.

Changes that are needed:

There is a strong drive in PNG Government policies (DNPM 2010; DAL 2020) to increase crop and livestock production substantially and develop *"a World Class agriculture sector that is responsive to international and domestic markets for a diverse range of products"*. This calls for a transition from the traditional subsistence and semi-commercial production system to an agri-business oriented Micro-Small to Medium Enterprises (MSMEs) and Small to Medium Enterprise (SME) model of agriculture farming to supply markets and to unlock the sectors premise as a major driver of the PNG economy providing employment and income earning opportunities. There is an urgency and focus required on developing and improving domestic and export marketing systems, value chains and trade (local, domestic and international) and relevant AR4D interventions are required to help enable smallholder men and women farmers to better link into economic opportunities.

The undertaking is a big task and will require major shifts in resourcing capacity, mind-sets, attitudes and aspirations by the state, rural communities and value-chain actors in order to create the social environment that will promote these agricultural value-chains. Major changes in use of technology along agricultural value-chains in terms of availability, access and capacity use will be required aside from the need to create a more conducive policy environment that provide incentives to take and manage risks in building up agricultural-based businesses. This includes the access to financial services, business advisory services, logistics and many more factors.

The major agricultural export commodities include coffee, cocoa, copra and palm oil are exported as raw products. However, there is ambition and scope to also export food products and supply formal markets with food products. An example are products of the Galip nut (*Canarium indicum*) that NARI has successfully launched into the domestic market after substantial AR4D investment by GoPNG and international partners. However, launching into the international markets requires compliance to high standards in consistent supply and quality, and with sanitary,

phytosanitary and CODEX International Food standards. The need to develop international food safety and sanitation standards and compliance systems requires commercial investment partners as well.

Targeted Results:

The following results at the AR4D system level will be targeted in *Priority 1* by NARI with its contribution in AR4D:

- Increased economic returns to value chain actors from production, sale and added value of crop and livestock products;
- Increased equity, inclusion and participation of women, youth and other socially vulnerable groups in priority value chain**s;**
- Market system actors take up novel business opportunities in production and downstream processing of crop, livestock, aquaculture or non-food products in an environmentally sustainable manner;
- Market accessions for export of PNG's agricultural products that promote local content of market share;
- An efficient institutional and policy environment that promotes productivity, food safety standards, and maintains an efficient value chain in all market levels;
- Increased localisation and import-substitution of target crops and livestock by locally based industries;
- Alternative agricultural export opportunities from crop, livestock, aquaculture and non-food products realised and reflected in the national agricultural development agenda;

AR4D strategies:

NARI will use a whole value-chain approach to address the constraints in selected priority value-chains. The ADD framework will be used to target suitable areas for particular value and supply chains and to derive interventions responding to ADD cluster specific bottlenecks in the value/supply chain. This will include development of relevant technology packages improving productivity, quality and consistency in production and postharvest management. A strong emphasis would be on development of more productive crop varieties that meet consumer and industry demand as well as production technologies that are sustainable, reduce drudgery and allow for inclusive participation of both women, men and youth as well as other socially disadvantaged groups. Postharvest practices including improved mechanisms that contribute to minimisation of food loses and wastage, and marketing of fresh or processed products need to meet high standards in food safety and quality. Overall, there is a strong need to explore business and enterprise models that are culturally sensitive to the PNG context, inclusive and maximise returns to value-chain actors.

There are a vast number of potential agricultural value chains, marketing and trade issues to be addressed. The Institute will conduct a further assessment on rates of return for investment in AR4D for selected value chains and associated issues and prioritise based on that. A recent study by Omot et al. (2019) on Agricultural Science and Technology Indicators showed that there is a considerable under-investment into crops such as banana and fruits given their production value. This would include the strengthening of value chains for such crops in the domestic market that should generate increased returns from producers while improving access and quality to consumers tying in closely with *Priority 3* on improving nutritional outcomes.

Other strategies will explore opportunities in enhancing value-addition or advancing other forms of down-stream processing of crop and livestock products and research interventions. A major focus has to be placed on exploring opportunities in finding and accessing new markets or marketing arrangement for fresh and value-added products, assessments of the macro-economic environment in trade and market access, drawing on information coming from market and policy intelligence.

It needs to be emphasised that focus on smallholders does not exclude large scale development of agri-enterprises as a development outcome. Issues of scaling and scalability of strategies, approaches, technologies, business models etc. need to be addressed in NARI's AR4D portfolio under this priority.

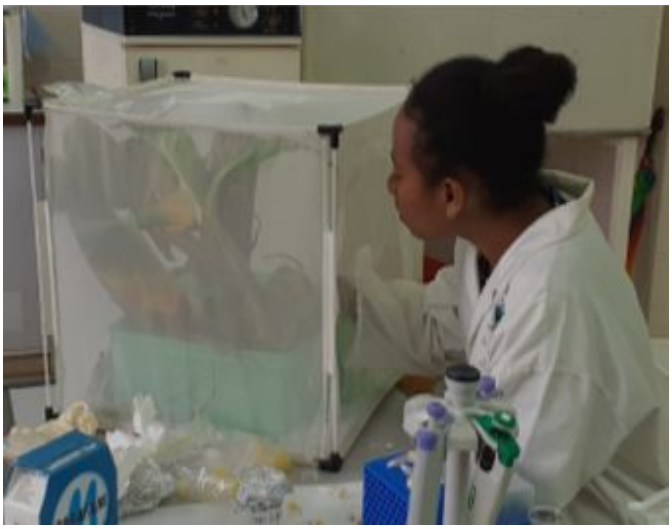
The key strategies that NARI in close collaboration with its partners will employ in contributing to Economic Development can be summarised as follows:

- Addressing bottlenecks in priority value and supply chains with technology and innovation in production, post-harvest management, marketing and communication using a whole value chain approach;
- Use of innovative and inclusive tools and approaches in facilitation of value chain actors;
- Development of business and enterprise models for smallholders and off-farm value chain actors for priority value chains;

- Investigating institutional and operational barriers and obstacles faced by businesses in integrating smallholders into their operations and respective value chains; -
- Feasibility assessment of domestic, regional, and international market access, opportunities and trends; and market & policy intelligence;
- Feasibility Assessments and zoning of potential sites for large scale industrial farming;
- Addressing bottlenecks in policy, institutions and capacity in a systematic manner;
- *Ex ante* assessments on feasibility and potential benefits from promising new value chains for fresh or processed agricultural crop and livestock products as well as opportunities in non-food product development and marketing;
- Novel value addition and processing options of diverse and nutritious crop and livestock products incorporating quality protection and food safety and linked to emerging marketing opportunities;
- Market diversification for crop and livestock products (fresh, dried, processed);

4.4.2 Priority 2 Resilience of rural communities and systems to climate, economic and demographic changes

Challenges and Opportunities:



Most rural communities are relying on the country's rich natural resource base for supplying all inputs into their traditional subsistence systems and livelihood strategies. Traditional shifting cultivation systems are low-intensity and self-sustaining. However, the population has more than doubled over the past 40 years, putting increasing pressure on existing systems and natural resources to produce food and generate an income. Rural communities and households have traditional coping strategies to respond to natural disasters and other calamities but the increasing frequencies of droughts and excessive rainfall, increase in temperature and the unpredictability of seasons due to Global Climate Change, coupled with the steep population increase, has resulted in high vulnerability of households to food insecurity and disruption of income generating activities due to their low adaptive capacity to manage those threats and risks to their livelihood. The last prolonged drought in 2015 left close to 3 million people severely food insecure. The latest Demographic and Health Survey 2016-2018 showed that more than half of the population experienced moderate to severe food insecurity (NSO 2019) at one time or the other. Other threats to household and system resilience include incursions of exotic weeds, pests and diseases of crops and livestock. Recent incursions of the Cocoa pod borer, coffee berry borer and the African Swine Flu have shown the vulnerability of production systems with incursions leading to the collapse of production with serious implication on income earning and assuring food security in households.

While cultivated land area has steadily increased, there are limitations to further expansion since more than 50% of the country are mountains and hills and 79% of soils have major limitations (Hanson et al. 2001). The ADD analysis (Annex 1) has shown that almost 40% of the population live on 18% of cultivated land area in domains with good and medium agricultural potential and access to services. It is predicted that the migration from low agricultural potential and access to services domains to those with high potential and access to roads and services will continue. Given the projected population increase due to the high population growth rate, pressure on natural resources including soils, water and biodiversity will further increase.

Overall, agricultural production in PNG is characterised by low productivity. The constraints are similar across the diverse environments as represented by the ADD clusters but the intensity may differ in different ADD clusters and will require customised responses. In general, they include the inadequate availability and access to improved planting materials, breeding stock, farm inputs, knowledge and skills to apply and use improved technologies and practices in soil fertility and pest and disease management and an inefficient use of land and labour resources.

Changes that are needed:

Attaining greater resilience to threats and risks associated with seasonal and climatic variability is closely linked to increasing the adaptive capacity of rural communities. It will require an increase in awareness, knowledge and appreciation for causes and effects of global climate change in a local context. It is important also for the aspiration of communities to move from a short-term aim of 'coping' with calamities, motivated by crisis and oriented towards survival, that would include starvation and migration, as coping strategies towards 'adaptation'. Adaptation is a continuous process that combines old and new strategies and knowledge and focused on finding alternative solutions. The aim should be to move away from mere survival to maintaining a standard of living and improving the quality of life in the face of adversity. Such a change in mindsets will also require the support of technological innovations which will include relevant, appropriate and culturally sensitive climate smart technologies

and strategies that households can use in their livelihood systems. This will build a strong farmer base implementing best practice agriculture and the technology based resilience strategies necessary to minimise impacts of adverse events.

However, equally important will be innovations in institutional arrangements with required policy support for communities to have better access to improved planting material and breeding stock and on-going local extension and advisory support to assist communities in this transformation. The greatest impact of climatic extremes is on people living in remote and inaccessible areas of the country. Appropriate support mechanisms including the use of ICT and digital communication innovations need to be explored to enhance access to information and knowledge for those communities.

The National Strategy on Responsible Sustainable Development for PNG (StARS) calls for an inclusive and innovative "green" growth path and a responsible economic growth model that is built on renewable resources with a priority placed on preserving the environment and sustainably using it by adding value to it. Agriculture system resilience is closely linked to the aspirations expressed in StARS. PNG's potential in agri-industries and intensive agricultural systems is still under-developed, which offers a unique opportunity for agricultural development interventions that counter unsustainable practices. There is opportunity to apply a more holistic approach that results in diverse and healthy agricultural environments and landscapes that provide services to people in the long-term. Agriculture system resilience will also require changes in the way PNG prepares for and responds to other natural threats including exotic weeds and pest and diseases of crops and livestock. Attainment of system resilience will require major changes in mind-sets and attitudes of policy makers, institutions as well as effective mechanisms to ensure active participation of communities in crafting strategies that serve their needs.

Targeted Results:

The following results at the AR4D system level will be targeted in Priority 2 by NARI with its contribution in AR4D:

- Diverse and sustainable agri-food systems at scale are established and maintained and reflected in the national agricultural development agenda.
- Farming households adopt livelihood strategies that enhance their resilience to climate, physical, and biological shocks, stresses and risks;
- Equitable access by stakeholders to gender-sensitive crop and livestock technologies and up-to-date socioeconomic, technical and scientific information;
- More productive and equitable management of natural resources and agri-ecosystems

AR4D strategies

AR4D interventions have much scope in addressing the threats and constraints to livelihoods and agricultural systems and to strengthen the resilience of the livelihoods of rural communities within the envisioned green growth development path of StARS. NARI together with its partners in development will deliver innovations that are focused on three major areas of focus.

The first area is the management and use of PNG's rich biodiversity and agro-biodiversity in particular. Such strategic assets need to be further explored for their potential as novel agricultural products, used in genetic improvement and adapted and made available for use in nutritious diets, as industrial or non-food products, feed formulations or value-chain development. Aside from technological innovations, there is an immediate need to strengthen relevant policies and regulatory frameworks to protect those genetic resources from

exploitation. A large area of concern is the lack of policies that protect farmer's rights on the use of their landraces and the lack of policies that would regulate seed supply and breeding stock to ensure access to quality inputs.

The second area of focus is the development of relevant, appropriate and culturally sensitive technologies and strategies that households in the diverse settings in PNG can use in their respective livelihood systems to adapt to the major threats arising from the effects of global Climate Change as well as demands from economic pressures on income generation. Examples of such technologies have been mentioned already above. Using insights from the analysis into constraints and opportunities in the different ADD clusters (Annex 1), appropriate responses need to be tailored to meet the needs of the respective communities as they arise in their specific biophysical and socioeconomic environments.

The third area of focus is the broader application of technological, social and policy innovations in a system wide approach to strengthen agricultural production systems in a sustainable manner. This will involve the development and assessment of novel mechanisms in facilitating the interaction between socioeconomic and agro-ecological systems, stakeholder engagements, learning approaches and information dissemination tools including digital agriculture innovations. Digital agriculture has been accorded much promise with tools and applications that range from increasing accessibility of information on production and marketing, advanced crop management and decision-making tools, land-use planning and much more which has been captured in the draft E-agriculture strategy (2018-2025) by the Department of Agriculture and Livestock (DAL 2020).

The Key strategies that NARI in close collaboration with its partners will employ in contributing resilient system can be summarised as follows:

- Inclusive management and conservation approaches for genetic resources including *in-situ* conservation of land races and crop wild relatives as well as livestock genetic resources;
- Discovery of non-food products from agro-biodiversity;
- Increasing access to quality foundation material (crop varieties/breeding stock of poultry, goats, pigs, fish) to stakeholders supporting community based and private seed producers and rural breeding centres;
- Genetic improvement of crops and livestock breeds resilient to biotic and abiotic stresses in PNG diverse environment;
- Addressing policy gaps on protection of intellectual property rights, patenting of novel genes, plant extracts or crop and livestock products, Farmer rights on their traditional PGRFA, implementation and compliance with commitments as contracting party in international treaties;

- Portfolios of sustainable intensification practices and strategies to balance risks to production and livelihoods;
- Risk assessments of critical pest and diseases under changing climates and management of new and emerging weeds, pest and diseases of crops and livestock in priority production and agri-ecosystems;
- Assess application models of land and water management options for watershed and agro-forestry systems;
- Vulnerability assessments of communities impacted by climate change and the impacts on food security systems;
- Integration of CSA products and approaches into diverse climate resilient and productive livelihood systems;
- Demand-driven support with innovative learning approaches in knowledge transfer and information access to reach rural communities in the diverse setting in the country;
- Generating data that inform evidence-based policies to increase investment in agriculture for greater adoption and scaling of research and system outcomes;
- Networking and brokering inclusive and equitable partnerships between stakeholders;
- Facilitate application of information resources and platforms that enable engagement in the policy development process.

4.4.3 Priority 3 Enhanced consumption of healthy and sustainable diets by rural and urban households

Challenges and Opportunities:

PNG is blessed with an abundance of natural resources and food crops can be grown all year round in sufficient quantities. The lush environment also gives rise to a large biodiversity of edible plant species that are growing across the different agro-ecological climates. French (2006) estimates that there are approximately 1000 species of edible plants with about 400 species used more commonly. Among them are a large array of highly nutritious leafy vegetables such as pumpkin tips (*Curcubita moschata*), aibika (*Abelmoshus manihot*), amaranthus (*Amaranthus sp.*), Rungia (*Rungia closii*) and Tulip (*Gnetum gnemon*) as the most commonly consumed species (Bourke and Harwood 2009).

Compared to other countries with a similar land mass, it still has a relatively small population and yet, the indicators for nutritional health and well-being are the worst in the region and PNG ranks at the bottom of the international scale along with worn-torn countries or countries that suffer from lengthy severe droughts or other calamities. The country is facing a severe nutritional crisis with a triple burden of malnutrition, i.e. under nutrition, micro-nutrient deficiencies and overweight/obesity (DNPM 2020).

Malnutrition rates are amongst the highest in the world with almost 50% of children severely stunted due to mostly lack of sufficient protein in their diets, high rates of anaemia among children (up to 50%) and women in child-bearing ages (on average 40%) and a prevalence of Vitamin A deficiency among children of more than 20% in some regions in PNG which is considered a severe public health problem (Hurney 2017; NSO and ICF 2019; Schmidt et al. 2019).

Children will suffer irreversible cognitive and physical impairments if undernourished in the first 1000 days of their lives, severely limiting educational and employment prospects. The current prevalence rate of 30% overweight in PNG is worrying due to the increasing number of premature deaths due to non-communicable diseases. Overall, the situation is dire and poses a major threat to integral human development and sustainable economic growth in PNG. The threat of a lost generation that is impaired in contributing gainfully to economic and social development and to sustain their own livelihoods is a major threat to the nations future. The annual cost of malnutrition is estimated at 508 Million $USD (2015/2016) which incur from the following pathways according to Hurney et al. (2017):

- Losses in productivity from a reduction in labour force due to increased childhood mortality, estimated at $USD 46 million;
- Losses in potential income and productivity from poor physical status and reduced cognitive function, estimated at $USD 459 million;
- Losses from increased health care expenditure in treating diseases associated with childhood under-nutrition, estimated at $USD3 million.

Changes that are needed:

It is hard to understand how a country with the abundance of natural resources to produce sufficient amounts of nutritious food is afflicted by such systemic problem of malnutrition. There is a clear link between prevalence rates of malnutrition especially under nutrition and micro-nutrient deficiencies with poverty rates and the educational status of mothers. In rural communities, 70-80% of the total value of food consumed is still own-produced with limited use of imported or purchased food. Hence, other factors need to be considered as the causes of the poor nutritional status of large parts of the population, including cultural practices and norms, food preferences, attitudes to consumption of food and inequalities in food access within households for women, children and other disadvantaged groups. Poor nutrition outcomes in urban settings on the other hand are clearly linked to poverty and access to affordable nutritious food in sufficient amounts especially for those dwelling in settlement areas. However, also here food preferences towards processed low quality food including noodles, biscuits, wheat products and rice, and perceptions and habits perpetuated within households and society that these foods are adequate for a child's diet is a concern.

Changes are required in all aspects of food and nutritional security, i.e. availability, access and use of nutrient dense food at all times including food safety considering the prevalence and

impact of food borne diseases, malnutrition and mortality of children. The assumption that economic growth alone will drive the improvement of nutrition outcomes has not been realised in PNG based on economic and health figures for the year between 2005-2014. Contrary to that despite continuous national GDP growth, stunting rates actually rose by 6% (Hurney 2017). Changes are needed nutritional awareness and education in order to accommodate changes diets, cooking skills, consumption patterns. General knowledge and awareness on food and nutrition and its relationship with the general health by all members of the household, also ensuring that pregnant women and children are given adequate access to nutritious food across the population. However, changes are also needed on how food is produced and prepared, the variety of food produced and the settings of traditional food gardens that are often long distances away from villages and residential dwellings making on-going access to fresh vegetables and fruits an arduous undertaking.

Addressing nutritional outcomes will require a multi-sectoral approach that includes raising incomes, diversifying consumption, improving access to markets, and special attention to the nutritional needs of young children to systematically address this problem much in line with the key policies of GoPNG including the PNG National Food Security Policy 2018-2017 and the Nutrition Policy 2016-2026 and supported by the National Nutrition Strategic Action Plan 2018-2022.

Targeted Results:

The following results at the AR4D system level will be targeted in *Priority 3* by NARI with its contribution in AR4D:

- Increased availability of and access to diverse nutrient-rich and safe foods;
- Partnerships operating to promote implementation of agriculture for nutrition and health strategies for agri-food value chain/food system innovations and interventions at scale;
- Evidence-based nutrition-sensitive policies are designed accompanied by effective implementation strategies;
- Consumers (rural and urban) and producers have capacity to make more informed food choices among healthier and safe foods that meet their needs and preferences

AR4D Strategies:

There are important linkages between agriculture and nutrition, and AR4D has a major role to play in contributing to the necessary changes outlined above. NARI and partners will be contributing with nutrition-specific interventions to the multi-sector approach of the Government in three major areas.

The first area is closely linked to enhancing overall resilience of households and communities but technologies and strategies developed need to be viewed through a nutrition lens to get the necessary focus and reach those most vulnerable to the problem. Diversification of food gardens with a range of nutritious food crops covering different food groups and providing most necessary nutrients will be an important strategy. This will require availability of nutrient dense crops and crop varieties as well as fortification of staple food. As mentioned earlier, PNG has no shortage of nutritious crops and diverse crop varieties. Major strategies would include introduction, selections as well as genetic improvement of key crops and make them available to stakeholders through improved seed systems.

The second area is focused on the grave deficiency of protein in the diets of most communities in both rural as well as urban settings. While a lot of protein intake can also be achieved from plant-based protein and ties in with above strategies, an increase of supply and

consumption of animal-based protein will address the prevalence of stunting. Keeping small livestock such as chicken, ducks, goats, pigs or raising inland fish as well as the regular consumption of these animal products has to be actively promoted and encouraged in rural households. NARI and partners will strategise to enhance access to appropriate and resilient breeds and breeding stock. Management practices that are feasible and affordable to ensure a high productivity and good returns to the household must be adopted. Incorporation of livestock into livelihood systems as another level of diversification will further enhance overall food security and nutritional resilience. Other strategies will explore options of small-scale environmentally friendly livestock and aquaculture systems suitable for peri-urban areas.

The third area for interventions is the awareness, education and changing attitudes, habits and perceptions of rural and urban dwellers towards food, diets, preparation and consumption of food. Among the selected strategies, NARI will work closely with partners using participatory and inclusive approaches in working with the communities implementing nutrition and health related strategies. A special emphasis will be placed on the production of learning materials appropriate towards targeted communities on crop and livestock production, use and consumption of food with a nutrient lens to help get important messages across. Other strategies include participation in wider programs such as school gardens, promotion of kitchen gardens as well as lobbying for a greater investment into knowledge of good healthy nutrition.

The ADD cluster framework will also in this priority guide not only targeting communities most prone to poor nutritional outcomes but also derive relevant responses and strategies to address the issues.

Key strategies that NARI in close collaboration with its partners will employ in contributing to Nutrition and Health can be summarised as follows:

- Introduction, selection and genetic improvement of crop genetic material with traits for nutrient dense variety development integrating gender-responsive participatory elements;
- Improving access to planting material for nutrient dense vegetables and staple crops and breeding stock especially to areas and regions most affected by poor nutritional outcomes
- Nutritious food product development from local staple crops, vegetable, fruits and nuts;
- Development of postharvest practices improving storage, food hygiene and safety in different market settings;
- Development of integrated livestock-crop systems adapted to diverse settings in PNG;

- Development of husbandry and feeding systems for small livestock and aquaculture appropriate and potential for scaling for peri-urban and rural communities;
- Promotion of egg-production and consumption in rural communities
- Testing agri-food value chain innovations and interventions for improved diet quality and diversity
- Assessments on underlying root causes of malnutrition in different social and socio-economic settings across ADD clusters;
- Networking and brokering inclusive and equitable partnerships in improving nutrition outcomes of rural families and scaling up of successful lessons through effective engagement of multi-stakeholder and multi-sectoral platforms;
- Generation of data and evidence on outcomes of nutrient-sensitive agricultural programs

4.5 Delivery at scale

NARI's strategy in delivery is directed towards outcomes and impacts at scale (Figure 5). While technical research outputs provide technology and management solutions, achieving downstream impacts with sustainable development outcomes from these is still a challenge. While some farmers will simply adopt an introduced technology as it is, targeting sustainable development outcomes requires innovative processes in which NARI will actively pursue the formation of strategic partnerships and networking with other actors in the sector and related sectors. This will promote effective learning, adoption, and integration required to scale the outcomes of research into socially inclusive, climate resilient, and economically conducive livelihood benefits for the wider and environmentally, agriculturally, and socially diverse communities throughout PNG.

A major part of scaling is the consideration of the policy environment and institutional arrangement supporting the sector and the inclusion of needs and aspirations of men, women, youth and otherwise disadvantaged groups including those suffering from HIV/AIDs, in the design and delivery of AR4D activities. This is in line with one of the pillars of the SDGs that emphasises that "no one is left behind" and is to address the wide gaps in equity and equality in terms of wealth, access to education, health and economic and social advancement. Policy gaps need to be addressed with compilation of required information and inclusion of mechanisms that ensure that an effective dialogue happens between policy makers and stakeholders.

In order to support this process, NARI is using the results-based planning and management approach to ensure that a clear line of sight is maintained from project activities to longer-term strategic objectives. This will be supported with a coherent Theory of Change linking all programs and projects activities and outputs to the longer term development outcomes.

A key requirement for the Institute and its partners to demonstrate success at scale and contributions to development outcomes and impacts (Outcome matrix in Annex 2) will be the strengthening and mainstreaming of a Planning, Monitoring, Evaluation and Learning (PMEL) systems at all levels of the Institute. The previous SRF (2011-2020) recognised the importance of investing in improved PMEL systems (Figure 6) to ascertain success and also to apply lessons learnt from feedback loops to improve and refine strategies, design of project and programs and adapt to changes in the internal and external environment. However, the Institute still needs to fully institutionalise PMEL system across all levels of the Institute and in its engagements with beneficiaries and partners.

In line with the process illustrated in Figure 6, the PMEL system will be developed and operating at different levels of the organisations. Clear pathways on information flow and how information is used at different levels to aid decision making would be a key component of the system. Emphasis will be placed on assessments and reviews at regular intervals in order to ascertain institutional learning and adjustments in priorities based on feedback from stakeholders or changes in the external and internal environment.

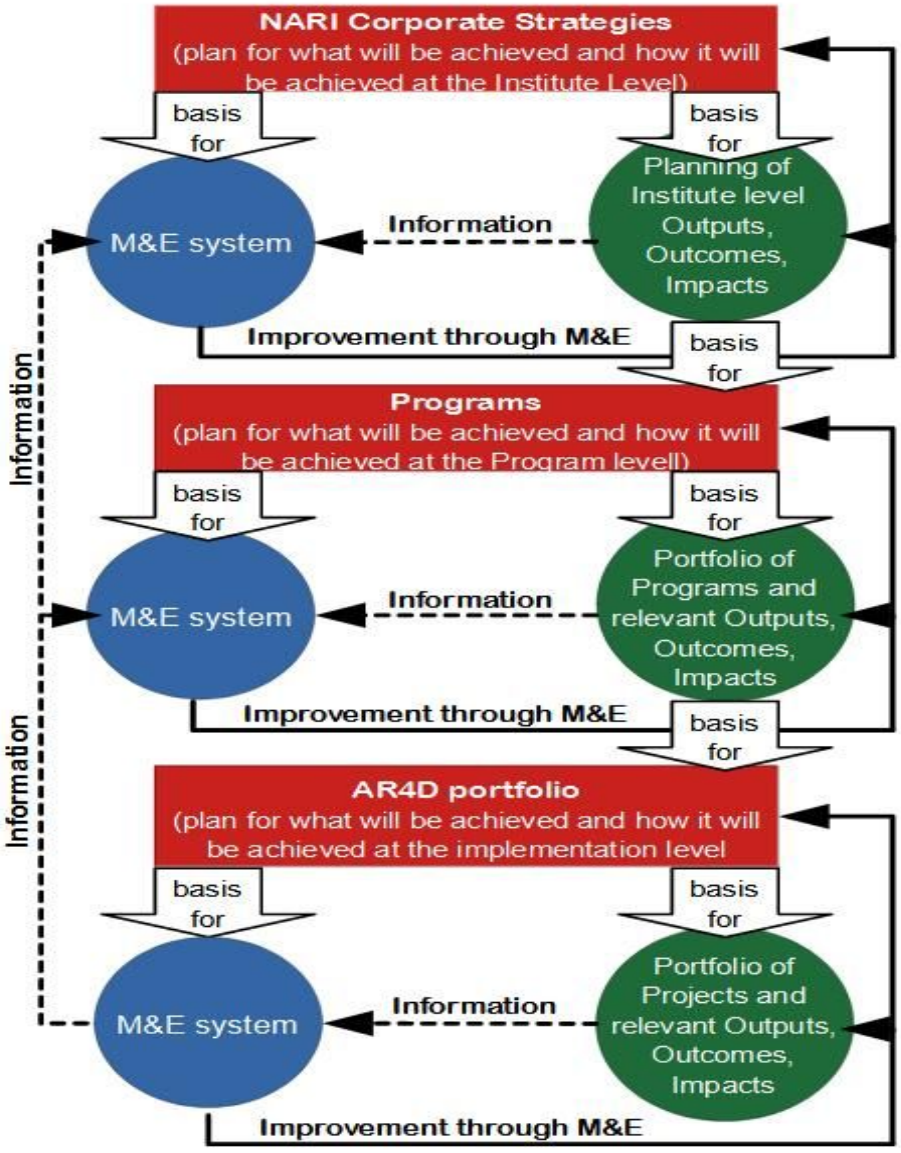


Figure 6: NARI Planning, Monitoring, Evaluation and Learning system

4.6 Setting the Institute up for delivery of AR4D outcomes

Issues to be addressed:

The implementation of the previous SRF (2011-2020) was a learning process to adjust organisational management systems in supporting the shift towards the AR4D paradigm and practice. The external review undertaken in late 2019 showed that this is very much a work in progress.

A major impediment in the delivery of its AR4D agenda remains the chronic under-funding in its recurrent budget since its inception. NARI's traditional sources of funding include annual and project-based grants from the GoPNG and additional grants from various other national and international donors, most importantly the Australian Aid Program and the European Union. However, while NARI is fortunate of having establishments in the major agro-ecological regions of the country aiding in the delivery and scaling of AR4D interventions, the resource envelope supporting the core functions of the Institute is insufficient to cover the overhead and operational costs in maintaining research infrastructure and facilities in the seven locations across the country. The funding situation also has flow-on effects on staff strength which is not adequate to gain critical mass comprising of necessary disciplines at strategic locations. There are critical gaps in social, economic and policy analysis and advocacy, and the associated expertise for effective Monitoring, Evaluation and Learning and the necessary expertise and capability in communication and digital innovation as a key capacity in a science and knowledge based organisations such as NARI.

NARI was established with its own Act as a statutory organisation and received strong support to establish a solid governance framework during its establishment phase. The Institute is known for its sound financial management and governance. However, management and governance systems need to change with major changes in strategy. NARI has been struggling to adjust its governance and management structure and systems in line with the paradigm shift towards AR4D and focus on farmers and actual people rather than on crop and livestock technologies alone.

Changes that are needed:

NARI remains committed to the change in its research paradigm and the need for change in how NARI conducts its business. This most important change to effect this is foremost a shift in mindsets and attitudes and the need to remove established routines, processes and habits, otherwise it is easy to fall back into a business-as-usual mode. This was one of the impediments and challenges during implementation of the previous SRF (2011-2020), which is not unique and unusual as this is something experienced across the globe where AR4D and similar approaches are being adopted (Francis et al. 2016).

Changes are needed in how the Institute mobilises and allocates resources to support a results-oriented delivery of the AR4D agenda. NARI cannot rely on its traditional sources of funding but needs to diversify its sources of income. The Institute needs to turn its regional centres and substantial land holdings from being current liabilities into assets that support the generation of internal revenue as part of its proof-of-concept in generating technologies and innovations that have commercial merit and ready for adoption by agricultural SMEs and investors.

Changes are needed in the attitudes and perceptions of staff, clients and partners on the role of research and other actors in the AR4D system. The Institute needs to address the issue of gathering critical mass in key disciplines and formation of multi-disciplinary teams within the Institute as well as in partnership with other organisations all focused on the ADD challenges

and opportunities. Biophysical scientists while focusing on their areas of expertise in natural agricultural sciences will need to also understand the systemic challenges of research and innovation in complex environments that influence the use and effectiveness of research outputs, while social scientists would need to have some understanding of the basic biophysical aspects of innovation and impact in order for multi-disciplinary teams to function effectively.

Lastly, the paradigm shift will not succeed unless the Institute is supported by a capable and visionary leadership team comprising of the NARI Council and Executive Management and management structures and systems that are responsive and flexible enough to accommodate the demands on the Institute to respond on short-notice to emerging needs of its primary clients and stakeholders, and changes in government priorities.

Targeted Results:

The following results will be targeted by the Institute for an improved institutional efficiency and capacity in supporting effective AR4D delivery :

- High visibility of the Institute's progress and achievements;
- Improved institutional arrangement, policies and increased investment in AR4D and agricultural development;
- AR4D agenda is resourced with adequate resources (expertise, financial and material resources);
- An enabling internal value-based institutional policy environment created and maintained.

AR4D strategies:

Delivery of the research for development agenda will require a substantial increase in financial resources, not only to support more complex and longer-term, impact-oriented program and project portfolios, including the associated technical support and infrastructure, but also to enable the Institute to actively implement and institutionalise its Planning, Monitoring, Evaluation and Learning system and conduct impact assessment that will ascertain NARI's achievements in its delivery ambitions. The Institute will use a multiple resourcing strategy to increase and diversify its revenue sources.

The first pillar of this strategy includes a drive to increase visibility of the Institute for our funders, especially the GoPNG and development partners, on our achievements and contributions to agricultural development in the country and where further investments can yield high returns in development outcomes and impact. This will include enhanced dialogue with GoPNG and partners to lobby for increased funding in AR4D to NARI. This undertaking will be supported by a communication strategy that outlines the approaches the Institute will take.

As the second pillar, the Institute will vigorously pursue national and international grants awarded by bilateral and multilateral partners for AR4D interventions, but with careful consideration of NARI's priorities in the SRF II 2022-2031 in addressing delivering research and innovations along the impact pathway.

The third pillar for the resourcing strategy is targeted at making better use of NARI's own assets, especially its landholdings and infrastructure at its Regional Centres. NARI will develop a business plan for income generating activities that will include production and sale of agricultural produce and services, engagement in public-private partnerships in land use and commercial activities that will also form part of the AR4D activities investigating

scalability of research outputs. Management systems and structures in Regional Centres will be aligned effectively to support an increased level of revenue raising activities.

The Institute will continue to place a strong emphasis on building capacity of its staff to increase knowledge and skills, address attitudes and promote talents. This will involve traditional short-term skills-based training and postgraduate studies and recruitment in the open market in PNG and overseas, but also engaging in strategic partnerships with sister organisations to access and share expertise. The Institute will strive towards establishing critical mass, not necessarily at each of the Regional Centres but as a cross-centre initiative that will draw on modern ICT technologies to enhance teamwork and communication for effective management and implementation of programs.

The Institute is striving for high integrity in leadership and stewardship that is effectively incorporated in the mechanisms, processes and structures of governance and management of the Institute and its relations with its primary beneficiaries and key stakeholders. NARI will actively seek to establish strategic partnerships as leader in the sector and engage with partners with a high degree of visibility, transparency and accountability. As part of the developing the annual corporate implementation plans, the Institute will review and update the existing organisational structure necessary for more effective delivery. This will be captured in the Strategic Results Implementation Plan.

The key strategies NARI will employ are summarised as follows:

- Advocate and lobby for increased investment by the government and donors into AR4D for a common purpose;
- Implementation of a Communication Strategy to guide public relations and support advocacy for AR4D with range of stakeholders;
- Stronger engagement with GoPNG and donors to align funding with research for development priorities as articulated in the SRF and implementation plans;
- Advocate for alternate funding mechanisms and more flexible funding modalities away from short-term project-based funding to longer-term program-based funding;
- Allocation of resources in fore-sighting and being at the forefront of research and policy innovations;
- Diversify revenue sources and increase engagement with the private sector for strategic partnerships and investment into research for development activities;
- Implementation of effective planning, monitoring, evaluation and learning systems at all levels of the organisation;
- Ongoing dialogue with staff and partners to ensure that key concepts including the cascading logic, results-based organisational structure, Agricultural Development Domain clusters are entrenched as the foundation for the organisational culture;
- Development and implementation of Human Talent Development strategy addressing critical gaps in skills and competencies incorporating short-to long-term training and career development opportunities, strengthening the NARI Cadetship Program and engaging in strategic partnerships with sister organisations in the NARS to access and share expertise;
- Support of a transparent, innovative and value based institutional culture displaying integrity at all levels of the Institution;
- Formation and management of formal partnerships with local, regional and international organisations and networks.

5. Way forward

The SRF will be implemented through cascading and coherent implementation plans. The next level implementation plan is the five-year Strategic Implementation Plan (SIP). The SIP will capture NARI's prioritised AR4D agenda for the entire 10-year planning period and show the priority programs and their deliverables as output and outcomes as well as resourcing needs for the first five years. Program outcomes need to clearly link to system outcomes identified in this document under each of the priorities.

Annual Implementation plans are the third level of planning and will summarise the annual research for development agenda with resources mobilised to deliver on the planned annual targets and results.

Development pathways are not static nor linear, hence this NARI SRF (2022-2031) has been designed to allow flexibility to adjust and re-prioritise without losing the long-term focus on contributing to the major societal development challenges the country is facing. Embracing agricultural research for development requires more a change in mind sets and a willingness to go beyond established comfort zones. Focusing on outcomes does not mean sacrificing good science as science is not in competition with development. On the contrary, sustainable development cannot happen without good science, research and innovation.

A move to Core Values was new for this SRF development - 111 staff participated over 7 sessions at HQ and regional centres in a value setting exercise.

6. References

Allen B, Bourke RM, Gibson J (2005) Poor rural places in Papua New Guinea. Asia Pacific Viewpoint 46:201–217

Anandajayasekeram P, Gebremedhin B (2009) Integrating innovation systems perspective and value chain analysis in agricultural research for development: Implications and challenges. International Livestock Research Institute, Nairobi, Kenya

Bourke RM (2018) Impact of climate change on agriculture in Papua New Guinea. In: Quartermain AR (ed) Climate Change: Our Environment, Livelihoods and Sustainability. Climate Change Conference 2018. University of Goroka, Goroka, Papua New Guinea, pp 35–50

Bourke RM, Harwood T (2009) Food and Agriculture in Papua New Guinea. ANU epress, The Australian National University, Canberra

Cámara-Leret R, Frodin DG, Adema F, et al (2020) New Guinea has the world's richest island flora. Nature 584:579–583. https://doi.org/10.1038/s41586-020-2549-5

DAL (2020) Agriculture Medium term Development Plan 2020 - 2022. Department of Agriculture and Livestock, Port Moresby, Papua New Guinea

DAL (2018) Papua New Guinea National Food Security Policy 2018-2027: Growing agriculture for food security, good nutrition and health. Government of Papua New Guinea, Department of Agriculture and Livestock, Port Moresby, Papua New Guinea

DAL, DFCD, DoE, et al (2016) Papua New Guinea National Nutrition Policy 2016 - 2026. Government of Papua New Guinea, Department of Agriculture and Livestock, Department of Community Development and Religion, Department of Education, Department of Health, Department of National Planning and Monitoring, Port Moresby, Papua New Guinea

DNPM (2020) PAPUA NEW GUINEA'S VOLUNTARY NATIONAL REVIEW 2020: Progress of Implementing the Sustainable Development Goals. Department of National Planning and Monitoring, Port Moresby, Papua New Guinea

DNPM (2010) Papua New Guinea Development Strategic Plan 2010-2030. Government of Papua New Guinea, Department of National Planning and Monitoring, Port Moresby

DNPM (2014a) NATIONAL POPULATION POLICY 2015-2024. Department of National Planning and Monitoring, Port Moresby, Papua New Guinea

DNPM (2018) Medium-term Development Plan III 2017-2022 - Volume 1 and 2. Government of Papua New Guinea, Department of National Planning and Monitoring, Port Moresby, Papua New Guinea

DNPM (2014b) NATIONAL STRATEGY FOR RESPONSIBLE SUSTAINABLE DEVELOPMENT FOR PAPUA NEW GUINEA -StARS, 2nd edn. Government of Papua New Guinea, Department of National Planning and Monitoring, Port Moresby, Papua New Guinea

DoTCI (2016) SME Policy 2016: PAPUA NEW GUINEA SMALL AND MEDIUM ENTERPRISE POLICY 2016. Government of Papua New Guinea, Department of Commerce, Trade and Industry, Port Moresby, Papua New Guinea

FAO (2006) Food Security: Policy Brief June, Issue 2. Food and Agriculture Organization of the United Nations, Rome, Italy

FAOSTAT (2020) Food and Agriculture Data. Food and Agriculture Organization of the United Nations, Rome, Italy

Fleming E (2007) Agricultural productivity change in Pacific island countries. Pacific Economic Bulletin 22:32–47

Francis J, Mytelka L, van Huis A, Roling N (eds) (2016) Innovation Systems: Towards Effective Strategies in support of Smallholder Farmers. Technical Centre for Agricultural and Rural Cooperation (CTA) and Wageningen University and Research (WUR)/Convergence of Sciences- Strengthening Innovation Systems (CoS-SIS, Wageningen, The Netherlands

Government of PNG (2009) Papua New Guinea Vision 2050. Government of Papua New Guinea, National Strategic Plan Taskforce, Port Moresby

Hall A, Carberry P, Djikeng A, et al (2016) The Journey To R4d: An Institutional History Of An Australian Initiative On Food Security In Africa. In: Francis J, Mytelka L, van Huis A, Roling

N (eds) Innovation systems: Towards effective strategies in support of smallholder farmers. Technical Centre for Agricultural and Rural Cooperation, Wageningen University, Research (WUR)/Convergence of Sciences-Strengthening Innovation Systems, Wageningen, The Netherlands, pp 183–201

Hurney M (2017) Cost of Child Undernutrition SHORT CHANGED: The Human and Economic Cost of Child Undernutrition in Papua New Guinea. Save the Children Australia, Port Moresby, Papua New Guinea

Komolong B, Maro J, Ryan J, Ghodake RD (2012) Development of strategic priorities for Agricultural Research for Development. Lae, Papua New Guinea

Maru Y, O'Connell D, Grigg N, et al (2017) Making 'resilience', 'adaptation' and 'transformation' real for the design of sustainable development projects. CSIRO, Canberra, Australia

Maru Y, Sparrow A, Stirzaker R, Davies J (2018) Integrated agricultural research for development (IAR4D) from a theory of change perspective. Agricultural Systems 165:310–320. https://doi.org/10.1016/j.agsy.2016.09.012

Mbabu AN, Ochieng C (2006) Building an Agricultural Research for Development System in Africa. International Food Policy Research Institute, Washington, USA

Mitchell DK, Aruga JA (2017) Papua New Guinea's 5th National Report to the Convention on Biological Diversity. Conservation and Environmental Protection Authority, Port Moresby, Papua New Guinea

NARI, (2011) Strategy and Results Framework 2011-2020: A Strategic Contribution to Realising PNG Vision 2050. National Agricultural Research Institute, Lae, Papua New Guinea

NARI (2006) NARI Stategic Plan 2006-15. Lae, Papua New Guinea

NSO (2013) National Population and Housing Census 2011: Final Figures. National Statistical Office of Papua New Guinea, Port Moresby

NSO (2011) 2009-2010 Papua New Guinea: Household Income and Expenditure Survey - Summary Tables. National Statistical Office of Papua New Guinea, Port Moresby, Papua New Guinea

NWS, ABM, CSIRO (2015) Current and future climate of Papua New Guinea. Pacific-Australia Climate Change Science and Adaptation Planning Program partners

Office of Climate Change and Development (2014) National Climate Compatible Development Management Policy. Ministry of Environment and Conservation and Climate Change, Port Moresby, Papua New Guinea

Omamo SW, Diao X, Wood S, et al (2006) Strategic Priorities for Agricultural Development in Eastern and Central Africa. Washington

Pacific Community (SPC) (2020) Pocket Statistical Summary 2020. Pacific Community, Noumea, New Caledonia

Rajalahti R, Janssen W, Pehu E (2008) Agricultural Innovation Systems: From Diagnostics toward Operational Practices. Washington, DC

Reddy M (2007) Enhancing the agricultural sector in Pacific island economies. Pacific Economic Bulletin 22:48–62

Shearman PL, Ash J, Mackey B, et al (2009) Forest Conversion and Degradation in Papua New Guinea 1972-2002. Biotropica 41:379–390. https://doi.org/10.1111/j.1744-7429.2009.00495.x

Thornton P, Schuetz T, Förch W, et al (2017) Responding to global change: A theory of change approach to making agricultural research for development outcome-based. Agricultural Systems 152:145–153. https://doi.org/10.1016/j.agsy.2017.01.005

UNDP (2019) Inequalities in Human Development in the 21st Century: Briefing note for countries on the 2019 Human Development Report - Papua New Guinea. United National Development Program, New York

Woltering L, Fehlenberg K, Gerard B, et al (2019) Scaling-from "reaching many" to sustainable systems change at scale: A critical shift in mindset. Agricultural Systems 176:102652. https://doi.org/10.1016/j.agsy.2019.102652

Appendix

Annex 1. Agricultural Development Domains

Farming communities are much influenced by their bio-physical and socio-economic environment which is highly diverse in PNG. Therefore, geographic information system (GIS) has been used to identify and depict spatial similarities and differences in agriculture and delineate the country into various Agricultural Development Domains (ADD) (Omamo et al. 2006). Clusters of those domains are then used to conduct a constraints and objective analysis to identify possible areas of intervention through AR4D that will contribute to achieving NARI's purpose in line with its mandate and create impact on smallholder farming and rural communities. Further information on the ADD approach in general and in the NARI context can be found in Omamo et al. (2006) and Komolong et al. (2012).

A total of eight ADD clusters have been identified (Figure 1). Table A1 shows a summary of the ADD clusters, percentage of total rural population, percentage of total cultivated area per domain and provinces with the highest share of population in a particular domain.

As seen Table 5, over 50% of the rural population and more than 80% of the cultivated land are located in areas with low access to markets and services. Most of that land also has a low to medium potential with one to several major constraints to production. Almost 40% of the population live on 18% of cultivated land area in domains with good and medium agricultural potential and within four hours travel time to the nearest service center or regional center. Demographic trends over the past 30 years are likely to continue over the coming decade. People from low agricultural potential and access to services domains will migrate into ADDs with high/medium agricultural potential and high/medium access to services (Allen et al. 2005; Bourke and Harwood 2009).

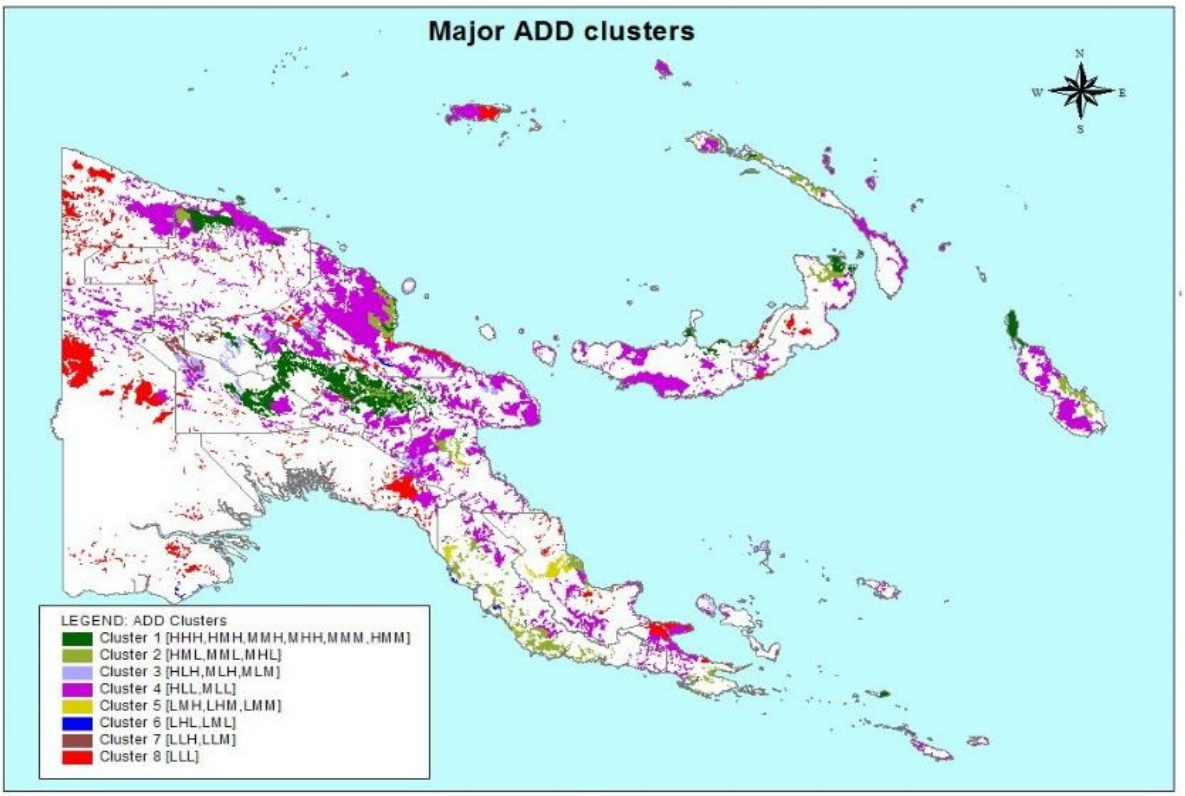


Table 5: Summary of major Agricultural Development Domain (ADD) clusters

ADD Clusters[1]	ADD contained in Clusters	% of total rural population	% of total cultivated land area	Major provinces represented in the ADD[2]
Cluster 1: HHH	HHH	2.92	0.38	ENB (100%)
	MHH	4.1	0.61	WHP (58%), EHP (27%), Madang (15%)
	MMH	19.3	4.2	EHP (25.4), Simbu (24.0), SHP (15.5)
	HMH	6.3	1.6	WHP (63%), SHP (24%)
	MMM	6.1	2.6	ESP (30%), EHP (23%)
	HMM	0.2	0.12	EHP (100%)
	Sub-total	**38.9**	**9.5**	
Cluster 2: HHL	HML	0.4	0.4	Morobe (90%)
	MML	6.0	6.3	Central (30%), NI (17%)
	MHL	0.5	0.4	ENB (65%), Central (35%)
	Sub-total	**6.9**	**7.1**	
Cluster 3: HLH	HLH	1.3	0.3	Madang (83%), Morobe (15%)
	MLH	5.5	1.3	SHP (47.0)
	MLM	3.5	1.6	Enga (36%), Morobe (23%)
	Sub-total	**10.3**	**3.2**	
Cluster 4: HLL	HLL	1.4	1.8	ARB (40%), Simbu (35%), Milne Bay (16%)
	MLL	28.4	41.7	Morobe (21%); Madang (13%), ESP (10%), WSP (9%)
	Sub-total	**29.8**	**43.5**	
Cluster 5: LHH	LMH	0.3	0.1	Morobe (65%), Central (35%)
	LHM	0.2	0.1	Central (100%)
	LMM	1.6	0.8	Oro (68%), Central (25%)
	Sub-total	**2.1**	**1.0**	
Cluster 6: LHL	LHL	0.04	0.05	Central (100%)
	LML	0.3	0.3	Western (43%), Central (38%)
	Sub-total	**0.34**	**0.35**	
Cluster 7: LLH	LLH	1.3	0.3	SHP (58%), Simbu (31%)
	LLM	1.8	0.9	SHP (43%), Enga (39%)
	Sub-total	**3.1**	**1.2**	
Cluster 8: LLL	LLL	8.5	34.3	Gulf (22%), Western (21%)
	Sub-total	**8.5**	**34.3**	
	Total	100	100	

[1] Agricultural potential (based on slope, rainfall and soil quality; Access to services: low-4-8 hours to reach provincial capital or urban centre (more than 1000 people); moderate-1-4 hours to a provincial capital or larger urban centre (>2000 people); high-less than 1 hour to major regional centre; Population Density- low: 0 - 60 persons/km^2; moderate: 61-100 persons/km^2; high: 101-713 persons/km^2

[2] e.g. MMH domain - 25.4% of the population in this domain is located in EHP

Annex 2. Outcome Matrix

Outcome statements	**Indicators of Success**	**Means of Verification**	**Assumptions**
Demonstrated Contribution to Development Outcomes			
Increased incomes and employment in rural areas especially for women and youth	• Median per capita rural income increased • Increase in farm income • Increase in on and off-farm employment esp for youth and women	National statistics, BPNG reports, international databases and information, Income and expenditure surveys, sample survey reports and studies; nutritional surveys; impact assessment reports	Partners, stakeholders, key Government agencies contribute effectively; Partner agencies and stakeholders appreciate and contribute to the improvement of the smallholder sector;
Enhanced stability and resilience in food production and supply for rural households and communities;	• Disaster-related damages and losses in food and agriculture sectors reduced. • Diversification of crops grown on farms increased		
Production, productivity and efficiency of crop and livestock products increased and producers better linked through efficient value chains to profitable markets at scale	• Increase in agricultural GDP attributed to smallholder food production • Increase in factor productivity and resource use efficiency • Increased resource productivity at aggregate level • Composite staple food production index increased • Increased volumes of produce traded in formal markets • CPI Annual Average Food Inflation		
Rural and urban households consuming healthy balanced and nutritious diets	• Ave. food protein consumption (g/kg body • weight/day) increased • Amount of protein in diet supplied from domestic animal (including fish) sources increased • Household dietary diversity score improved		

Outcome statements	Indicators of Success	Means of Verification	Assumptions
Improved standards in Food and Feed safety in agricultural production and food/feed use are applied	• Improved adherence to food safety standards • Food related health issues reduced • Increased number of producers supply formal markets • Number of food/feed processors supplying formal markets increased		
Enhanced and equitable benefits from agri-ecosystem goods and services	• Increased benefits including non-monetary returns from use of natural resources		
Agricultural production systems are sustainably managed under changing climates	• Improved agricultural environment parameters		
Priority 1 Value chains, Markets and Trade			
Increased economic returns to value chain actors from production, sale and added value of crop and livestock products;	• Net returns increased for value chain actors • Increased shares of profits directly going to women and youth	Income and Expenditure surveys, Health and Nutrition Surveys, other surveys and Impact Assessment reports; GoPNG statistics and information; other M&E reports	AR4D capacity available in the wider NARS and appreciation of the role of NARI and roles of other partners positive response by farmers/stakeholders in up-taking technologies Community support and participation in technology develo0ment, piloting and scaling Appropriate funding support by donors, GoPNG, private sector
Increased equity, inclusion and participation of women and youth in priority value chain**s**	• Increased shares of women and youth in on and off-farm activities		
Market system actors take up novel business opportunities in production and downstream processing of crop, livestock, aquaculture or non-food products in an environmentally sustainable manner;	• Number of newly established micro-and small businesses established and operating		
Market accessions for export of PNG's agricultural products that promote local content of market share;	• Increased volumes of exports of agricultural raw and processed products produced in PNG		

Outcome statements	Indicators of Success	Means of Verification	Assumptions
An efficient institutional and policy environment that promotes productivity, food safety standards, and maintains an efficient value chain in all market levels;	• Availability of relevant policies responsive to sector needs; • Food safety standards available and applied; • Improved market options and standards of facilities		Other external factors are congenial for adoption
Increased localisation and import-substitution of target crops and livestock by locally based industries;	• Reduced import volumes of target crops and livestock		
Alternative agricultural export opportunities from crop, livestock, aquaculture and non-food products realised and reflected in the national agricultural development agenda;	• Increased number and type of agricultural export products realised		
Priority 2 Resilient Systems			
Diverse and sustainable agri-food systems at scale are established and maintained and reflected in the national agricultural development agenda.	• Increased productivity of targeted production systems per unit of limiting resource • Increased quality of crop and livestock products • GoPNG responds with development and improvement of GR policies	Income and Expenditure surveys, Health and Nutrition Surveys, other surveys and Impact Assessment reports; GoPNG statistics and information; other M&E reports	AR4D capacity available in the wider NARS and appreciation of the role of NARI and roles of other partners positive response by farmers/stakeholders in up-taking technologies Community support and participation in technology develo0ment, piloting and scaling Appropriate funding support by donors,
Farming households adopt livelihood strategies that enhance their nutritional status and resilience to climate, physical, and biological shocks, stresses and risks	• Consistent supply of food at household level throughout the year • Share of rural population vulnerable to climate change associated risks reduced • Increased number of farmers with consistent income sources		
Equitable access by stakeholders to gender-sensitive crop and livestock technologies and up-to-date socioeconomic, technical and scientific information	• Relevant technologies and information matching needs of different stakeholders generated • Diverse access mechanisms operating across the country		

Outcome statements	Indicators of Success	Means of Verification	Assumptions
More productive and equitable management of natural resources and agri-ecosystems	• Increased gender equality in access to resources and decision making; • improved environmental health parameters for agri-ecosystems		GoPNG, private sector Other external factors are congenial for adoption
Priority 3: Healthy and nutritious diets			
Increased availability of and access to diverse nutrient-rich foods	• Increased volumes of nutrient dense food traded in markets; • release of nutrient dense crop varieties and food products to producers and consumers; • households maintain diversity in food crops and livestock holdings •	Income and Expenditure surveys, Health and Nutrition Surveys, other surveys and Impact Assessment reports; GoPNG statistics and information; other M&E reports	AR4D capacity available in the wider NARS and appreciation of the role of NARI and roles of other partners positive response by farmers/stakeholders in up-taking technologies Community support and participation in technology development, piloting and scaling Appropriate funding support by donors, GoPNG, private sector Other external factors are congenial for adoption
Partnerships operating to promote implementation of agriculture for nutrition and health strategies for agri-food value chain/food system innovations and interventions at scale.	• Increased number of multi-partner nutrition-specific programs		
Evidence-based nutrition-sensitive policies are designed accompanied by effective implementation strategies;	• Information on outcomes of nutrition specific interventions generated; • increased policy dialogue across sectors and stakeholders; • increased funding for nutrition specific interventions in the agriculture sector		
Consumers (rural and urban) and producers have capacity to make more informed food choices among healthier and safe foods that meet their needs and preferences	• Composition of diets and daily intake of major food groups and micro-nutrients in households		
Setting the Institute up for delivery			

Outcome statements	Indicators of Success	Means of Verification	Assumptions
High visibility of the Institute's progress and achievements	• Annual reports furnished in timely manner • Diverse visibility actions (press-releases, media article, shows and exhibitions, presentations etc) implemented • NARI represented in diverse fora	Annual and M&E reports; Reports to donors and GoPNG; publicity materials and media articles;	GoPNG and donors are responsive to the resourcing needs in NARI and the sector Required staff competencies are available in the open marketed
Improved institutional arrangements, policies and increased investment in the agriculture sector	• Agricultural development policies informed by facts and figures • Increased scale of adoption of improved agr. Technologies • Increased formation of formal and ad hoc partnerships and networks between AR4D system actors		
AR4D agenda is resourced with adequate resources (expertise, financial and material resources);	• Efficient use of HT across NARI locations implemented; • Diversity in sourcing of expertise for delivery of AR4D agenda • Diversity in revenue sources • Improved use of NARI assets and resources		
An enabling internal value-based institutional policy environment created and maintained.	• improved decision using inclusive and equitable management mechanisms • Institute policies are up-to-date and comply with public service and common law		

The National Agriculture 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:

1. any branch of biological, physical and natural sciences related to agriculture;
2. cultural and socio-economic aspects of the agricultural sector, especially of the smallholder agriculture; and
3. matters relating to rural development and of relevance to PNG.

NARI is also responsible for providing analytical, diagnostic and technical advisory services and information to support the agriculture sector in PNG.

The Institute's Strategic Objective (purpose) is to enhance productivity, efficiency, stability and the sustainability of the smallholder agriculture sector in the country so as to contribute to the improved welfare of rural families and communities who depend wholly or partly on agriculture for their livelihoods. This is intended to be accomplished through NARI's Mission of promoting innovative agricultural development in PNG through scientific research, knowledge creation and information sharing.

The Vision for NARI is "*Prosperous PNG Agricultural Communities*". NARI's core values are Leadership, Innovativeness, Integrity, Communication and Organisational Excellence.

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.

For any further information, contact the NARI Head Office at Sir Alkan Tololo Research Centre, P.O. Box 4415, LAE 411, Morobe Province, Papua New Guinea

Phone: (675) 79864776, 7606 1118

Email: naripng@nari.gov.pg

Website: https://www.nari.gov.pg


NARI