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Contents

1. Acknowledgments 3
Figures and Tables 4
Abbreviations 4
2. Executive summary **6**
3. Background **8**
4. Objectives **11**
5. Methodology **12**
6. Achievements against activities, outputs and milestones **20**
7. Key results and discussion **28**
7.1 Changes in farming practices 28
7.2 Cocoa processing and marketing 31
7.3 VEW Model 32
7.4 Livelihood surveys 44
7.5 Community resilience 46
7.6 Chocolate Festivals 49
8. Impacts **52**
8.1 Scientific impacts – now and in 5 years 52
8.2 Capacity impacts – now and in 5 years 52
8.3 Community impacts – now and in 5 years 55
8.3.1 Economic impacts 55
8.3.2 Social impacts 56
8.3.3 Environmental impacts 57
8.4 Communication and dissemination activities 57
9. Conclusions and recommendations **58**
9.1 Conclusions 58
9.2 Recommendations 62
10 References **65**
10.1 References cited in report 65
10.2 List of publications produced by project 66

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Figures and Tables

Figure 3.1 Linking project objectives with impacts
Figure 6.1 Relationship between the number of chronic health conditions and cocoa sales for families in Bougainville
Figure 6.2 Daily cocoa bean prices 2018-2022
Figure 7.1.1 Changes in land tenure 2016-2022
Figure 7.1.2 Changes in cocoa planting materials 2016-2022
Figure 7.1.3 Changes in the number of cocoa farm workers 2016-2022
Figure 7.1.4 Daily ICCO prices and aggregated volumes of PNG cocoa beans imported (a proxy for production), 2010-2020
Figure 7.2.1 Exposure to past and current farmer training activities (2022)
Figure 7.2.2 Number of households trained by VEWs (2022)
Figure 7.2.3 Number of households that received training from VEWs, by district and topic
Figure 7.2.4 Breakdown of the Bougainville Cocoa Farmer's app
Figure 7.3.1 Changes in the wealth index in 11 districts across Bougainville, 2016/17-2022
Figure 7.3.2 Changes in food security in districts across Bougainville, 2016/17-2022
Figure 7.3.3 Changes in dietary diversity index across Bougainville, 2016/17-2022
Figure 7.4.1 Productivity changes in food crops (reported volumes) during COVID lockdowns reported by farmers in 11 districts of Bougainville, 2022
Figure 7.4.2 Productivity changes in cocoa during Covid lockdowns reported by farmers from 11 districts in Bougainville, 2022

Table 3.1 One Health principles
Table 5.1 A One Health Research Framework for investigating low productivity of cocoa farmers
Table 7.2.1 Farmer training session topics
Table 7.2.2 Activities initiated by the VEWs
Table 7.2.3 What worked well for VEWs.
Table 7.2.4 Areas of VEW support in need of improvement
Table 7.5.1 Summary of Chocolate Festivals, bean quality assessment data, cocoa quality improvement and capacity building
Table 8.2.1 Participants in training activities at the Mars Cocoa Academy in Sulawesi, and with cocoa buyers in Singapore

Abbreviations

ABG Autonomous Bougainville Government
ARoB Autonomous Region of Bougainville
ARSF Alumni Research Support Facility
AVDRC Asian Vegetable Research and Development Centre (now the World Vegetable Centre)
BACRA Bougainville Agricultural Commodities Regulatory Authority
BP Bougainville Partners
CARE Cooperative for Assistance and Relief Everywhere
CB Cocoa Board of PNG
CCI Cocoa and Coconut Institute of PNG (until 2017)
CIAT International Centre for Tropical Agriculture
CGIAR Centres for International Agricultural Research
COE Council of Elders
COVID Coronavirus disease of 2019
CRG Collaborative Research Grant
CSF Commodity Support Fund
DPI Department of Primary Industries and Marine Resources
DoH Department of Health
FAO Food and Agriculture Organisation of the United Nations
FFT Family Farm Teams
ICCO International Cocoa Organisation
IFPRI International Food Policy Research Institute
IPDM Integrated Pest and Disease Management

NGNY Ngakkan Nyaagu
NGO Non-Government Organisation
PD Public Diplomacy
PNG CB Papua New Guinea Cocoa Board
SDG Sustainable Development Goal
TADEP Transformative Agriculture and Enterprise Development Program
UNICEF United Nations Children's Fund
UNRE University of Natural Resources and Environment
USAID United States Agency for International Development
VA Village Assembly (now Ward)
VEW Village Extension Worker
VRC Village Resource Centre
WHO World Health Organisation

2 Executive summary

Sustainable development and adoption of extension messages are best supported by long-term, broad-spectrum interventions that include consideration of the community, health, environment and economic influences, as all are needed to tackle poverty and inequity in developing countries[1]. Agricultural development projects often leave little impact because their focus is too narrow and they fail to engage with family needs or address key economic, environmental, social or human health constraints. This project addressed these concerns by adopting a One Health approach.

Early in the project we identified that the main challenge to the sustainability of cocoa farming in Bougainville is the poor productivity and profitability of cocoa under current agricultural practices. Intensification of cocoa production depended on the project effectively engaging with communities of farming families to identify their most significant challenges.

This 6-year project aimed:

1: To improve the productivity, profitability and sustainability of cocoa farming and related enterprises.

This transdisciplinary, One Health research partnership recognised that to improve the value chain, activities should recognise and be designed within the context of the complex and rapidly evolving social environment in Bougainville. A survey of 5,172 people from 2,346 cocoa farming families in 2016/17 showed, for the first time, that families were trapped in poverty by poor education, poor family health and limited income diversification. Malnutrition, poor health, limited educational opportunities and gender inequity reduced the availability of labour to implement best practice, explaining the limitations of past programs to boost productivity.

Despite the significant impact of Covid, the project demonstrated that the hub & spoke[2] model is an appropriate design for participatory training of cocoa farmers with special emphasis on field-based discovery learning on the basics of cocoa intensification and income diversification. The project design enabled all strata and groups of farmers, including women, school children and youth, to participate because the training approach was farmer-centric, bottom-up, and practical. Farmers were able to immediately apply what they learned and see the benefits of the inputs, resulting in strong motivation, enthusiasm, commitment, and interest to learn.

Village Extension Worker (VEWs), with the support of DPI and CCI, established an extensive network of village-level budwood gardens and nurseries to provide grafting and planting material for farmers rehabilitating their cocoa farms. Nurseries that propagated supplementary crops such as vegetables and vanilla were also developed, depending on the interests of local communities. They often grew into new village businesses.

After consultation we recruited one volunteer Village Extension Worker (VEW) from each of the 33 participating Village Assemblies (VAs). VEWs were trained in cocoa agronomy, food crops, sanitation, hygiene, nutrition and Family Farm Teams, and became project contacts in each VA. VEWs were supported by Regional Hub Managers in Southern, Central and Northern Bougainville who reported to the in- country coordinator and Project Leaders.

Nineteen new village resource centres were established by communities or converted existing spaces for activities and meetings. VEW activities included food crop cultivation to improve family nutrition and diversify of women's income.

The project built human capacity, established and improved infrastructure, laboratory and field facilities for the DPI and identified the significant infrastructure challenges facing the ARoB.

2: To understand and raise awareness of the opportunities for improved nutrition and health to contribute to agricultural productivity and livelihoods

A significant majority of households in the 2016/17 survey reported multiple health issues, rudimentary housing, unimproved sanitation and unimproved water. Over two-thirds of cocoa growers did not sell any cocoa bags in 2014-2016, resulting in low incomes and greater food insecurity compared to families selling cocoa. Families that produced no saleable cocoa were

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[1] *Herforth et al. (2015) Strengthening the links between nutrition and health outcomes and agricultural research. Food Security* **7**, *457–461*

[2] *Hafid and McKenzie (2012).Understanding farmer engagement in the cocoa sector in Sulawesi: A rapid assessment. Discussion Paper, ACIAR, Canberra, Australia*

more likely to have rudimentary housing, unimproved toilet facilities and unsafe water, factors that increase the likelihood of chronic disease and exacerbate malnutrition and poor labour productivity.
A report on the results of a Livelihood Survey of Cocoa Farmers in Bougainville (September 2018) was presented to the ABG providing a snapshot of the livelihoods of cocoa farmers on Bougainville. A sub-project which focused on sanitation and clean water, maternal and infant health and Family Farm Teams training in 10 villages with a high prevalence of severe stunting, childhood malnutrition and unsafe water showed the value of targeted education and assistance in vegetable cultivate and nutrition.

3 To foster innovation and enterprise development at community level

We connected stakeholders from cocoa farming communities along the value chain with traders and chocolate makers. Together with the Bougainville Partnership we organised and managed five successful Bougainville Chocolate Festivals that provided opportunities for community building, information exchange, public diplomacy and links with international chocolate makers. Feedback to growers from festival judges helped improve cocoa quality. Beans produced in the project by James Butubu were awarded gold in the 2021 Cocoa of Excellence competition in Paris. We have worked closely with The Cocoa Provider to import and warehouse small shipments of cocoa beans from 2023 for distribution to chocolate makers.
The Family Farm Teams program developed by Professor Barbara Pamphilon AM has built gender equity, family and community capacity and resilience. The evidence from the two surveys and VEW survey shows that the One Health approach increased the range of choices and opportunities for individuals and groups by improving human and social capital while not challenging traditional power structures in villages. Individuals, particularly women, were empowered with training, health and nutrition advice and by being enabled to work more effectively in groups and become more effective members of their villages. New village level enterprises, such as nurseries, processing, training and block maintenance services) were established.
New resources were developed to assist farmers, including the Bougainville Cocoa and Health Facebook page with over 1,700 members; the free Bougainville cocoa farmer's mobile app, launched in July 2022 that provides an online resource of information on cocoa farming, cocoa processing and marketing, food crops, soil management, nutrition, health and sanitation; the Cocoa Curriculum developed by the Cocoa Board for high school students rolled out in 2022; the Bougainville Village Livelihood Program designed for village volunteers; and the Bougainville Cocoa and Health project on the University of Sydney website that contains all the reports and outcomes of the project (https://cocoa-research-science.sydney.edu.au)

4: To strengthen value chains for cocoa and associated horticultural products
Five successful Chocolate Festivals were held, with one goal to introduce national and international Judges and chocolate makers to growers. Judges provided feedback on cocoa quality and Bougainville beans to grower workshops, contributing to the improved quality now recognised with many international awards.
Training has been provided for food crop cultivation, composting, nutrition and income diversification as part of the Family Farm Teams program.
We have built human capacity, established and improved infrastructure, laboratory and field facilities for the DPI and identified the significant infrastructure challenges facing the ARoB.
Team members learned from study tours to Australia (multiple visits), Indonesia, Malaysia and Singapore (2017), Thailand (2018), Solomon Islands (2019) and Europe (2022). James Butubu completed an ARSF project on integrated cropping of cocoa and food crops, Kenneth Dovaro and Wendy Pihau completed John Dillon Fellowships.
Partnerships were developed between the Department of Health and the Department of Primary Industries within the ABG to develop village livelihood and Family Farm Teams training. Cocoa production has recently increased despite the COVID-19 pandemic and a severe drought at the time of the 2022 survey. New local service enterprises have been established and Bougainville is on the threshold of assuming regulatory authority of its cocoa industry. The ABG recently established the Bougainville Agricultural Commodities Regulatory Authority (BACRA) recruiting staff and facilities from our project to develop and manage cocoa exports.

3 Background

Cocoa and coconut plantations were established on Bougainville in the late 19th century by German missionaries. Plantations were appropriated to Australian ownership after WW1, abandoned and re-established following WW2 when Bougainville became the largest cocoa producing province in PNG. Cocoa farming was disrupted by the loss of plantation labour to the newly established Panguna copper and gold mine, and the 'Crisis' that lasted from 1990 until 1998. After the 'Crisis' Bougainville was left with fractured communities, burnt infrastructure, few services and a disorganised cocoa economy.

Since the closure of Panguna mine cocoa has become the major cash crop for local smallholder farmers and for settlers from atolls affected by rising sea levels. More productive cocoa farming and improved quality would support economic and social development in Bougainville.

Before the start of this project cocoa farming communities specifically requested assistance to better their circumstances in the major areas impacting their lives – profitable crops and better access to education and healthcare.

However, the potential benefits of previous cocoa farmer training activities have not materialised because of poor access to extension support, limited labour availability, inefficient cocoa supply chains and poor farmer health and nutrition. Indeed, cocoa production in ARoB fell between 2009 and 2016, with reduced productivity and profitability also associated with ageing trees and increasing damage from the invasive cocoa pod borer.

Our strategy was informed by the shortcomings of past smallholder farmer training programs, not just in PNG but globally. Despite extensive efforts to improve farming productivity, average global cocoa yields have not changed over the past 50 years. Many evaluations point out the long adoption times and low rates of adoption for new technologies in the cocoa industry, reflecting strong cultural and economic barriers to behavioural change.

This suggested to us that awareness of good farming practices – the focus of most farmer training programs - was not the primary constraint to productivity improvements. As pointed out by Martyn (2015) labour is 50% of the cost of smallholder cocoa production, so our focus was on identifying if labour productivity was a primary constraint to implementing good farming practices.

A parallel focus was on building capacity within the ABG, across the Departments of Primary Industries, Health and Local Government. Previous research in HORT/2012/026 established several budwood gardens and nurseries in Bougainville for use as central training facilities and resource centres. Trained "Village Cocoa Specialists" had established demonstration and training sites in their own villages with the aim of increasing productivity and initiating an "organic spread" of improved farming across the island. However, the collapse of CCI and lack of capacity within the DPI to continue support for these villages ended this activity. These villages were excluded from this project to avoid confounding carry-over effects in this study.

The four linked objectives and impact pathways are represented in Figure 3.1:

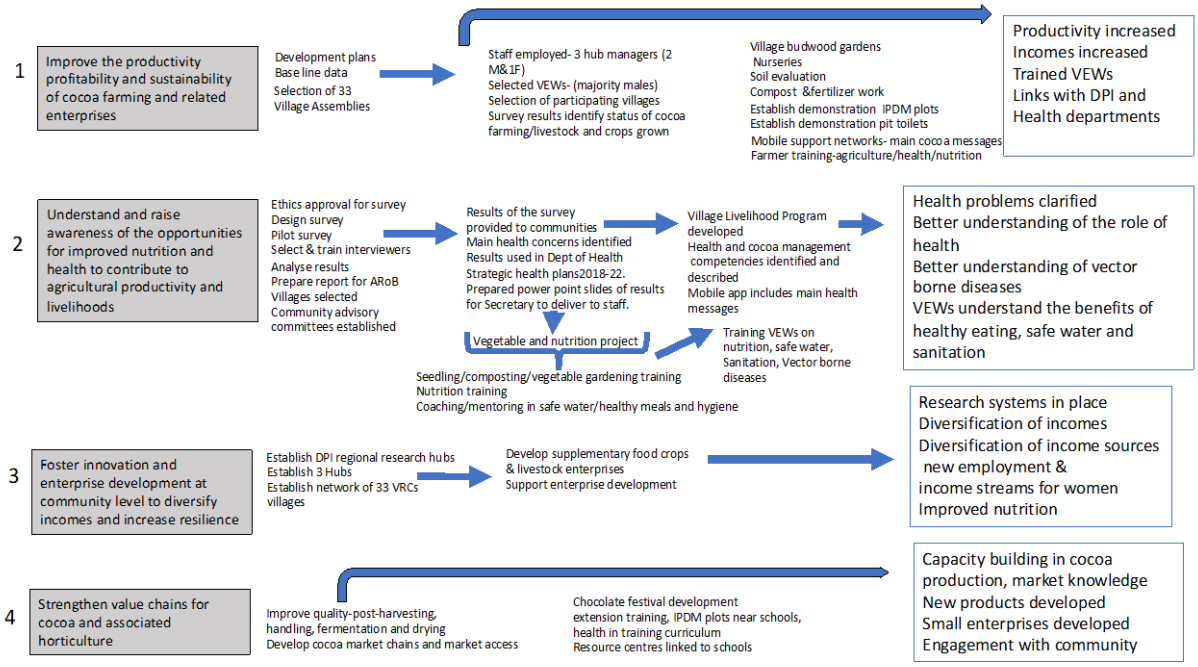

Figure 3.1. Linking project objectives with impact

A transdisciplinary, One Health, approach offers a deeper understanding of the intersection of factors limiting smallholder productivity. One Health collaborations across disciplines work towards optimal health for the planet - its environment, plants, animals and humans[3]. We know that sustainable economic development requires long-term, broad-spectrum interventions that simultaneously address community, gender, health, environment, infrastructure and economic constraints[4]. Underpinning the 17 Sustainable Development Goals (SDG) is the recognition that poverty cannot be addressed by a singular focus[5,6]. Rather the SDG agenda requires a more holistic approach; one that appreciates the many complex cultural, health and livelihood issues that surface in the relationship between humans and the ecosystems in which they live[7].
Our team included experts in cocoa farming, public health, nutrition, economics and marketing working closely with the ABG and with close local community consultation. Disciplines such as agriculture, health and nutrition have traditionally been siloed, ignoring clear links. Labour constitutes half the cost of production of smallholder cocoa, but agricultural research has rarely factored in the impacts of human health status on productivity, Similarly, agricultural processes have rarely been factors impacting the design and implementation of community health and nutrition initiatives[8].
Our project used systems thinking to better understand multi-directional linkages between the livelihoods of cocoa farmers and their health and nutrition. Our method of integrating health and nutrition goals into agricultural system development projects anticipates that productivity and sustainability of agricultural systems will improve but also maximise contributions to the health

[3] *One Health/Eco health/Planetary health and their evolution, Grant hill- Cawthorne in One Planet One Health editor Merrilyn Walton, University of Sydney, 2019.*

[4] *Herforth A., Lidder P., Gill M. Strengthening the links between nutrition and health outcomes and agricultural research. Food Sec. 2015;7:457–461.*

[5] *Hallariel G., Gandolfo A. 2016. Poverty and exclusion among Indigenous Peoples: The global evidence.*

[6] *UN General Assembly. Transforming our world: the 2030 Agenda for Sustainable development, A/RES/70/1. New York[Online] Available at: www un org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_RES_70_1_E pdf*

[7] *Rolfe J. Peacekeeping the pacific way in Bougainville. International Peacekeeping. 2001;8(4):38–55*

[8] *Hoddinott J. Reshaping agriculture for nutrition and health [Internet] International Food Policy Research Institute 2020 Conference Book; 2012. Agriculture, health, and nutrition: toward conceptualizing the linkages; p. 13*

and wellbeing of communities[9].
Table 3.1 describes the principles enshrined in a One Health approach[10].

Table 3.1: One Health Principles

Systems thinking	A systems approach considers the relationships among the different elements. For example: Cocoa farming system: soil & environment/ land availability/climate/farmer capacity (health & nutrition, education, income)/labour/crop management/ production/markets/transport infrastructure/cocoa sales Market system: producers/buyers/consumers/infrastructure/ industry/regulations/technology/information/informal markets Health system: Service delivery/health workforce/ health information/accessibility/ medical technologies/ health financing/ leadership & governance Food system: production/ processing/ packaging/ distribution/ marketing/ consumption
Transdisciplinary research	The team is made up of those with knowledge representing different scientific perspectives, integrated research methodologies and tools across multiple disciplines as well as those with lived experience of the situation being investigated- cocoa farmers/village leaders, household heads/local government.
Participation	Engaging the stakeholders (Village Assemblies, leaders, Government departments, outreach services, NGOs) throughout the research helps resolve conflicts, reduce barriers, solve research dilemmas, ethical problems, dissemination of information, and more.
Sustainability	The interventions are environmentally, culturally and socially sustainable and capable of enduring in the long term, but change may not be as expected. Understanding the enablers (strong leaders) or impediments (extreme poverty) in a community will give greater depth to understanding how change occurs in a given place or community.
Gender and social equity	One Health addresses unequal and unfair environmental and social condition that negatively impact on women and children who frequently suffer ill health, malnutrition and levels of violence.
Knowledge to action	Managing the tension between research and improving livelihoods is part of One Health endeavours. This means documenting pre-existing conditions and the changes during the interventions. Knowledge translation bridges the 'know'- 'do' gap and is a continuous changing process that analyses, disseminates and exchanges knowledge attentive to ethics and culture.

[9] *Pinstrup-Andersen P. The food system and its interaction with human health and nutrition. Reshaping Agri. Nutrit. Health. 2012;21*

[10] *Charron D. Ecohealth: Origins and approach. In: Charron D.F., editor. Ecohealth Research in Practice Innovative Applications of an Ecosystem Approach to Health. Springer; International Development Research Centre, Canada: 2012.*

4 Objectives

Within the broader development goal of contributing to the sustainable and socially equitable economic development of Bougainville, our specific aim, applying a One Health methodology, was to improve the gender equity, profitability and vitality of smallholder cocoa farming families and communities. We fostered and strengthened public and private sector partnerships and facilitated the development of enterprises that enhance quality and access to premium markets, We empowered communities and built stakeholder capacity by improving access to information and support.

The four project objectives, each underpinned by a research question, were used to achieve the above outcomes:

1: To improve the productivity, profitability and sustainability of cocoa farming and related enterprises.
Key research question: Among the many technologies available for intensification of cocoa production, which options and combinations are most appropriate to the social and biophysical context of Bougainville?

2: To understand and raise awareness of the opportunities for improved nutrition and health to contribute to agricultural productivity and livelihoods.
Key research question: To what extent is poor health and nutrition a barrier to improved agricultural labour capacity and living standards?

3: To foster innovation and enterprise development at community level, enhance productivity and access to premium markets, promote gender equity and community well- being.
Key research question: Can public sector R&D investment catalyse enterprise development leading to diversified and stable incomes and improved social outcomes for cocoa farming families?

4: To strengthen value chains for cocoa and associated horticultural products
Key research question: How can market access and value chain efficiency for cocoa and other farm and garden outputs of Bougainville be enhanced to improve farm family livelihoods?

5 Methodology

Objective 1: To improve the productivity, profitability and sustainability of cocoa farming and related enterprises

Our project used a framework developed by Lebov et al.[11] to identify key factors underpinning production of cocoa within Bougainville. Using this One Health framework we predicted that intersecting factors such as food insecurity, poor health, unsafe water, vector-borne diseases, sanitation practices, health services, labour shortages, poor infrastructure, transport systems and climate change are likely to impact on smallholder cocoa production [Walton et al. 2020] (Table 5.1).

Table 5.1. A One Health Research Framework for investigating low productivity of cocoa farmers (Lebov et al. [22][11]). Factors in bold are new One Health factors identified in this project.

Farming factors	Potential environmental factors	Potential animal factors	Potential human health factors	Potential human behaviour/susceptibility factors
				Poor adoption of improved production methodologies
				Few incentives to increase production
				High price volatility
			Malaria	Fortress crop (crops for cash when needed)
			Disease vectors (mosquitoes)	Labour shortages
			Tuberculosis	**Poor education**
Cash crop (cocoa, copra) production	Farm management	Domestic animals	**Respiratory diseases**	**Poor access to government services (health, education, agriculture and veterinary)**
Food crop production	Water sources	Pigs	**Communicable diseases**	**Poor roads**
Farm management skills	Soil degradation	Chickens	**Non-Communicable diseases**	**Poor transport systems and market access**
Income diversification	Deforestation	**Wild animals**	**Other chronic conditions (Diabetes)**	**Low borrowing capacity (Banks)**
Number and size of blocks	**Forest conservation**	**Loss of animal habitat**	**Lack of medications**	**Poor housing conditions**
Market knowledge	Food security	**Extinction**	**Lack of health professionals**	**Unimproved water sources**
Pests	**Climate uncertainty**	**Food sources**	**Lack of health services**	**Unimproved sanitation**
			Prevalence of Domestic violence	**Proximity to animals**
				Food insecurity
				Nutrition insecurity
				Women's roles
				Cultural norms (births, deaths)
				Beliefs (health, food, witchcraft)
				Religion

While there are many single explanations for low smallholder productivity, disciplinary-based interventions over the past 50 years have failed to achieve their goals. A One Health methodology explores all the possible factors associated with poor cocoa production. While not a comprehensive list, it captures the key intersecting factors that emerged from discussions with the research team and workshop participants.

5.1.1 ABG, District, CoE and village consultations

A three-day (3–5 February 2016) meeting with attendees from the Autonomous Bougainville Government (ABG), ACIAR, PNG Cocoa and Coconut Institute (CCI), University of Natural Resources (UNRE), NGOs, district and village representatives was held in Buka. The agenda was structured with plenary sessions by key stakeholders and the research team with small

[11] Lebov J., Grieger K., Womack D. 2017. A framework for one health research. *One Health. 3:*44–50.

group discussions to develop and refine research plans and give feedback during plenary sessions. Field trips with the ABG-DPI, ACIAR, Cocoa Board, UNRE and other stakeholders were also undertaken. We consulted with other ABG Departments (Health, Local Government) and communities across Bougainville, World Vision, CARE, the World Bank-funded Productive Partnerships in Agriculture Program (PPAP) and the PNG Science and Technology Secretariat to explain and seek feedback on the aims and approaches of the project, to raise awareness of the project and generate community interest.

A Workshop report was produced and circulated. Achieving gender equity in representation at the workshop was a challenge notwithstanding that Bougainville is a matrilineal society where land ownership is mostly passed through the women. Women played a major role in the peace agreement and continue to play a major role but with the demands of the household, children, gardens and selling vegetables at the market, women often find it difficult to make the time for formal leadership activities.

Following the stakeholder workshop, a governance structure facilitated by the ABG Ministry of Community Governance was implemented consisting of Government, District, Village Assembly and village levels. Annual meetings were held with the different levels of administration and with stakeholders (except during the pandemic when travel was not permitted), and more frequently with highly engaged stakeholders.

Updates on the research activities and challenges were provided to the regional committees and the ABG. “Work around” options were agreed upon when a situation demanded it, particularly during the Covid lockdowns of 2020-2022. Project groups using platforms such as WhatsApp and Facebook were established to facilitate ongoing consultation between stakeholders and provide project updates to a wider community. The Facebook group, currently with over 1,700 members of whom over half are women, will be moderated by a trained in-country project team member after project completion. Farmers have been invited to engage with the Facebook group, but we recognise the challenges they face with limited access to electricity, poor internet connectivity and low mobile phone ownership in remote communities.

Information was shared with the villages through the hub managers and VEWs as well as project team visits, FFT trainings and the Chocolate Festival when possible. Participatory stakeholder engagement including with the villages was a key principle of a One Health approach, and central to this project.

To maintain community involvement in decision-making and implementation of project activities, advisory committees were established in each region. The committees, attended by village leaders and representatives from women, youth, cocoa farmer groups and members of the project provide leadership for developing the regional hubs and Village Resource Centres (VRCs). Discussions with local and Australian-based project staff and communities were conducted in English and *Tok Pisin*.

Annual planning meetings were held with the advisory boards in each region and project partners, until COVID-19 travel restrictions prevented them. Members of the advisory board were appointed by the DPI in consultation with local Government representatives and the Minister for Local Government.

5.1.2 Baseline information collection and analysis

Validated survey tools were used to collect baseline and end-line information from cocoa-growing communities. An agriculture survey previously used in HORT/2012/026 was supplemented with validated instruments (UNICEF Multiple Indicator Cluster Surveys, the USAID Demographic and Health Survey and the WHO World Health Survey). The baseline survey was used to document and monitor changes in farmer family livelihoods, including geopolitical factors, economics, populations, livelihood strategies, housing standards, education, healthcare, access to mobile phones, banking, farm sizes and enterprises, details of cocoa activities (number and age of trees, management, yields, fermentation and drying, marketing etc.), and exposure to past training.

Comprehensive data was collected by trained staff in 2017 and data entered into tablets using CommCare software, downloaded, compiled and analysed in Sydney. The 2022 survey was modified to exclude questions about health as the project did not include any interventions to improve health. All other questions remained the same with some additional questions about whether a family member had Covid.

5.1.3 Selection of participating villages

The main research advisory committee finalised the selection of the Village Assemblies (Appendix 3). A total of 33 Village Assemblies (VAs) were purposively selected using a list of principles detailed below. All households within the selected VAs were eligible for the project as well as the base line livelihood survey.

Households were given information about the project and survey by their local extension officers prior to data collection. A smaller sample of the same households were used for the end-line survey.

The Village Assembly selection principles developed by the Advisory Committee were**:**

- Had to be growing cocoa or identify as a cocoa farming community
- Motivated and showing leadership
- Possibility for expansion outside of Village Assembly (VA) with large population group
- Need to complement existing projects on the ground
- Balance between villages with good transport access with hard to reach, disadvantaged communities.
- Balance between communities that have and have not received support before
- Avoid duplication with other projects
- Potential for diversification
- Security of farm ownership and potential for a Village Resource Centre
- Geographic spread of villages

The Committee also ratified the recruitment process to hire 30 interviewers (10 for each region with an equal number of male and female interviewers) to conduct the survey. Initially more men than women were nominated, requiring the recruiting team to remedy the gender disparity. We used this as a learning experience to support more equitable recruitment processes for the future.

Transparent criteria were developed by the project Advisory Group to select 33 communities across Bougainville with available volunteers and a willingness to establish and maintain Village Resource Centres (VRCs). A Village Resource Centre was a space to bring together village members for information and advice sharing, education and training. Agreements included arrangements to facilitate villages wishing to opt out.

5.1.4 Training of DPI Senior Facilitators, District Officers and selected VEWs

Intensive training for 10 DPI and project staff and 4 farmers took place over three weeks in 2017 at the Mars Cocoa Academy in Sulawesi, Indonesia. The roles of VEWs were based on those of Mars Cocoa Academy graduates, “Cocoa Doctors”, in providing village level support promoting smallholder farming as a business. Most participants also travelled to Singapore to visit cocoa buyers and processors.

As well as specific training aimed at developing smallholder farming as a business, participants met with Indonesian farmers and industry stakeholders and appreciated the potential role of cocoa farming in providing community facilities, services and infrastructure.

Food crops were planned as a supplementary source of income for women in an integrated cocoa farming system and a way of improving nutrition. Training in vegetable cultivation for 2 DPI and UNRE staff was given in 2018 by the World Vegetable Centre at Kasetsart University, Thailand. Follow-up training was provided by the Cocoa Coconut Institute (CCI) and the University of Natural Resources and Environment (UNRE) staff. UNRE staff, Charles Maika then Kathleen Diapong, and local farmer Michael Pearson provided training in goat husbandry.

Family Farm Teams training, developed by Professor Barbara Pamphilon AM with the Bougainville Women’s Federation, was provided by accredited Master Trainer Dr Josephine Saul-Maora. Dr Saul-Maora was trained by Professor Pamphilon in 2017, then trained other project members including VEWs and DPI staff, in 2018 and 2022. FFT promotes negotiation of family goals and ownership of the responsibilities of each family member required to achieve those goals. The focus is understanding how gender equity empowers families to develop smallholder farming businesses that pay for ongoing living expenses such as health and education. Dr Saul-Maora also led FFT training in the PNG cocoa project (HORT/2014/096) and FFT training became a component of the TADEP in 2021.

VEWs were trained in cocoa husbandry (IPDM, certification, nursery establishment and management, grafting and propagation, soil management, cocoa drying and fermentation), food crops and livestock management, nutrition, sanitation, Family Farm Teams and enterprise development.

5.1.5 Establish village budwood gardens and nurseries

Twenty-seven VEWs, with the support of DPI and CCI, established 49 village-level budwood gardens and nurseries to provide approved grafting and planting material for farmers rehabilitating their cocoa farms. This was a goal of CCI that was facilitated under this project. It should be noted that carrying potted seedlings to remote villages is a very difficult task and having local budwood gardens is an important step in supporting cocoa rehabilitation.

5.1.6 Evaluate soils and compost and fertiliser requirements

Results from past and current cocoa soil nutrition research (Nelson et al. 2011[12], HORT/2010/011, HORT/2012/026, SMCN/2014/048) were used to guide the development of improved soil management and cocoa nutrition recommendations, including for use in the Bougainville Cocoa Farmers App. As fertilisers are not widely available in remote villages, waste material from pruning, weeds and manures were used to produce composts as organic fertilisers. Composting is a useful strategy to encourage farmers to improve the management of their cocoa blocks and safely dispose of prunings, weeds, pod cases and organic wastes. Demonstration trials showed the benefits of compost fertilisers on crop yield and quality, pest and disease levels and severity.

5.1.7 Establish IPDM demonstration plots

A total of 43 demonstration plots were established by 23 VEWs to showcase cocoa intensification to relevant stakeholders/beneficiaries in villages. IPDM plots used both rehabilitated plantings and selected clones managed according to the four levels of IPDM outlined in ACIAR Monograph 131[13].

5.1.8 Establish mobile support networks

The free Bougainville Cocoa Farmers App was released in 2022 and includes relevant information on cocoa, food crops, livestock, safe water and sanitation, rubbish removal and nutrition for VEWs and DPI extension officers as well as farmers. The app is available in both Android and Apple smartphone versions. Once downloaded the app does not require a network connection to function.

5.1.9 Farmer training

While on their own farmer training programs have failed to increase the productivity of smallholder cocoa farms, diversified farming skills (including cocoa farming) remain an important component of sustainable integrated livelihood strategies. Hubs were established as training centres for VEWs, based on the model developed at the Mars Cocoa Academy in Sulawesi, where DPI, UNRE and CCI staff shared their expertise. Trained VEWs subsequently conducted more than 416 training sessions for farmers with support from DPI, CCI and UNRE.
Training was not possible during the pandemic, but in a six-month period in 2022, 102 training sessions were conducted. In addition, the CB Cocoa Curriculum and allied business training was introduced to high schools.

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[12] Nelson P.N., Webb M.J., Berthelsen S., Curry G., Yinil D. and Fidelis C. 2011. Nutritional status of cocoa in Papua New Guinea. ACIAR Technical Reports No. 76. Australian Centre for International Agricultural Research: Canberra. 67 pp

[13] Konam JK, Namaliu Y., Daniel, R. and Guest DI. 2011. Integrated pest and disease management for sustainable cocoa production: a training manual for farmers and extension workers (2nd edition). MN131, Australian Centre for International Agricultural Research: Canberra. 36 pp

Objective 2: To understand and raise awareness of the opportunities for improved nutrition and health to contribute to agricultural productivity and livelihoods

5.2.1 Establish the extent to which health (including nutrition) and disease impacts on farming activities and workforce availability

This objective was achieved by undertaking a mixed methods survey to ascertain the health and livelihood status of cocoa farmers on Bougainville. The following steps were successfully undertaken:

- Established base line data about the health of cocoa farming families
- Selected validated WHO tool(s) for collecting health data
- Established the extent to which health and disease impacts on farming activities
- Established the health priorities of each community
- Developed an evidenced-based cocoa-health Framework (Cocoa Farmers Health Framework) that describes best practice in healthcare for communities.
- Linked with the Department of Health to facilitate community access to and use of existing health care services in Village Resource Centres.

5.2.2 Advisory Committees

Consultations with participating communities guided the studies on the impacts of health on agricultural labour productivity.

Consultations included:

- Approval of the research objectives.
- Scope of the health research including data collection.
- Opting out of the health surveys and data collection.
- Confirming the criteria for selecting the Village Assemblies.
- Development and approval of mobile-based tools for collecting data.
- Development of educational and training material and technological aids.
- Identification of locations for data repositories.
- Management of Village Resource Centres.
- Discussion and interpretation of survey results and prioritisation of actions.

5.2.3 ABG, district, CoE and village-level consultations

The impetus for the health component was initiated by cocoa farming families during a preliminary meeting with the community in Malasang 3 on Buka Island. This invitation led to initial, but extensive, community consultations and observational visits. We held interactive discussion groups with some of the intervention communities to identify their specific needs and agree upon a realistic focus for the next steps.

The questions addressed with this approach were:

- What are the main health concerns for the community?
- How are the initial health needs of the community currently met?
- Can community members access relevant information via a spoken web application on basic mobile phones?
- Is the Cocoa Farming Health Framework (CFHF) within the Village Livelihood Program (Appendix 4; https://cocoa-research-science.sydney.edu.au/village-livelihood -program-bougainville/) a useful framework for identifying best practice in meeting a community's health care priorities?
- Will this be a sustainable model?

By answering these questions we were able to:

- Recognise that poor family health has a significant impact on productivity.
- Better understand how communities access and utilise primary healthcare facilities.
- Understand the challenges the ABGhas in providing health services to rural villages.

The Cocoa Health Farming Framework (piloted with cocoa farmers in Sulawesi[14]) identified the health challenges and provides a tool for educating VEWs and other DPI and Health staff. (Appendix 4. Bougainville Village Livelihood Program)

5.2.4 Estimate the impact of health educational strategies (written and telephone aids)

The CRG survey was conceived to identify any changes in the food security status linked to mentoring villages in vegetable cultivation, clean water and sanitation training activities (Appendix 5). Health questions were omitted from the endline survey as no interventions were permitted to improve farmer's health status.

5.2.5 Confirm that a village empowerment model using existing local resources is sustainable.

Many extension structures collapse when project funding ends. A key measure of sustainability will be the number of volunteer-VEWs who establish self-supporting enterprises resulting from the training received during the project. A second measure will be the adoption of the VEW model by neighbouring villages.

5.2.6 *Link health information to roll out of satellite farmer training*

By engaging both DPI and DoH we linked health programs with satellite farmer training centres in remote villages across Bougainville through the Village Extension Workers, based in Village Resource Centres.

[14] *Walton et al. 2021. Implementing a One Health volunteer program in West Sulawesi, Indonesia: A pilot study. Global Public Health 16(11), 1741-1756.*

Objective 3: To foster innovation and enterprise development at community level

5.3.1 Support the establishment of DPI Regional research hubs in Bougainville

We appointed three Regional Hub Coordinators who established IPDM Demonstration plots at hubs in North, Central and South Bougainville with support from DPI, Department of Health, UNRE and CCI. Some VEWs also used these sites for training activities for non-target villages and NGOs. The Government of the ARoB remains committed to redeveloping the Duncan Research Centre as a DPI research facility once land ownership issues are resolved.

5.3.2 Establish Village Resource Centres linking CCI, UNRE, AVRDC with DPI and DoH

Village-level Resource Centres serve as planning and training centres for establishing cocoa nurseries, implementing improved cocoa management, soil management, diversification into small livestock, food and vegetable crops and supplementary cash crops. Resource Centres such as that at Malasang are also used for Family Farm Teams training, community health training, sharing, women's and youth resource centres for technical training in nutrition, bookkeeping, and entrepreneurship.

5.3.4 Develop supplementary food crop and livestock enterprises

Farmers were shown how to generate extra income in the following ways

1. Intercropping young cocoa plantings with food crops helps generate income from immature plantings
2. intensifying cocoa production to free land for food crops, alternative high value crops or small animals. UNRE and project staff trained farmers in food crop production, goat husbandry, business, and marketing skills.

5.3.5 Support economic development through enterprise development

Training a cadre of VEWs in the intensification of cocoa farming and diversification of incomes created new small business enterprises targeting women and youth in cocoa and food-crop nurseries, cocoa fermentation and drying, livestock, compost manufacturing, the provision of block sanitation services and intercropping.

5.3.6 Monitor farming systems.

We conducted baseline and follow-up surveys to monitor changes in farming practices and livelihoods. These surveys were developed from HORT/2012/026 and other instrument, and adapted for data collection using Commcare.

Objective 4: To strengthen value chains for cocoa and associated horticultural products

5.4.1 Improve quality through better post-harvest handling, fermentation and drying

Chocolate Festivals were linked to farmer training through feedback provided by the judges. Once farmers recognised how to amend quality defects caused by poor postharvest handling they were then empowered to negotiate fewer price discounts. Award-winning beans were entered into international competitions to raise recognition of the Bougainville "brand".

For this incentive to be attractive buyers and traders need to be able to identify and segregate beans of different quality. While this may be slow in the commodity market, specialist chocolate makers are quicker to respond to the opportunity of a new source of high-quality beans. Entering Bougainville beans into international competitions will raise awareness and demand for specialty beans.

5.4.2 Develop cocoa value chains and market access

Price volatility inhibits investment. Cocoa farming families prioritise food, shelter and cultural and community obligations. Farming families can invest spare labour in a multiplicity of activities to improve farm productivity and incomes: fertiliser application, trimming and pruning, general farm husbandry, pod splitting, fermentation and drying facilities, and on-farm storage. The investment by the cocoa farmer can be in the form of cash and / or labour. The return of that investment can be measured in a number of ways such as return on capital, return on labour, and return per hectare. Each of the measurements require a price level. But given the volatility of prices, a commodity cocoa farmer is always unsure what future prices will be. For cocoa farmers with little protection offered by income diversification there is a natural reluctance to undertake different forms of investment.

We monitored global bean prices and attempted to collect data on local prices. While farmers complain about low bean prices, we aimed to provide market information to show that low prices were a consequence of quality discounts rather than profiteering by cocoa buyers. Better processing will produce more income for farmers by reducing these discounts.

5.4.3 Extension, education and capacity building

The establishment of Village Resource Centres facilitated the rollout of extension services. VEWs became community-based generalist extension workers and points of contact with experts in cocoa, livestock, foodcrops, entrepreneurship, health and nutrition. The development of web-based information and the Bougainville Cocoa Farmer smartphone App will assist the VEWs in their training activities.

VEWs were also engaged by other agencies to extend their training to other villages not included in our project.

Ongoing and regular consultation with stakeholders over the term of the project maintained the focus and impacts of the project.

5.4.4 *Link resource centres with schools/technical colleges to facilitate technology/skills training and transfer*.

The Cocoa Curriculum developed by the Cocoa Board (Appendix 6) was piloted in high schools after training by the CB, enriching the learning experience and demonstrating the potential of agriculture as a viable career for young people. These learnings are passed onto the rest of the family.

5.4.5 Chocolate Festivals

Annual chocolate festivals were held in different locations in Bougainville (Arawa, Buin or Buka) each year, with enthusiastic participation from communities, families, men, women and youth and a few tourists. Farmers provided bean samples that were made into 70% chocolates and evaluated by trained judges from cocoa buyers and chocolate companies (including Jasper+Myrtle, Spencer Chocolates, Cravve, Bayen, Ratio, Daintree Estates). Judging followed internationally recognised Cocoa of Excellence protocols. The awards ceremonies included presentations from growers, judges and chocolate buyers as well as stimulating Q&A sessions. The festivals included field days demonstrating new planting materials, nursery practice, IPDM, fermentation, drying and quality control and all aspects of the cocoa value chain, as well as information on food crops, livestock, nutrition, health, entrepreneurship and financial literacy from stallholders including ABG Departments of Agriculture, Health and Local Government, PNG-Cocoa Board, University of Natural Resources and Environment and the World Vegetable Centre. Other exhibitors included the World Bank, PNG Women and Youth in Agriculture, Banks, NGOs, Cocoa buyers, chocolate manufacturers and service providers. Other events, including big bean competition, grafting competition, cultural, music and sports events were organised as part of these festivals. Festivals were an important component of public diplomacy for DFAT and ACIAR. Festival judging also linked the distribution of the Gold/Silver/Bronze medals to farming practices, such as fermenting and drying, to various regions and thus were a guide to more targeted extension efforts. These festivals had an important outreach and communication role to publicise agriculture and health impacts of the project and generated wider interest from extended communities.

6 Achievements against activities, outputs and milestones

Objective 1: To improve the productivity, profitability and sustainability of cocoa farming and related enterprises

6.1.1 While the lockdowns of 2020 to mid 2022 prevented project travel, weekly Whatsapp calls with the project team maintained regular discussion. The in-country team led by James Butubu thrived on the extra responsibility and support available.
Sylvia Kungkei replaced Borgia Sinato as the VEW Coordinator in 2019 and continued to monitor and develop the network of VEWs.
Once travel was possible, the Australian team members made their first visit to Bougainville from 12th-17th July 2022. Meetings were held with Minister for Agriculture and Secretary for DPIMR and Secretary for Health to update on project activities and develop future research priorities. Planned meetings with Village Advisory Committees were not possible during Covid travel lockdowns and were planned, but cancelled, in February 2023. These meetings should be conducted as soon as possible.

6.1.2 Baseline data were collected in 2017. A report on the survey results was provided to the ABG Government in 2018 (Appendix 7). Five peer-reviewed journal articles have been published. The results were also used to inform the CRG pilot study on food crops and nutrition (Appendix 5).
The Final survey was completed in November 2022 and data are being analysed for later publication.

6.1.3 VEWs met to discuss successes and failures in September 2021. Feedback was positive. VEWs and Hub Managers were surveyed on their experiences in 2022 (Appendix 8; see 7.2).

6.1.4 Ten DPI, CCI and UNRE officers and 4 farmers were trained at MARS Indonesia and cocoa traders in Singapore.
Health and DPIMR staff were upskilled in nutrition and vegetable garden cultivation as part of CRG Nutrition project
Thirty-three VEWs, 3 Hub coordinators, 3 CCI Project staff and DPI officers were trained on Sustainable Livelihood, IPDM, cocoa propagation and nursery set up, Family Farm Teams, including business modules on small enterprises, record keeping and decision making.
FFT training in villages was completed. DPI and DoH staff were trained as FFT trainers.
DPI staff participated in a marketing tour of the Solomon Islands.
The winners of the 2018 Chocolate Festival, the Saveke family, travelled to Melbourne to meet chocolate makers at a Taste and Tell event at Ratio Chocolates.

6.1.5 Forty-nine Village budwood gardens and nurseries have been established in 33 villages, with 20 VEWs responding to requests for training from neighbouring villages. Trained VEWs now run successful training, nursery and processing businesses. Fourteen VEWs charged a fee, with 17 providing a free service.

6.1.6 With training from CB staff, VEWs constructed 18 compost huts for training exercises. Composting emerged as a new business enterprise in some villages.
Soils and composting information have been included in the Bougainville Cocoa Farmers app.

6.1.7 Forty-three IPDM plots were established and used for farmer training. Plots have also been established in schools as part of the CB Cocoa Curriculum rollout under the project.

6.1.8 The Bougainville Cocoa App was officially launched in Buka on 14th July 2022 with the launch of the Bougainville Food Security Policy. The app has been well received and we expect more farmers to download and use the app is awareness increases.
The app was promoted via the project Facebook page which now has over 1,700 members
While it had been planned that the App developer (NGNY) would train the DPI IT specialist Solomon Norg to manage the app, the training will now be done in April 2023 under a separate DFAT grant. Training will include managing and maintaining the mobile app, Facebook page, DPI

Blog and Commcare survey platform for future applications.

6.1.9 VEWs conducted over 416 farmer training sessions on over 22 topics.
FFT training was completed in villages in the North (Teopasuna, Tinputz, Baneo, Tinputz, Ratsua, Selau, Nehan, Novah, Malasang, Sorom) in June 2021, in Central (Bava Pirung, Toboira, Sivuna, Onkosira, Vito, Manetai, Dantanai, Lower Aropanari, Onoring, Koianu, Rauvira, Wakunai) in September 2021, and South Bougainville (Nakorei, Buin, Aku, Buin, Tarapa, Siwai, Kutin, Siwai, Mihero, Siwai, Koora, Bana, Karato/Lautan, Torokina) in February 2022.

Objective 2: To understand and raise awareness of the opportunities for improved nutrition and health to contribute to agricultural productivity and livelihoods

6.2.1 A report on the results of a Livelihood Survey of Cocoa Farmers in Bougainville was presented to the ABG in September 2018 (Appendix 7). The results show that cocoa is the main source of income for South and Central Bougainville while copra is the main source in North Bougainville. Most farmers either own their land or use clan lands. Cocoa farming communities reported high levels of chronic health conditions, poor nutrition, justification of domestic abuse, poor water and sanitation and food insecurity. The strongest correlations with cocoa production were education level, chronic health and physical afflictions[15].
Healthier, well educated farmers produced more cocoa and tended to be wealthier. Farming families with low levels of education reporting multiple chronic health problems tended to live in relative poverty.
The clearest correlations with smallholder cocoa production were with farmer family health. There were clear correlations between physical limitations to labour, chronic illness and poverty. Conversely, healthier farmers are wealthier, independent of other biological, geographical or socioeconomic factors. While the correlation is consistent, the only way to prove causation would be a controlled study that splits the communities into two groups that receive different interventions. Such a design was not appropriate for this project because of the likely confounders.
These data support the integration of farmer health messaging with agronomic and FFT training. We now have strong evidence that improving farmer health will also increase cocoa production in Bougainville, and the wealth of rural smallholder communities.
A bivariate analysis showed that the average cocoa production for women was significantly higher in the food secure group (n = 307) than the food insecure group (n = 210). Food secure households (60%) were found to produce more cocoa. Men aged 15–49 suffering from angina (n = 68) produced significantly fewer bags of cocoa compared to those never diagnosed with angina (n = 420). Men who chewed buai (n = 389), also produced significantly fewer cocoa bags compared to those who did not (n = 99). Other health factors were not significantly associated with production.
The cumulative chronic health data show that many households produced no bags of cocoa for sale between 2014–2016, and that poor family health is associated with lower cocoa production (Figure 6.1). Furthermore, while the trend is not significant (t = −1.126, p = .26), there were no high producers (>150 bags) in families with three or more chronic conditions.

[15] *Walton, M., Hall, J., Van Ogtrop, F., Guest, D., Black, K., Beardsley, J., ... & Hill-Cawthorne, G. (2020). The extent to which the domestic conditions of cocoa farmers in Bougainville impede livelihoods. One Health, 1*

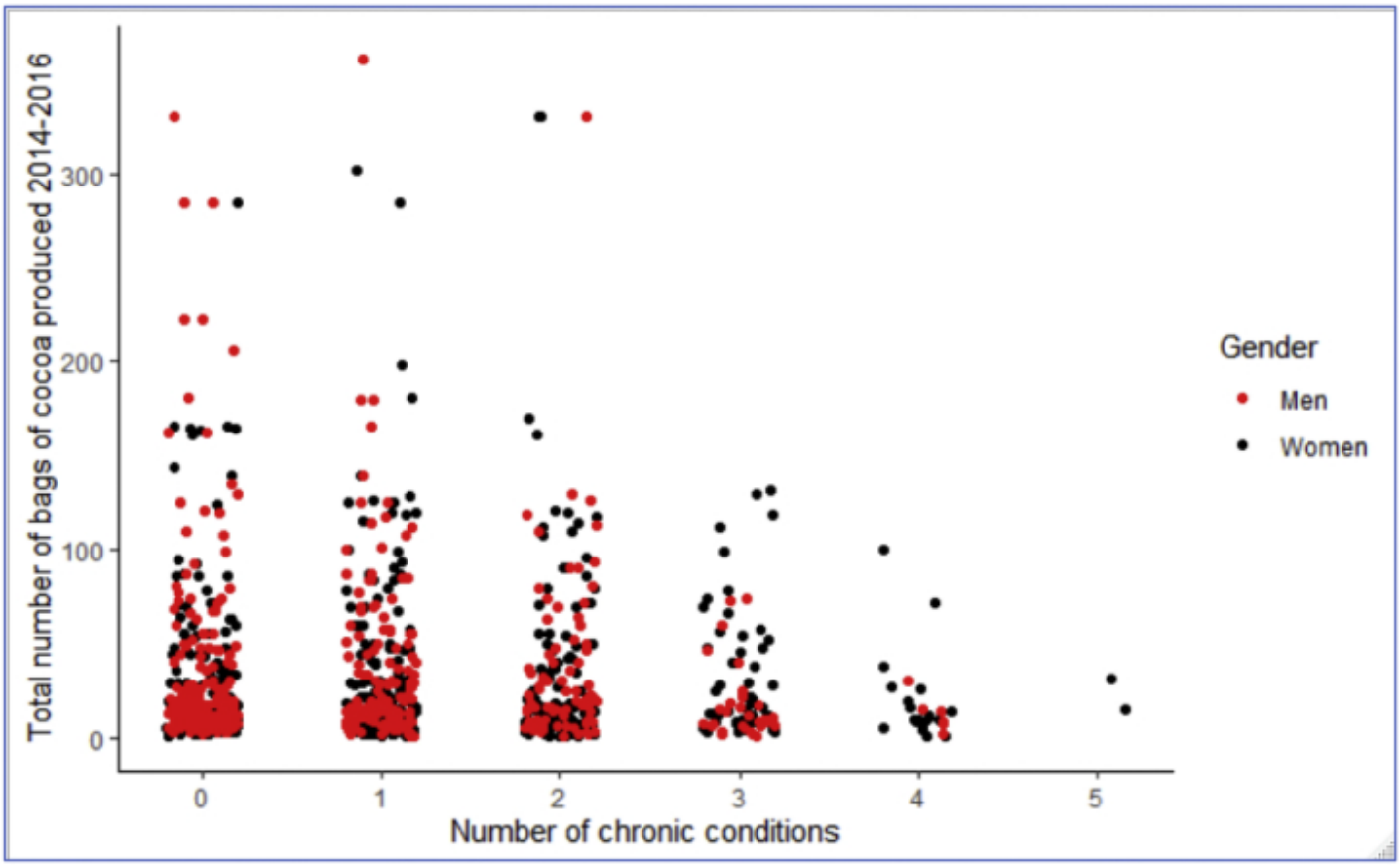

Figure 6.1. Relationship between the number of chronic health conditions and cocoa sales for families in Bougainville

6.2.2 All the activities listed were achieved except for the development of qualitative and quantitative and tools for collecting data. The tool for measuring lost days to sickness was not feasible as many health conditions remain undiagnosed and people continued to do some work when sick. The results of the survey demonstrated the impact of poor health on productivity, making the tool redundant. Tools for the collection of data in real time from cocoa farmers were successfully piloted with cocoa farmers in Sulawesi [16].

6.2.3 The survey showed that families with the fewest reported health issues tended to produce more bags of dry cocoa beans than those with multiple health problems. Over two-thirds of cocoa growers did not sell any cocoa bags in 2014-2016 resulting in low incomes and greater food insecurity compared to families selling cocoa. Families that produced no saleable cocoa were more likely to have rudimentary, unimproved toilet facilities and access unsafe water, factors that increase the likelihood of chronic disease and exacerbate malnutrition and poor labour productivity.

6.2.4 Health programs were linked to farmer training sessions. Hub managers, VEWs and health staff nominated by the Secretary of Health from each region were trained in on water, sanitation, vegetable production and nutrition. Relevant health information is part of the FFT program, the CRG sub-project and has been included in the Bougainville Cocoa Farmers App.
The Bougainville Village Volunteer program, adapted from the program piloted with cocoa farmers in Sulawesi in a project funded by the Australia-Indonesia Centre in 2017, showed how village volunteers can be upskilled and prepared to help with basic public health information and improved cocoa management. [17]

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[16] Walton M, Arsyad DS, Alimuddin S, Arundhana AI, Guest D, McMahon P, Doel R, Nasir S. Implementing a One Health village volunteer programme in West Sulawesi, Indonesia: A pilot study. Glob Public Health. 2021 Nov;16(11):1741-1756. doi: 10.1080/17441692.2020.1836247. Epub 2020 Oct 22. PMID: 33091327.

[17] Walton M, Arsyad DS, Alimuddin S, Arundhana AI, Guest D, McMahon P, Doel R, Nasir S. Implementing a One Health village volunteer programme in West Sulawesi, Indonesia: A pilot study. Glob Public Health. 2021 Nov;16(11):1741-1756. doi: 10.1080/17441692.2020.1836247. Epub 2020 Oct 22. PMID: 33091327.

In addition, many health professionals in Bougainville are trained in hospital environments remote from village life. The Sulawesi pilot program hypothesised that significant health benefits can be experienced when individuals understand the causes of poor health and how they can, by changing behaviours, minimise or avoid contacting diseases.
The Bougainville Village volunteer programme is designed for village volunteers to assist their community improve livelihoods. Changing behaviours and minds requires instruction in real time and place. This project did not include any further development of the program; this should be considered in future projects.
Health and nutrition are addressed in further detail under the CRG Vegetable and Nutrition study (Appendix 6).

Objective 3: To foster innovation and enterprise development at community level

6.3.1 Hubs have been established in Buka (Cocoa Quality lab), Toniva (BACRA mini lab) and Buin (model farm). The former Duncan Plantation is planned to become the third research hub for field experiments when land negotiations are complete.
Investigations into social network structuring, time allocation, information flow, knowledge, attitudes of production/marketing and perception constraints; entrepreneurship, and key incentives and motivations that drive decision-making were prevented by COVID travel restrictions.
The HORT/2012/026 agriculture survey and parts of the Livelihood Survey were used to evaluate the effectiveness of IPDM training and other activities (Appendix 8). The VEW survey undertaken in 2022 showed that of the original 33 VEWs, 31 were still operating and answered the survey. Of the 33 originally appointed 22 were still participating as a VEW and the remainder joined the project later as replacements for departed VEWs. Five had been in the position for less than two years and four VEWs had three to four years' experience. The majority of VEWs (n=26, 84%) said that the villages accepted them in their role as a VEW with three advising they were not accepted and two did not know if they were accepted by the village. A total of 30 VEWs said that the VEW model/approach helped farmers to improve their cocoa crops.

6.3.2 Nineteen Village Resource Centres have been established with 12 VEWs saying that one had not yet been established. Eleven VRCs were physical structures with a roof, 1 centre was under a tree and 7 centres were not described. Often VRCs are linked to community farming groups and cooperatives. Each is distinct in its operations and a VEW meeting in 2021 enabled exchanges of ideas and initiatives.

6.3.3 Food crop production and income diversification, including livestock, was promoted in our training of VEWs.
Training was combined with nutrition and sanitation as well as composting and soil management. Goats were introduced to the Hubs for evaluation of their potential as a small ruminant livestock capable of eating wastes from the cocoa block and household, providing manure for composting and as a source of meat. UNRE collected a breeding herd from the Highlands, established a quarantine facility at Kairak Training Centre, and distributed them to our project and to HORT/2014/096.
However shipping delays and poor goat health hampered the progress of this initiative. Despite their popularity and support from local goat breeder Michael Pearson, NAQIA Veterinary Scientist Dr Farrell Magtoto and UNRE Scientists Kathleen Diapong and Charles Maika, the population of goats has not increased. Following his diagnosis of intestinal parasites and possible toxicity (Appendix 9), goats were treated with appropriate medicines and supplements and their health improved. However, the capacity to successfully farm goats on Bougainville remains untested.
With support from our project and HORT/2014/096 ("TADEP PNG Cocoa Project"), UNRE established a Goat Breeding and Farming Centre for research and development of goat husbandry, and have prepared a Goat Husbandry Training Manual. The Manual will be added to the Bougainville Cocoa Farmer's App. UNRE students also started a goat nutrition trial, under Kathleen Diapong, that is continuing.
We recommend a separate goat husbandry project including appropriate expertise in animal husbandry and health to support these initiatives. Such a project would improve the capacity of UNRE to teach, train and conduct research supporting the adoption of small livestock.
The CRG project focussed on vegetable cultivation and nutrition (Appendix 5). The study focussed on 10 villages with significant malnutrition and was designed to improve vegetable

production and nutrition for cocoa farmers through targeted education and training. Changes have included adding gates on kitchens to keep animals out, improved preparation and storage of food, improved collection of drinking water and storage, more nutritious diets. COVID lockdowns promoted the local production of food crops that provided nutrition as well as income when surplus production was sold at booming roadside markets.

6.3.4 Case studies (Appendix 10) show the success of this activity. Many VEWs report that they now have successful businesses arising for the training and opportunities offered through the project. Twenty VEWs have been asked to provide training to non-target villages, with 12 of these VEWs training more than 3 villages each. A total 14 VEWs said they provided an activity for a fee with 17 not charging any fee for the service.
The CRG final report for the CRG project "Initiating vegetable cultivation to improve nutrition in Bougainville" (Project C001486) describes the impacts of promoting vegetable production on nutrition and incomes (Appendix 5).
Based on the emergence of these opportunities, Bougainville Partners, through the Commodity Support Fund (CSF), and the World Bank (through PPAP2) allocated grants to community organisations to promote private sector investment.
Specialisation was a key to engaging youth in cocoa farming enterprises.

6.3.5 Farming systems were recorded in the 2016/17 survey and changes monitored in the 2022 survey. Intermediate surveys were not possible because of COVID travel restrictions. Over the project more farmers claimed ownership of their land, planted new hybrid clone cocoa genotypes and used more youth labour (see 7.1.1). These are encouraging signs for the future of the cocoa industry.
It should be recognised that the pandemic lockdowns of 2020-2022 have independently driven significant changes in farming practices.
Future projects should build in real time monitoring using Comcare applications and tablets, as was successfully piloted with cocoa farmers in West Sulawesi.

Objective 4: To strengthen value chains for cocoa and associated horticultural products

6.4.1 Training at Village Resource Centres promoted improved fermentation and drying practices, and training in bean quality evaluation. With the assistance of CCI, consultants and project staff, VEWs established a range of cocoa fermenters and dryers. Three CB Combination dryers were installed and a number of "Solomons" solar dryers built to improve drying during wet weather.
VEWs experimented with a range of fermentation and drying techniques and times. Farmers awarded prizes during the Chocolate Festival judging typically drained wet beans overnight in bags, used repaired kiln dryers for the first two days of drying, finished by sun drying for several days. Cocoa bean processing techniques are included in the Bougainville Cocoa Farmer's App.
An active trade in wet beans within villages was identified. This is driven by opportunistic harvesting of pods, often by women, for trade for food and other family expenses. While individual volumes are small, consolidating wet beans provides an opportunity to have sufficient volumes to support proper fermentation and good bean quality.
Some villages established central fermentaries and dryers supervised by a person trained in aspects of cocoa quality. These have become contact points for cocoa buyers interested in premium quality beans.
Julie Rereve was trained in chocolate making by Chocolate Festival judges and was scheduled to participate in a week-long training at Jasper+Myrtle in Canberra in February 2023. This training will now be funded separately by DFAT and completed in April 2023.
A Chocolate Laboratory was established and equipment to monitor cocoa quality, including balances, pH and moisture meters was sourced and installed. A range of samples of packaging for final product were provided. This facility was used to train DPI staff and VEWs. In 2022 CSF supported the building of two new cocoa quality laboratories for BACRA – one in Kubu (North) and a mini-lab at Toniva (Central). Simple equipment for growers to undertake their own quality assessment has been provided.
The involvement of cocoa buyers and chocolate manufacturers has been critical in providing feedback about quality during the annual Chocolate Festivals. An entry from Bougainville was awarded Gold at the Cocoa of Excellence competition in Paris, and several other international judging events.

6.4.2 Dry cocoa beans are exported as bulk commodities by Agmark and Outspan, via their export hubs in Rabaul and Lae.
For the five-year period 2018-2022, the project kept daily cocoa prices (Figure 6.2). Given that 99 percent of Bougainville cocoa is grown for the ultimate purpose of selling on the international market, the project tracked international prices. These prices are determined by the stock exchanges in London and New York that trade cocoa futures. They are recorded by the International Cocoa Organisation (ICCO) and are freely available.
Local cocoa prices on Bougainville follow the direction of the global prices, albeit with a lag and at certain times of the year local prices may vary from the ICCO's world prices as traders deal with local issues such as closing out contracts. Farmers receive 80-90% of the market price for dry beans, for example current prices in Bougainville are about $US2,200/tonne which is 87% of the world market price. We found no evidence of excessive profiteering by cocoa traders.
Over the five years, cocoa prices on Bougainville demonstrated two outstanding features: price volatility, and an extremely slow rate of growth (Figure 6.2). Price volatility can be measured in two ways: the gap between the high and low prices in any given period, and the number of times in any given period prices change. Figure 6.2 illustrates these two types of volatility.
Over the five years for which the project kept daily prices, the price of cocoa fluctuated between $US2,000 and $US2,750/tonne, but the trend line moved only marginally from US$2,300 / tonne at the beginning of 2028 to US$2,400 / tonnes at the end of 2022 (Figure 6.2).

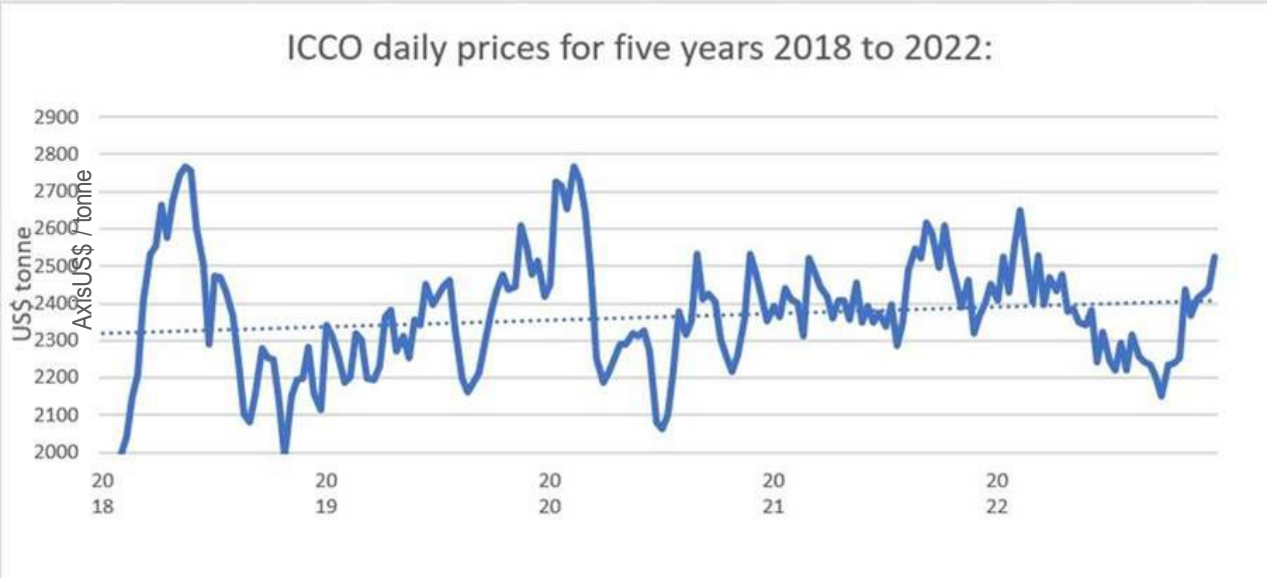

Figure 6.2 Daily cocoa prices monitored by the project

Farmers complain that there was no premium for quality beans in this market. 'Short market chains' directly linked cocoa farmers in Bougainville to speciality chocolate makers in Australia and NZ, and through the Cocoa of Excellence globally. While contracted sales to specialty makers is unlikely to take large volumes of beans, the high prices send a signal to encourage improved quality.
The overall approach taken was to address the lack of knowledge that growers had about cocoa marketing. Documents referred to can be read on the Project Website.
One approach was to produce an irregular cocoa marketing newsletter. Eventually 170 cocoa market newsletters were circulated by the end of July 2022.
A blogsite hosted by the DPI was established https://dpimrabg.blogspot.com/
The project subscribes to an international data source. This will become the sole property of the Bougainville DPI when the project ends. In the process of compiling the graphs in the Newsletters over 1,000 observations have been recorded. This will be given to the DPI.
Conscious that connectivity was not universal throughout Bougainville, the Newsletters were collected into an annual document and circulated in photobook hard copy format. The newsletters are archived on the University project website.
As part of increasing market awareness, a number of studies of world trade in whole beans and cocoa derivatives were circulated. International Trade contains examples of the type of studies undertaken. These were updated when the international data became available.
Presentations were made on how the world prices come about and what this means for Bougainville cocoa producers. More recently presentations on the challenges micro lot marketing

have been made.
Variations of the same format were used to brief officials in Port Moresby from Australian High Commission, Market Development Facility (MDF), PHAMA Plus, and Bougainville Partners.
Many presentations were made to increase growers understanding of how their cocoa becomes chocolate.
The efforts noted above have resulted in growers on Bougainville being more aware of world cocoa prices and the working of the world cocoa market, and help to build trust along the value chain. These have been used as a pricing guide for those undertaking and contemplating undertaking the development of cocoa derivatives for export.
Visits were made to a number of international events partially and fully funded by the project. These included attendance at the Cocoa of Excellence Program in Paris in 2017 and 2019, and the cocoa associations of Europe and Asia. Trip Reports are attached as Appendix 12**.**
International trade data were used to measure the impact of Covid on PNG, and by extension Bougainville, cocoa production. Unlike nearly all other analyses, the project used data from importing countries rather than export data from PNG. The results showed that contrary to expectation overall exports from PNG in Covid-impacted 2020 and 2021 were 40 percent higher compared with non-Covid 2019.. These data have been shared with agencies in Bougainville, Papua New Guinea, and Australia as a basis for policy making for the future.
The project was able to gain international recognition of Bougainville as a separate cocoa producer rather than part of Papua New Guinea. This was cemented by the 2021 Cocoa of Excellence where Bougainville was awarded a Gold Medal. It was also recognised as a separate entity in the Pacific Cup by the Pacific Cacao and Chocolate 2022. This follows visits to the Cocoa of Excellence in 2017 and 2019.
Brochures were developed for market exploration associated with attending the program. Brochures were developed for both missions, Cocoa of Excellence**.** The brochures have been used in other efforts to promote Bougainville cocoa.
Under the project a delegation of ABG, Cocoa Board and UNRE staff visited cocoa grinders in Malaysia and Singapore to understand buyer requirements.
ABG officials visited the Solomon Islands to observe SOLCHOC, the Solomon Islands chocolate festival. Discussions based on commissioned papers were held with experts on grower-based marketing organisations.
The two facets of vegetable production involve quality of the vegetables and income diversification. The latter involves marketing. Preliminary studies were made of the marketing of vegetables at the Buka market as a means of understanding the dynamics of the market and this suggest interventions to improve the process.

6.4.3 Local capacity has been significantly increased through project activities, and project staff are being recruited to DPI and BACRA.
The project partners, PNG-CB and UNRE built capacity through their involvement in the project and developed important links with the industry in Bougainville. The establishment of BACRA was linked to a continuing collaboration with the PNG CB and UNRE as partners in future research and training. Many UNRE students originally from Bougainville were able to undertake practical work components of their degrees and provide a source of DPI recruits.

6.4.4 Forty teachers from primary, secondary and technical schools participated in one-week in-service Cocoa Curriculum training run by the Cocoa Board team at Tununu Catholic mission. Participants were presented with a certificate of participation at the end of the training.
The planned rollout of the CB Cocoa Curriculum (Appendix 6) was delayed by the COVID pandemic shutdowns and subsequent severe drought. Further rollout, supported by the Bougainville Cocoa Farmer’s App, remains a priority for future programs.
Youths (>15) took a larger role in cocoa farming activities over the time the project (Figure 7.1.3) and the Cocoa Curriculum is designed to support better cocoa farming practices.
Students told us they acquired skills they can pass back to their parents, and teachers told us that successfully managed school plots also generated small incomes for the schools.

6.4.5 See 7.5 for a detailed discussion of the Festivals. Training by Bougainville Festival judges developed local expertise in cocoa and chocolate assessment.
The Bougainville Festival was the template for the Pacific Cacao and Chocolate 2022 in Auckland July 2022.
We fostered the development of an Australian cocoa/chocolate association comparable with the European and Asian cocoa associations to act as a conduit for the industry’s opinion to move up

to and down from government. Such an industry association could have prevented the introduction the restrictive and highly unusual trade marking of the term “bean-to-bar”, eventually removed in 2023. Taste and Tell started the development of such an industry body. It should be continued in Australia by Australian chocolate makers.

7. Key results and discussion

7.1 Changes in farming practices

Two surveys capturing data from the same households were completed. In 2016-2017 every household in 33 villages was surveyed. The endline survey was delayed due to COVID travel restrictions and not completed until November 2022. Time limitations obliged us to randomly select five households from the same 33 villages sampled in the baseline survey. Some households farmed more than one block under different tenure arrangements, allowing multiple responses to this question. Comparisons were made by comparing households that had completed both surveys. The biggest change in land tenure were an increase in the number of households that owned their land (Figure 7.1.1).

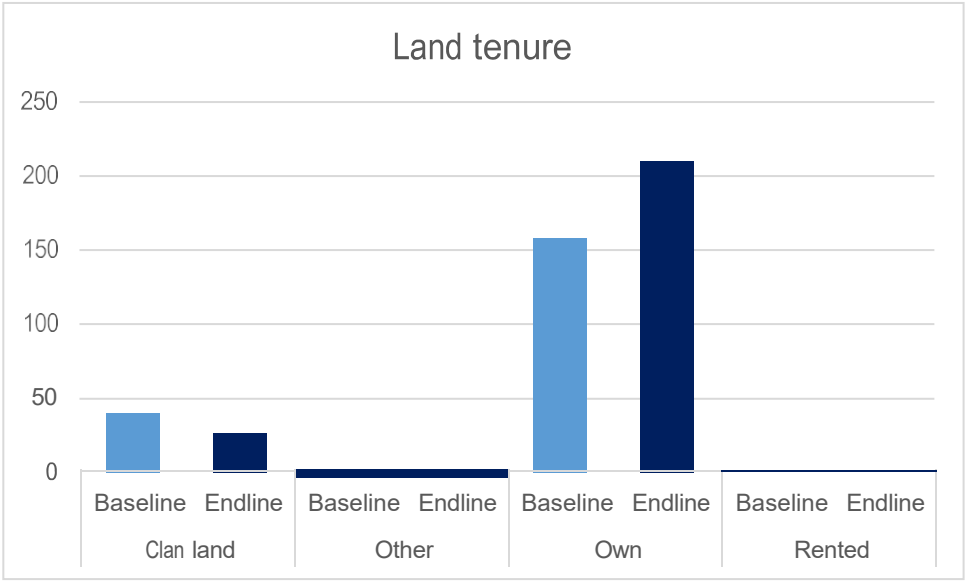

Figure 7.1.1 Changes in land tenure 2016-2022

The type of planting material used indicates awareness of new technologies, the availability of planting material and the willingness of farmers to invest in new planting materials. The most significant change was the increased plantings of the most recent hybrid clones (Figure 7.1.2). This demonstrates the impact of the village nurseries established by VEWs making elite planting materials available to remote villages, and the willingness of farmers to rehabilitate their cocoa when new material is readily available.

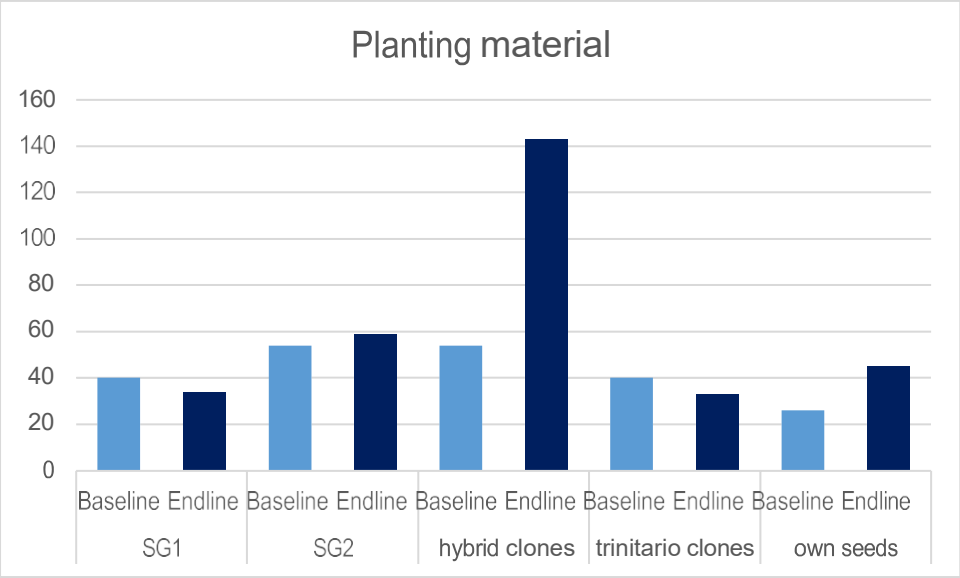

Figure 7.1.2 Changes in cocoa planting materials, 2016-2022

The most significant change in labour was the increase in the number of youths (over 15 years old) and school age children (10-15 years old) working on the cocoa farm (Figure 7.1.3). Many school leavers returned during the COVID lockdowns and have since stayed in their villages. It will be interesting to follow if this is a temporary return or if young farmers are attracted to a more productive cocoa industry. The increased numbers of 10-15 year old children helping on the family farm should be monitored to make sure farm labour is not compromising their education.

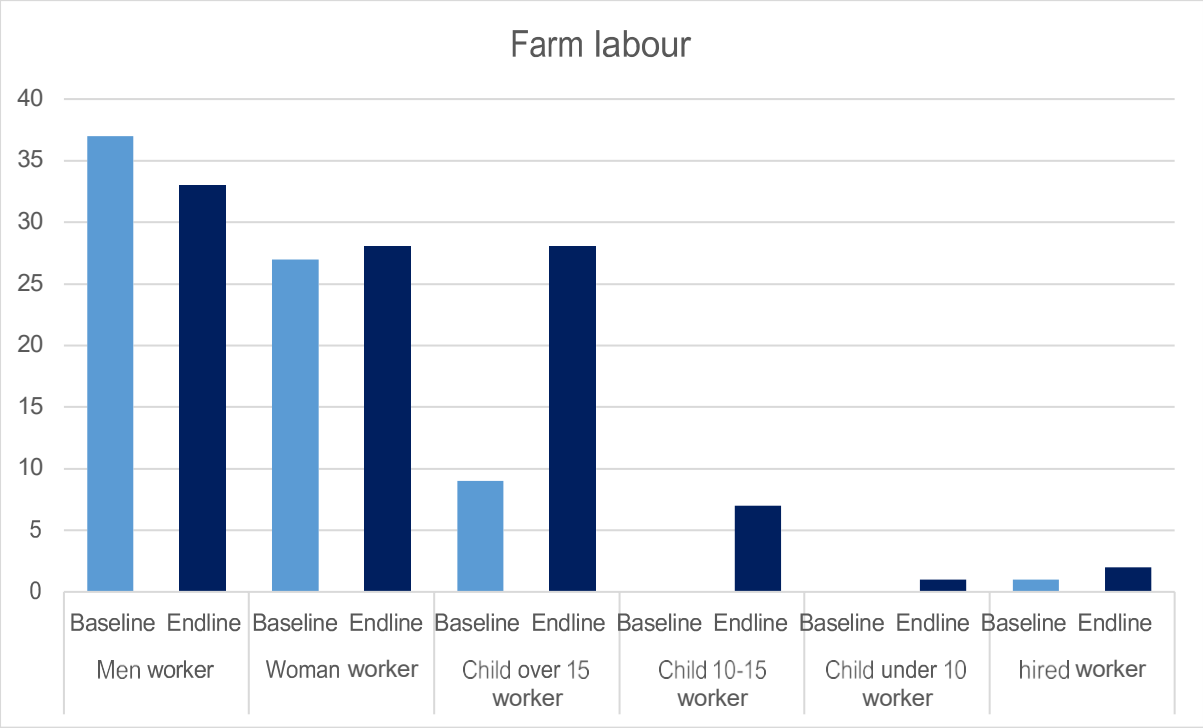

Figure 7.1.3 Changes in the number of cocoa farm workers, 2016-2022

Data from the 16 largest cocoa importers was aggregated to estimate total bean production in PNG between 2010 and 2020 (Figure 7.1.4). Daily bean prices are included to demonstrate that changes in production are not closely related to market price signals. Over the project there was an increase in investment in cocoa in Bougainville, indicated by an increase in investment in land ownership, labour and elite planting materials. Increased production in Bougainville contributes to the increase in cocoa imports from PNG since 2019 (Figure 7.1.4).

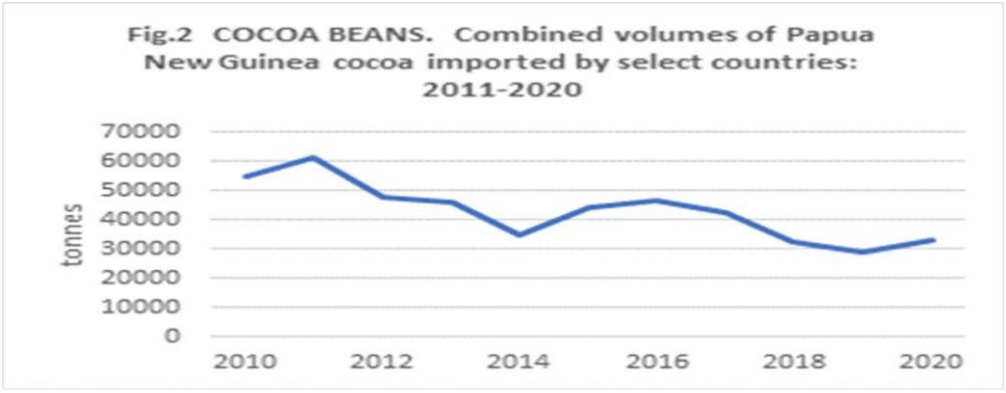

Figure 7.1.4 Daily ICCO prices and aggregated volumes of PNG cocoa beans imported (a proxy for production), 2010-2020.

7.2 Cocoa processing and marketing

The festival judges identified smoky beans and under- or over-fermentation as the main quality problems. Smokiness results from defective kiln dryers. During the project the solar combination dryer was introduced to produce premium quality (Gold award winning beans) as certified by the Cocoa of Excellence program led by the Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT), part of the CGIAR and organized in partnership with the International Cocoa Organization (ICCO), and other stakeholders. The main lessons learnt were:

1) Better fermentation practices. Wet beans were allowed to drain excess mucilage (Cocoa juice) overnight, then turned daily. Temperature was monitored to maintain 45^0C daytime/280C nighttime temperatures in the fermenting heaps. The optimum fermentation time was 5 days.
2) Monitoring and Controlling Kiln and Solar drying process (See also fermentation & Drying sections on the Bougainville Cocoa App). The first 2 days of drying was critical to prevent mould growth

Data from Chocolate festival samples shows all award winners have used a combination of kiln and solar drying, making sure the beans are not contaminated with smoke in the first 2 days, a process called ‘Skin dying’. After 2 days the beans are sun (Solar) dried) where the beans are spread on a canvas and turned regularly until dried to 6-7% moisture content.
The current Cocoa Board marketing system licenses two traders- Agmark and Outspan. Beans collected from Bougainville are shipped to Rabaul or Lae and bulked with beans from other sources for export. Accurate figures for Bougainville cocoa production are not available, but data from buyers indicates a modest increase in Bougainville cocoa production since 2019 and anecdotal evidence suggests further increases in cocoa production since then. Only when BACRA starts keeping accurate records of Bougainville production will the true size of the industry become clear.
An analysis and explanation of cocoa price trends was included in the 170 Cocoa Market Reports circulated. Price volatility and uncertainty provides an explanation of the reluctance of farmers to invest in cocoa, and the reluctance of lenders to lend. These Reports were widely circulated and stimulated many discussions with stakeholders.

7.3 VEW Model

Establishing a “hub and spoke” network (Hafid and McKenzie 2012) to support cocoa farming communities has built capacity at all levels. The Village Extension Worker (VEW; also supporting food crops and livestock) network, the Bougainville Cocoa and Health Facebook page, the Bougainville Cocoa Farmer’s Mobile App and the DPI Blog have extended the reach of the ABG into remote areas of Bougainville. Hub managers made a total of 124 training visits to the VEWs with 14 VEWs saying they had more than six visits from a hub manager. Fifteen of the VEWs said they received no visits from the hub manager. Future projects should develop training schedules to ensure all VEWs and communities receive regular support.

Our insistence that VEWs be trained, but not salaried project staff originally met scepticism. Rather than encouraging rent-seeking salaried staff, our approach of training volunteers has led to the emergence of a cadre of professional trained consultants and service providers who are available to their own, and other villages in Bougainville. Examples of VEWs who have used their training to bring their communities together or establish small enterprises are available in Appendix 10 and on the project website https://cocoa- research-science.sydney.edu.au

Village Extension Workers (VEWs) were interviewed in 2022 to ascertain their experience as a VEW working with a range of villages in their Village assembly (Appendix 8). Of the original 33 VEWs, 31 answered the survey. Of the 33 originally appointed 22 were still active. Five had been in the position for less than two years and four VEWs had three to four years’ experience. The majority of VEWs (n=26, 84%) said that the villages accepted them in their role as a VEW with three advising they were not accepted and two did not know if they were accepted by the village. A total of 30 VEWs said that the VEW model/approach helped farmers to improve their cocoa crops. One person did not know if the model helped the farmers.

VEWs were the most important source of training given to farmers in Bougainville (Figure 7.2.1). Other training given through this project includes FFT, Cocoa Board, UNRE and DPI. VEWs also trained other organisations including CARE.

Figure 7.2.1 Exposure to past and current farmer training activities (2022)

VEWs had contact with a total of 129 villages during the life of the project (Figure 7.2.2). Some VEWs were more active than others, but the majority of farmers received training in all villages. Wakunai received no training as they left the project due to an unrelated matter. Twenty-eight of the VEWs said they understood what their role was and felt prepared to take on the role when they were appointed. Sixty-eight percent (n=21) said they felt supported during their time as a VEW with 10 (32%) stating they did not feel supported, particularly during the Covid lockdowns when travel was impossible.

All VEWs (n=30) but one used cocoa rehabilitation techniques when training farmers. In the 6 months prior to the survey VEWs had conducted over 102 training sessions. In the life of the project VEWs said they had conducted more than 416 training sessions on the following topics set out in Table 7.2.1. The number of training courses on each topic are shown in Figure 7.2.3.

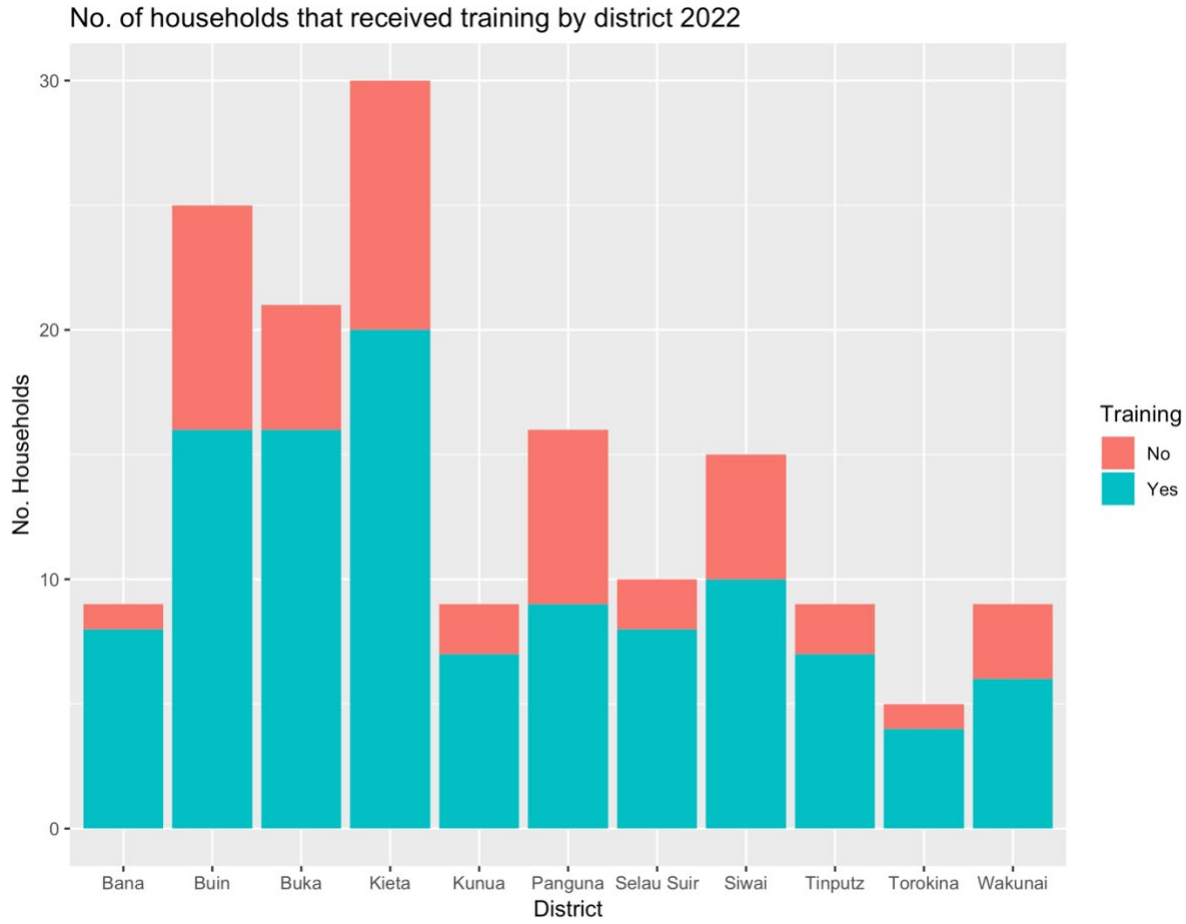

Figure 7.2.2 Number of households trained by VEWs in 2022

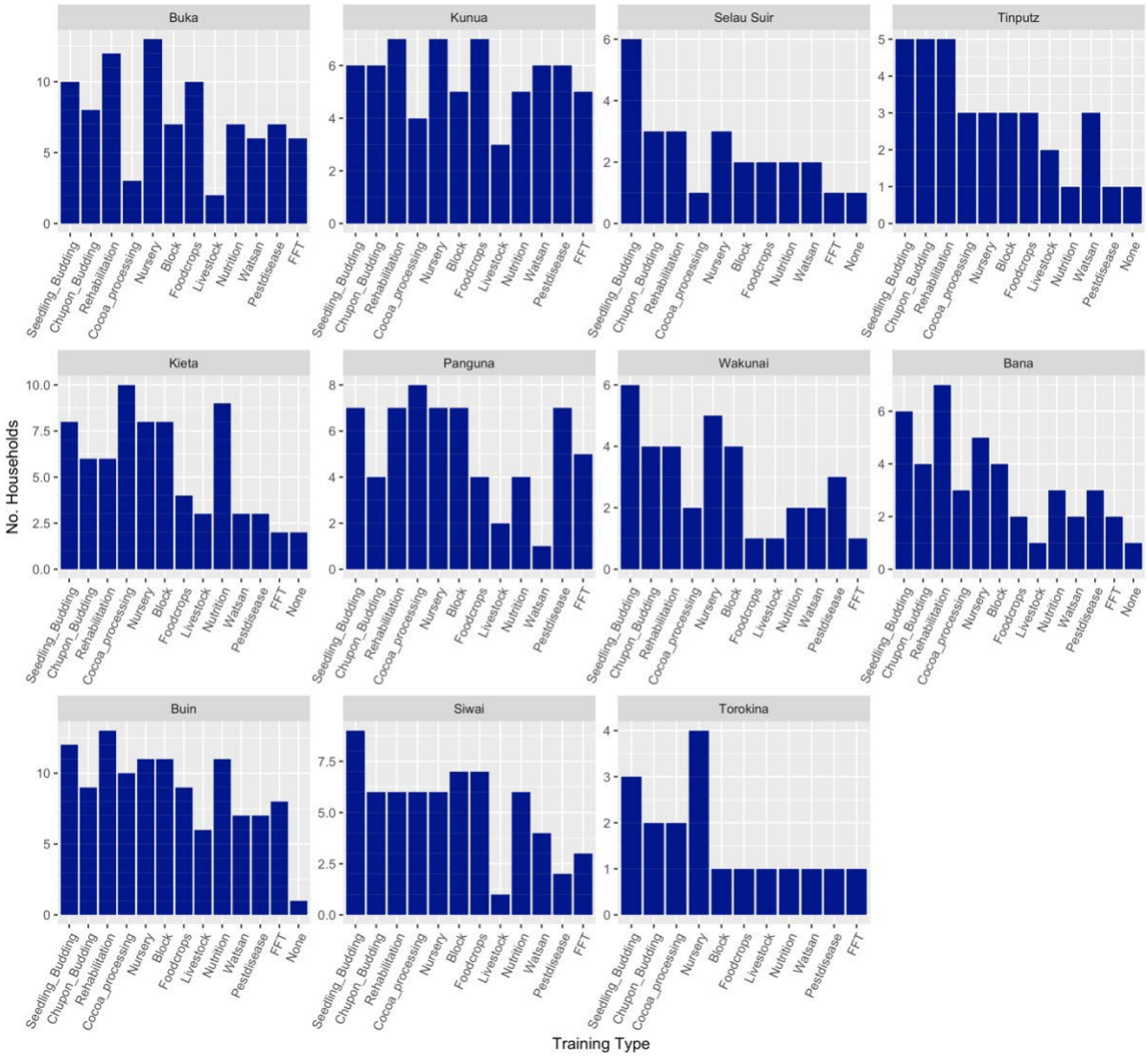

Figure 7.2.3 Number of households that received training from VEWs, by District and topic

Table 7.2.1: Farmer Training session topics

TOPIC	NUMBER OF TRAINING SESSIONS CONDUCTED BY THE VEWS
BUDWOOD GARDEN ESTABLISHMENT AND MANAGEMENT	28
COCOA MANAGEMENT	26
Ipdm TRAINING	25
NUTRITION	25
ESTABLISHING A nursey MANAGEMENT	25
COMPOST MAKING AND APPLICATION	23
HYBRID CLONES	21
FAMILY farm team TRAINING	21
FERMENTATION	19
DRYING	19
GRAFTING	16
VEGETABLE SEED PROPAGATION AND MANAGEMENT	16
CHEMICAL HANDLING	15
ORGANIC INSECTICIDES TRAINING	13
LIVESTOCK	12
FINANCIAL LITERACY/SAVING MONEY	12
HEALTH AND DISEASES	12
WATER	10
SANITATION	10
OTHER PRUNING WEEDING cocoa QUALITY VANILLA TRAINING IN HAND POLLINATION organic INSECTICIDE	10
PIG NUTRITION TRAINING	6
RICE PROPAGATION	4

Twenty VEWs said they were asked by villages outside the project to provide training in IPDM. Twelve VEWs had more than 3 villages request training, six VEWs had three villages requesting training, one VEW had two requests and one VEW had one request.
Women were included in the training by 27 VEWs with 3 VEWs saying that no women were included in their training. Those that included women in training said that women were interested in food security and nutrition as well as cocoa management. The comments below were in response to the following survey question “How did you encourage women to be involved?” Quotes from VEWs when asked about their experience of training in the 2022 survey included:

> “*Cocoa farming is not only for man, women. Family must work together with man, learn new skill and make money for yourself”.*
>
> *“I encourage them to attend training because this will help improve production, improve income, family living standards”*
>
> *“Women were encouraged by telling them how Important the training is and that what gained from the training will help their family and improve the way they do things within their household”.*
>
> *“I always tell women that they are the manager of the household and that its important that they come and attend all training”.*
>
> *“Women were encouraged to be involved especially in cooking nutritious food eg steaming vegetables and not overcooking”.*
>
> *“I always encourage women to come attend training because it would be beneficial to them as women mainly look after the family and manage their household and they are more attentive. I mainly make announcements for training after church”.*
>
> *“I do not encourage women to come and attend. I only relay message to them that there is going to be training conducted on a particular topic and it’s up to them to attend depending on their interest”.*

All 31 VEWs said they had developed new activities in their role as a VEW. The following Table 7.2.2 describes the activities and the number of VEWs who initiated them.

Table 7.2.2: Activities initiated by the VEWs

Activity	Number of VEWs who initiated the activity
Cocoa bud wood garden	27
Demo cocoa block	23
Cocoa nursery	22
Cocoa IPDM block	20
Poultry house	18
Compost hut	18
Vegetable greenhouse/ plot	16
Demo vegetable farm	13
Vanilla garden	11
Copra dryer	8
Accreditation of budwood garden	8
Goat house	7
Combination dryer	6
Cooperative	6
Clan treasury	6
Rice propagation	3
Other Fermentary Budgeting and infrastructure of the village Balsa Piggery Goat house	4

A total 14 VEWs said they provided an activity for a fee with 17 not charging any fee for the service.

Quotes from the VEWs:

"*Fees were charged for belonging to the group and then the money was used to supply tools to my group of 25-50 farmers".*

"Charged 1 kina a tree for pruning. Training on pruning is free".

"Sold a goat for 1000 kina"

"Sold Vanilla"

A large majority (n=27) said that the farmers valued the advice the VEW provided them. Two said farmers did not value the advice and two did not know.

A Village Resource Centre had been established by 19 VEWs with 12 saying that one had not yet been established. Eleven resource centres were structures with a roof, 1 centre was under a tree and 6 centres were not described.

A mobile app, built to support VEW activities, is described in Figure 7.2. The mobile application was released in mid 2022 and only 2 VEWs had downloaded the app onto their mobile phones in November 2022. Awareness of the app, particularly amongst tech-savvy youth, is spreading. The development of the mobile application, and the Village Volunteer Program, are now available for a new project to implement and evaluate their effectiveness and utility. We recommend that VEWs be offered a credit voucher to cover the costs of downloading the App.

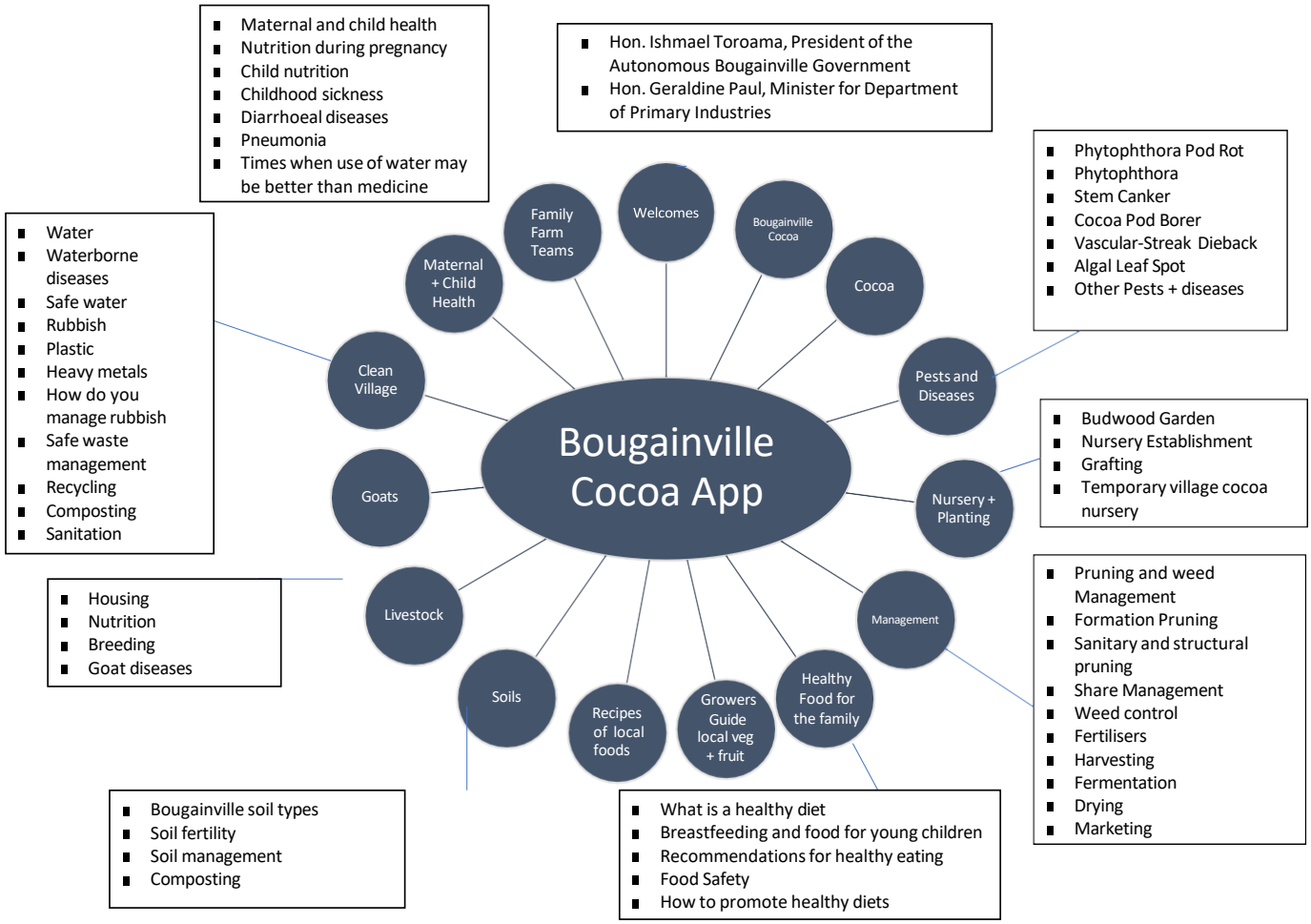

Figure 7.2.4 Breakdown of the design of the Bougainville Cocoa Farmer's App.

What worked well

VEWs were asked to talk freely about what they thought about the project. They identified what worked well as well as identified areas for improvement. Table 7.2.3 identifies the themes of what worked well. Table 7.2.4 identifies themes around need for improvement.

Table 7.2.3: What worked well for VEWs

The top 5 themes centred around better cocoa and vegetable cultivation, coupled with a changed mindset about managing money and improving livelihoods.

Quotes from the VEWs:

"Improving cocoa, cocoa management improvements. Learning to budget and manage money. Engaged youth to work on the block"

"Family farm teams encourage and promote cocoa fermentation and drying helping families be more organised more structure to the villages benefit to way think and approach daily activities".

"Improvements in cocoa change in farmers mentality/ more proactive. VA better organised, good governance improvements in health WFD stalls and selling produce".

"Farmers slowly cooperated, farmers learnt new techniques for farming and cash economy is improved in the village, cocoa production improved, farmers now have income and living standard improving now".

"Cocoa trainings, establishment of budwood garden, nursery seedling propagation & distribution".

"About 10% of the farmers in the VA now own a cocoa block which in the past never own a block. They also know how to manage the cocoa block to an extent and have also gone into integrating various food crops with cocoa"

"The hub coordinator has assisted the women well in establishing vegetable crop gardens in their garden which has greatly enhanced food security in the household and also sustain their livelihood. At times they also sell some of their garden produce".

"I like the project very much. Especially the training on composting and regular visits by hub manager who takes lead in the conducted training and also demonstration of bokashi composting. As a VEW, I have gained knowledge and skills in composting. The project has brought farmers to cooperate and work together as one. Youths are now going into poultry and selling local chickens".

"Health & Nutrition assisted with malnutrition at Kikimogu".

"Farmers are satisfied with the trainings conducted esp for cocoa trainings which has greatly enhanced productivity of cocoa in the VA for active farmers. Farmers have become more productive as they are now utilizing skills/knowledge gained to make vegetable gardens and faith gardens to improve food security at home".

"One thing good about this project is that not only training on cocoa was conducted but also on vegetable crops and health and nutrition which really improved our livelihood at household level".

"I have farmers who have practised what I have taught them and they have become more successful and wealthy from their incomes earned from the farm".

"The project has brought a lot of improvement and positive changes in the ward at household level".

"Most farmers now own new cocoa blocks through the ACIAR project and know how to better manage the cocoa blocks as a result of the trainings conducted for cocoa production and management. They now practice IPDM and other cocoa management practices learnt in the trainings

conducted. Farmers have also gone into vegetable gardening because of the training conducted on vegetable gardening".

Areas in need of improvement

The main concern identified by the VEWs was the lack of working tools to conduct the training followed by the problems caused by the Covid lockdowns, access to remote locations (scattered and hard-to-reach villages) and lack of a regular training allowance (Table 7.2.4). Many VEWs kept the tablets they were provided with during the baseline survey but these need to be replaced regularly. The VEWs also wanted more assistance from the Hub Managers and the Department of Primary Industries. One very productive VEW had all his work destroyed in an unrelated dispute. The VEW subsequently left this VA and was not replaced.

This feedback indicates that scaling up the VEW model in future projects should include a "start-up kit" and be well- supported by Hubs with dedicated and adequately resourced Managers.

Table 7.2.4 Areas of VEW support in need of improvement

Themes	Number of VEWs who made a comment
Need tools to implement training (inc mobile phone)	6
Need more assistance from DPI/hub managers	4
Scatted villages Mountain villages need more opportunity	4
No regular incentive allowance	4
Training promised but not delivered/cancelled	3
Struggle to get farmers engaged with cocoa management/training	2
Transport cocoa to market difficulties	1
Customary land issues	1
Lack of support from village to establish dryer	1
Destruction of materials/work	1
Interference of other NGOs	1
Political support required	1
More food security training at village level	1
Training on goats	1

"Need tools to implement training budwood knife knapsack pole pruner more visits from hub managers to provide more information continuous visits would have great impact on the farmers. the visits keep them motivated".

"Farmers need new tools, VEW has tools for training, VEW not paid allowance regularly, customary land issues, transporting of cocoa to market so we need freight subsidy"

"Training for compost never done, goats not given to VEWs, no allowances at times, lack of logistics and mobility".

“One of the best VEWs set up research centres and a relative destroyed everything _ compost house, solar dryer budwood garden nursery He became very depressed and left the village”.

“Farmers expected to be given things and explaining that the training was to give them knowledge”.

“Trying to set up a nursery/have no tools and materials/have to use own tools”.

“Cancelling of organized or planned training by the Hub Coordinator without notifying VEW and without proper update”.

“Capacity building for VEW so he can perform his role as VEW to provide and also organize training to/for his farmers. The VEW feels that their needs to be more training conducted for VEW and also assistance with setting up of facilities such as resource centre and assistance with setting up of demonstration block to accommodate and assist with facilitating of training in the VA”.

“The VEW expressed the need to have another VEW in his ward to assist him with work as most farmers are scattered about and not in one village and most time he is busy”.

The Hub Managers

The hub managers also responded to a survey about their role. Two of the three hub managers had been appointed on commencement of the project with one hub manager being appointed three years into the project, having replaced the hub manager for the North. All hub managers had contact with more than five Village Assemblies. All three were very familiar with their role and the requirements of the position. They also said they were supported in their role by the project coordinators and felt supported by the Bougainville project coordinators. They confirmed that the villages accepted them in their role. All three hub managers had used cocoa rehabilitation techniques.

All three hub managers expressed strong support of the VEW model and the One Health approach to improve cocoa farming; but that greater support would improve the model further. In the last six months hub managers said they had conducted more than 6 training sessions for VEWs. Their activities included cocoa husbandry training, vegetable seed distribution to VEWs, family farm training, coordinating and combining monthly advisory visits to VEWs including cocoa board and UNRE officers. Overall all three said they had each conducted more than 20 training sessions covering a diverse range of topics. Each said that about three villages (not in the selected 33 VAs) (n=9+) had approached them requesting training.

In response to a question about how they encouraged women to attend training the following is a summary response..

“ I advised the VEWs that every women had the right to contribute to the decision making in their household and told them they had to encourage women to attend trainings also”.

Hub managers said they charged a fee for some of their activities including cocoa nursery and accreditation of the budwood gardens. Overall the hub managers thought that the VEWs valued the service provided. They confirmed the establishment of the Village Resource Centres in 19 VAs. All three had downloaded the mobile application but were yet to become familiar with it or use it in their work.

In response to a question about what worked well the following comments were made:-

“Farmers adopted new skills especially on cocoa management.”
“They are now selling dry cocoa bean bags and earning value”
“Farmers are now happy to know how to manage their balanced diets, planting the right crops to sustain their income.”
There is greater awareness of health and hygiene in the community.”

“Farmers are now sending their children to schools and contributing to donating funds to churches, schools and on cultural obligations”.
“Homes have better kitchens, building pit latrines, better drinking water which is stored more safely”

The hub managers commented that “*farmers are selling more cocoa both wet and dry beans. They have also built proper houses and not spending more money on medical costs.”*

In response to an open question about any comments they wished to make:

‘More supervision so I can identify my weaknesses”
‘Transport availability was a disadvantage after the North Bougainville hub manager project vehicle was wrecked in 2019’.
‘Being unable to meet with the VEWs due to shortage of funds was a challenge’.
“The participartion of DPI and health staff was poor.”

One hub manager commented “ *My renumeration package was too narrow without any savings included.. and no risk allowance as well.” “There was also no petty cash for daily tasks”.*

Conclusion
Overall, the VEW model was successful with the majority of VEWs remaining in their role notwithstanding the challenges that COVID bought and the limitations on travel and training for two years.
The approach used in this project was not to distribute free tools and equipment to farmers, as this model is fundamentally unsustainable and undermines local business. VEWs were trained and an allowance provided for tools, mobile phones and basic equipment to establish VRCs and support their local travel and expenses. Future projects should provide start-up assistance for VEWs, and ensure that new VEWs also receive support packages and ongoing support for local travel and training expenses. Nevertheless, despite the small allowances there was a very low overall attrition rate of VEWs over the life of the project and VEWs were strongly supportive of the hub and spoke model.
While the succession of VEWs in some VAs suggests VEWs establish their own businesses based on skills learned from the project, it may also have meant that some later-appointed VEWs missed out on receiving the start-up support provided to the foundation VEWsl
The VEWs as early adopters have proved that this model works and is one sustainable and appropriate for Bougainville. This project has established that the VEW model with the changes suggested by the VEWs is one that could benefit all cocoa farmers in Bougainville and elsewhere. VEWs will be formally recognised for their efforts early in 2023.
Lessons learned for future work:-

- Need to expand the number of VEWs to share the workload and demand from farmers. The demand exceeded our expectations creating pressure on the VEWs.
- Improve engagement with DPI officers
- Provide orientation, intensive training and refresher training for VEWs. (This was planned but limited due to Covid).
- Support the VEWs by providing a start- up kit. (mobile phones, tools and farming equipment for training, tablets for monitoring training.)

7.4 Livelihood surveys

Our comprehensive survey of cocoa farming villages in 2016/17, including data on 12,397 people identifying as members of cocoa farming families, provided a snapshot of the lives of those families.

While only families identifying as cocoa farmers were included, a high proportion sold no fermented dry beans directly to traders. Further discussions with communities revealed an opportunistic, active informal trading system for wet beans within villages. As a result, monitoring the number of bags of dry beans sold underestimates individual family production.

The wealthiest and healthiest families received significant amounts of “off-farm” income, primarily remittances from family members. Children leave villages for high school and often do not return but seek employment in towns and cities, depleting available labour in villages. Increasing reliance on remittance income disincentivises aging farmers from investing in better farm management and higher farm incomes.

Overall average wealth did not change (2.8 in both surveys), but changes were seen in individual villages (Figure 7.3.1). The biggest decreases in poverty were seen in Selau and Central Bougainville. Noticeable increases in poverty were observed in areas that were experiencing a severe drought at the time of the 2022 survey.

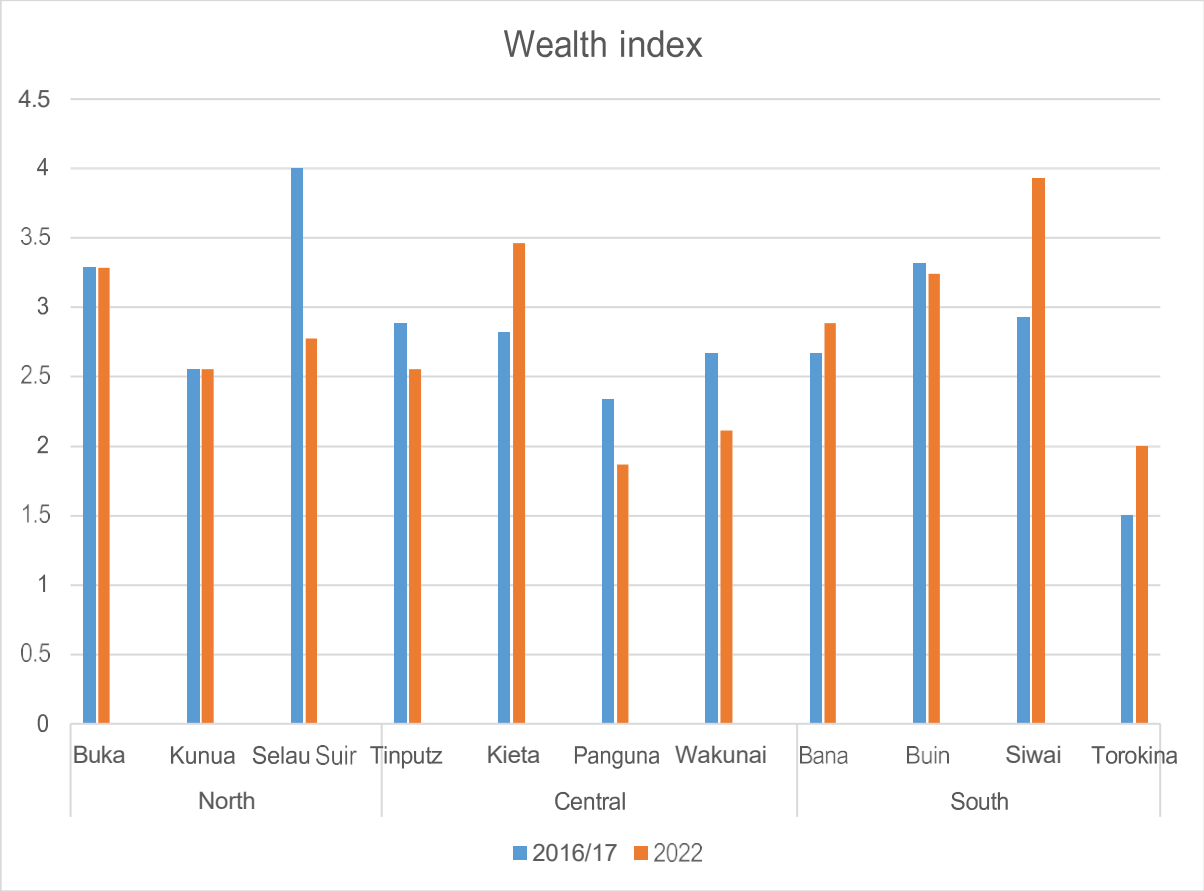

Figure 7.3.1 Changes in the Wealth Index in 11 districts across Bougainville, 2016/17- 2022. 1 = wealthiest; 5 = poorest.

Very high rates of childhood stunting were confirmed in the 2016/17 survey and linked to diet and poor sanitation. A consequence is that malnourished children are more likely to have poorer schooling performance, become a poorly educated workforce and vulnerable to chronic adult diseases. When this level of malnutrition was identified we developed a small research project with additional funding from DFAT to inform communities of nutrition and health risks. These interventions were a partnership between the project team, and the ABG Departments of Primary Industries, Health and Local Government. Information on improving health and nutrition became an important component of the Bougainville Cocoa Farmer’s mobile app and FFT training. Food crop production became an important source of income for farming families, particularly for women.

Changes in Food Security Index showed an overall increase in food insecurity between the two surveys (Figure 7.3.2). We believe this reflects the severe drought affecting North and Central Bougainville at the time of the second survey and the residual effects of COVID shutdowns. Food crop production and roadside market stalls flourished during the lockdowns, stimulated by returning labour and increased demand for locally-produced food. As lockdowns eased in 2022 labour returned to off-farm employment, and combined with the drought this led to reduced food crop cultivation and short-term food insecurity.

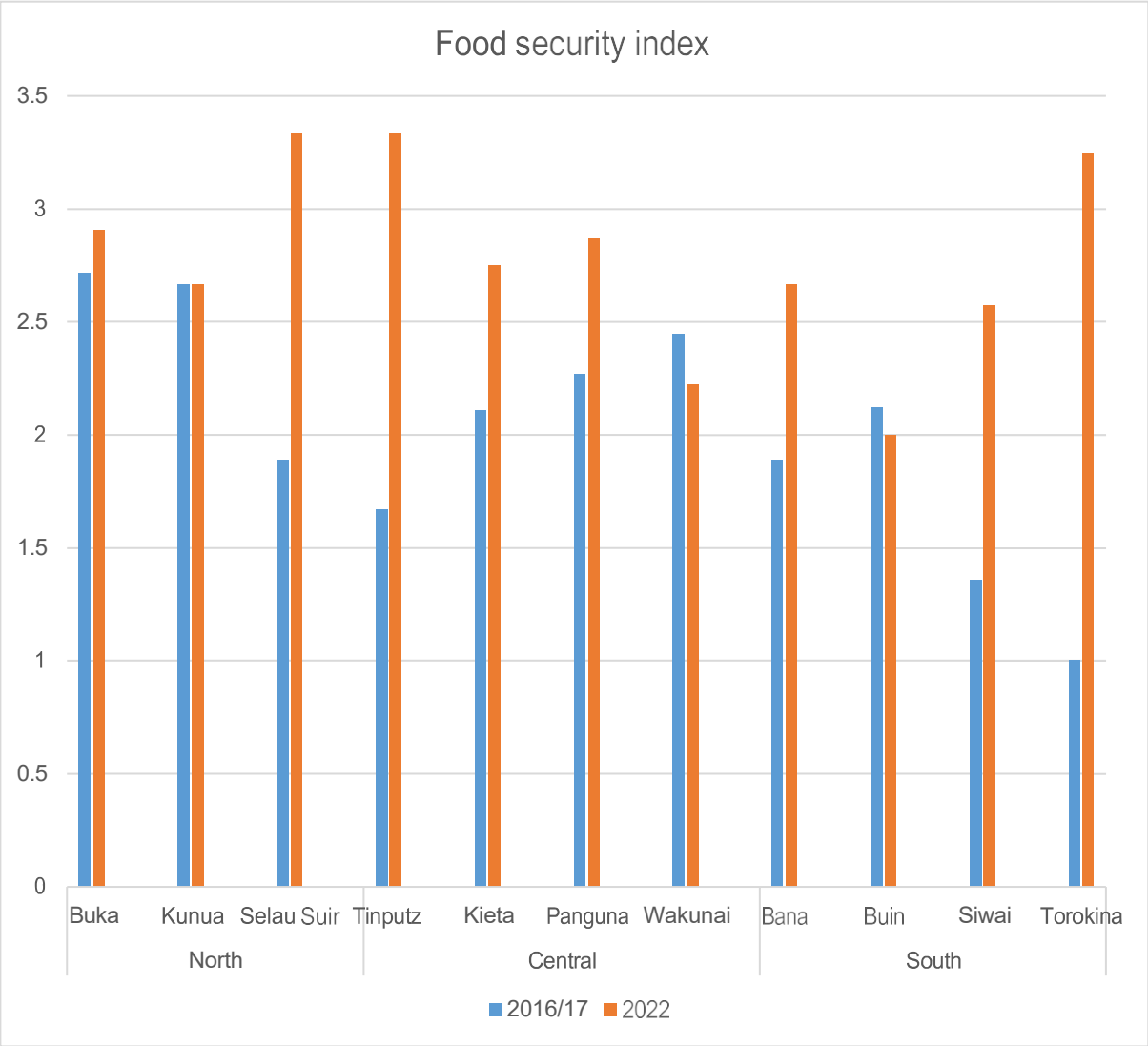

Figure 7.3.2 Changes in food insecurity in districts across Bougainville, 2016/17-2022. HFIA food security index: 1 = Food secure, 2=Mildly food insecure, 3=Moderately food insecure, 4=Severely food insecure.

No consistent changes were observed in the Dietary Diversity Index (Figure 7.3.3).

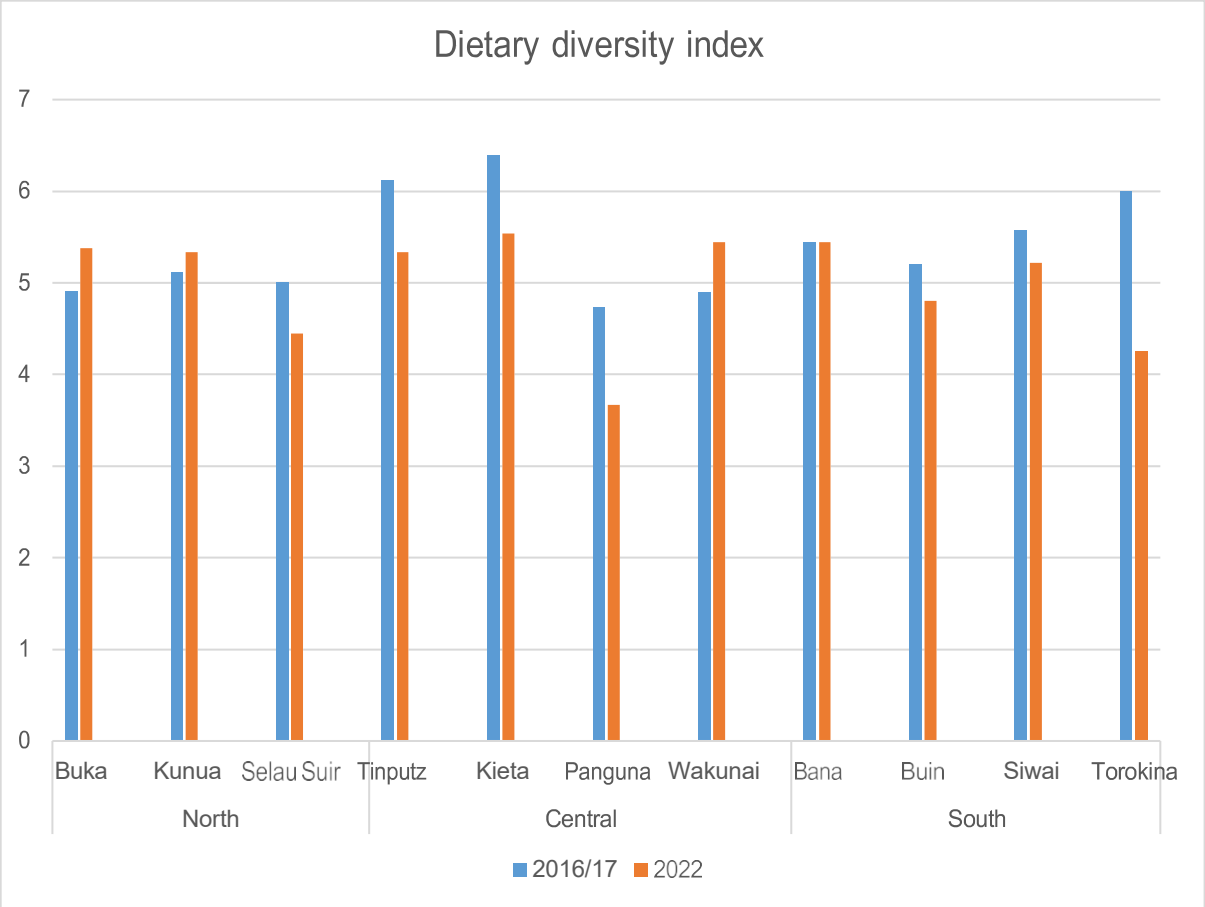

Figure 7.3.3 Changes in Dietary diversity index across Bougainville, 2016/17-2022

7.5 Community resilience

Family Farm Teams training was fundamental to establishing successful village-level programs. FFT training develops trust, gender equity, communication skills, sets family and community goals and empowers families and their VEWs to arrange assistance for farming and health initiatives. For example, several village groups within this project were able to access funding for processing equipment and tractors from the Bougainville Partnership CSF program.

FFT Training was delivered to communities in 33 VAs including 360 women and 396 men (Appendix 11).

Training was delivered under the supervision of Dr Josephine Saul- Maora, a certified FFT trainer and cocoa research scientist. She was assisted by Robert Tuala before the Covid lockdowns. Dr Saul trained staff in the DPI (Julie Rereve and Bradley Tiva) who also became accredited FF trainers. TADEP funded FFT training in Buka in 2021, run by Dr Saul-Maora and Ian Viore from Bougainville Youth in Agriculture. Hub Coordinators and staff from both DPI and Health were trained as accredited trainers who trained village members and continue to meet requests from other villages for FFT training programs.

Our observations of the response to COVID-19 lockdowns also support the proposition that labour limits productivity. Some commentators predicted food shortages in villages when relatives returned from former jobs in towns and cities. However, our observation has been that this returning workforce was young, healthy, better educated and more, reducing reliance on imported (usually processed and low value) foods. Cocoa production in most Districts is reported to have increased following block maintenance initiated during COVID lockdowns (Figure 7.4.2). The exceptions were in Districts with opportunities for off-farm employment (Buka, Kieta and Panguna), and in parts of the Central region that were badly affected by drought and cocoa pod borer (CPB) damage at the time of the 2022 survey.

Interestingly, our analysis of family income showed that reliance on remittance income had

increased pre-COVID but this income source vanished with lockdowns. With an influx of productive labour and the disappearance of remittance income, farming families had new incentives to invest in food and cash crops. Whether the returned labourers will stay on the farm and maintain production levels is uncertain.

The COVID-19 pandemic highlighted the vulnerability of urban and rural communities on remote Pacific Islands to food security disruptions (Diao et al. 2021; Iese et al. 2021; Robins et al. 2020). However, our observations of rural cocoa farming communities in Bougainville shows the local response to the pandemic had little impact on food security.

The rapid lockdown of the island of Bougainville in 2020 helped limit viral spread. The lockdown also closed regional food markets. However, the 80% of the population who identify as cocoa farmers also produce food crops and are insulated from disruptions to the supply of imported foods. Sales at local roadside markets and informal exchanges of surplus domestic food crop production supplemented incomes and home-grown supplies of food.

We have shown previously that labour is a significant constraint to improving crop production, with poor education and health the biggest constraints to labour productivity (Walton et al. 2020 One Health 10, 100142; Walton et al. 2020 One Health 10, 100143). Significantly while the predicted return of migrant labour from urban centres increased the demand for food, this relatively young and healthy workforce can potentially introduce new skills, innovations and labour, all of which contribute to increasing local food supplies (MIJARC/IFAD/FAO 2012). Increased attention to food gardens can also decrease the reliance on imported foods. Returning family members bring new experiences and skills and are less risk averse to the adoption of new technologies.

The influx of labour has also helped commodity crop production, in defiance of the anticipated slump in markets. Commodity crops provide cash income in rural villages that is essential for local transport, medical care, school fees, clothing and food. Spending this cash stimulates town and Provincial economies. Once again, the returning young farmers have rehabilitated farms and increased production. By and large, export markets remain robust and prices unchanged.

In many ways the local response to COVID-19 pandemic has demonstrated a resilience buffered against the globalised economy. This supports our One Health proposition that the poor education and health of rural smallholder farming communities limits their adoption of good farming practices and thus productivity. Investment in improved access to education and health services should be a priority that results in more productive, healthier and more food secure communities, particularly in remote Pacific Islands.

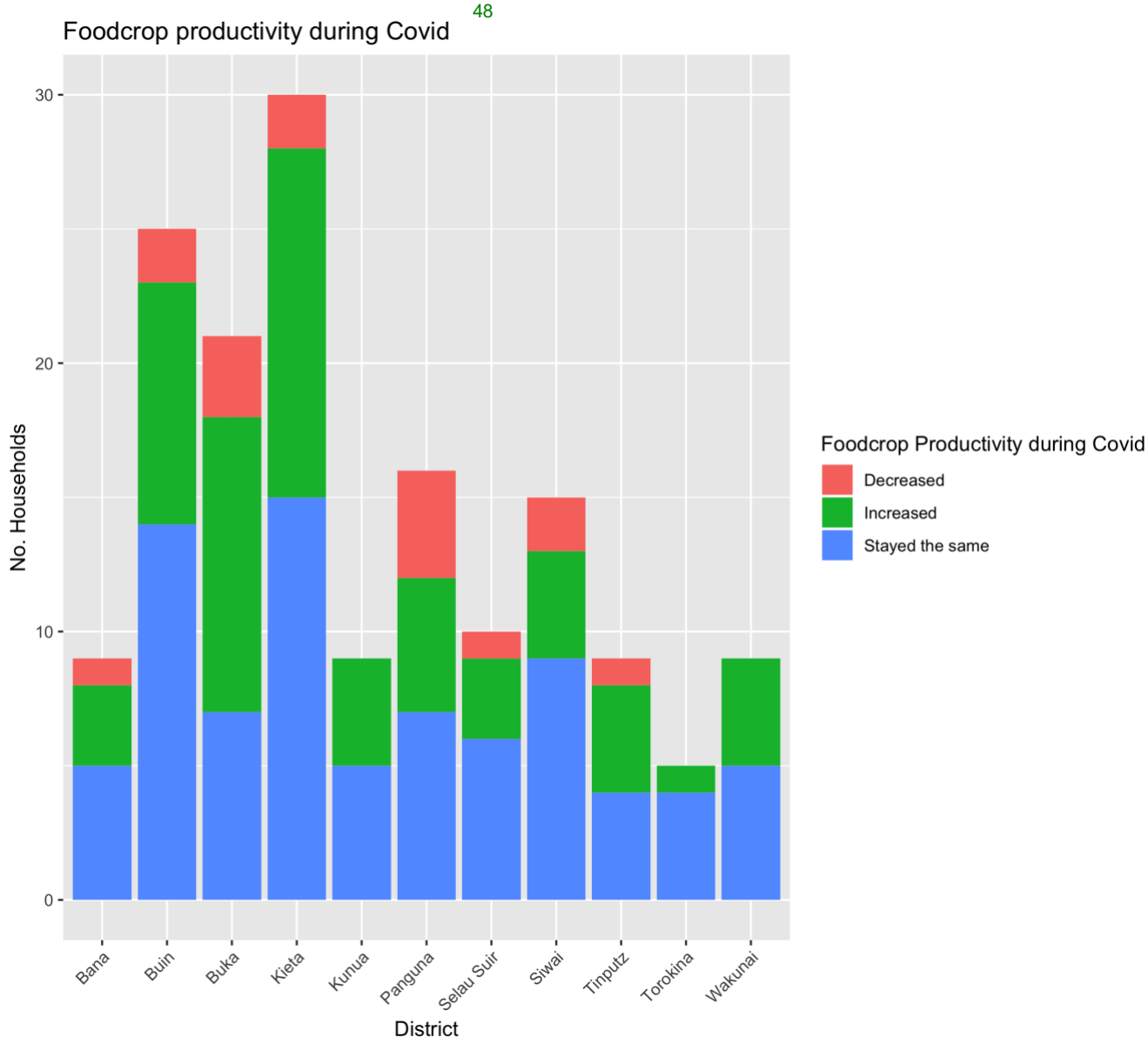

Figure 7.4.1 Productivity changes (reported volumes) in food crops during Covid lockdowns reported by farmers from 11 districts in Bougainville, 2022.

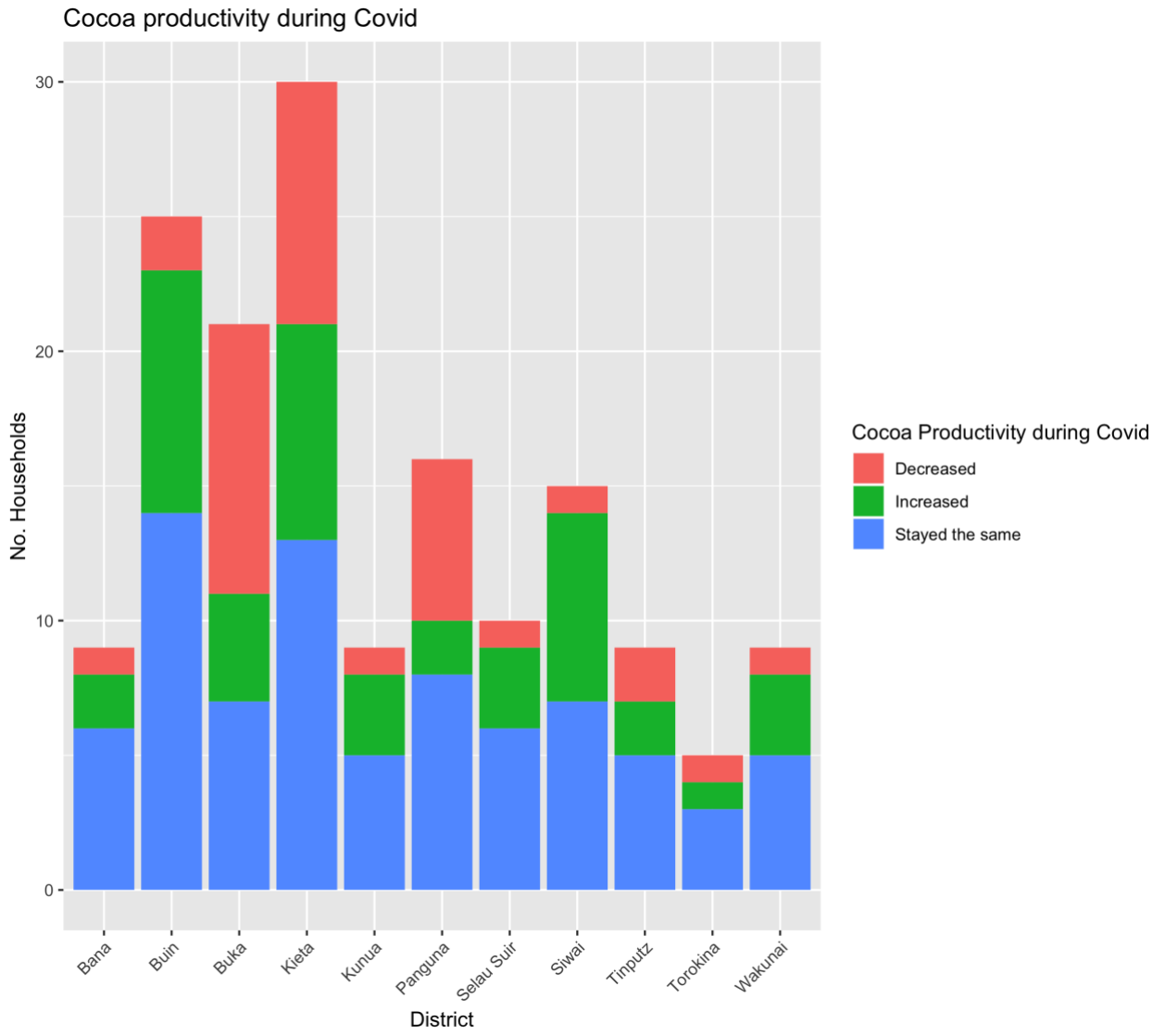

Figure 7.4.2 Productivity changes in Cocoa during Covid lockdowns reported by farmers from 11 districts in Bougainville, 2022.

7.6 Chocolate Festivals

We sponsored and organised annual Chocolate Festivals that are now a model for others in PNG and the Pacific region (Table 7.5.1). The festivals celebrate cocoa farming and promote understanding of cocoa farming and processing, as well as promoting healthy livelihoods and prosperous villages.

The annual Chocolate Festival had many good outcomes that were never expected at the start. In the first two years (2016 & 2017) there was not much data for bean assessment as there was no local capability to assess bean quality or local processing of chocolate samples. Chocolate sample processing was done by Paradise Foods (Queen Emma) in Port Moresby. Since 2018 with the setting up of the mini-chocolate lab was established for processing chocolate samples locally in DPI-Buka with training given to the technical officers.

The Chocolate Festival recommenced in 2022 and will continue after the project ends showcasing new innovations and information as well as awareness conducted for the farmers, youths,' women, students and the wide public They have become a major community-building event in Bougainville and the Minister of Agriculture, with support from the Bougainville Partnership, has committed to continuing the Festivals beyond this project. The 2023 Festival will be run over 4 days with expanded workshops and information sessions.

Table 7.5.1: Summary of Chocolate Festivals, bean quality assessment data and cocoa quality improvement and capacity building

Year (Venue)	Total samples	Bean sample quality assessment and data collection	Location of Samples assessment	Location of Chocolate processing
2016 (Buin & Arawa)	unknown	Unknown Low data collection capability	DPI-External assessors No capacity at DPI department as yet	Paradise Food Ltd (Queen Emma)-Port Moresby
2017 (Arawa)	41	Unknown Low data collection capability	DPI-External assessors-No capacity at DPI department as yet	Paradise Food (Queen Emma)- Port Moresby
2018 (Buka, Hutjena)	126	• **26.2%** (33/126) high quality •**73.8 %** (93/126) poor quality (13.5% (17/126) low smoke + 60.3% (76/a26) high smoke tainted, under or over fermentation, poor bean flavor/odour) •**60.3%** Rejected –being for high smoke tainted, under or over fermentation, poor bean flavor/odour Other detailed physical assessment available but not included	Training of over 20 on cocoa bean Assessment (DPI and exporters) with ACIAR Project at Buka-DPI Bean Quality Assessment done in DPI by trained officers ''Chocolate lab set up''	Local processing in DPI/ACIAR Mini-Lab in Buka DPI-HQ -Approximately 33 top quality farmers' beans processed to be judged by international judges.
2019 (Arawa)	78	• **53.8 %** (42/78) high quality •**46.2.8 %** poor or low quality (13.5% low smoke + poor bean flavor/odour) •**0 %** Rejected –being for high smoke tainted, under or over • fermentation, poor bean flavor/odour •Other detailed physical assessment available but not included	Assessment done by trained staff at DPI-Buka chocolate Lab	**Local processing at DPI/ACIAR mini-Lab in Buka** **Developing high capability with Chocolate festival improvements & Government decisions to develop and control the Cocoa industry in AROB**
2020	Nil	**No Festival held due to Covid 19 Pandemic**	Mini labs continued activities in assessing samples from farmers	**DPI/ACIAR** Mini-Labs produced small amounts of Chocolates
2021	Nil	**No Festival held due to Covid 19 Pandemic**	Mini labs continued activities in assessing samples from farmers and provided reports	**DPI/ACIAR** Mini-Labs produced small amounts of Chocolates and other products
2022 (Arawa)	15	• **50 %** (5/10) high quality •**50 %** poor or low quality (13.5% low smoke + poor bean flavor/odour) •**0 %** Rejected –being for high smoke tainted, under or over • To improve on fermentation and drying	Australia-Chocolate manufacturers	**DPI/ACIAR** Mini-Labs produced small amounts of Chocolates and other products such as powder, oil and buther.

2023 (BuKa)	To be determined	**To be in Buka (Hutjena) to be funded by ABG and Bougainville Partnership (DFAT)**	New BACRA Lab-in Kubu, Buka will be utilised	-BACRA Lab-Chocolates to be processed, -Continue to produce small amounts of other products such as powder, oil and butter R&D and quality compliance on export beans, -Regular assessment on quality from exporter and farmers to be maintained to enforce the Bougainville cocoa regulations

The judging system, including feedback from judges, is aligned with the Cocoa of Excellence judging and can be directly credited with the Gold awarded to Bougainville's 2021 entry in the Cocoa of Excellence competition held in Paris.

Establishing reliable logistics to deliver beans ordered by specialty buyers was challenging. Until recently the Bougainville cocoa industry was regulated by the PNG CB, including licencing of fermentaries and exports. These regulations did not allow exports of small shipments of specialty beans from individual smallholders or communities. Even when exports were possible, shipping and warehousing is unreliable, expensive and strict biosecurity protocols must be observed in Australia. The recent establishment of The Cocoa Provider in Melbourne may be one avenue for imports of small batches of beans destined for the boutique market. Realistically, large sales of beans to the Australian specialty chocolate market (a market of about 600 tonnes annually) are not going to support an expansion of the Bougainville cocoa industry on their own.

We believe the strategy of educating growers about the benefits of investing in better processing supports a more sustainable industry. International awards build brand recognition and demand for Bougainville cocoa, and the establishment of BACRA will enable direct incentives to be paid to growers for quality, an incentive that has not been available under the previous marketing system.

The capabilities of the new BACRA Cocoa Quality lab in Kubu were supported by the training given to DPI staff, in particular Ms Rereve. Farmers can submit samples to the lab for processing and quality assessment, and entries to the Festival are handled through this lab. There is intense interest in downstream cocoa processing on Bougainville to produce a variety of products, including cocoa powder and cocoa drink for local use, cocoa butter and chocolate.

8. Impacts

8.1 Scientific impacts – now and in 5 years

Improving the productivity of cocoa farming will support improved smallholder farmer incomes, promote gender equity, reduce poverty and end child labour. Higher productivity will also secure future supplies of beans for the confectionary industry as pests, disease and climate change impact affect the viability of existing production areas.
Without recognising the broader context of cocoa farming in farmer livelihoods, smallholder farmer training initiatives have made little progress towards these goals, suggesting that poor agricultural practice is not the constraining limit to productivity improvement. Poverty underpins malnutrition, deforestation, child labour and gender inequity. Poor education and ill health prevent farming families implementing conventional training aimed at increasing productivity and sustainability.
Our published research confirms that education, limited income diversification and poor health prevent Bougainville cocoa farmers from allocating the labour required to improve agricultural practice. Our research in Bougainville, and our earlier research in Sulawesi, shifts the focus away from conventional agricultural extension to focus on the well-being of the farming family from a holistic One Health perspective.
Transdisciplinary One Health approaches are gaining recognition for their impacts in resolving complex challenges such as rural poverty. We were invited to give a Plenary presentation at the opening session of the International Congress of Plant Pathology (ICPP) in 2018 in Boston. This was the first time One Health was presented in the context of plant disease management, and the forthcoming ICPP this year in Lyon has an entire session on One Health aspects of Plant Pathology. Our research highlighted links between the health of soil, water, crops, livestock, humans and the environment in smallholder cocoa production. Our approach impacts the entire cocoa industry, where conventional approaches to alleviating poverty and malnutrition amongst cocoa farmers have failed.
We expect One Health approaches to be widely adopted in development agriculture research and development programs over the next 5 years.

8.2 Capacity impacts – now and in 5 years

The Crisis during the 1990s stripped Bougainville of infrastructure and human capacity. A focus of this project has been to build capacity at the human and organisational levels. The “Hub and spoke” model of support for VEWs and farmers has been a successful model for improving outreach to farmers in a resource-limiting environment and has been adopted for the restructuring of the DPI. Links developed with other Government departments such as Health and Local Government, the Cocoa Board and UNRE build capacity to provide services tailored to the needs of local communities.

The baseline survey (2016/17) provided comprehensive data on livelihoods, health, education and food security, and project reports were used to develop the Bougainville Food Security Policy (2022-2032). Project data was used to formulate policies on the Health of Cocoa farmers in Bougainville (in Section 8.9), Sanitation (Section 8.9.2), Food Security (Section 8.9.3), Water (Section 8.9.1), Child and Adult health (Section 8.8.5), and many other sections. The reports and materials produced are continuously used and referenced for other developmental and planning work, as this project has compiled the most substantial data on these subject areas for Bougainville.

The BACRA has been a priority for the ABG since 2011 with several proposals passing through the House of Representatives but failing to be implemented because of the lack of capacity. However, nothing eventuated until this project (2016-2022) contributed to building the expertise and capacity of ABG Departments to establish the Authority. BACRA will not only manage exports but will now regulate the whole cocoa industry. Subsequently other commodities such as coconut, coffee, and spices will be included when regulations based on those for cocoa have been developed. PNG CB powers are now taken by BACRA and officers will work under BACRA but their salaries paid by CB to enforce the Bougainville cocoa regulations until 2025. Project

Staff and facilities will transition to roles in the restructured DPI and BACRA.

These legacies of the project will persist in through DPI-BACRA, The Bougainville Chocolate festivals, the VEWs with Village Resource Centres, and the DPI staff.

At the individual level, project staff were involved in the following training activities. Trip reports are attached as Appendix 12.

Name	Role
Thomas Betitis	Acting Secretary, ABG-DPI
Peter Nomoreke	ABG-DPI
Jacob Momoi	ABG-DPI Minister's Office
Elizabeth Pisiai	Hub Coordinator
Theodore Kisu	Hub Coordinator
Normal Tola	Hub Coordinator
Joe Yabom	CCI
Charles Maika	UNRE
Sam Rangai	Project team
John Konam	Project team
George Tonai	Farmer
Glen Tovirika	Farmer
Xavier Pirigi	Farmer
Peter Kinana	Farmer

- Mars Cocoa Academy, Sulawesi and meetings with cocoa buyers in Singapore (10 staff of DPI, CCI and UNRE, 4 farmers)
- World Vegetable Centre, Thailand (Elizabeth Pisiai, DPI Southern Hub Coordinator and Inia Bunsa, UNRE)
- John Dillon Fellowships, Australia (Wendy Pihau and Kenneth Dovaro). Both have senior leadership positions in DPI.
- Kenneth Dovaro and James Butubu visited the Solomon Islands to learn their system of cocoa marketing, a model for BACRA.
- ARSF, Australia (James Butubu)
- Jasper+Myrtle, Australia (Julie Rereve, CB)
- NGNY, Australia (Solomon Norg, DPI)
- Family Farm Teams (DPI, Ven nWs, farming families, Bougainville)
- VEWs and farmers were trained in cocoa and food crop production.
- The Village Livelihood Program, supported by the CRG Nutrition and Health sub- project and the Bougainville Cocoa Farmer's Mobile app, developed capacity in identifying community goals and actions.

At the institutional level, the project supported

- Development of an extension network engaging DPI, Health Department, CB, UNRE, Regional Hub Coordinators, VEWs and farming families
- Construction of DPI cocoa quality and chocolate making labs in Kubu and Toniva
- Developing online resources such as the Bougainville Cocoa and Health Facebook page and the Bougainville Cocoa Farmers app.

- Establishment of DPI Field station in Buin, Village Resource Centres, IPDM demonstration plots, clonal gardens, budwood gardens and village nurseries
- Establishment of the UNRE Goat Breeding and Husbandry Centre in Vudal, building capacity for research and training activities
- Establishment of the Bougainville Agricultural Commodity Regulatory Authority (BACRA) to facilitate cocoa marketing
- Gold award for Bougainville entry to Cocoa of Excellence

At the level of soft skill development:

- Teamwork
- Strategic planning
- Survey development
- Punctuality
- Presentation skills
- Integrity and leadership

8.3 Community impacts – now and in 5 years

Communities were supported in diverse project activities:

- Establishment of Village Resource Centres by cocoa farming communities
- Training VEWs in cocoa management
- Introduction of the CB Cocoa Curriculum to schools
- Establishment of budwood gardens and nurseries to provide local access to improved planting materials
- Family Farm Teams training, including training of DPI/Health trainers
- Project Facebook page
- Bougainville Cocoa Farmers App
- Chocolate Festivals
- Income diversification (food crops, livestock, service provision, processing etc.)
- Accurate data on the health and education status of cocoa farming families (schooling, childhood nutrition, sanitation, water, immunisation rates) was used to develop the Bougainville Food Security Policy
- Improved village sanitation and diets

The long term benefits of investment in community resilience were illustrated during Covid lockdowns. The return of labour and local travel restrictions stimulated a boom in food crop production, roadside vegetable markets and food security.

8.3.1 Economic impacts

The survey data showed that the most productive cocoa farmers were the best educated and healthiest farmers. While cocoa production is increasing and food security improving in many villages, average estimates of average wealth did not change over the project. Several confounding factors, including COVID and the severe drought of 2022, make interpretation of short-term economic impacts difficult. However, if the initiatives established through this project are supported to continue, and the emerging trends in investment of productivity continue significant improvements are expected in the medium-term.

Cocoa market reports were published and circulated regularly. These newsletters often stimulated vigorous online discussion. Farmers appreciated the role of cocoa buyers and exporters in the value chain, and awareness of global price trends supported better relationships between sellers and buyers.

A network of cocoa buyers and makers in Australia and NZ was established. Marketing and shipping logistics from Bougainville are inefficient and were further impacted by Covid. Shipments organised as part of our activities were blocked by PNG CB Export regulations, and those that were exported often arrived in poor condition. The CB revised export guidelines to facilitate small batch exports, and these are now regulated by BACRA. With appropriate infrastructure and expertise BACRA has the potential to build exports to both specialty and commodity markets.

8.3.2 Social impacts

Cocoa farming is a family business that involves all family members. Gender targets were part of the original design of the project and are referenced throughout the project document.
For example:

- A gender balanced target (>40%) of Regional Managers, VEWs and project staff
- Gender balanced target (>40%) for staff and farmer training activities

Surveys are gender disaggregated (wherever relevant) to facilitate intersectional analysis.
The survey results showed (a) women had low levels of education, (b) women had key responsibilities were cocoa, livestock and food crops with their income sources being cocoa, copra and selling food crops. The main health issues facing women were chronic backpain (58.2%), arthritis (36.8%), angina (21.3%), and depression (7.4%). Over half of women justified intimate partner violence. Bougainville has poor health infrastructure. Under half had received the recommended antenatal visits. Several women reported unplanned/unwanted pregnancies, highlighting the lack of reproductive choice.
FFT addressed some of these challenges by actively engaging men and women in goal setting, sharing of responsibilities, activities and benefits. FFT training has been delivered to all 33 participating villages, and DPI staff have been trained as FFT trainers.
ABG DPI has a “Women in Agriculture” program that we actively support, for example by appointing a female Hub Manager (Elizabeth Pisiai), Chocolate Lab Manager (Julie Rereve) and VEWs.
The Family Farm Teams training has provided the knowledge and tools for cocoa farming families to work toward a more equitable and planned approach to running the family farm as a small business. This is encouraged through joint decision-making and equitable distribution of workloads. The training encourages women’s participation and voice within households and the community. The trainings that have been conducted through this project have received positive feedback from women and men within these communities and villages external to the project have requested to receive training in their villages.
Training on vegetable cultivation and diversification has also provided farming households with an alternative source of income, This activity has predominantly been undertaken by women in the villages.
The project has supported several female team members to take-on leadership roles and training.

8.3.3 Environmental impacts

It is generally accepted that higher productivity and incomes will reduce pressure on forests as farmers produce the same amount of cocoa from smaller areas. Improved soil and water health management is fundamental to the One Health approach and training had positive impacts. Significant impact can be made on the health of cocoa farmers with the education and introduction of safe water (storage and drinking) equipment (water tanks, covering water storage containers, safe water preparation) and village led programs to eradicate “open defecation”. Sanitation, safe water and clean village programs are part of FFT training and the Bougainville Cocoa Farmers App.

8.4 Communication and dissemination activities

The project engaged closely with stakeholders from the community level, value chain, Governments, NGOs and the cocoa bean market. Communication involved face to face presentations and discussions, electronic publications and media:

- Stakeholder meetings
- Weekly DPI radio program
- ACIAR Annual Reports
- Project website https://cocoa-research-science.sydney.edu.au
- Monthly and bi-monthly TADEP updates
- Over 170 cocoa market reports
- Bougainville cocoa and health Facebook page
- Bougainville cocoa farmers mobile app (available through App Store for iOS, Google Play store for Android devices)
- Conferences and public presentations
- Publications
- DFAT briefings and PD materials

9. Conclusions and recommendations

9.1 Conclusions

The Bougainville Cocoa and Health surveys provided comprehensive snapshots of the opportunities and challenges facing smallholder cocoa farmers in 2016/17 and 2022. It generated vast amounts of data that have been presented back to communities and Government, used to formulate policy, and published in the scientific literature.

A key finding was that conventional technology-focussed farmer training schemes failed to engage smallholder farming communities because they do not recognise or address the most compelling problems faced by the women, men and children of cocoa farming families. In our study these were identified as low labour productivity caused by aging farmers, poor education and poor family health, and poverty compounded by a lack of income diversity, particularly for women. This significantly improves our understanding of the dominant constraints faced by smallholder farming communities, and the refocussing of development agriculture interventions.

It was predicted that the COVID-19 pandemic would expose the vulnerability of urban and rural communities on remote Pacific Islands to food security disruptions (Diao et al. 2021; Iese et al. 2021; Robins et al. 2020). However our observations of rural cocoa farming communities in Bougainville shows the local response to the pandemic in rural villages appears to have demonstrated surprising resilience.

The rapid and strictly enforced lockdown of the island of Bougainville in 2020 helped limit viral spread. Productive labour returned from off-farm employment, remittances dried up and demand for food crops increased. The lockdown also closed regional food markets. However, the 80% of the population who identify as cocoa farmers also produce food crops and sales at local roadside markets and informal exchanges of surplus domestic food crop production supplemented incomes and home-grown supplies of food. Local food crop production insulates rural communities against disruptions to the supply of imported foods. Lockdowns also revealed the role of young, educated, healthy and productive labour in food and cash crop productivity.

We have shown that labour is a significant constraint to improving crop production, with poor education and health the biggest constraints to labour productivity (Guest et al., 2023; Walton et al., 2020 One Health 10, 100142; Walton et al., 2020 One Health 10, 100143). Significantly while the predicted return of migrant labour from urban centres increased the demand for food, this relatively young and healthy workforce introduced new skills, innovations and labour, all of which contributed to increasing local food supplies (MIJARC/IFAD/FAO 2012).

Cash crops provide cash income in rural villages that is essential for local transport, medical care, school fees, clothing, and food. Spending this cash stimulates town and local economies. Once again, the returning young farmers have rehabilitated farms and increased production. By and large, export markets remained volatile but robust. Food Security in villages improved following training in food crop production, income diversification, improved sanitation, hygiene and female empowerment.

In many ways the local response to COVID-19 pandemic has demonstrated a resilience not seen in urban areas. This supports our One Health proposition that the poor education and health of rural smallholder farming communities limits their adoption of good food and cash crop farming practices and thus productivity. Investment in improved access to education and health services should be a priority that results in more productive, healthier and more food secure communities, particularly in remote Pacific Islands.

Where to from here?

This project in Bougainville found that labour availability limits smallholder farmer livelihoods and food security (Guest et al., 2023; Walton et al. 2020)[2]. Labour productivity is limited by poor diets, seasonal food shortages and unsafe water result in a high prevalence of malnutrition, in particular stunting. These children are at greater risk of developmental delays, cognitive impairment, poor educational outcomes and are more susceptible to disease and infections such as diabetes, cardiovascular disease, cancer and mental disorders). Thirty percent of women were

overweight/obese indicating the double burden of malnutrition[18]. While women prepare meals they are often last to be served and tend to eat what others left, often rich in fats and carbohydrates but lacking in protein.

A recent IFPRI report (Schmidt et al. 2019. Papua New Guinea: Survey Report: Rural Household Survey on Food Systems[3]) noted the link between agricultural productivity with overall consumption and nutrition outcomes, concluding that households in Southern Bougainville are not consuming sufficient calories or protein to sustain a healthy life. They identified that starches are the main food group being consumed (roots, tubers and sago) and that the majority of households in Southern Bougainville did not treat their water. Stunting in Southern Bougainville was also noted [19].

A 2015 Report by the Asian Development Bank[20] identified PNG as vulnerable to the negative impacts of climate change because 69% of the population depend on agriculture and fisheries for livelihoods and food security. Given that Bougainville has a relatively high percentage share of agriculture in they face significant challenges in adapting to climate change[21].

Climate change, environmental degradation and pollution have undermined ecosystem health and therefore food production potential, increasing vulnerability to climatic events. Climate change will affect food production all along the food chain, from primary production to end-point consumption and export. While warmer temperatures could benefit some crops, for example by extending fruiting seasons, wetter or drier conditions may offset any gains. Important cash crops (sugar, coffee, copra and cocoa) are likely to experience production, yield and quality declines due to changed climatic conditions.

Climate change will also alter agro-biodiversity across the Pacific and change pest and disease regimes, both of which will adversely impact on agricultural production. Coastal fish harvests could be reduced by 50% by 2100, leaving only a few countries able to obtain half their daily protein needs from this source. The main causes in the near term will be increased overfishing and coastal pollution and in the medium and long term, the direct effects of global warming and ocean acidification on fish and invertebrate species, and the indirect effects on their habitats (coral reefs, mangroves, seagrasses and intertidal flats).

Projected rising sea levels are likely to affect food security, particularly in low lying atoll countries and coastal areas of high volcanic islands through loss of land to erosion and salinisation. Climate change impacts may damage infrastructure, especially transport systems. Imported foods may become more expensive due to production changes elsewhere. Such effects are generally longer term and could have a major impact on regional food production later this century.

Numerous social and economic issues interact to contribute to declining food security status. Insecure land tenure and lease of customary land, intensified by rapid urbanisation, mining, forestry, poor governance and lack of technical and administrative capacity, have discouraged sustainable land use practices to support long-term agricultural productivity.

Land productivity is low because of inadequate resource management exacerbated by loss of human productivity related to poor nutrition and health, rural-urban drift and lack of interest in

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[20] Asian Development Bank, International Food Policy Research Institute. Climate change, food security, and socioeconomic livelihood in Pacific Islands. Mandaluyong City, Philippines: 2015.

21 https://www.awe.gov.au/sites/default/files/env/pages/275228c5-24db-47f2-bf41-82ef42cda73d/files/food-security-report.pdf

agriculture, especially on the part of youth. As young, educated children leave villages for employment in towns and cities, rural villages have become more dependent on remittance income to purchase imported foods. In addition, population growth adds pressure on resources and increases poverty and hunger, especially in urban areas. Ultimately, these factors have led to deteriorating terms of trade and international agreements that may conflict with food security goals.

Apart from improving the nutrition and dietary needs of the people and the deteriorating international trade situation, Bougainville could encourage, promote and sustain the production and marketing of cocoa, major food staples, including rice, to reduce high reliance on imports. PNG (including Bougainville) imports approximately 400,000 tons of rice valued at K600 million annually (Department of Agriculture and Livestock, 2018). The viability of rice farming, or any large scale commercial food crop farming, has not been thoroughly evaluated in Bougainville.

Other staples include sweet potato (*Ipomoea batatas),* banana *(Musa spp),* yam *(Dioscorea spp.),* taro *(Colocasae esculenta),* cassava *(Manihot esculenta)* and sago (Metroxylon sagu). that constitute the main traditional staple food in Bougainville. We have shown that cocoa can be successfully underplanted with food crops. Not only do food crops provide nutrition and family income, but because they require frequent attention more attention is also paid to looking after cocoa trees. Intercropping and agroforestry increase food availability and incomes, improves biodiversity, provides multiple ecological services and mitigates climate change.

Sourcing and supplying quality seeds and other forms of planting materials requires the establishment of seed banks and germplasm collections. Food crop collections must be supported by good biosecurity and diagnostic capacity to ensure only disease-free planting materials are distributed. Planting material of drought tolerant crops (Yams, sweet potato and Bananas) is especially important in the Atolls.

Health and nutrition

Undernutrition is common among rural infants and young children in Bougainville, (over 50%). Deficiencies in iron, iodine and vitamin A are also widespread. Poor living conditions related to rural poverty (lack of water and sanitation and food safety issues) affect the risk of infections that further reduce nutrient uptake.

Directly associated with nutrition is the requirement for safe water. Almost half of households surveyed drank from unsafe water sources. Similar figures (42%) were also reported for the whole of PNG in the 2017 WHO report Drinking Water and Sanitation, and Hygiene drank from unsafe water sources, and around 20% in Central and North.

Under-nutrition in cocoa farming communities is associated with direct losses in cocoa production from:

1. a reduction in physical productivity due to illness, fatigue and other health related problems,
2. a reduction in cognitive development and educational performance due to malnutrition in early life, and
3. losses in household resources from increased healthcare costs.

In February 2021 the initial *Bougainville Food Security Stakeholders Consultation Workshop* was held in Buka with The Food and Agriculture Organization of the United Nations (FAO), and the Department of Primary Industries and Marine Resources (DPIMR) of the Autonomous Bougainville Government (ABG). The workshop established the Bougainville Food Security Policy released in 2022 which identifies six strategic priorities:

- Productivity and farm output growth of the main food staples, horticulture, small livestock and fish farming and increasing efficiencies along the entire value chain;
- Building stability and resilience into food production and supply systems;
- Enhanced nutrient content and balance of food products consumed nutritionally vulnerable households and individuals;

- Maximize participation and empowerment of women in agriculture;
- Sustainable use of natural resource management; and
- Strengthened governance, coordination, monitoring and communication.

Gender

Female empowerment has resulted from the Bougainville project activities, leading to greater engagement by women in village production decisions and marketing activities, as well as recognising and legitimising their roles in the nutrition & health domains in the village.

Food security training has been linked to the Family Farm Teams (FFT) approach developed by The University of Canberra. FFT focuses on supporting gender equity in planning and decision making on smallholder farms. Empowering women and improving gender equity will increase farm output, improve food security and address malnutrition. Training includes modules on financial literacy, conflict resolution, food and nutrition. DPI and project staff have been trained under the Bougainville Cocoa Value Chain project as accredited FFT trainers.

Our project team includes men and women at all levels of leadership and provides encouragement and positive role models by boys and girls.

Community engagement

Our Bougainville Cocoa and Health Facebook page has over 1,700 members and has become an important engagement with the community. We have also developed the Bougainville Cocoa Farmer's mobile app that contains information on cocoa farming, food crops, livestock, diet, child health, water and sanitation as well as develop a Village Volunteer Program to improve cocoa production and health.

These platforms are designed to engage and inform our network of Village Extension Workers (VEWs) supported by Regional Hub Managers. VEWs are volunteers trained in cocoa production, food crop production, water, sanitation, nutrition and health and are advocates in the community. In the current project we trained 33 VEWs and the evidence is that we under-appreciated the workload and distances needing to be travelled, and the unexpected impact of Covid.

In 2019-21 our Vegetable Cultivation and Nutrition CRG pilot study aimed at improving the diets of people living in 10 villages in South, Central and North Bougainville. The pilot study included a baseline survey to ascertain current food choices and diets and comprised three components:

- building capacity for Government staff in nutrition, safe water and gardening cultivation
- providing nutrition and gardening education to the selected villages and
- delivering Family Farm Team (FFT) workshops to the selected villages.

Staff from the Departments of Health and Agriculture were trained as facilitators to deliver the nutrition and vegetable gardening program as well as provide monthly coaching, support, mentoring and data collection using CommCare (tablets). The FFT program was a 1- day workshop in each village led by accredited FFT trainers. The evidence showed that significant more training is required and better engagement with the health staff nominated by the Secretary of Health.

Feedback from the training and information sessions with the hub managers and VEWs has been positive. Since the initial monitoring visits, we have recorded self-reported changes being implemented within the communities to improve their health, nutrition and vegetable cultivation practices. Such changes have included adding gates on kitchens to keep animals out, improving preparation and storage of food, improving how drinking water is collected and stored, adding more variety into diets and building compost bins. We have developed a mobile, freely available app providing advice on cash and food crop production, recipes and nutritional information, with basic water, sanitation and health information. Food crop cultivation has improved diets and also provided income, primarily through the work of female household members. In future programs real time monitoring and evaluation should be incorporated into the work requirements. This way activities can be monitored and challenges and issues identified in real time.

These low-cost but important changes potentially lead to improvements in health and nutrition

and the overall productivity of these cocoa farming communities. The pilot study also identified some of the challenges including staff turn-over, lack of available seeds, climate (excessive rainfall preventing visits), cultural obligations, existing work demands preventing regular monitoring.

The model of education, training, mentoring and monitoring proved to be an effective way for improving vegetable diversity, vegetable production, improved water and sanitation, diets and nutrition within a household. Village communities today are an underutilised resource, yet they have the expertise of their lived experience and with the right resources are in the best place to make the changes necessary to achieve the 17 Sustainable Development Goals (SDGs).

9.2 Recommendations

The following recommendations are designed to improve food security by implementing a family-focussed program for improving cocoa production, food and water safety, nutrition and food garden cultivation program for farming families in Bougainville.

- Future work in Bougainville should build on the One Health approach to further improve cocoa production and food security for cocoa farmers on Bougainville.
- Continue to develop and expand the hub and spoke model to improve cocoa production by
    - Expanding the number of VEWs recruited for each VA
    - Expand the number of VAs to be included in the project
    - Building capacity by training ABG instructors
        - The two-day training workshop for instructors from the Departments of Health and DPI.
    - VEW intensive training in a 4-day workshop using
        - the curriculum outlined in the Bougainville Village Volunteer Program and the mobile app
        - Train and provide skills development to VEWs in workshops using the Training Manuals developed by the Kastom Gaden Association (KGA[22]). The relevant manuals include
            - Household gardening skills (http://kastomgaden.org/wp-content/uploads/2010/03/h_garden_skills_03.pdf)
            - Community seed Saving (http://kastomgaden.org/wp-content/uploads/2010/03/seeds_02.pdf)
    - Mentoring and monitoring the volunteers
        - Each month the village will be visited by 1- 2 VEWs and using CommCare on tablet devices, record the visits for monitoring purposes and provide monthly reports to the Advisory committee or alternative governance arrangements. Reports are to be analysed and published on a suitable media platform.
        - VEWs should receive a start -up kit comprising the necessary resources.
        - VEWs will be trained in using the Bougainville cocoa farmers App
    - Continue the development of Village Resource Centres
    - Develop a strategy to promote the use of the mobile app by farmers
    - Source vegetable seeds and seedlings prior to implementation.
    - Support further investigations into goat farming through the UNRE Goat Breeding and Husbandry Centre
    - Integrate the VEW model into a restructured DPI (currently in progress)

[22] http://kastomgaden.org/training/

    - Build DPI research and development capacity to better support smallholder farming communities
    - Evaluate and build the capacity of national biosecurity and disease diagnostic expertise to support the exchange of seeds and livestock.
    - Build specialisation (nurseries, provisions, central fermentaries, quality control etc.) and income diversification strategies in development programs
    - Regular communication, including annual or bi-annual meetings of VEWs and hub managers.
    - Create a local advisory committee to provide guidance and oversight.
    - Build in a sustainable pathway to maintain the VEW program.
    - This proposal aligns with the objectives of the Global Action Programme on Food Security and Nutrition in Small Island Developing States:
        - STRENGTHEN the enabling environments for food security and nutrition
        - IMPROVE sustainability, resilience and nutrition-sensitivity of food systems
        - EMPOWER people and communities for food security and nutrition
- Many budwood gardens and nurseries established by the project have become new business enterprises and have encouraged replanting and rehabilitation with improved cocoa genotypes. This network of village nurseries should be expanded and other local enterprises supported.
- Chocolate Festivals have become a highlight of the annual calendar and serve important community-building functions in the rapidly-evolving Bougainville environment.
- The links established along the value chain need to be further developed to support the success of BACRA.
- If productivity is to increase, farmer health needs to improve by improving water and sanitation practices and diets. Building a responsive health system for the community is a challenge when a majority of the population live in small villages with difficult access to health centres. While the ultimate goal is to establish and integrate outreach village health clinics with the village resource centres providing education to VEWs and hub manages using the Bougainville Village Volunteer program will fill an urgent need for addressing water, sanitation and nutrition.

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