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1 Acknowledgments

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2 Executive summary

Vanuatu is renowned in the Pacific for its beef industry. Since the early 1990s there has been limited investment in research, development, and extension in the cattle industry in Vanuatu. This has coincided with a decline in beef cattle production, the value of beef exports and smallholder participation in formal cattle markets. In 2013, the Government of Vanuatu requested the assistance of ACIAR to address these trends and ACIAR responded by commissioning this project (locally known as 'Bisnis Blong Buluk') to identify the opportunities to improve the productivity and profitability of smallholder cattle farmers. The project consisted of three integrated components (livelihoods, economics and marketing, and production) and largely concentrated on the East Santo Area Council due to its relatively high density of smallholder cattle farmers, access to a large number of sales channels, and its accessibility.

The livelihoods analysis demonstrated the importance of cattle to social structures, particularly ceremonial use. Initial research on the ceremonial market for cattle suggested that approximately 40% of all turn-off of smallholder cattle (approximately 15% of all stock on-hand) may directly enter this market. It found that the ceremonial market was easy for many smallholder cattle farmers to access with low transaction costs and low product quality requirements. It also found ceremonies were important in maintaining social traditions and community structures, provide a source of animal-based protein for communities and were commonly associated with some type of benefit (cash or otherwise) to the provider of the cattle. Information availability and skills, access to mentoring, labour resource allocation, and access to capital are the main constraints to practice change by cattle farmers. There was little medium to long-term planning practiced but households identified this as an opportunity for them too. It is expected that by involving all household members (men and women) in a planning approach, that takes into account social, ceremonial, and gender issues, these will be considered in the farm plans that are developed and implemented. The project developed a recommended strategy for engaging women in farm planning decisions and monitoring of farm income and expenditure, which was extended to other women's groups through farmer-to-farmer extension.

Detailed economic models were developed to simulate the income effects, reported as returns to labour, from changes in herd structure, size, and productivity. The project also developed and pilot tested a range of training materials in farm management. The training addresses fundamental issues such as stocking rates, herd management, and costs and revenues under different options. The project has reviewed, investigated further where required, and documented all aspects of the smallholder cattle value chain, concentrating mainly on on-farm aspects, through training farmers to integrate schedules (class-weight-price) into farm plans, and comparing the attractiveness of different sales channels (that use different purchase measurements and terms). Post-gate interventions were designed to improve measurement (weighing), information, aggregation, and transport, while the potential of new (inter-island) market channels are being tested.

The project has collected farm, herd, and animal level data from between 30 to 50 smallholder household herds in the East Santo Area Council at the start and end of each dry season. Data has been collected within the two main cattle farming systems, namely cattle grazing under coconuts (copra) and cattle grazing open and semi-open lands (bush). Data collected included farm area, type of production systems, stocking rates, and indicators of productivity (annual liveweight production, reproduction rates) as well as a preliminary analysis of the quality of diet consumed by cattle and internal parasite burdens. The on-farm baseline data suggest that productivity can be increased from a very low base (e.g. increases in annual liveweight production from less than 100 up to 200 kg/animal and calving rates from 30 to 65% may be possible with improved farm planning and management). The major constraints to productivity were low calving rates (likely a function of nutrition and bull access), over-grazing and high weed burdens, and a lack of

drinking water. The underlying issues were poor access to information and training, low farm-gate prices through the formal markets, long lag times for return on investments, and challenges in accessing inputs to implement farm improvement plans. On-station research to support farm improvements identified several promising grasses and legumes with production characteristics that are more suited than those currently recommended for use. Grazing studies using these new forages are in progress and will develop recommendations on grazing management, as are studies to determine the liveweight response of cattle to the supply of drinking water and to copra meal supplementation.

The project has increased the understanding of the existing smallholder cattle households and production systems in the East Santo Area Council and compared these with systems on the island of Malekula. It makes recommendations that could immediately be scaled-out by the Government of Vanuatu or their development partners to increase the capacity of smallholder farmers on farm planning, the engagement of women in (cattle) farm planning, and to increase productivity and farm gate prices in the smallholder cattle sector. In addition, the project has identified opportunities for further research that may contribute to additional increases in capacity and productivity.

3 Background

The Republic of Vanuatu is a geographically isolated country located in the south-west Pacific, consisting of 83 dispersed islands (Figure 1). Approximately 75% of its population of 250,000 people live in rural areas, with members of these rural households reliant on traditional subsistence agriculture for their livelihoods. Rural and agricultural development is a priority of the Government of the Republic of Vanuatu to improve the livelihoods of the Ni-Vanuatu people. Approximately 50% of rural households raise cattle (15,500 smallholder households, 1500 semi-commercial households out of a total of 35,000 rural households; Cardno, 2014; VNSO, 2011). Improved cattle production and marketing practices will provide opportunities for increased household cash flow and access to goods and services that may improve livelihoods.

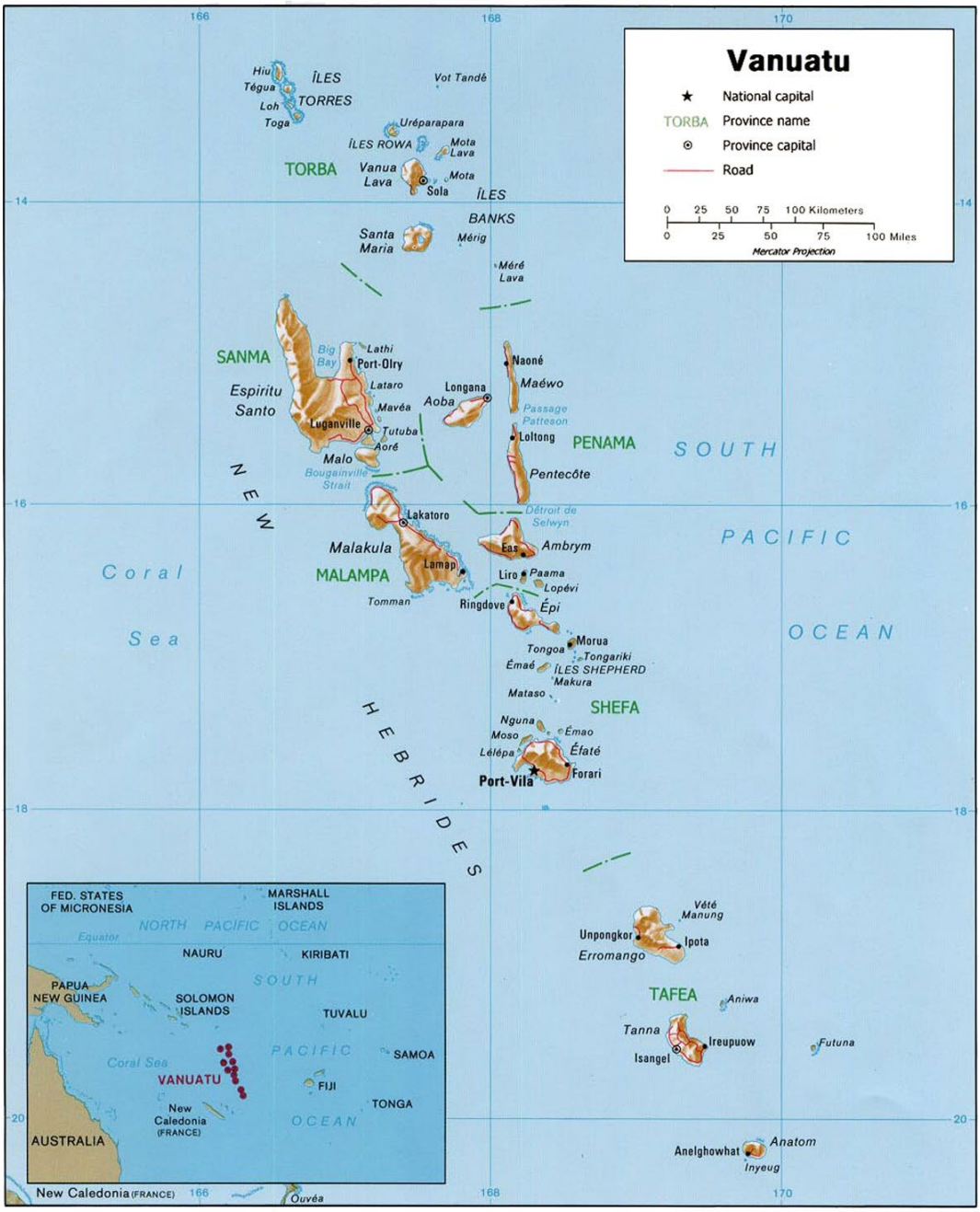


Figure 1. Map of Vanuatu. (Source: https://www.nationsonline.org/oneworld/map/vanuatu-map.htm).

Between 20 and 25% of national GDP in Vanuatu is derived from agriculture, with livestock contributing approximately 2% to national GDP. Beef is currently the fifth highest value export commodity behind kava, coconut products, cocoa and timber products (VNSO, 2019), declining from been third highest value export in 2015. Approximately 70 to 80% of all households are reliant on subsistence/semi-subsistence agriculture to support their livelihoods (income, social obligations, nutrition). Whilst over 90% of all cattle farmers are smallholders, they contribute less than 10% of all cattle entering the formal beef market. For these reasons, the Government of Vanuatu has placed a high priority on developing the cattle sector.

The Ministry of Agriculture, Livestock, Forestry, Fisheries and Biosecurity (MALFFB) have set an ambitious target for a national cattle herd of 500,000 by 2025 (National Livestock Policy, 2015 to 2030; MAFFLB, 2015). The *National Livestock Policy* (2015 to 2030) and its supporting *Action Plan and Monitoring and Evaluation Framework* place an emphasis on engaging and encouraging smallholder farmers to participate in livestock farming. To rebuild the national cattle herd MALFFB has implemented a cattle restocking program to distribute cattle to smallholder farmers and has legislated bans on the slaughter of productive female cattle (pregnant and/or less than 7-years of age) without a permit (Cattle (Slaughter, Spaying, Castration) Act [CAP 103]; executed May-2017). Whilst the MALFFB has a vision for a larger cattle herd, increases in productivity rather than size of the existing herd would also increase throughput in the formal sector, increase incomes of smallholder cattle producers, and increase the resilience of households to climatic and other shocks.

Vanuatu's climate, disease-free status, and established beef processing sector provide favourable settings to further develop the beef industry to meet growing domestic and international demand for beef products. Smallholder farmers account for approximately 40% of Vanuatu's beef herd (Cardno, 2014) and stand to benefit from this increased demand through improved on-farm cattle production and access to alternative enterprise mix and marketing options. The remainder of the industry consists of larger well-established producers. The industry is serviced by two export accredited abattoirs (Santo Meat Packers Ltd on Santo and the joint private/public Vanuatu Abattoir Ltd on Efate), with a third abattoir (Wong Sze Sing) also operating on Santo. In addition, there are an increasing number of urban butchers (reliant on service kills through accredited abattoirs), registered rural butchers and co-operatives, and extensive ceremonial channels. Despite a well-developed commercial beef sector and high demand for beef, turnoff into the accredited abattoirs has declined by approximately 30% between the production peak in 1994 and 2010 (Cardno, 2014; FAOSTAT, 2020). The large commercial abattoirs are currently operating at less than 50% capacity and urban butchers/retailers are unable to source desired product in sufficient quantities to meet demand. This is largely believed to be due to decreased supply from the smallholder sector. The proportion of beef derived from smallholder cattle processed through the abattoirs declined from approximately 50% in 1994 to between 5% and 10% (Bazeley and Mullen, 2006; Cole et al. 2019), with a 30% decrease in total beef production reported over a similar period (FAOSTAT, 2020). This decline in engagement in the formal sector and the associated speculation that productivity in the smallholder cattle sector has declined have been variously attributed to a lack of investment in research and development activities, the downsizing of government extension services in the 1990s, the development of alternative income generating industries (e.g. kava), low prices paid for cattle (by global standards), and growth in local demand for beef through rural butcheries and ceremonies.

Whilst there had been limited investment in the beef cattle industry since the early 1990s, the sector has received increased attention at a macro level from 2012 by a number of donors. The Enterprise Challenge Fund (DFAT) supported the *Sarami Project – an alternative approach to beef sector development* in 2010 as a means to link smallholder farmers with large holders and the formal markets (Proand Assoc., 2013). NZ MFAT commissioned Cardno to undertake a value chain analysis of the Vanuatu beef industry (Cardno, 2014), Cole and Bangalini (2015) reviewed the beef industry and developed

proposals to support implementation of the EDF-11 program, and NZ MFAT funded a large scale survey of approximately 750 cattle farmers across the islands of Efate, Epi, Malekula, and Santo (Phase 1; NZ MFAT, 2017), followed by the Phase 2 *Nambawan Buluk Project* (Phase 2). The Department of Livestock released its *National Livestock Policy* (2015 to 2030) and a supporting *Action Plan and Monitoring and Evaluation Framework* (2015) while NZ MFAT (2017) also developed an *Industry Development Plan*. It was within this context that the current project was implemented. The current project took a grass roots, localised approach to complement and inform other programs of work operating at a macro-level. Through formal research and action learning, the project aimed to provide much-needed information on the structure, productivity, and objectives of smallholder beef producers in Vanuatu and the social, institutional, and agribusiness environment within which they operate. The project therefore attempted to answer the following research questions,

What is the productivity of existing smallholder cattle systems?

What factors influence the cattle management and marketing decisions made by smallholder cattle farmers in Vanuatu?

What production, business models and marketing interventions can be successfully implemented that increase cattle production, and returns to smallholder cattle producing households?

The overall aim of the project was *to increase the productivity and marketing options of smallholder cattle farmers in Vanuatu;* thus contributing to increases in rural household incomes and livelihoods choices, meeting undersupplied existing and emerging beef markets, and developing the national beef industry. The project aimed to identify the social, economic, policy, biological, or technical drivers that influence smallholder cattle farmers and their approach to cattle management and marketing.

4 Objectives

The objectives of the project were:

1. To describe the economic, policy and social settings within which smallholder cattle farmers operate and their livelihood objectives and strategies,
2. To sustainably increase beef production of smallholder households through change in on-farm management practices,
3. To increase the returns to smallholder cattle farmers through whole-farm and cattle enterprise economic analysis, business training, and marketing interventions, and
4. To create pathways to sustain and extend project outcomes and impacts beyond the scope of the current project.

5 Methodology

Location

The majority of the project research activities were conducted within the East Santo Area Council (60,700 ha) on the island of Espiritu Santo (Santo; 407,000 ha) in SANMA province (comprising the islands of Santo, Malo and Aore) of Vanuatu (Figure 2). The study location was selected by the project team based on census data available at the time (VNSO, 2016) which indicated the East Santo Area Council had a large number of smallholder households (686; ~75% of all households in the East Santo Area Council) rearing cattle within biophysical systems that were likely to be reflected elsewhere in Vanuatu (i.e. cattle under copra plantations, cattle in semi-cleared bush), and on local expert opinion of where greatest engagement of smallholder cattle farmers in project activities would be expected. Approximately 37% of the national cattle population are located in SANMA province with approximately 8% of the national cattle herd located in the East Santo Area Council (9450; 14 cattle/household) (VNSO, 2016). Within the East Santo Area Council the project concentrated on smallholder farms within three main village areas of Khole, Sara, and Port Olry, which represented coastal, upland, and drier regions within the Area Council respectively (Figure 2). Additional households from surrounding villages participated in some activities (Natawa, Pene, Hog Harbour). In addition to the relatively high density and number of households and cattle, smallholders in the East Santo Area Council have access to a number of diverse market channels (two abattoirs, urban and rural butcheries, inter-island trade, large-holder farmers, and the non-formal ceremonial market) and large areas of land classified as suitable for further development for agriculture, plantations, and pastures (Quantin, 1982; Simeon and Lebot, 2012).

In addition to the work undertaken in the East Santo Area Council, a scoping study was conducted on the island of Malekula in MALAMPA province (comprising the islands of Malekula, Ambrym and Paama) (Activity 1.7). This activity was conducted to evaluate the transferability of findings and recommendations from research conducted in the East Santo Area Council to other areas of Vanuatu. MALAMPA province has been identified by the Government of Vanuatu for expansion of the cattle herd in Vanuatu, with a relatively large cattle population already in existence from which further expansion could be built upon. The visit focused on the central, southeast, and northwest areas of Malekula (Figure 3). These areas were visited due to their accessibility, history of engagement with local Department of Livestock officers, and the number of households that raise cattle (VNSO, 2016).

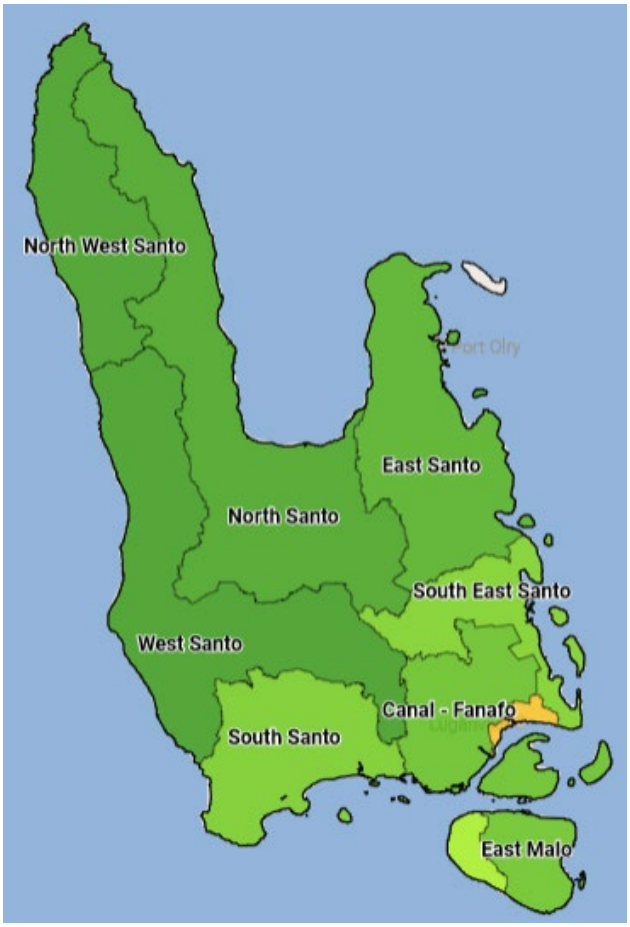
Integrated approach

The project adopted an integrated approach where each of the three main research components (livelihoods, production, economics, and marketing) were implemented within the same communities. Results from different components informed other components (e.g. productivity data informed economic models and training module development).

Field researchers (Navian, Sul, Nasse) were employed to implement research day-to-day under the supervision of senior staff within the Department of Industry (Antfalo; CommCare, economics, marketing, catchment meetings), Department of Livestock (Boe; on-farm production), and Rihai (Livelihoods). An additional field researcher (Nehiva) was employed at the Vanuatu Agriculture Research and Technical Centre (VARTC) to implement activities conducted on-station under the supervision of senior researchers. Staff from the Vanuatu Skills Partnership (VSP) participated in some training activities and field days. In-country teams worked with Australian based researchers (Addinsall, Waldron, Cox, Quigley) to develop and implement project activities. Students from universities (The University of the South Pacific, The University of Queensland) participated in research activities, whilst students from the Vanuatu Agriculture College

(VAC) gained valuable experience in animal husbandry, pasture management, and research methodologies.

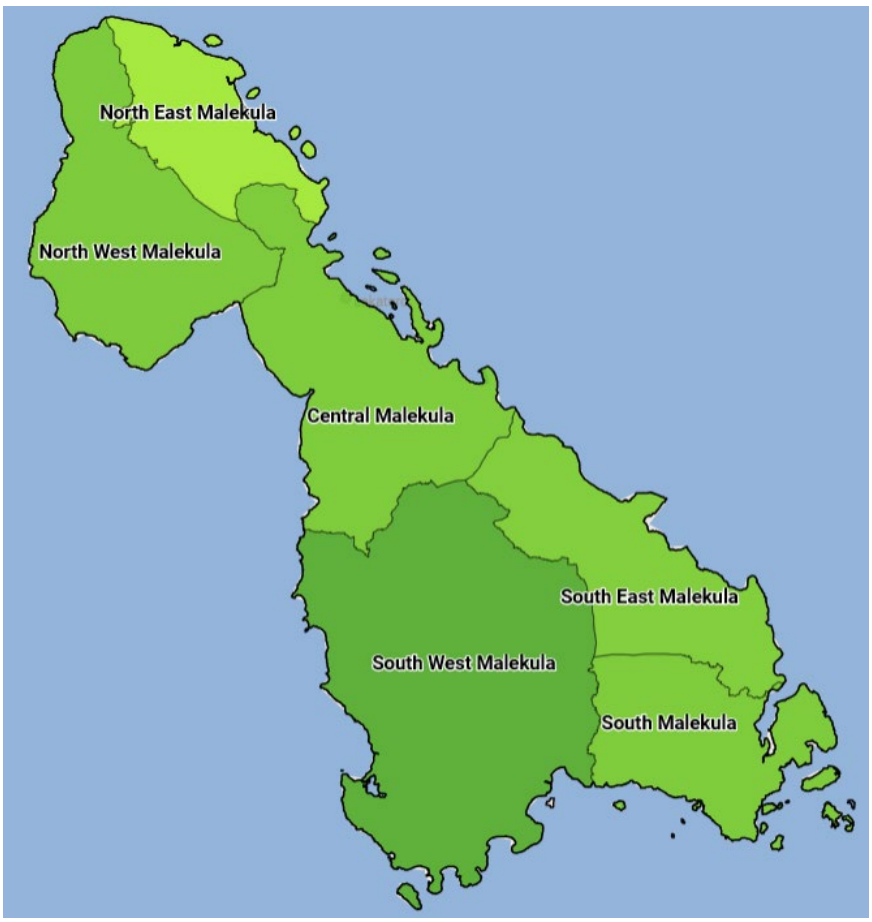
Data was collected at the village, household, farm, household member, and cattle herd and individual animal level, and from agribusiness actors throughout the value chain. Data was collected through a combination of in-depth interviews, storian sessions, farm walks, and quantitative digital surveys. Secondary data sources were accessed when available and as required.



a.

b.

Figure 2. Map of Area Councils on Espiritu Santo, Vanuatu (a.; Binkhoff, 2020) and the location of Khole, Sara and Port Olry villages in the East Santo Area Council (b.; GoogleEarth).



a.

b.

Figure 3. Map of Area Councils on Malekula, MALAMPA province, Vanuatu (a.; Binkhoff, 2020) and the location of sites visited on study trip (b.; GoogleEarth).

Methodology

Human ethics (approval numbers: 2016001175 and 2019000687) and animal ethics (SAFS/082/16/ACIAR) approvals for the work undertaken within this project were obtained from the relevant committee's at The University of Queensland.

Component 1. Situation analysis, livelihoods, and engagement of women

A detailed description of the various methodologies is provided in Appendix 1. In brief, however, a range of one-on-one qualitative and quantitative interviews and storian sessions (focus group discussions) were held with farmers, community leaders, and agribusiness actors. Farm walks were conducted to measure farm area and also assess the condition of the cattle farming systems and farm infrastructure. In some, but not all cases, quantitative data was collected using CommCare software (Dimagi) installed on tablets. Secondary data was accessed from VNSO and other available sources (e.g. NZ MFAT surveys). Baseline and end-line data were collected for the livelihood's analysis using the same methodologies described above. Reports were generated describing the social and cultural, livelihood, production, and business environment. These detailed reports are also presented in Appendix 1 and were informed by the generation of a profile of the Vanuatu beef industry (Cole et al., 2019; Appendix 5).

A case study approach was used to develop a strategy to engage women in farm planning and decision making. Information generated in the livelihoods analysis was used to develop a gender-sensitive training programme grounded in the female farmer to farmer strengths-based, and interactive training approach as a strategy to better engage women in agriculture and build their capacity based on their priorities. The gender-sensitive training programme was based on the concept of women only storian sessions.

Component 2. On-farm and on-station research on the productivity of cattle farming systems

A series of research activities were conducted on-farm and on-station with the broad objective of understanding the existing productivity of smallholder cattle systems in East Santo, the major constraints to productivity and to identify and test strategies to increase productivity. A brief description of the various methodologies is described below with further detail provided in Appendix 2.

Activity 2.1 and 2.2 (on-farm research)

Soil samples and rainfall data were collected across the East Coast Area Council. Baseline and end line surveys were conducted with participating households collecting data on their cattle management and marketing practices, perceptions of major constraints to productivity, and preferences for training and capacity building.

A total of 58 smallholder cattle farming households within the East Coast Area Council participated in one or more aspects of on-farm research from October-2016 to July-2019. Farms were classified according to the below description based on the conditions under which cattle were managed,

1. Cattle under copra plantation – heavily weeded,
2. Cattle under copra plantation – overgrazed,
3. Cattle under copra plantation – well managed,
4. Cattle in unimproved bush, and
5. Cattle in improved bush.

Farms were mapped and farm area and stocking rates were determined. Longitudinal monitoring of cattle was undertaken by a team of two field researchers on most occasions,

with assistance from students from the Vanuatu Agricultural College and other project team members occurring on an *ad hoc* basis. Measurements were conducted at the start (May to July) and end (October to November) of the dry season each year. Pilot testing of monitoring systems commenced in October-2016, with final monitoring occurring in July-2019 (i.e. 2.5 years of monitoring data across six monitoring events). Monitoring included the recording of liveweight, body condition score, and lactation status, and investigations into management practices (weaning, sales), internal parasites, and diet quality. A portable crush allowed for safe data collection and demonstration of best-practice husbandry activities (dehorning, castration). Cattle were maintained under the prevailing management conditions throughout the monitoring period. This typically involved free-grazing of unimproved fenced lands with little segregation of herds with only a small number of farmers segregating cow-calf and fattening systems on different blocks of land (e.g. copra and bush respectively). Households typically maintained small plots of land near to houses for staple and cash crops, with these secured to prevent crop damage by cattle. Cattle were generally maintained with no inputs [e.g. no supplementary or improved feeding, no animal health treatments, and with the exception of weaning, no strategic management of cattle classes (e.g. creep feeding, controlled mating were not practiced)]. The extensive nature of the production systems meant that accurate data capture was an ongoing challenge for the research team. Data was collected in CommCare software (Dimagi) installed on Samsung Galaxy tablets.

On-farm forage demonstration and evaluation sites were established, with farmers assessing different forages and then selecting preferred species for establishment on their own farm from stocks within their own plots. The project worked with a single farmer to establish a site to investigate the effect of water supply on herd productivity. A simple Excel model was developed to support extension officers when they are assisting farmers to make decisions regarding water supply and storage for cattle. The model uses local rainfall and forage dry matter data coupled with water requirements for different classes of cattle to determine the amount of water required by a herd of cattle and the storage capacity required to supply water throughout the year.

Activity 2.3 Copra meal supplementation

Steers grazed local unimproved pastures as a single mob from November-2018 to October-2019. Steers were individually offered 5 g copra meal/kg liveweight.day through the wet season or dry season or remained unsupplemented throughout the year. Liveweight gain and copra meal intake were determined through the wet and dry seasons. Diet quality was estimated using faecal NIRS and internal parasite burdens estimated from faecal egg counts.

Activity 2.4 (Desktop)

Review of the potential use of apps for smallholder cattle farming systems in Vanuatu

The project used CommCare for the collection of research data. The software also allowed the near real-time transfer of data and recommendations to help farmers make decisions regarding the management and marketing of their cattle. Data was printed and provided to farmers at the end of monitoring.

Existing apps relevant to cattle management and marketing were evaluated. Existing app stores and databases were searched, and apps were downloaded where possible. Suitability of apps were evaluated against the following criteria:

- Language,
- Cost,
- Network requirements and operating system,
- Additional requirements (equipment, other interfaces), and
- Relevance to smallholder cattle production systems in Vanuatu.

Activity 2.5 (Desktop)

Review of non-forage feed resources for cattle in Vanuatu

Field visits and stakeholder interviews identified any potential by-product and non-forage based feed resources that could be used for cattle feeds. Limited information was available on production of the identified feeds. Literature and existing nutritional databases were referenced to confirm feed value. Proximate analysis was conducted to confirm nutritive value of products in Vanuatu was similar to values reported elsewhere in the literature. This was expanded to include a number of grass and legume species that are well adapted to Vanuatu.

Activity 2.6 (On-station)

Evaluation of grass and legumes

A replicated evaluation trial was established under full sun conditions at VARTC to measure biomass production, ground cover, and persistence of 17 grass lines and 14 legume lines. Measurements were conducted every 6 (grasses) or 12 (legumes) weeks for a period of approximately 30 months (May-2016 to October-2018).

Evaluation of legumes under shade

A replicated single-row evaluation of the establishment and persistence of a number of herbaceous legumes and leucaena was established under 10-year-old coconuts at VARTC. Herbaceous legumes were established from seed, with the exception of *Arachis* spp and *Desmodium heterophyllum*. Leucaena was established from seedlings established in a raised seed bed and then transplanted at between 0.5 and 0.8 m in height. Seedlings were transplanted into either a single-row sown into a deep-ripped furrow (0.5 m depth) at 0.5 m spacings, or into holes dug to 0.2 m depth with yam spades in double-rows at 1 m spacing between seedlings.

Grazing trial

Well-adapted grass (*Brachiaria brizantha*) and legumes (*Neonotonia*, *Centrosema* and *Stylosanthes*) identified in the above on-station replicated forage evaluation were established in a replicated grazing site at VARTC to determine persistence of legumes and liveweight gain of growing steers. Six (1 ha) paddock replicates were set stocked at low (1.4 AU/ha) or high (2.9 AU/ha) rates or under a high rotational grazing system (2.9 AU/ha). Liveweight was measured every month and pasture persistence assessed every 6 months.

Water trial

Two groups of heifers were rotated between two adjacent paddocks every month at VARTC. One group had *ad libitum* access to drinking water at all times, while the other group received restricted access to water which was comparable to the prevailing conditions on smallholder cattle farms. Liveweight gain was determined at the end of each month prior to paddock rotations.

Component 3. Economics, training, and marketing

Data for economic models were sourced from secondary data on production (especially from the Vanuatu Pasture Improvement Program), and from the following sources

- Monitoring data on farm, herd and productivity from the current project,
- Price and transport information from abattoirs and traders,
- Price and cost information from input suppliers,
- Management and cost information from farmers through detailed interviews, and
- Repeat interviews with case study farmers

A partial, steady-state model of a cattle farm, with scope for seasonal (monthly), annual and long term (10 year) time horizons was developed in Excel. The Excel model consisted of eight linked input sheets and two output sheets (profits and cash flow) and used returns to labour as the key indicator. Other farm activities (copra, kava, vegetables) were analysed as discrete activities. The model captured all (even minor) aspects of cattle production. Based on the model, a training manual was developed to simplify material in a step-by-step process that can be used by extension staff, agencies, and farmers (Appendix 3). The training manual was further broken down into a set of four training modules each of which was delivered over one day training session for the full range of project stakeholders. Four scenarios or models of smallholder cattle production and marketing systems were identified, simulated, and compared against each other, and against major on-farm non-cattle activities (copra and kava). This model enables a detailed analysis of the returns, incentives, and options of smallholder farmers in the East Santo Area Council.

More than 40 interviews with agribusiness actors were conducted with all agribusiness actors on Santo and ongoing consultations were conducted in the current project to investigate opportunities for marketing interventions. All conceivable marketing options and interventions were considered, and the two best-bet marketing interventions are being trialled and assessed as part of Mr Noel Kalo’s M. Phil. research. The study has been suspended due to COVID and is expected to be resumed in 2021.

6 Achievements against activities and outputs/milestones

Objective 1: To describe the economic, policy, and social settings within which smallholder cattle farmers operate and the livelihood objectives and strategies

No.	Activity	Output / Milestone	Completion date	Comments
1.1	Situation analysis	Description of the broad operating environment of smallholder cattle farmers in the project catchment area documented and available to LIWG, PHAMA, other development programs/agencies and SANMA provincial and GoV agencies.	Y2, M6	A large amount of information has been collected describing the local operating environment. These include: • the appendices in this report, • book chapter on strategies to engage women in Agriculture in Vanuatu, and • country profile of the Vanuatu beef sector. The information is yet to be collated into a single source, but the country profile of the Vanuatu beef industry contains most of this information.
1.2	Define household typologies and identify households with which the project will work	Typologies of cattle farming households in the project catchment area are defined. Households who are considered progressive cattle farmers are identified and agree to participate in project.	Y1, M3	A typology was developed that included criteria on scale of production, geographic location, production system, and degree of commercialisation. The project made some reference to types of households. For example, the project did not work directly with very large plantation/estate producers, did not work with very small producers (e.g. with 3 cattle). However, outside these broad parameters, a typology was of limited value. For example, agro-climatic and cultural conditions were similar across all three project sites, all farmers had mixed (cow-calf and fattening) operations, there was a weak relationship between scale and productivity, and virtually all farmers disposed of cattle through mixed channels (formal markets, ceremonies) with weak links to productivity. As a result, a decision was made in the project to work with any type of smallholder, Ni-Vanuatu producer if they were willing to participate (enthusiastically) in project activities and would benefit from participation. A typology of production and land use systems was found to be more useful and has been developed to describe cattle production systems under copra and in secondary bush.

No.	Activity	Output / Milestone	Completion date	Comments
1.3	Participatory appraisal of cattle production systems	Results are documented and reported to LIWG, PHAMA, other development programs/agencies and SANMA provincial, and GoV agencies,	Y1, M6	A broad description of cattle farming practices and constraints was undertaken with approximately 30 households in East Coast Santo through a combination of in-depth interviews, farm walks, and quantitative surveys. Farmers identified access to capital as the major constraint to increasing cattle productivity, followed by lack of drinking water for cattle. Farmers identified the need for better planning and improved linkages with markets as key areas for training in the future.
1.4	Agri-business analysis of cattle and associated industries	Results reported to project stakeholders, especially farmers.	Y4, M12	Agribusiness structures of cattle and associated industries in Santo are reported in detail in the master's thesis and presentations of Kalo (forthcoming, 2020), Cole et al., 2019, Activity 3.5 and Appendix 3.
1.5	Livelihoods analysis	Role of cattle in the livelihoods of households defined, reported to PHAMA, LIWG, other development programs/agencies and SANMA provincial and GoV agencies and published in scientific literature. Impact of project interventions on livelihoods of households evaluated over the life of project, with case-studies reported in local media and extension materials. Gender analysis conducted within the livelihoods analysis to develop a gender strategy for the project.	Y2, M6 Y4, M12	The project aims to improve livelihoods through cattle. The economic analysis uses returns to labour (the value of production divided by labour input) as a tangible indicator of the contribution to livelihoods. This is established for cattle under a range of scenarios, which can be compared on an equivalent basis with other farm and off-farm activities, as a basis from which farmers can make livelihood decisions. The project incorporates the role of cattle in ceremonies as an outlet for cattle production, and value in social cohesion and as a logistics unit for nutrition. The role of cattle in ceremonies was analysed in detail in an honours project. Project participation has increased households' knowledge of cattle farming business planning, productivity, and marketing, which has provided opportunities to improve lives. However, due to long farm improvement and cattle cycles in cow-calf production in extensive systems, it is hard to discern direct and immediate impact on incomes or other social indicators impact. The project established a women's group for gender specific training. Women extended their skills and experiences to other women groups, building their own confidence and competency as trainers.

No.	Activity	Output / Milestone	Completion date	Comments
1.6	Integration of activities 1.1 to 1.5	Description of the integration of the socio-economic information collected in Objective 1 reported to partners, policy makers, other programs/projects and published in scientific literature.	Y4, M12	A number of reports (appendices to the final report) and book chapters have been completed or are near completion. The training materials integrate all aspects of data collected from livelihoods, economic, marketing, and productivity research. These will be made available to partners, policy makers and other programs upon completion of the final report. A scientific paper is proposed to integrate the economic and social influences on smallholder cattle marketing and management.
1.7	Conduct situation, livelihood, and participatory appraisal of cattle production systems on Malekula	Description of the broad operating environment and household production systems of smallholder cattle farmers in Malekula documented and available to LIWG, PHAMA, other development programs/agencies, and SANMA provincial and GoV agencies. Determine what, if any, successful changes in practice developed on Santo are transferrable to Malekula and the appropriate extension methods to be used	Y3, M12	Social, economics, and production researchers visited Malekula in June-2019. Provincial and government officers, local agribusiness actors, and farmers were consulted during the visit. The biophysical environment on Malekula was similar to that of Santo with cattle within bush the major production system, with very similar pastures and weeds present. In some areas water was not a constraint (southeast) but it was potentially limiting in other areas (northwest). One major difference to Santo was the increased amount of cocoa grown under coconuts, meaning there was less opportunity to develop cattle grazing systems under coconuts on Malekula. There were fewer market options for smallholder farmers on Malekula than Santo but prices were still high and demand from local butchers was commonly unfilled. Roads, communication, and utilities were all comparable to Santo (in the areas visited). Farmer training and farmer demonstration models are likely to be appropriate on Malekula, with local Department of Industry and Department of Livestock officers having good relationships with local rural communities.

Objective 2: To sustainably increase beef production of smallholder households through change in on-farm management practices

No.	Activity	Output / milestone	Completion date	Comments
2.1	Monitor on-farm cattle production and management	On-farm data collection and reporting procedures are established. Baseline data on all aspects of cattle production and management is documented for LIWG, PHAMA and GoV agencies and presented at an international conference/regional workshop. Opportunities to improve production and priority research issues identified.	Y2-Y4	Data collection systems were established using mobile crush, portable panels, and scales and CommCare software installed on tablets. Baseline and longitudinal monitoring of existing systems was conducted over two and half years (October-2016 to June-2019). Preliminary results were presented at annual meetings. Summary results will be available for stakeholders at the end of the project and presented at any local conferences that are held in future. Priority research issues identified as constraints to productivity include systems to provide drinking water for cattle, grazing management and weed control, and the causes of low reproduction rates.
2.2	Implement and monitor on-farm interventions to improve production	Interventions implemented by participating farming households. Adoption and results of interventions monitored and reported in project reports, field days and farm visits. Case studies describing the process and outcomes of interventions developed and reported in local media and extension materials/technical bulletins.	Y3-Y4	On-farm forage evaluation sites (20) were established in all areas the project was operating. Farmers were surveyed throughout the process. Farmers (4) have extended this to new, larger grazing areas (0.5 to 1 Ha) ideally for weaning and weaner management. The project has assisted one farmer to establish a water catchment and storage system to supply drinking water to cattle. Case study surveys need to be completed with farmers involved in the forage expansion and water catchment activities. Farmers will be asked to relay their stories to other farmers at the end of project field day.

No.	Activity	Output / milestone	Completion date	Comments
2.3	Monitor performance of smallholder cattle on commercial farms	Liveweight gain and health of smallholder sourced cattle and commercial management practices included in project reports, presented in an international conference/regional workshop and included in extension materials.	Y3, M12	The objective of this activity was to evaluate the annual liveweight gain of weaners sourced from smallholder farmers under commercial best-practice management and compare against their own improved cattle genotypes. This activity was not conducted within this project due to challenges in allocating resources and establishing an appropriate research model and partnership to undertake the monitoring of cattle. An alternative on-station activity was conducted at Monbiftec farm under the Dept. Livestock (see Copra meal supplementation, Activity 2.6). The original concept is still a valid researchable issue, with commercial farms an accepted market channel for smallholder cattle. It would therefore be useful to quantify the typical response of smallholder bred cattle under these different management conditions. However, it is difficult to see how such an activity could be undertaken in future projects.

No.	Activity	Output / milestone	Completion date	Comments
2.4	Review of potential non-forage feed resources for cattle in Vanuatu conducted	A review of available crop by-products and potential on-farm fodder crops is produced and included in extension materials. Nutritive value of potential feedstuffs analysed. A database of potential feedstuffs and potential use by different classes of animals is developed and provided to DoI and extension staff for farmer training activities.	Y1	Only a small number of potential non-forage feed samples were identified. These have been collected and imported for proximate analysis at The University of Queensland (UQ). Given the small processing sector, geographic dispersion of growers, and low returns for cattle there is limited non-forage feed options available to smallholder farmers. Copra meal is the main non-forage feed available, but responses measured in the current project would suggest it has limited value at current prices on higher quality pastures found in Vanuatu. Other by-products are of limited availability and present some nutritional limitations regarding their use for cattle (palatability, high lipid content). The nutritive value of all products tested was in agreement with existing nutritional databases. Forage crops are not routinely grown in Vanuatu and are considered an unlikely option for most smallholder cattle farmers due to high input and capacity requirements. Some crops that are already grown by smallholders may offer dual-purpose for cattle and human consumption (cassava, sweet potato). Given the above points the most feasible and cost-effective strategy to increase feed quality of cattle is by improving the existing feed-base through improved grazing management and potentially developing small areas of legumes specifically for young cattle. As such a large number of local and improved forages have been collected from Efate and Santo for nutritive analysis. Analysis will be completed and included in the database by the end of the project.

No.	Activity	Output / milestone	Completion date	Comments
2.5	Assess the suitability of new cattle and pasture management software, databases and “apps” to assist with farm management decisions	A range of herd management software and apps to assist with management decisions are evaluated and used by field researchers and GoV agencies to assist with data collection and assisting farmers with their decision making.	Y4	The project designed surveys and collected data using Commcare software. Whilst this software was primarily used for research data collection, the software was used to provide data and recommendations back to farmers in near real-time to assist with decision-making. The use of CommCare by the project did not enhance project implementation or data analysis. Significant time inputs were required to establish surveys, train staff, implement the surveys, and then access and analyse data. To implement CommCare in a new project operating environment where there were many uncertainties regarding project implementation, to also roll-out a new data collection platform created significant challenges for the team. The project attempted to collect too much unrelated data using CommCare, making app navigation for users quite convoluted, resulting in missed data. There is no doubt CommCare is powerful and could collect almost all aspects of quantitative data and it certainly will be used by the team in very specific circumstances in the future to compliment other data collection methods. Whilst project team members became proficient in the use of digital data collection methods, they missed out on training on more traditional data collection and analysis methods (e.g. Excel). A simple desk-top study was conducted to assess the suitability of existing apps to smallholder cattle production systems in Vanuatu. Whilst features of some of these apps would be relevant to the context, none of the apps were directly transferable due to language, cost, network access, operating system, and relevant context (temperate vs tropical).

No.	Activity	Output / milestone	Completion date	Comments
2.6	Conduct on-station research activities in Vanuatu	Forage evaluation trials established at VARTC under plantation and open grazing systems with results published in scientific papers, presented at field days and included in extension materials. Supplementation strategies to increase liveweight gain of growing cattle in the wet and dry season conducted at VARTC with results published in scientific papers, presented at field days and included in extension materials. Other cattle research conducted as determined by needs of project at VARTC published in scientific papers, presented at field days and included in extension materials.	Y1-Y4	Forage evaluation experiments have been completed in both open and shaded environments. (a total of 17 grass lines and 14 herbaceous legume lines were evaluated; plus 3 varieties of leucaena, including the local kasis. A copra meal supplementation experiment was completed in October-2019. An experiment examining the effect of stocking rate on persistence of herbaceous legumes in Mekong grass pasture is in progress and will continue until the end of the current project. An experiment examining the response of cattle liveweight to drinking water availability is in progress and will continue until the end of the current project.

Objective 3. To increase the returns to smallholder cattle farmers through whole-farm and cattle enterprise economic analysis, business training, and marketing interventions

No.	Activity	Output / Milestone	Completion date	Comments
3.1	Collect and analyse whole-farm and household economic data	Data collection and reporting procedures established. Household monitoring and interview data compiled and reported.	Y2, M6	Data to calibrate models were collated from: • Secondary data on production (especially from the Pasture Improvement Program), • Current project monitoring data on farm, herd, and productivity, • Price and transport information from abattoirs and traders, • Local expert opinion, • Price and cost information from input suppliers (hardware stores), • Management and cost information from farmers through detailed and repeat interviews with 4 case study farmers, and • Labour information from a labour diary with project farmers.
3.2	Conduct economic analysis of smallholder systems	Whole-farm economic model developed and calibrated. Desktop testing of incentives to adopt various management, enterprise, and marketing options. Opportunities identified to improve returns and livelihoods identified and reported to farmers.	Y2, M6	This data was used to develop a model of a representative smallholder cattle farm in East Santo. The model is expressed in three forms: • A detailed partial, steady-state model of a representative cattle farm on East Santo. The model is too complex to be used for policy or training purposes in Vanuatu, • Based on the model, a training manual has been developed to simplify material in a step-by-step process that can be used by extension staff, agencies, and farmers. This allows farmers to understand and collate information on their current cattle production system and to plan and test the economic impacts of other options, and • Parts of the manual have been further broken down into specific training modules, Additional analysis has been done on alternative cattle management scenarios. Partial budgets have been developed copra and kava. Using a common indicator (returns to labour) and price sensitivities, the incentives to undertake substitute and complementary activities is assessed.

No.	Activity	Output / Milestone	Completion date	Comments
3.3	Conduct training, provide advice, and facilitate implementation of improved management and enterprise options	Training and advisory material (budgets, technical and interventions from Objective 2) developed and delivered. Management and enterprise options selected, adapted and implemented by project households. Monitoring and reporting on management and enterprise changes (case study approach).	Y3, M1	Training sessions were conducted which covered four modules: farm management, cattle herds and revenues, cattle marketing, costs, and profitability. The sessions were conducted in 2018 and 2019 for 1-2 days each for ~12 participants each, including farmers (project and other) and trainers (livestock and vet officers, Dept. of Industry, VARTC, VAC, VSP). The training sessions were designed as pilots to test and refine material. Surveys conducted to assess the training were favourable and feedback was used to refine material. There is scope to use other training methods and to formalise the material in local programs, for example, the VSP and VAC.
3.4	Assess and implement alternative smallholder cattle marketing interventions	Report on price, specifications, and terms of buyers. Budgeting and feasibility study of marketing options for producers. Facilitation of communication between buyers and sellers, deals, and trials of improved marketing systems. Monitoring and reporting on marketing trials.	Y2, M1	All conceivable agribusiness interventions have been investigated and analysed, and the most promising trialled: facilitating discussions between farmers and buyers at field days, training farmers in the assessment of different cattle marketing options, and facilitating cattle sales to alterative (non-abattoir) markets (butcher in Santo and Port Vila) through objective measurement and competitive selling. The costs, benefits and sustainability of the models are being assessed in the Master of Philosophy thesis of Kalo. The study has been suspended due to COVID and is expected to be resumed and completed in 2021.
3.5	Conduct whole-of-chain participatory engagement	Structures and incentives of farmers and agribusiness actors assessed. Agribusiness actors participate in project activities and forums. Initiatives to consolidate linkages and trust between producers and agribusiness actors examined and where feasible implemented.	Y2, M1	See above Detailed interviews and ongoing consultation were conducted with all agribusiness actors in Santos, Port Vila, and other provinces. Waldron and Kalo alone have conducted at least 40 interviews with agribusiness actors in the current project, while local partners (Antfalo, Boe, Tabiaga) have weekly contact. The structure and the incentives of lead firms in Santo preclude formal marketing agreements with households, but flexible arrangements suited to local conditions have been facilitated and other alterative linkages (particularly butchers and markets) have been developed.

No.	Activity	Output / Milestone	Completion date	Comments
3.6	Collate data from Objective 3 and integrate into Activities 1.4 and 1.5	Relevant data collated and used in reports for Activities 1.4 (agribusiness analysis) and 1.5 (livelihoods analysis).	Y4, M12	Agribusiness structures of cattle and associated industries in Santo are reported in detail in the Master's thesis and presentations of Kalo (forthcoming, 2020) and in Cole et al., 2019. For detail see Activity 3.5 and Appendix 3.

Objective 4. To create pathways which sustain and extend project outcomes and impacts beyond the scope of the current project

No.	Activity	Output / milestone	Completion date	Comments
4.1	Form a Project Advisory Group to meet with the Project Management Group	Project Advisory Group representing industry stakeholders formed. Project Advisory Group meets with Project Management Group twice yearly (at least one of these linked with project annual meeting).	Y1-Y4	A number of groups already exist (LIWG) or are planned (farmer associations). This includes members of the project team sitting on these external groups. Therefore, it was deemed redundant to form a new group. Instead members of existing groups are informed of project activities (through newsletters) and invited to attend project annual meetings.
4.2	Initiate Project Catchment Area Group meetings	Project catchment area stakeholders meet every 2 to 3 months.	Y1-Y4	Project catchment meetings are held every 4 to 6 months. There are challenges associated with participation of farmers in these meetings. The meetings evolved into planning meetings rather than facilitated farmer-to-farmer discussions of project activities and learnings.
4.3	Implement a monitoring and evaluation strategy	Monitoring and evaluation of project occurs each year at annual meetings with a report submitted to all project partners and ACIAR. Project activities, communication strategy, and impact pathways are refined based on monitoring and evaluation findings.	Y2, M6	Project activities were reviewed at annual meetings. The PIPA was reviewed at annual meetings but not revised at any stage. Generally, the major revisions to implementation of project activities were around methods to better engage farmers in monitoring activities and catchment meetings, in addition to adjustments in internal project communication strategies which simply were not working at the start of the project. There were no revisions to overall project objectives.
4.4	Train project participants in project activities	Project staff are independently conducting project activities on-farms and with households.	Y1, M12	Project participants are able to independently undertake research activities. Limited engagement of project organisation staff in project activities resulted in limited extension of capacity beyond the project employed team and participating students.

No.	Activity	Output / milestone	Completion date	Comments
4.5	Demonstration and extension of research activities and outcomes to farmers and other industry stakeholders	Farmer visits to participating progressive farms that have successfully adopted interventions. Farmers visits/field days at VARTC to observe forage evaluation and cattle management activities. VARTC research activities extended and adapted into on-farm participatory research activities. Promote project activities and outcomes through agricultural shows, field days, and mass media.	Y1-Y4	Farmers and stakeholders participated in the annual meetings, field visits, and field days. Farmers are invited to catchment meetings and visit research activities and on-station and on-farm demonstration sites. Farmer groups have visited research in progress at VARTC and Monbiftec. This included a large field day attended by 100 farmers, students, and support agency staff at VARTC and a field day in Sara attended by 115 farmers. Recommendations from VARTC forage trials formed the basis of on-farm forage evaluation plots. Research on drinking water provision has been extended on farm. The project had a display at the National Week of Agriculture on Santo in July-2018. The project held a field day at VARTC attended by 100 participants in October-2018. A number of newspaper, radio, and television reports have been generated from project activities over the last 12 months. The project maintains an active Facebook page.

No.	Activity	Output / milestone	Completion date	Comments
4.6	Involve students (VAC/University of the South Pacific)	Students from project catchment area offered scholarships to attend VAC, and students successfully complete studies and graduate. Students from VAC involved in all aspects of project activities. Project team members to present lectures/short-course training to VAC students. Project provides research topics for potential postgraduate research topics for students enrolled at University of the South Pacific with thesis successfully completed.	Y1-Y4	Due to administrative issues no scholarships were available for students. VAC students (~30) participated in on-station and on-farm research activities. Project team members from Australia presented lectures at VAC to students on beef cattle nutrition, forage research, use of GPS and livelihoods analysis. Mr John Meonga was the recipient of an ACIAR funded University of South Pacific University of Sunshine Coast scholarship and conducted research within the project in Vanuatu on copra meal supplementation of cattle through USP. Mr Noel Kalo is the recipient of an Australia Awards scholarship and is conducting research on the beef value chain and marketing interventions in Vanuatu for his M. Phil at UQ. Ms Fyn DeDuanton (UQ) received a Crawford Fund travel award and undertook an analysis of the ceremonial markets in east Santo for her Honours project at UQ. Ms Peta Stockwell (UQ) was the recipient of a Future Leaders in Agriculture scholarship and undertook a one-week trip to Vanuatu in October-2019 to join the team establish on-farm activities and farmer interviews.

No.	Activity	Output / milestone	Completion date	Comments
4.7	Build linkages with other organisations and programs	Inform other programs/projects of project activities through the LIWG/PHAMA. Project team members participate in regional meetings, conferences, and planning meetings where possible. Project newsletter circulated to other programs/projects every second month. Project resources are available for use by SPC animal health work.	Y1-Y4	Good communication existed between the project and the now discontinued NZ MFAT funded program. This included sharing of de-identified survey results (from NZ MFAT), and technical information (from the current project). Farmers working with the NZ MFAT program also attended the current projects field days and training activities. Project team members sit on the LIWG in Vanuatu. Chair of the LIWG is invited to meetings. The Project Leader met with LIWG members and PHAMA co-ordinators on visits in country. Communication on EDF-11 was via project team members who sit on the various implementation groups. Project team members are involved in PARDI2. Engagement with PARDI2 and other ACIAR funded projects (Agroforestry, small ruminants) occurred on an ad hoc basis. Project team members participate in the Pacific Week of Agriculture. Project team members participated in the TropAg conference in Queensland. Representative from the Project Management unit responsible for implementation of EDF-11 participated in project meetings. Project team members are also involved in EDF-11 planning and implementation. Project newsletters were circulated two or three times each year. SPC or other animal health programs made no approaches to the project for access to project resources.
4.8	Placement of volunteers through Scope Global attached to project in-country	Volunteers are located in Vanuatu.	Y2	Jamie Quilliam completed his 12-month volunteer assignment in June-2018.

No.	Activity	Output / milestone	Completion date	Comments
4.9	Internal project communication strategy implemented	Project newsletters are produced every second month for both internal and external communication of project achievements and plans. Project Management Group to meet by Skype every two weeks in the early phases of the project. Project meetings held each year, with final project meeting to be held in Australia.	Y1, M12	Fortnightly meetings are held with the project team on Santo (the project leader joins by Skype). Over the first two-half years of the project, progress emails were circulated to the project team every month, and 2 or 3 project newsletters were produced each year. These declined over the final stages of the project due to the workload of the project leader and the general lack of response and contribution from the rest of the team to these forms of communication. Similarly, challenges existed in engaging senior members of some partner organisations in both planned and *ad hoc* communication and meetings. Project annual meetings held each year of project operation, including July-2019 in Queensland.
4.10	Annual meetings are held to review project progress and amend project structures and activities if necessary	Project is reviewed including access to project sites, meetings with project partners, and participants. Recommendations of review are made available to project team.	Y1-Y4	Project annual meetings held each year of project operation, including July-2019 in Queensland. A mid-term review was held in May-2018. No recommendations from the review were provided to the project team.
4.11	Conduct participatory impact pathway analysis	Impact pathway developed in the early stages of the project and revisited during monitoring and evaluation at annual meetings.	Y1, M12	Participatory impact pathway analysis and stakeholder analysis completed and revisited at annual meetings.

7 Key results and discussion

Component 1. Situation analysis, livelihoods, and engagement of women

Detailed reports are provided in Appendix 1.

Activity 1.1 Situation Analysis

An analysis of the operating environment of smallholder cattle farmers in East Santo has been completed. This sits within the broader national cattle sector and is subjected to many of the same settings as those described in detail by Cole et al. (2019). The Situation Analysis of East Santo encompasses several specific activities within this component of the project, including:

- Description of household typologies (Activity 1.2),
- Appraisal of farming systems (Activity 1.3),
- Livelihoods analysis, including a gender strategy (Activity 1.5), and
- Agri-business analysis of cattle and associated industries (Activity 1.4).

Given that much of the project aims to describe the existing systems, structures and actors it could be argued that the entire final report is one large Situation Analysis, rather than a discrete activity within the project. Detailed results are included in Appendix 1. The key findings include:

- Cattle have an important role in meeting livelihoods objectives of households.
  - Cattle are important for savings, large cash outlay items (e.g. school fee's), resilience after natural disasters, and in maintaining the social fabric of communities, including ceremonies, nutrition and community support.
  - Households participate in many competitive on-farm (e.g. kava) and off-farm (e.g. private transport) activities to meet livelihoods objectives.
- High demand for beef exists within the East Santo Area Council, domestically [household consumption and by the service (mainly tourism) industries] and internationally.
  - Supply of required volumes of a consistent product is a challenge faced by most markets.
  - Many market options are available to smallholder farmers in East Santo, including ceremonies, rural butchers, urban butchers, abattoirs, and live trade to other farmers on Santo or Efate (Figure 4).
- Bio-physical resources and the environment are favourable to cattle production in East Santo however standard indicators (calving rate, annual liveweight production) of productivity would suggest considerable scope to increase productivity.
  - High stocking rates result in overgrazing and weed ingress.
  - Unproductive females are retained on-farm, contributing to the above overgrazing.
  - Access to drinking water by cattle is largely limited to surface water in the wet season.
  - Access to sound, fertile bulls may be contributing to low reproductive rates.
  - Diversity in systems (copra and bush mix) and large area of land available for improvement provides flexibility and an ability to buffer against natural disasters and other shocks.
  - Low productivity is a function of the capacity of households to:
    - Develop planning, business and technical skills, and

  - Access financial resources and inputs (e.g. labour, seed, wire, bulls)
- Infrastructure is generally limiting (i.e. low quality roads, limited electricity, limited communication networks) resulting in isolation and high access (transport) costs which subsequently influence's the decisions smallholders make (e.g. marketing, access to inputs, access to information, participation in training).
- Capacity building priorities identified by farmers in East Coast Area Council include farm and business planning, grazing management and market access.

Activity 1.2 Define household typologies and identify households with which the project will work

A typology was developed that included criteria on scale of production, geographic location, production system and degree of commercialisation (Table 1). The project made some reference to types of households; for example, the project did not work directly with very large plantation/estate producers, did not work with very small producers (e.g. with three cattle). However, outside these broad parameters, a typology was of limited value. For example: agro-climatic and cultural conditions were similar across all three project sites; all farmers had mixed (cow-calf and fattening) operations; there was a weak relationship between scale and productivity; virtually all farmers disposed of cattle through mixed channels (market, ceremony) with weak links to productivity. As a result, a decision was made in the project to work with any type of smallholder, Ni-Vanuatu producer if they were willing to participate (enthusiastically) in project activities, and that would benefit from participation. A production classification was found to be more useful and has been developed that describes cattle under copra and in secondary bush at different levels of management.

Table 1. Proposed typology of cattle farmers in the East Santo Area Council.

Parameter	**Indicator**				
Village	**Khole**	**Sara**	**Port Olry**		
Land tenure	Customary	Other	Other		
Production system	Copra plantations	Bush	Copra and bush		
Enterprise	Cow-calf	Fattening	Both		
Herd size (total cattle number)	Small (1 to 20)	Medium (21 to 100)	Large (> 100)		
Cattle related farm infrastructure	Fencing	Stockyard	Water supply		
Other income sources	Private transport	Kava	Copra	Coffee	Cocoa
Social and cultural obligations	Yes	No			
Women involved in cattle farming	Yes	No			

Activity 1.3 Participatory appraisal of cattle production systems

The East Coast of Santo is a wet tropical environment with greater than 2000 mm annual rainfall, with July to September the driest months of the year. Cattle production systems were solely based on the extensive grazing of cattle under copra and in bush based pasture systems. Cattle typically graze unimproved carpet grass or Buffalo grass, with overgrazing and weed ingress common. In well managed areas, naturalised legumes (*D. heterophyllum*, *Centrosema*) exists in these pastures. Signal and glycine are recommended grass and legume species for pasture improvement programs based on information generated in the Vanuatu Pasture Improvement Program. Aside from pasture and surface water cattle do not have access to drinking water. Farmers have a good understanding of best practice cattle husbandry and management (e.g. rotational grazing) and implement some of these (i.e. weaning is commonly practiced; rotational grazing when infrastructure permits) but had little understanding of productivity indicators and how these could be calculated or used in farm management and planning. Farmers identified

farm and business planning, grazing management and market access as key areas for capacity building. These assessments resulted in an alternative system to describe households and their farming practices based on their production system.

Activity 1.4. Agri-business analysis of cattle and associated industries

The project conducted close, detailed, ongoing analysis of the Santo beef industry over the course of the project, documented in Figure 4, Appendix 3.4 and Cole et al. (2019). This provides the expertise to address common misconceptions about the industry and the effectiveness of various marketing interventions and options.

Firstly, the major constraints to throughput and quality are on the supply-side. Market demand for beef in all sectors (local, Port Vila, suitcase, export) was high throughout the project. All abattoirs in Vanuatu are running far under capacity because they cannot secure supplies of cattle, especially to specification. No amount of stimulus or uptake in expanded or improved cattle production would change supply to the extent that it puts downward pressure on prices.

Secondly, Santo has a relatively well functioning cattle and beef market. Households have numerous options through which to sell cattle, with healthy competition and information. Santo has two mechanised abattoirs (Santo Meat Packers, SMP; Wong Sze Sing, WSS) but these are running at ~20% of capacity (i.e. slaughter one day a week). High per unit overhead costs (due to under-capacity) and costs in power and transport constrain prices that can be paid for cattle. One abattoir (SMP) has an over-the-hooks class-weight-price schedule that is published and which well-understood by sellers, with large spreads and high premiums for heavy steers. Another (WSS) abattoir has an unpublished over-the-hooks schedule and seeks to capture the (larger) market for lighter steers and other cattle. It also plays an important role in the industry as a service slaughter provider for butchers in Santo and Port Vila.

The efficacy of the market is reflected in price trends. Prices paid by these major buyers have increased for cattle, especially heavy steers (34% increase from 2016 to 2019) with smaller increases for cows and bulls, while heifer slaughter is formally banned. The increases reflect domestic and international trends in the period and, with the entry of WSS in 2016, competition for dwindling cattle supply. The mooted closure of SMP may reduce competition in turn affecting prices and slaughter fees into the future.

Thirdly, due to the market structures, interventions to improve cattle and beef marketing have to be considered very carefully. Measures to simulate additional “high value” markets, to forge “high value” chains involving smallholders or to build sophisticated market services seen in developed countries (such as formal grading or feedback systems) are deemed unfeasible, low-priority and low-return investments for a development agency. It is also important to note that various interventions including estate-smallholder links, contract production systems and auctions have failed for systematic reasons (trust and reneging).

However, few marketing services (measurement, information, brokering, and advertising) are provided in the chain. There are for example no local professional cattle traders or brokers in Santo and limited cattle transporters. There may be scope to increase delivery of the services, but the sustainability of the services depends on the capacity of the provider (public, private, hybrid) and the willingness of user to pay for the services. These questions are being investigated through focus groups, training, trials and analyses by Kalo.

Fourthly, policies and measures to channel cattle through the formal (abattoir) sector and away from the informal (ceremony) sector are misplaced. A project-related study (de Daunton, 2017; Appendix 3) calculated that 30 to 70% of cattle in the East Santo Area Council are consumed in ceremonies. This is an important and valuable distribution channel for smallholders, for all or part of their cattle disposals. This is not necessarily a major constraint to development on the production side. Cattle used in ceremonies are valued at market rates, where cattle used in ceremonies generate either cash income or an equivalent value in beef / protein consumed by community members.

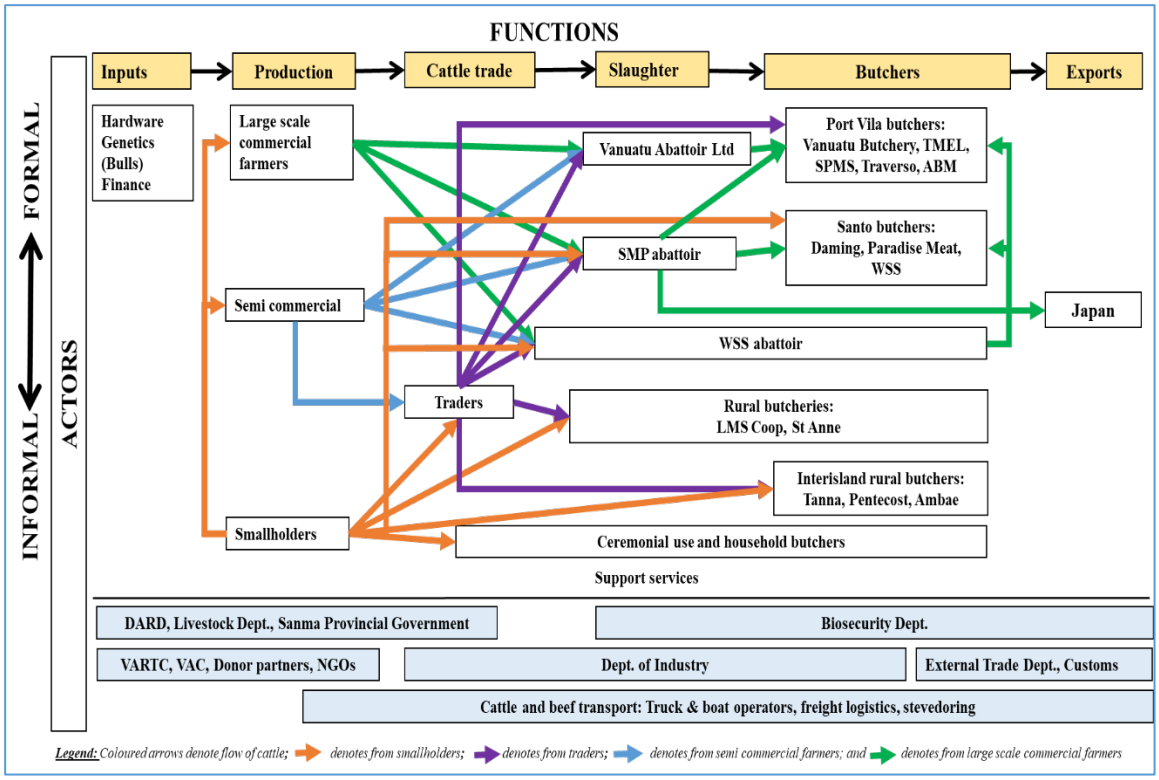


Figure 4. Santo beef value chain map. (Source: Kalo, unpublished).

Activity 1.5. Livelihoods analysis and gender strategy

Baseline

The project linked with large numbers of farmers that raised cattle and developed plans for a wide range of objectives. Detailed training was done with small and large farmers that raised cattle to increase cash incomes as part of their livelihoods strategy. Most planned to do so through increasing grazing areas and herds, but training emphasised the importance of productivity and returns to labour (not just income). Returns to use cattle in ceremonies was valued equally with sales to outside buyers.

Baseline livelihoods data collection from some participants suggested a key reason for having cattle was to meet mainly subsistence and custom needs. Many participants talked of a number of factors why they were not expanding their herds, a key one being the larger the herd the more you were called upon by community and family to donate cattle for custom ceremonies if community members (particularly family) did not have the money to purchase them. This social obligation for farmers with larger herds to contribute more to custom ceremonies appears to act as a deterrent for many smallholders to increase their herds. While some participants didn't feel particularly burdened by community and custom commitments of donating cattle, they did suggest that they did not have the time or investment to expand and then to be seen as a dominate farmer within the community. It was suggested by some participants that it's best to either have a small herd (that just

meets your immediate household needs) or a very large one to account for the loss of cattle to custom, community, drought and family obligations. Cattle were also seen as a key strategy for ensuing food security with a number of households suggesting they had slaughtered cattle in times of food shortages (e.g. crop failure).

The Vanuatu Financial Services Commission (2016) lists the key logistical limitations to raising smallholder cattle numbers as poor transport, lack of access to credit and limited extension programs. While these factors were mentioned by participants as limitations, the key limitation given in these sessions to increasing cattle numbers appeared to be the high occurrence of cattle mortality from lack of water in the dry season and the expense of transporting water to the farm. Approximately 50% of households in SANMA have no access to alternative sources of drinking water and lack proper water storage for animals (VNSO, 2016). From the data in both the baseline livelihoods analysis and storian sessions this was identified as a key constraint to the expansion of the smallholder cattle farmer industry as transporting water is too expensive to warrant increasing numbers of cattle and many households were experiencing water shortages in their homes let alone for livestock. There were examples of smallholder farmers who had attempted to increase their numbers in 2016 only to lose over half of their calves to dehydration. They attributed this to a longer than usual dry season, lack of storage facilities and the expense of transporting water. Accessing reliable and affordable transport is a major logistical constraint in new activities and scaling up. The Vanuatu National Livestock Policy 2015-2030 highlights the need for access to water to be addressed and states that the "government will ensure farmers have enough portable water to supply their animals" (MALFFB, 2015). Therefore, addressing this issue through participatory research aligns with government policy.

These options are taken up in the farm management options and economic modelling (Activity 3).

End-line

The findings from the end-line livelihoods analysis indicate that the majority of households within the project have increased their household income over the last three years. The frequency of loans taken out by households has also decreased. The importance of cattle to households' livelihoods, resilience and the informal economy (which ensures food security as well as an important part of cultural, religious and community-based activities) has decreased. While the importance of cattle to household income generation has increased. Some concerning trends occurred in the transition from the consumption of root crops and fresh meat to packaged food and tinned meat in the last three years. This is a significant change in three years which may lead to increased prominence of non-communicable diseases. It is important to note that no direct link between the income from cattle sales and food consumption patterns has been demonstrated, nor is any such link suggested here.

Gender strategy

Findings from the gender analysis within the broader livelihoods analysis, demonstrated women's daily activities were almost double those of men. Female participants showed a high level of labour commitments in the informal economy such as: subsistence farming; household duties, such as washing or cleaning; community obligations and helping other women in the community with childcare. Findings also revealed that gender patterns of control over income were seen to be largely influenced by land tenure systems, the type of crops and characteristics of the households. Within some households, cash income 'belonged' to whoever produces the goods for sale, while in other households, men controlled all household income. Men were predominantly seen to be the decision makers on the farm and within the household; although, a small number of female participants suggested they were able to make decisions about how income was spent that was directly earnt by them (e.g. through their market gardens). Findings from the gender

livelihoods analysis showed that both male and female participants were unanimous in their preference for farmer to farmer information exchange over participating in workshops or training days at institutions. However, the majority of the female participants suggested that due to cultural and custom considerations they would be more comfortable participating in training with women only.

Based on these findings the authors developed a gender-sensitive training programme grounded in the female farmer to farmer strengths-based and interactive training approach as a strategy to better engage women in agriculture and build their capacity based on their priorities. The gender-sensitive training programme was based on the concept of women only storian sessions. New knowledge, skills and competencies were developed through the interactions between participants and sharing of existing local knowledge and experience. In this way the programme is a low cost, sustainable option for any organization or community. Participants were trained in a participatory manner in topics that they had requested such as: agricultural/livestock extension; compost training; improved banking, saving and skills in financial management for agricultural/livestock; small business activities; increased capability to access microfinance; and building gender inclusive decision-making capacity within the family and community.

Storian sessions with the female Ni-Vanuatu participants uncovered a number of issues when comparing mixed gender to the female only training. Data from storian sessions found overwhelming sentiments that both the female participants and trainers preferred the female only training over mixed gender. Ni-Vanuatu female participants in this project were particularly responsive to this model of horizontal sharing, suggesting it was less intimidating than top down conventional methods they had experienced in the past. Participants also suggested how the gender sensitive training program had enabled them to have the confidence to approach their husbands about their spending and how they could manage their finances better. A key finding from the evaluations conducted on the household level training found that mixed gender household level training will not engage Ni-Vanuatu women in a meaningful way if they haven't first been empowered to feel confident in public speaking and back up what they say, it is essential that this is done in a non-threatening environment. Therefore, the key principles to the gender-sensitive training programme put forward in this case study include,

- Training in mixed gender groups or at the household level will not engage women if you haven't first empowered them to feel confident and back up what they say, this need to be done in a non-threatening environment,
- Don't make training too difficult. Build up the skills slowly, don't underestimate the power of farming women teaching other farming women, its builds self-esteem and enhances understanding of the subject,
- Care about women's needs not just project objectives, listen to them in the design of training materials, and
- Ensure training is family friendly and enables women to still meet their other livelihood priorities.

Activity 1.6. Integration of Activities 1.1 to 1.5

The report of Cole et al. (2019) provides a report of much of the information collected across these Activities (Appendix 5). A multidisciplinary scientific paper will be prepared describing the social and economic considerations that influence decision making with respect to cattle farming and marketing.

Activity 1.7. Conduct situation, livelihoods, and participatory appraisal of cattle production systems on Malekula

The climatic and biophysical conditions and the strong local demand for beef are all favourable for cattle production on Malekula. The settings for smallholder cattle farming on Malekula are largely similar to those in the East Santo Area Council. The exceptions to

this would be the smaller number of formal market channels for cattle and the integration of cocoa under copra plantations on Malekula. The recommendations and strategies generated in Bisnis Blong Buluk and planned for subsequent research on East Santo are likely to be applicable to smallholder farmers on Malekula. The following recommendations are made to guide future engagement and capacity building of smallholder cattle farmers on Malekula,

- Farm mapping is encouraged to engage smallholder cattle farmers in project activities on Malekula and it provides households with essential information for farm planning and management.
- Recommendations on cattle management and farm improvement made on East Santo will be relevant to smallholder cattle farmers on Malekula. Therefore, demonstration sites rather than specific research activities are recommended and should include:
  - Dry season production of improved grasses,
  - Introduction and management of improved leucaena varieties,
  - Weed control, and
  - Water catchment and conservation for cattle drinking.
- The exception to the above would be to undertake new research specific to the integration of cattle within the existing copra-cocoa systems to utilise the valuable feed available surrounding these areas.
- Farm planning skills are largely absent and require development using gender sensitive approaches developed in Bisnis Blong Buluk. The involvement of children in this process appears extremely relevant to Malekula and would provide an important capacity building opportunity. Practical training on cattle husbandry, cattle yard design and cattle marketing assessments would be high priority areas for farmer capacity building.
- More in-depth investigation of the local value chain, particularly the community and ceremonial beef markets, may be warranted. Research on the potential to aggregate cattle lines for interisland trade (e.g. Tanna, Efate, Santo) may be warranted.
- Demonstration and training (and new research) activities should focus on the more accessible Area Councils with the highest cattle population and the highest proportion of households raising cattle (Southeast and Northwest Malekula are recommended). Cross visits from other Area Councils could be supported without a need to be actively working in all Area Councils.
- Upgrading of the MALAMPA butchery to facilitate an increase in processing throughput (under larger development program funding) may be warranted to increase the opportunity for smallholders to access this channel.

Component 2. On-farm and on-station research on productivity of cattle farming systems

Detailed results are provided in Appendix 2.

Activity 2.1 Monitor on-farm cattle production and management

Size of farms and stocking rates

The farms were geographically dispersed across the East Santo Area Council (Figure 5) and ranged in size from 1 to 80 ha, with copra farms (13 ha; n=28) smaller than bush farms (42 ha; n=21). The majority of copra farms were a combination of copra and bush (proportions yet to be calculated), with the small areas of bush on each farm potentially providing an opportunity for strategic pasture improvement for weaners within these mixed herd systems. The larger bush farm areas provide potential to develop significant areas of land with improved pastures to increase productivity, however such a program would require detailed planning and investment (fencing, labour).

Figure 5. Location and maps of individual farms involved in project activities. (Source: GoogleEarth).

Calculations of stocking rates across the classification systems reflected the visual assessment of land condition and were 2.5 (weed ingress under copra), 4.0 (overgrazing under copra), 1.4 (well managed Buffalo grass under copra), 0.9 (semi-improved bush) and 1.6 (improved bush) AU/ha. The Vanuatu Pasture Improvement Program recommended 2 AU/ha on open Buffalo grass-legume pastures, and approximately 1 AU/ha on Buffalo grass under coconut plantations (at ~50% light inception under 20 to 30-year-old coconut trees). It is likely that the high stocking of pastures under coconuts will result in low productivity, however it is also appreciated that high stocking density will allow for easier harvesting of coconuts which is an important consideration for most households. Rotational grazing would allow for coconuts to be harvested after grazing plus providing pastures with a chance to recover before the next grazing event.

Cattle monitoring

Forty-nine households participated in regular cattle monitoring at various stages of the project across the five cattle production system classifications. A total of 1244 cattle were registered across the 2.5 years, from which a total of 1944 animal measurements were recorded; this equates to approximately 1.5 measurements per registered animal. However, 61% of all registered animals presented for a single measurement at registration only. Numbers enrolled and numbers monitored peaked during the 2017_R02 and 2018_R01 rounds and declined thereafter. The peak in monitoring and enrolments may have been related to a spike in farmer interest or (from a logistics perspective) the organisational assistance of a volunteer working with the team from July-2017 to June-2018. No new animals were enrolled at the final monitoring event of 2019_R01. The low numbers of animals returning for repeat measures was largely a result of incomplete musters, rather than disposals (sales, gifts, obligations, exchanges) or mortalities. At the 2019_R01 muster the project introduced a rewards scheme for farmers to encourage a more complete muster resulting in over 50% of farmers presenting more than 75% of animals that had previously been enrolled in the project. The incentives offered were small tools that could be of assistance with farm improvement (wire, pliers, fencing strainers). This type of incentive should be considered as a reward for farmer's time when data collection is beyond their own requirements but places an increased burden on their time.

Cattle management practices

Information on herd level cattle management practices were collected at each monitoring visit on each farm. Rotational grazing was reported on 80% of all herds monitored, this was higher than expected. This typically involved a small number of paddocks on each farm (two to four) with cattle rotated at fixed times rather than based on pasture availability. Only 10% of farms reported having drinking water available for cattle at the time of monitoring, which is comparable to other surveys conducted by the current project and NZ MFAT (2017). No animal health treatments were applied to any cattle over the monitoring period. Approximately 10% of all cattle monitored were tethered, with the majority of these steers and heifers during and after weaning with an average liveweight of 265 kg. Approximately 25% of all cattle monitored were either castrated or dehorned by the project team and the ability to do this safely was a major incentive for farmers to participate in cattle monitoring.

Herd profile

Herd profile was determined using two methods. Initially household surveys indicated a total herd profile across 48 households (Figure 6). The proportion of cows within the herd appears high (60% of cows, steers and heifers) and, considering the low proportion of calves (i.e. low reproduction rates) and low number of replacement heifers on hand, this would suggest farms are carrying a large number of unproductive breeders which would be contributing to the high stocking rates identified earlier. The overall proportion of bulls is high (3.4%) but expected given the small herd sizes (i.e. at least one bull regardless of number of breeders), however it is noted that 20% of farms recorded no bulls, with all of these having herds under coconuts. As all farms reported some calves it is understood that neighbours' bulls may be used on some occasions. Data collected at regular monitoring visits using a combination of animal count (cattle present in yards) and farmer supplied data (cattle not present yards) resulted in a similar herd profile.

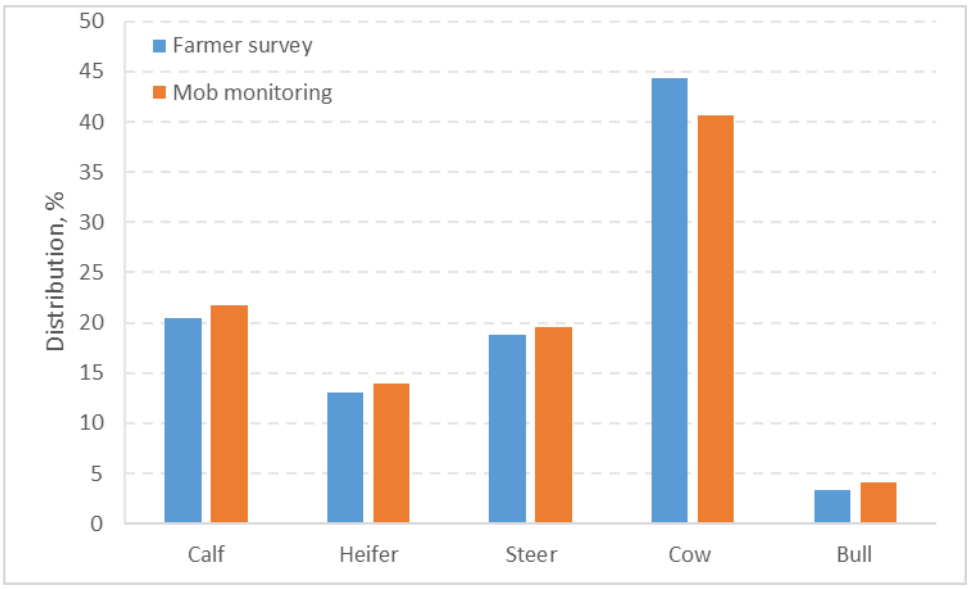


Figure 6. Profile of cattle herds in East Coast Area Council from farmer surveys and at regular monitoring visits.

Calving distribution and calving percentages

Month of calving data was recorded for cattle born in 2016, 2017 and 2018. Calving occurred throughout the year but with a peak in the late wet- and early dry-season (43% in June, July and August; Figure 7). This would correspond to a conception period of October to December probably in response to the break in the wet season. Whilst calving during the peak wet season is not desirable due to the high humidity and increased risk of internal parasites, calving in the early dry season may also be undesirable, particularly in drier years, if drinking water is unavailable resulting in suppressed milk production and an increased risk of calf dehydration and incidence of calf mortality. Lactating cows require double the water intake of dry cows (on a kg/kg DM intake basis; Freer et al., 2007) and this is unlikely to be available on most smallholder farms through the dry season.

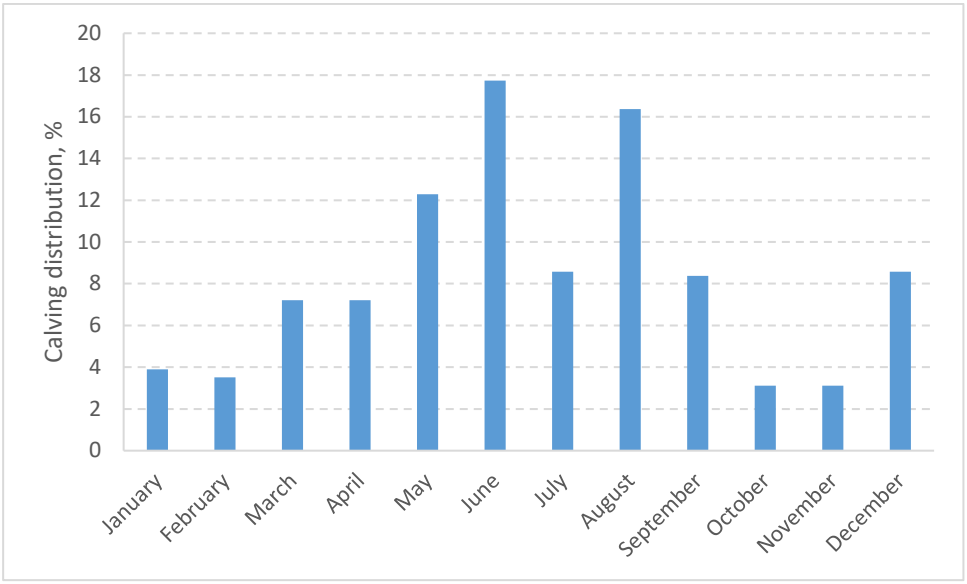


Figure 7. Distribution of calving in cattle herds in the East Santo Area Council.

Calving rates were determined by several methods. Initially from farmer supplied survey data a calving rate of 46% was determined (number of calves/number of cows in a single herd). Herd profile counts at regular monitoring visits, a combination of physical counts of animals in yards and farmer supplied information on the number of animals not present in

yards, indicated a calving rate of 53%. Whilst the regular monitoring data of cows present in the yards suggested that the number of cows lactating across all herds and monitoring events was 42.5%; this is likely to be an under-estimate if it is assumed that a higher proportion of cows with calves at foot were not mustered to the yards at monitoring. These data align closely with the NZ MFAT survey data (2017) which reported a calving rate of 40% for smallholder cattle farmers with herds of less than 50 cattle. Regardless of the exact value a calving percentage of below 50% is low by any standard. These low calving rates will translate to low weaning rates which are key drivers of profitability in cow-calf production systems. Addressing these low reproduction rates is likely to significantly increase herd profitability; it is not unreasonable to suggest that modest increases in calving rate from ~45 to 65% are possible through improved herd management (weaning, adjusting stocking rates by culling unproductive females and ensuring access to sound bulls).

Analysis of the calving data disaggregated by cattle production system classification should be viewed with caution due to the small numbers of households and cattle present in some of these systems. Only small numbers of cattle were available for analysis, particularly in the improved bush systems which are typically used for growing out steers rather than breeding, so data from these systems were combined. Nevertheless, the data indicates calving rates of approximately 30% for cattle under copra plantations and 60% for those herds managed under bush respectively. There was little difference in calving rate between the different cattle systems under copra (28 to 32%); data for farms with weed ingress were omitted due to data anomalies where more calves than cows were reported in two herds inflating the overall calving rate to almost 100% which is unlikely.

Cow body condition score and liveweight

The average liveweight and body condition score of all cows across all monitoring events was 360 kg and 2.8 respectively with 40% of all cows were recorded as lactating across all monitoring events. Non-lactating cows (365 kg) were marginally heavier than lactating cows (352 kg) and this was reflected in marginally higher body condition score in non-lactating cows (2.9 v 2.7) as expected. Cows were slightly heavier (370 kg) at first round muster (early dry season) than at second round muster (late dry season) (353 kg). Across all measurements cow liveweight ranged from 172 to 544 kg and 1 to 5 body condition score.

Body condition score ranged from 2.4 to 3.4 (Table 2) and was relatively consistent throughout the year and between grazing systems. Cows tended to be of higher liveweight and body condition score at the early dry season muster round, regardless of lactation status or grazing system, with the exception of cows grazing under copra with high weed ingress which appeared in better condition at the end of the dry season. Cows grazed under copra on well managed buffalo grass were heavier and in better body condition than cows grazed under copra at higher stocking rates. Interestingly cows grazing areas with higher weed ingress were not as light in liveweight or body condition as those where over-grazed buffalo grass and carpet grass existed but weeds had not established to the same extent. This would suggest that these non-grass species were forming a significant part of the diet and were of higher nutritional value than otherwise expected. Despite lower stocking rates and more available biomass cows managed under bush-based systems were no heavier or in higher body condition than those under copra on well managed buffalo grass pastures. This demonstrates that it is possible to maintain cows in good condition under copra with appropriate stocking rates.

Table 2. Body condition score and liveweight of lactating and non-lactating cows managed in bush grazing systems or under copra with well managed Buffalo grass, overgrazed Buffalo grass or with high weed ingress in the East Santo Area Council.

Production system	Early dry season		Late dry season	
Body condition score	Lactating	Non-lactating	Lactating	Non-lactating
Bush	2.75 (34)	3.10 (29)	2.80 (81)	2.80 (71)
Copra – well	2.70 (10)	3.40 (55)	3.05 (23)	2.95 (50)
Copra – overgrazed	2.65 (38)	2.63 (83)	2.40 (67)	2.90 (94)
Copra – weeds	2.66 (9)	2.92 (9)	2.90 (14)	2.80 (19)
Liveweight, kg	Early dry season		Late dry season	
Production system	Lactating	Non-lactating	Lactating	Non-lactating
Bush	370	351	349	341
Copra – well	387	432	393	408
Copra – overgrazed	357	344	320	341
Copra – weeds	344	359	374	382
Value in parenthesis is number of animal records per measurement				

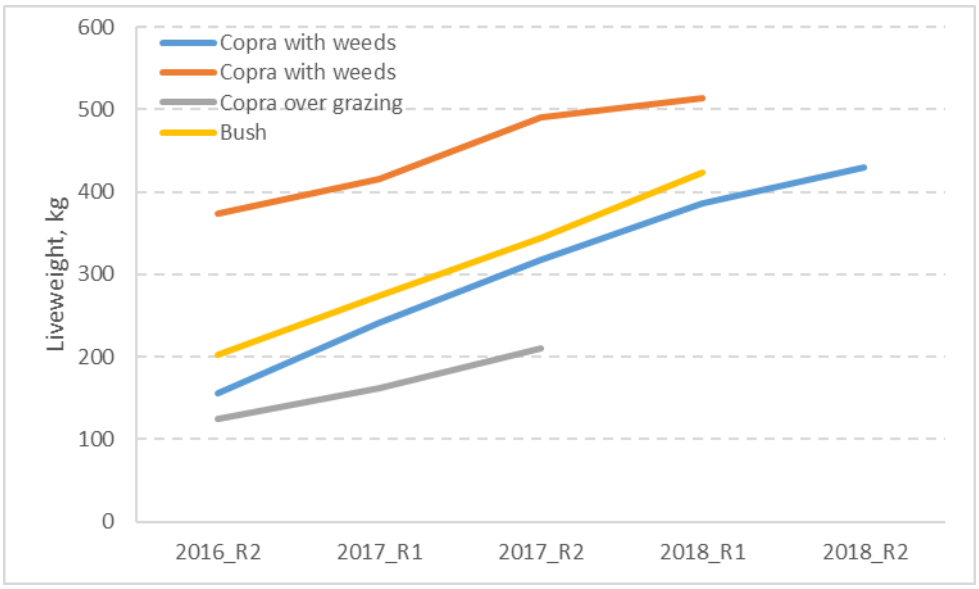
Liveweight gain

Overall growth rates were higher for steers and calves over the dry season and for cows and heifers over the wet season. Anecdotal evidence has indicated this is common in the wet tropics where high water content of pastures, coupled with humid and hot climatic conditions result in decreased dry matter (and hence ME) intake. Seasonal and annual growth rates were low across all systems (Table 3) with flow on effects on the time taken for cows to recover body condition, the time required for heifers to reach a critical mating weight (assumed to be 65% of mature size; 3.5 years) and the time taken for steers to reach slaughter weights which would attract price premiums on existing price grids (~4 years).

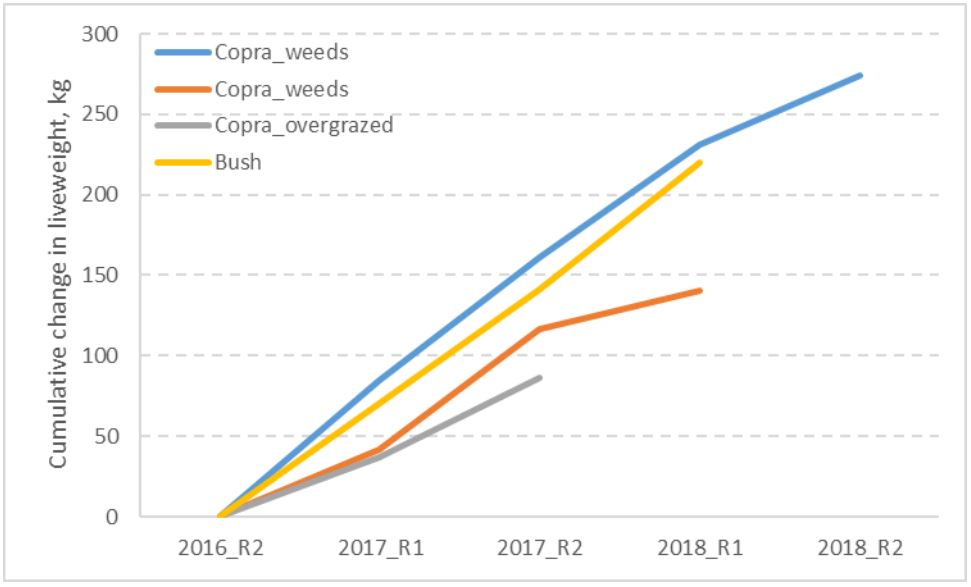
Table 3. Liveweight gain of calves, heifers, steers and cows in the wet and dry season averaged across all production systems in the East Santo Area Council.

Class	Wet season, kg/day	Dry season, kg/day	Annual liveweight production kg
Calves	0.34 (38)	0.41 (30)	136
Heifers	0.39 (22)	0.16 (29)	106
Steers	0.27 (101)	0.33 (58)	110
Cows	0.07 (101)	-0.06 (86)	5
Values in parenthesis are numbers of animals recorded Annual liveweight production calculation was extrapolated using a 210 day wet season and 155 day dry season			

The intention was to unpack the data further by grazing system, however repeat measures for individual animals were limited. Some examples of longitudinal data collected on four farms with three to five steers is presented in Figure 8. Whilst low growth rates were common across all herds, these appear lowest for cattle under copra when overgrazing has occurred, and when heavier more mature steers were maintained under copra plantations. In both scenario's there would be insufficient ME available to sustain growth rates. For these heavier steers there were limited financial gains in retention by farmers, particularly as they would already attract the highest price on the existing price grids. These heavier steers were simply consuming pasture which could be utilised by lighter animals but were not gaining any liveweight.



a.



b.

Figure 8. Liveweight (a.) and cumulative change in liveweight (b.) of steers under different grazing systems in the East Santo Area Council. (Each line represents the mean liveweight of three to five steers on a single farm).

Internal parasites of cattle on selected farms in the East Santo Area Council

Given the high stocking density and wet and humid conditions for much of the year it was hypothesised that internal parasites may have an effect on productivity of smallholder cattle herds. Enumeration and identification of eggs in faeces of cattle mobs managed under different systems revealed the presence of strongyle eggs and *Eimeria* oocysts in cattle across all systems. However, burdens detected were likely to be lower than those required to have a negative impact on productivity across the measurement period. Spikes in egg loads were detected in some systems (semi-cleared bush, weeds under copra) for one or two months but quickly returned to low levels.

Quality of diet consumed by cattle on selected farms in the East Santo Area Council

Near-infrared reflectance spectroscopy (NIRS) of faecal samples collected from cattle can be used to predict the crude protein (CP) content, digestibility (DMD) and non-grass proportion of the consumed diet. Calibration equations generated for young, growing cattle fed a range of tropical forages in northern Australia were used to estimate the CP content, DMD and proportion non-grass in the diet consumed by grazing cattle in the East

Santo Area Council. The estimated CP content of the diet consumed by cattle across all farms generally fell within the 7.6 to 16.3% range, tending to be lower in the late dry season months of August and September each year, as expected. Diet DMD reflected that of CP content across all farms and generally ranged from 44 to 68%. The higher than expected predictions of diet quality consumed by cattle under unimproved conditions (overgrazing and weeds under copra plantations) are attributed to a high proportion of non-grass in the diet, which was relatively constant throughout the year. Local leguminous plants and other shrubs and trees are available across much of Vanuatu in addition to small amounts of leaf regrowth of native grasses which would also provide small quantities of green, high protein material in the dry season. The prediction of the proportion of non-grass in the diet was variable (0 to 65%, mean 24%) across the farms but appeared highest on farms where cattle grazed under copra plantations with heavy weed burdens. While the quality of the diet consumed by the cattle on the farms monitored may be high, the quantity may have been limiting production, particularly where cattle grazed under copra at high stocking rates where pasture biomass was low or weed burdens were high; F.NIRS equations were not developed to test ME or DM intake. In these circumstances, cattle are likely to have been consuming quantitatively low amounts of these forages, resulting in a low ME intake with a relatively high CP content (i.e. young regrowth or leguminous weeds).

Activity 2.2. Implement and monitor on-farm interventions to improve production

As a result of on-station research visits, participation in project training activities and individual farmer discussions two main on-farm interventions were proposed for testing. These included 1. On-farm forage evaluation plots, with the potential to be used to develop larger areas of grazing land, and 2. Catchment and conservation of water for cattle.

Twenty households across the three village sites were offered access to training and provided with wire and seed to establish small (20 x 20 m) forage evaluation plots on their own farms. A range of grasses (Signal, Mulato, Mekong, Mombasa and Sabi) and legumes (Rongai, Tinaroo, Milgarra, Temprano) were selected based on farmer feedback from the on-station visits and researcher experience. Farmers monitored the establishment and growth of their plots both before and after light grazing events and were surveyed to record their preferences. Farmers preferred Signal and Mulato grasses and Rongai and Milgarra legumes largely due to their high proportion of leaf to stem and preferential selection by cattle. While all farmers indicated their intent to transplant these forages on their grazing areas, 12 months later only two farmers had done so on a small scale. The reason for the lack of scale-out was because farmers had no fenced off areas of land to transplant and establish the forages before grazing commenced. Whilst all farmers considered the research activity useful in that they were able to evaluate forages on their own land, the majority also indicated that it was laborious and required considerable commitments in weeding and maintaining fences to exclude cattle from the plots. This was a valuable learning for the project, in that if farmers find managing a small plot a challenge it is unclear how they would manage a larger area (1 to 10 ha) of pasture improvement, particularly when they need to organise all inputs (wire, herbicide, seed, labour) for establishment and ongoing management.

A single household established a water catchment and conservation system in the form of a cement tank to address the unavailability of drinking water for cattle. The farmer had observed breeder and calf mortality in previous dry seasons. The farmer had supplied additional water to cattle in the dry season through banana trunks and transporting water to the farm, which was expensive and time consuming. The farmer expects to reduce breeder mortality and redirect cash and labour previously used for water provision to weed management on the farm. The establishment of the system is only just completed and is

filling this wet season before cattle will be provided access in the 2020 dry season, with follow up surveys conducted then.

Activity 2.3. Copra meal supplementation

Intake of copra meal by steers was lower than expected during both the wet season (2.8 g (as fed)/kg LW.day) and dry season (2.4 g (as fed)/kg LW.day). Copra meal intake tended to increase throughout the wet season (< 1 g/kg LW.day December-2018 and January-2019 to 3.6 g/kg LW.day in April-2019) and declined in the latter part of the dry season period (2.8 g/kg LW.day from May to August-2019 and 1.7 g/kg LW.day mid-August to early October-2019).

Regardless of the quantitatively small changes throughout the year, intakes remained low (<4 g/kg LW.day) compared to other studies where responses in liveweight gain to copra meal supplementation have typically been reported (McLennan, 2004; Gulbransen et al., 1990). It is important to note these other studies where higher intakes of copra meal and greater liveweight responses are reported were conducted in situations when the protein content of the basal diet was low (<50 g CP/kg DM). The quality of the diet consumed by unsupplemented steers in the current experiment never fell below 85 g CP/kg DM or 55% dry matter digestibility suggesting that steers had access to forages that were not limiting in protein or energy. The predicted non-grass proportion in the consumed diet was typically averaged 39% across the entire period and approached 50% in the majority of months, suggesting local legumes and some weeds were forming a large portion of the diet consumed by the steers. Given the high CP and DMD content of the basal diet it is unsurprising that intake of the copra meal was lower than anticipated. Whilst the copra meal did not appear rancid after prolonged storage it is possible that this affected palatability and intake, however it is noted that intakes were low from the very start of the experiment and did not increase whenever fresh copra meal was used.

Steers supplemented with copra meal during the wet season grew at 0.48 kg/day compared with 0.34 kg/day for unsupplemented steers over the same period. This equated to an additional 24 kg of liveweight/steer over the 154 day wet season treatment period (56 vs 79 kg liveweight/steer). Steers supplemented with copra meal during the dry season grew at 0.43 kg/day compared to unsupplemented steers that grew at 0.40 kg/day (03-May to 04-Oct-2019). The response to copra meal during this period equated to a 4 kg difference in liveweight between supplemented and unsupplemented steers (53 vs 49 kg over 154 days). Given the current price of copra meal (1000 vatu/25 kg) and the logistics and labour inputs required for the sourcing and storing of copra meal the returns on investment for copra meal supplementation are likely to be very low when the quality of the pasture base is high as appears to be the case under most systems monitored in this project (Activity 2.1).

Activity 2.4. Review of non-forage feed resources for cattle in Vanuatu

The potential use of non-forage feeds for cattle in Vanuatu appears limited due to the localised, small scale of production, the limited manufacture and processing sector (so limited opportunity for value-adding) and competition from human requirements. Copra meal is the only non-forage feed source produced in sufficient quantities to make any significant contribution to the nutrition of cattle at a broad level. However, declining production, high international demand (and prices) and transport and storage logistics in the wet tropics mean this is an unlikely feeding option for smallholder cattle farmers Vanuatu. The use of unharvested coconuts, which are otherwise wasted in the field, may warrant further investigation but this would also incur high labour inputs for collection and opening of coconuts to provide flesh for cattle to consume; the high lipid content of this product may result in low intakes. The potential development of dual-purpose systems for some of these crops (e.g. sweet potato, cassava) warrants research on the development of systems that encourage weed control, and produce feedstuffs (e.g. leaves) for livestock

and products (e.g. tubers) for human consumption. At this stage there is limited potential for non-forage feeds to be incorporated into cattle feeding systems in Vanuatu but more importantly, there is actually very little need for these types of feedstuffs given the potential high nutritive value of pastures throughout the year. Equivalent, or higher, rates of productivity are likely to be obtained through improved grazing management of the existing or improved forage resources.

A database of approximately 80 non-forage and forage (naturalised and introduced) feedstuffs is in development and will be available to partner organisations by the end of the project.

Activity 2.5. Review of the potential use of apps for smallholder cattle farming systems in Vanuatu

There are no existing apps which would be directly transferable to smallholder cattle production systems in Vanuatu due to language, cost, network requirements and relevance to the context (i.e. smallholder grazing cattle systems in the tropics).

Many of the existing cattle monitoring and nutrition or feed formulation apps were overly sophisticated, not relevant to the cattle management conditions in Vanuatu or required RFID connectivity to attain the most benefits, whilst pasture based apps were typically designed for use within temperate systems. Whilst marketing apps provided excellent information, these only included market information relevant to Australian livestock. Unsurprisingly, none of the apps evaluated were in Bislama, which would obviously eliminate their use by the target users in Vanuatu. Nevertheless, there were features across all these apps that could be incorporated into apps developed to support smallholder cattle farmers in Vanuatu. Relevant features in existing apps which may adapted if apps were designed for smallholder cattle farming systems in Vanuatu include, look up databases (animal diseases, weeds), land condition and ground cover monitoring, animal pedigree and animal husbandry calculators, market information, GPS and farm mapping tools, the use of decision tree approach to guide users through problem solving and farmer wallets. Whilst the use of apps is increasingly reported in agriculture, including smallholder systems in developing countries, there is little empirical evidence on how adoption has impacted on the livelihoods of users (or what those levels of adoption may be assuming a download rate is not an indicator of usage). This may be the case in Vanuatu where the number of users will be small and network coverage is very limited. The use of digital methods for capacity building (e.g. instructional video's) and decision support tools for farmer mentors and extension officers may be a more valuable investment than the development of cattle farming specific apps.

Activity 2.6. On-station research activities (VARTC)

Evaluation of grass and legumes

Grass herbage yield was initially assessed 12 weeks after establishment, and on 5 to 7 week harvest cycles thereafter due to rapid regrowth after cutting. High annual yields between 13 and 25 T DM/ha.year were achieved by some grasses, including a range of *Panicum maximum, Brachiaria brizantha* and *Brachiaria* hybrids. These grasses out-yielded the local comparators Basilisk *Brachiaria decumbens* and *Stenotaphrum secondatum* over the experiment, mostly due to superior growth the year after establishment. Legume herbage production was mostly assessed on 12 to 14-week harvest cycles over two years after establishment. A range of legumes regrew well after cutting and produced up to 10 T DM/ha.year. The highest yielding legumes were *Stylosanthes guianensis*, *Desmodium intortum* and *Neonotonia wightii*. These best performing grass and legume cultivars are all commercially available from Australia and present an alternative grass option for any pasture improvement program to be undertaken by cattle farmers in Vanuatu.

Evaluation of legumes under shade

Preliminary results from the replicated single-row evaluation of legumes under shade suggest that *Neonotonia wightii*, Desmodium *intortum*, *Arachis* spp and *Leucaena leucocephala* all established and persisted well under coconut trees of this age and on this soil type. These present a diverse range of legumes for producers to consider when developing strategic areas of legumes for feeding young cattle under coconut plantations, with different growth habits, persistence under grazing and management requirements.

Grazing trial

A grass (Mekong[*Brachiaria* spp]) and mixed legume (Tinaroo [*Neonotonia* spp], Cardillo [*Centrosema*] and Nina [*Stylosanthes*]) pasture was successfully established to support an experiment to assess the effects of three grazing regimens (set stocking at high and low stocking rates, and a rotational or spelling system using a the high stocking rate) of pasture productivity and composition and animal performance. After one year of grazing, pasture productivity and legume composition in pasture have been maintained under Low-Set and High-Rotational/spelling grazing management, but feed on offer (particularly Mekong) declined markedly in the High Set-stocked treatment. The weed content in pastures also increased in the High-Set stocked treatment. Tinaroo glycine has been the most productive legume to date, whereas Nina stylo has declined from a low starting point. Cardillo centro has declined in all except the High Rotational treatment. Grazing management did not affect the quality (protein and energy content) of the diet consumed by steers over the 12 month monitoring period. The proportion of legume consumed by cattle was lower than expected and highly variable. Similarly, faecal egg counts, and hence internal parasite burdens, were also unaffected by grazing management and remained low throughout the first 12 months, after initially treatments were administered. Annual liveweight production per steer was highest for the Low-Set (225 kg/steer) grazing management system but highest per ha (660 kg/Ha) for the High-Rotational grazing system. It may be possible for steers maintained under the Low-Set stocking rate on these pastures to achieve liveweight associated with premium prices at the abattoir at approximately 2 years and 2 months of age within this system. Whilst the High-Rotational grazing system, at the current stocking rate, will result in better utilisation of the available pasture, individual steers will take longer to reach 500 kg liveweight (~3 years and 3 months of age). A High-Set stocking rate (of 2.7 AU/ha) on this pasture mix is not sustainable from either an animal productivity or pasture sustainability perspective.

Water trial

Heifers with *ad libitum* access to drinking water showed a modest 20 kg increase in liveweight above heifers maintained under the prevailing conditions over an initial 6 month period (40 kg liveweight/ha at current stocking rates). The quality (120 g CP/kg DM, 62% DMD, 700 g water/kg fresh pasture) and quantity (2000 kg DM/ha) of the pasture was not limiting within the experimental model likely resulting in high amounts of water intake from pastures which would typically be higher than that available to smallholder cattle where pasture (and hence water) availability would be much lower. The data obtained was from a typical dry season with rainfall above 50 mm each of the six months.

In addition to the above on-station activity a simple desk-top activity was conducted to develop a calculator to estimate water requirements of smallholder cattle herds. The Excel model was developed incorporating rainfall data, temperature range, pasture moisture content, and breed, class, dry matter intake and productivity of animal in a herd. The model may assist extension officers and farmers to make decisions regarding their investments in water supply systems to cattle. However, despite its availability there has been little interest from any officers for training or testing of the model.

7.1 Component 3. Economics, training modules, and marketing

Activity 3.1. Collect and analyse whole-farm and household economic data

Data for economic models were sourced from secondary data on production (especially from the Vanuatu Pasture Improvement Program), and from the following sources

- Monitoring data on farm, herd, and productivity from the current project,
- Price, and transport information from abattoirs, and traders,
- Price and cost information from input suppliers (hardware stores),
- Management and cost information from farmers through detailed, and
- Repeat interviews with case study farmers

A partial, steady-state model of a cattle farm, with scope for seasonal (monthly), annual and long term (10 year) time horizons was developed in Excel. The Excel model consisted of eight linked input sheets and two output sheets (profits and cash flow) and used returns to labour as the key indicator. Other farm activities (copra, kava, vegetables) were analysed as discrete activities. The model captured all (even minor) aspects of cattle production.

Activity 3.2. Conduct economic analysis of smallholder systems

The analysis compared four small holder cattle production models, which are then compared with two other non-cattle activities, which may complement or compete with cattle for household resources. This enables policy makers, extension agents, development agencies and farmers to assess the range of activities and options available to farmers and which might be most suitable to different types of farmers. Detailed results are provided in Appendix 3 and summarised here:

- Scenario 1 “Av herd, over-stocked, low productivity”. This is the base scenario (based on a real household) typical of smallholder cattle farms on the East Coast of Santo. The household has 10 cows on 14 ha of copra-bush land. While calving rates are low, growth rates are also low which mean the household has to keep females 2.5 years to reach puberty and steers 3 years to reach a (viable) slaughter weight. This increasing stocking, on unimproved, weedy pastures, which exasperates over-grazing. The low liveweight and dressing percentage limit prices and revenues. Significant labour is still required in the system, largely because of tethering. “Returns to labour” is consequently modest at VT983 (~AUD12 per day).
- Scenario 4 “Large herd, over-stocked, low productivity”. This household increases cow numbers to 16 and land size (on 2 blocks) to 23 ha, which remains unimproved and over-stocking in cow-calf production. Calving and growth rates remain low, but the herd size and sales revenues increase but this is mitigated by the additional labour (over two blocks and for tethering). As a result, returns to labour barely increase over the base case. There are also significant investment costs in developing the new block (rudimentary perimeter fencing) and the household reduces sales of culled cows and heifers for 3 years in the herd building up stage (total cost VT300,000).
- Scenario 2, “Large herd, balanced stocking rate, high productivity”. In this scenario, cow numbers are also increased (to 16) over 2 blocks (14 ha) but the land is fully fenced, and pastures improved at a (high) rate of 1 ha per year. Higher growth rates lead to a large increase in the sale of heavier steers at higher prices over the hooks. The increase in revenues is higher than the increase in labour (partly due to fencing and reduced tethering), leading to very large increases incomes (VT1,787 per labour day or 82% increase over the base case). However, the costs of investment and herd

build up are high (VT508,000 AUD6,300) as are the skill and motivational demands and clearly not for all households.

- Scenario 3“Small herd, balanced stocking rate, high productivity”. This option involves reducing cow numbers (to 6) on the same land area as Scenario 1 but which is now improved through grasses, legumes and fencing. This increases calving rates and growth rates which means fewer heifers are kept on farm. It also means that steers could be sold at heavy weight in 3 years but also the option of very heavy steers (670 kg, 57% dressing) at 4 years of age. Labour input increases but at lower rate than revenues, which increase returns to labour to VT1,319, 41% higher than the base case. Importantly, the revenues from the sale of destocking can be used to cover the initial improvement costs (cost neutral).

The general conclusion is that different management options will be suitable to different households depending on endowments of land, labour and capital and household objectives. Scenario 1 appears to be sub-optimal, but there are low skill or capital requirements and returns are positive and consistent over a large proportion of the year. Many households interviewed and that attended training choose to expand their herd and area grazed but without accompanying training improvement this approach is unlikely to be worthwhile or recommended. Households with capital, land and skills should choose Scenario 2 but may have to forgo other household activities (at least for male labour). Scenario 3 generates good returns, with low net investment costs and would not prohibit other household activities but would require good and consistent application of cattle management skills.

Further economic analysis was conducted on major activities that complement or substitute for cattle, including copra and kava. These are compared with returns to cattle production for Scenarios 1 and 2 above, based on price changes over 10 years (Figure 9).

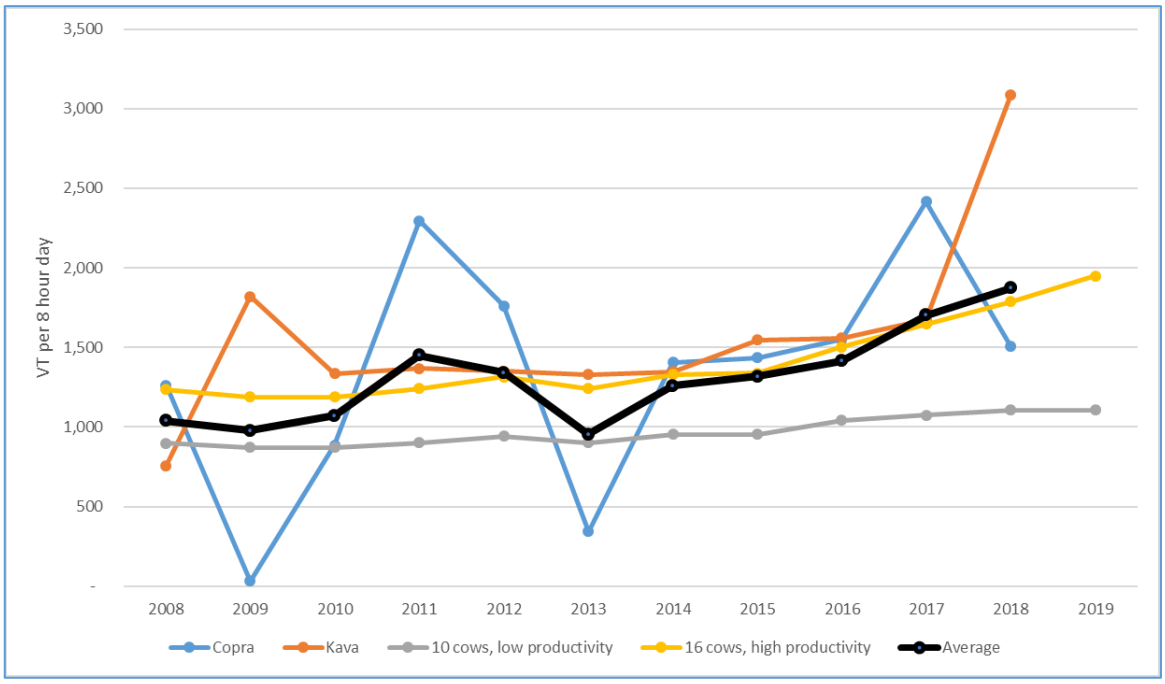


Figure 9. Relative profitability of major household economic activities in the East Santo Area Council, 2008-19

The results in Figure 9 confirm the large differences in profitability (measured as returns to labour) between the two different cattle production scenarios. Because of the larger increases in prices for heavier cattle, especially since 2015, profits for the high productivity farmers have increased to become nearly double that of the low profitability systems. The

profitability of kava has tracked quite closely to that of higher productivity cattle production, until 2017 when there was a rapid increase in prices. Copra profitability is subject to the volatility of international commodity prices. Copra production is highly profitable in periods of high prices (2010, 2011, and 2017) but low in other years (2009, 2013 and 2019) when farmers may not have bothered harvesting much copra. If the returns to labour for all activities are averaged over the four activities, there has been an overall steady increase of 80% over the 8 year period, or a 6.1% compound average annual growth rate. In some years (e.g. 2018) high kava prices compensated for low copra prices.

The analysis shows the benefits to households of running multiple activities. However, there are limits to the number and the scale of activities that households can engage in, including land and capital. Labour is the largest constraint. The activities of cattle (Scenario 1) requires full time labour allotment (612 days) for two adult family members. Given the other commitments (fruit and vegetables, household work, construction, transport, and off-farm work), the family must use labour from children, older generations, relatives, and hired labour. The labour obligations become higher for households that plan to increase herd numbers and productivity (in Scenario 2). This may limit incentives to take this management option and could mean that the family may give up other activities or will hire in additional labour.

Activity 3.3. Conduct training, provide advice and facilitate implementation of improved management and enterprise options

Four training sessions were conducted which covered four modules: farm management; cattle herds and revenues; cattle marketing; costs and profitability. The sessions were conducted in 2018 and 2019 over 1 to 2 days each with ~12 participants attending each session. The participants included farmers (project and other) and trainers (Department of Livestock, Biosecurity Vanuatu and Department of Industry officers, and VARTC, VAC and VSP staff). In addition to training farmers and trainers, the training aimed to test and refine the training material itself. Large scope was provided for formal and informal feedback. Feedback on the training was positive. Amongst the aspects that were of most interest to trainees were: the use of maps, a graphical picture of a cattle herd, a labour diary, calculations of the differences of selling through different channels, and expressing returns on a “returns to daily labour” basis.

Several lessons emerged from the training. One was that there was a lack of or lapsed understanding, including by extension staff, on fundamental aspects of cattle management (e.g. how to calculate land size, cattle numbers, stocking rates and productivity). Presenting and updating this information was perhaps the most important contribution of the training, especially for trainers. Capacity building for trainers was a central aspect of the training. Another lesson from the training is that it is too rigid, constraining and artificial (and therefore confusing) to impose specific management options on the trainees. Trainees devised their own farm plans based on their own resources and objectives and then assed the economic effects.

Famers that attended the training tested cattle management plans that they were considering or that were underway, sometimes as a result of participation with the project. In virtually all cases, plans were based on land and herd expansion, which involves retaining females with a negative effect on returns over the short-medium term (three to five years). Returns after that depend on cattle performance and labour inputs. Training attempted to reinforce the objectives of productivity and returns to labour (not just income).

Evaluation questionnaires were conducted for two of the training sessions and are included in Appendix 3.

Activity 3.4. Assess and implement alternative smallholder cattle marketing interventions

Interventions to improve cattle and beef marketing have to be considered very carefully. Existing spot market systems are functional, and buyers have incentives to maintain flexible and informal arrangements. Measures to simulate additional “high value” markets, to forge “high value” chains involving smallholders or to build sophisticated market services seen in developed countries, such as formal grading or feedback systems, are unfeasible, low-priority and low-return investments for a development agency. It is also important to note that various interventions have failed, including estate-smallholder links, contract production systems and auctions for systematic reasons (trust and reneging).

A range of marketing arrangements were assessed including:

- Cattle auctions,
- Out-grower schemes, and
- Input/credit arrangements.

Other marketing arrangements were trialled including:

- Measurement of the output/value of offal, and
- Sales of beef to alternative markets (Pentecost/Solomon Islands).

These assessed or trialled interventions were not pursued because of their low marginal value.

The marketing interventions assessed to be the most feasible and beneficial were:

- Facilitating discussions between farmers and buyers at field days,
- Training farmers in the assessment of different cattle marketing options, and
- Facilitating cattle sales to alterative (non-abattoir) markets (butcher in Santo and Port Vila) through objective measurement and competitive selling.

The costs, benefits and sustainability of the models are being assessed in the M. Phil. thesis of Mr Noel Kalo. Study was suspended due to COVID-19 and is expected to recommence and complete in 2021.

An important way to increase farm-gate prices or reduce marketing costs and risk was to empower farmers to formally assess sales and management options in training. Material on cattle marketing (on sales options, buyer preferences, price schedules) was incorporated into household level analysis and the training undertaken by Waldron, Antfalo, and Kalo.

Activity 3.5. Conduct whole-of-chain participatory engagement

Detailed interviews and ongoing consultation were conducted with all agribusiness actors on Santo and Port Vila. Waldron and Kalo conducted at least 40 interviews with agribusiness actors in the current project, while local partners (Antfalo, Boe, Tabiaga) have weekly contact with these actors. Key actors (abattoirs, traders, estates, input suppliers) have attended project events (workshops and field days).

The structure and the incentives of lead firms in Santo preclude formal marketing agreements with households, but flexible arrangements suited to local conditions have been facilitated (see above).

Activity 3.6. Collate data from Objective 3 and integrate into Activities 1.4 and 1.5

Described in Activities 1.4 and 1.5.

7.2 Component 4. Capacity building, linkages, and pathways

More detailed descriptions of results and outputs are provided in Appendix 4.

Activity 4.1. Project Advisory Group

A formal project advisory group was not formed by the project. The number of actors involved in the industry are small with the same individuals often present on existing groups (e.g. the Livestock Industry Working Group). The PHAMA supported LIWG consisted of a Chair and individuals representing a range of actors in the livestock sector in Vanuatu, including the Directors of the Department of Livestock and Department of Industry (i.e. project partner organisations). It therefore seemed redundant to form another group with many of the same local stakeholders involved. It was instead decided that written briefings be provided to the LIWG at their meetings, the Directors could provide updates and receive feedback from the LIWG at meetings, and the Chair of the LIWG was invited to attend project annual meetings. The LIWG met approximately twice/year throughout the life of the project until its conclusion in 2019, with project progress reported as requested. The Chair of the LIWG attended the project inception workshop (Mar-2016) and annual meetings in March-2017 and May-2018. The lack of a formal Project Advisory Group did not appear to have a negative impact on the project.

Activity 4.2. Project catchment meetings

Project catchment meetings were initially proposed as a means to facilitate farmer-to-farmer experiential learning, and to extend project outputs to other non-participating farmers. The small numbers of farmers participating in project activities and challenges in co-ordinating attendance at meetings made this difficult to achieve. Project catchment meetings did occur two or three times each year but were mainly for identifying farmers interested in participating in project activities and for then planning these activities. The farmer-to-farmer (peer-to-peer) approach to training and extension still appears to be valid method to engage and empower smallholder cattle farmers in Vanuatu, however the project should have invested more time in developing the capacity of project staff (partner organisation and project employed) to facilitate this. This is clearly an area of capacity that needs to be developed within the local extension services. Rather than ‘rebuilding’ the extension services *per se* through more officers, more equipment and larger budgets providing them with appropriate extension tools and technical knowledge to better engage farmers is likely to be a better approach for the sustainable development of capacity of farmers.

Activity 4.3. Monitoring and evaluation strategy

The PIPA was reviewed at annual meetings and used to guide annual monitoring and evaluation of project progress. No significant changes were made.

Activity 4.4. Capacity building of project team in project activities

The entire project team (both Vanuatu and Australian team members) increased their knowledge of smallholder cattle farmers and farming systems in Vanuatu and on a wide range of research methodologies. Participating farmers are developing a more detailed understanding of their production and marketing systems through feedback on cattle herd productivity and value, market specifications and new forage varieties and grazing systems and by participating in pilot testing of farm management training materials. A major focus has been on involving support agency staff and farmers in the development of farm planning and business training materials, so capacity has been developed in this area whilst also improving the relevance and delivery method of the materials themselves.

The capacity of the project employed team (on-farm, on-station and administrative) increased significantly throughout the project, to the point that much field work could be independently completed to a high standard. The team developed skills cattle and

pastures research, livelihoods analysis, and the use of GPS and digital platforms for data collection. The team were involved in all aspects of pilot testing training modules for farm economics and farm planning. Partner organisation staff (mainly Antfalo, Tabiaga, Natapu) developed a wide range of technical (marketing, economics, forages, animal nutrition), research (design, data collection methods, data analysis and presentation) and management (co-ordination of research resources) skills through their involvement in the project.

Mr Keith Antfalo (Department of Primary Industries) participated in a MAD (mobile acquired data) masterclass in Canberra in 2016. Mr Noel Kalo (Department of Industry) is the recipient of an Australia Awards scholarship to undertake a M. Phil at UQ. Mr Steglar Tabiaga (VARTC) completed the John Dillon Fellowship in October/November-2019 with a placement at UQ. Other project team members have been supported in their applications for Australia Awards scholarships to undertake course work and research master's studies.

Scientific communication skills were developed through attendance at conferences and publication of book chapters. Ms Jerine Natapu (VARTC) and Mr Stephenson Boe (Department of Livestock) presented poster and oral presentations at the TropAg conference in QLD in 2017 developing their skills in scientific communication. Norah Rihai (VAC) and Antoinette Nasse both co-authored a book chapter with Dr Cherise Addinsall on the engagement of women farmers in project activities in Vanuatu.

Activity 4.5. Demonstration and extension of research activities and outcomes to farmers and other industry stakeholders

The project built a good profile locally through a combination of field days, presence at local events and mass media. Formal meetings and presentations were more limited but did engage higher level stakeholders.

Field days, site visits and local events

- February-2017 - Farmers (20) visited the forage evaluation trial in progress at VARTC
- October-2018 - Farmers, government officers and students (90) attended a project field day at VARTC
- February-2020 - Farmers (115), government officers and external reviewers, and ACIAR and project staff attended a project field day Sara village, East Santo
- Vanuatu Week of Agriculture
- SANMA day

Presentations and meetings

- ACIAR High Commission and Policy Advisory Council – March-2018, Port Vila
- DARD Extension Officers – July-2019, VARTC
- Fiji Prime Minister meeting – June-2017, UQ
- Vanuatu Prime Minister meeting – June-2018, UQ
- Reports to LIWG meetings (2016 to 2018)
- Presentations to Dept. Livestock officers annual retreat (2016 to 2019)
- Presentation to EDF-11 Technical Advisors

Mass media

- Television Blong Vanuatu, Vanuatu Broadcasting and Television Corporation
  - February-2016 (inception workshop)
  - September-2016 (office lunching)
  - February-2017 (farmer field day VARTC)
  - October-2018 (farmer field day VARTC)
- Radio Vanuatu, Vanuatu Broadcasting and Television Corporation

  - Communication for VARTC field day, October-2018
  - Communication for Sara field day, January-2020
  - Other interviews by Keith Antfalo
- Vanuatu Daily Post / Port Vila Times
- 'Improve cattle farmers and increase market access' (https://dailypost.vu/news/improve-cattle-farmers-and-increase-market-access/article_3dde260a-0dc1-5816-88f2-664493172748.html)
- 'New project to improve beef cattle production on Santo' (https://www.vilatimes.com/2018/01/09/new-project-to-improve-beef-cattle-productivity-on-santo/)
- 'Women take on Bisnis Blong Buluk project' (https://dailypost.vu/news/women-take-on-bisnis-blong-buluk-project/article_a0d34702-bff8-5034-a8af-2f319e9eba54.html)
- Jean Pierre Niptik video (https://www.facebook.com/groups/DailyPostGroup/permalink/1387500401449667/?__tn__=CH-R)
- 'Empowering women through farmer to farmer knowledge transfer' (https://dailypost.vu/news/empowering-women-through-farmer-to-farmer-knowledge-transfer/article_a8dca1e5-f97c-503d-bb8c-3a69f1524a30.html)

Activity 4.6. Involve students in project activities

Students (~30) from the VAC participated in a range of on-farm and on-station research activities. This provided students with access to resources and expertise that would not have been available if not for their engagement in the project. These activities included participation in on-farm cattle monitoring and establishment of forage plots and on-station forage and cattle research, providing students with both basic animal husbandry and pasture skills and research experience for testing new technologies on their own farms in the future. Funds were available in the budget to support scholarships for a small number of students to attend the VAC, however in the early stages of the project it was decided that a better model would be to use these funds to support high ranking students with internships in either the private sector, government agencies or within the project itself after graduation. Students were identified at various stages however the program did not proceed due to administrative issues in relation to the transfer of funds from the Commissioned Organisation to the Partner Organisation. Researchers from Australia delivered formal lectures to students on ruminant nutrition research, use of GPS in farm planning, pasture research, livelihoods analysis and value chain analysis.

In addition, student interns attached to the Department of Industry and Department of Livestock participated in project activities at various times gaining valuable hands-on experience in cattle production and marketing research.

Mr Noel Kalo (Department of Industry, MTCITnVB) was awarded an Australia Awards scholarship and is undertaking a M. Phil. at The University of Queensland. He is undertaking research on the beef cattle value chain in the East Santo Area Council which is highly relevant and integrated with the current project. Noel is expected to submit his thesis in July-2021.

Mr John Meonga (a Solomon Islands national) was awarded an ACIAR funded USP-USC twinning scholarship to undertake his Master of Science research within the project. John undertook his research on copra meal supplementation of cattle conducted over 12 months at Monbiftec farm on Santo (Activity 2.6).

Ms Fyn DeDaunton (UQ) received a Crawford Fund travel award to undertake a small research project on the importance of cattle to ceremonies in East Santo for her Honours thesis submitted for her B. Ag. Sci. degree at The University of Queensland (2017).

Ms Peta Stockwell (UQ; B. Ag. Sci.) was the recipient of an AgriFutures Horizon Scholarship (2016 to 2019) and used this funding to undertake a short work experience placement with the project team on Santo in October-2019. Peta was also the recipient of a scholarship to attend the Crawford Fund conference in Canberra in 2019 and has a strong interest in pursuing a career in international agriculture research. This exposure resulted in Ms Stockwell submitting an application for the ACIAR internship program. Whilst ultimately unsuccessful the participation of Ms Stockwell in the project opened a new career opportunity that she is keen to pursue.

Activity 4.7. Build linkages with other organisations and programs

PHAMA

The project linked loosely with PHAMA through the representation of staff from project partner organisations on the LIWG. PHAMAs focus on market access was not directly aligned with the projects focus on household and farm level research activities. Nevertheless, the project provided updates to LIWG meetings which were facilitated by PHAMA employed market access officers. This engagement was largely meaningless in that no tangible outcomes resulted.

NZ MFAT

Over the period 2016 to 2019 the current project built a strong relationship with the NZ MFAT funded cattle project. Whilst the projects were taking very different approaches to implementation, they had the common goal of increasing capacity of cattle farmers in Vanuatu to increase productivity. The project leaders met by Skype every 1 to 2 months to discuss industry issues, potential opportunities for engagement and sharing of results (e.g. forage and grazing trial results, detailed survey findings, industry development plans). Farmers from the NZ MFAT project participated in the current projects field days and farm planning training activities. This was an extremely beneficial linkage for both projects. It is hoped that the Phase 2 project can build similar linkages with the NZ MFAT funded program of work on the identification and release of biocontrol agents for weed control in Vanuatu.

EDF-11

Engagement with EDF-11 was limited through the life of the project. Directors of the Departments of Livestock and Industry are both representatives of the EDF-11 Implementation group and provided updates on EDF-11 progress and processes. Representatives from the Office of Aid Co-ordination attended project meetings and provided further updates and advice on linkages across programs. EDF-11 Technical Support only arrived in Vanuatu in the final 3 to 6 months of the current project and there has been limited opportunities for linkages at this stage. Offers to EDF-11 implementing partners to assist with the development of proposals have not been responded to. Department of Livestock did request a proposal submission on the gender engagement strategy developed in the current project, however this submission was then deemed unsuccessful for unknown reasons. If EDF-11 is to be a critical part of any impact pathway then better linkages will be required, and this may happen now that Technical Support is now in country.

Vanuatu Skills Partnerships

The VSP have a key role in facilitating training across Vanuatu. The project has met with local VSP staff and they have attended pilot testing sessions of training materials. The VSP would be a key organisation in scaling-out of any project derived training materials. As the transition to a Phase 2 project occurs this will be an important partnership to build further.

ACIAR projects

PARDI2. Addinsall and Quigley are both participants in PARDI2. At this stage the involvement of Quigley has been minimal given that PARDI2 is not working in any livestock value chains. Addinsall has had greater involvement through her oversight of the livelihoods analysis undertaken in PARDI2. This linkage has been relatively weak in terms of specific outcomes for both projects.

Pacific Beef SRA. Waldron and Quigley conducted a scoping study and prepared country profiles on the beef industry in Fiji, Samoa, Solomon Islands, Tonga and Vanuatu. The report provides an overview of the existing beef industries in each country and identifies opportunities for research and development. It describes high biophysical similarity between the countries and (with the exception of Fiji) very similar operating environments for beef cattle, including a strong cultural importance. Given these similarities, the project recommended future research continues in Vanuatu as a model for other countries but that individuals from these other countries visit to Vanuatu for capacity building. The recommendations from this report were critical in formulating the design of the Phase 2 project in Vanuatu and as such this was a critical linkage.

Mobile Acquired Data project. The current project was identified as a case study project for the overarching MAD project. Project team members participated in MAD masterclasses and training and drew on MAD expertise to assist with development of a project CommCare app for data collection. The project provided data to the MAD research team through interviews with researchers, policy makers and farmers at various stages of implementation. The project utilised CommCare throughout its life, staff capacity in the use of digitally acquired data techniques was greatly increased (from a very low base) and the project provided the MAD researchers with an interesting case study. This was an extremely important and beneficial linkage for both projects.

Sandalwood project. The project provided the Sandalwood project with recommendations and a range of legume seeds to act as hosts for sandalwood. There has been limited further engagement between these projects.

Activity 4.8. Placement of volunteer within project team

Mr Jamie Quilliam completed a volunteer assignment with the project based in Luganville between July-2017 and June-2018. The Host Organisation for the assignment was nominally The Department of Livestock but in reality Jamie spend the majority of his time building capacity of project employed staff in the implementation of project activities including early stages of cattle monitoring and establishment of on-farm forage evaluation and demonstration sites. The project benefited greatly from this engagement and further volunteer opportunities should be explored in future projects.

Activity 4.9. Internal project communication strategy

Attempts to organise regular Skype and phone meetings with senior project staff failed due to challenges in co-ordinating schedules and restrictions on accessing Skype through government networks.

Email updates were prepared and circulated by the Project Leader to all project team members each month during the first half of the project. However, this declined over the latter stages of the project due to a general lack of engagement and feedback from team members, coupled with the Project Leaders excessive commitments on other projects.

The project team on Santo and the Project Leader met by Skype every second Friday. These were very successful in co-ordinating short-term work plans amongst this small group. However, generally officers from the partner organisations rarely attended these meetings. This resulted in inefficiencies in co-ordinating project activities and allocating project resources. However, more significantly it meant that these officers were unaware of project activities and therefore were largely disengaged from the project and did not participate in valuable capacity building activities.

Activity 4.10. Annual meetings are held to review project progress

Meetings were held each year of the project and included an inception workshop (March-2016, Port Vila), an annual meeting and Participatory Impact Pathway Analysis (March-2017, Luganville) and mid-term review (May-2018, Luganville) and a final annual meeting (July-2019, Brisbane). A final review meeting was held in February-2020.

The meetings were primarily held as a means of formally updating a range of stakeholders of project progress for their own reporting purposes, and to provide them with an opportunity to further inform project direction. Provincial Secretary Generals (or representatives), Directors, CEOs and senior partner organisation officers participated in all meetings. Director Generals and/or Ministers and representatives from the Project Management Units or Prime Minister's office also attended meetings. The Chair of the Livestock Industry Working Group participated in all workshops held in Vanuatu.

Activity 4.11. Conduct a Participatory Impact Pathway Analysis

Stakeholder Analysis and Participatory Impact Pathway Analysis were conducted after 12 months of operation. The workshop involved 16 project team members and was held over one day and facilitated by an external consultant. The timing was selected so that assumptions made were based on some level of reality after 12 months of project operation. The results were revisited at each of the annual meetings. No major changes in project design occurred as a result of these reviews. The Stakeholder Assessment and Participatory Impact Pathway Analysis are presented in Appendix 4.

8 Impacts

8.1 Scientific impacts – now and in 5 years

Data on livelihoods and productivity of cattle under different production systems for smallholder cattle farmers in Vanuatu was limited or non-existent prior to the current project. The data will be of interest to other donors and the Govt. of Vanuatu to assist in policy decisions.

Some of the research initiated in the current project is likely to be incorporated into proposals to be prepared for EDF-11 funding (e.g. digital technology, tree legumes, water provision, marketing interventions). The NZ MFAT program utilised project results in their recommendations to farmers within their program on forages and forage establishment. Researchers at VARTC utilised herbaceous legumes established by the project to reinvigorate old coffee plantings as a result of N fixation.

8.2 Capacity impacts – now and in 5 years

Partner organisations have access to research resources that allow them to conduct the research both within and outside of the project (e.g. cattle crush and scales at VARTC allow for additional research and general improved management of the VARTC cattle herd).

The entire project team (both Vanuatu and Australian team members) continue to increase their knowledge of smallholder cattle farmers and farming systems in Vanuatu and on a wide range of research methodologies. Capacity in faecal egg counts have been used to assess internal parasite burdens in commercial cattle herds.

Participating farmers are developing a more detailed understanding of their production and marketing systems through feedback on cattle herd productivity and value, market specifications and new forage varieties and grazing systems and by participating in pilot testing of farm management training materials. A major focus has been on involving support agency staff and farmers in the development of farm planning and business training materials, so capacity has been developed in this area whilst also improving the relevance and delivery method of the materials themselves. Farmers outside of the initial project villages have become active in cattle monitoring activities, and some have accessed pasture seed or vegetative stocks, including one farmer from Pentecost who attended the VARTC field day and has started to plant improved forages. Farmers previously involved in the NZ MFAT project have also joined the projects field days and pilot testing of training materials and have contacted the project regarding access to pasture seed. Farmers were enthusiastic participants in field days and attendance increased their awareness of project activities and recommendations (e.g. cattle marketing, forage species, farm management and business planning) and provided an expanded list of farmer contacts through which further training and research may be conducted.

Approximately 30 students from the Vanuatu Agriculture College participated in on-station and on-farm research activities within the project. This provided them with experiences that would not have existed without the project. Noel Kalo is the recipient of an Australia Awards scholarship and has commenced his M. Phil at UQ. Steglar Tabiaga completed the John Dillon Fellowship in October/November-2019. John Meonga was the recipient of an ACIAR funded USP-USC scholarship and will submit his M. Phil. thesis to USP in December-2020. Other project team members have been supported in their applications for Australia Awards scholarships to undertake course work and research master's studies. Bachelor of Agricultural Science students (Ms Fyn DeDaunton and Ms Peta Stockwell) were exposed to research for development by participating in project activities as part of their studies at The University of Queensland.

8.3 Community impacts – now and in 5 years

The smallholder cattle sector in Vanuatu had experienced decades of decline in farmer support and research and development activities. The project created a sense of enthusiasm and focus amongst smallholder cattle farmers in Vanuatu. Farmers often simply appreciated the opportunity to engage with government officers, project researchers and other farmers through farm visits, village meetings and field days.

Economic impacts

The project aimed to increase the productivity and incomes of small-holder cattle farmers in Santo. There are difficulties in quantifying the types and degrees of economic impacts with a project cycle, but the following provides a guide. The estimates are based on impacts on 100 households that engaged with the project to varying degrees (monitoring, forage trials, farm management training, women's groups, marketing surveys/training).

The households have changed production systems in various ways, four of which were simulated in budgeting (see Section 7). The results showed the income effects that may be possible under the assumption that 100 households change production and marketing systems over a 3 to 4 year cycle to produce and sell a steer (Table 4).

Table 4. Increases in revenues and cash profits under four farm scenarios, assuming uptake by 100 households over a 3 to 4 year cattle production cycle.

	Scenario 1[1]	Scenario 4	Scenario 2	Scenario 3
Number of cattle in the representative household	25	42	20	41
Revenue per household (VT)	240,000	316,416	328,958	753,627
% increase over base		32%	37%	241%
Increase in revenue *100 households (AUD)		95,520	111,198	642,034
Cash profit per household (VT)	226,200	273,616	287,958	564,627
%increase over base		21%	27%	150%
Increase in profit *100 households (AUD)		59,270	77,198	423,034
[1]Base case				

The results suggest that revenue to the 100 households can increase by between AUD95,520 and AUD642,034, and that cash profits can increase by between AUD59,270 and AUD423,034. Note that these revenues do not include labour costs / inputs. Given the limits in alternative income sources, these increases are substantial. Comparisons with other activities (copra and kava) are shown in Section 7. Importantly, cattle are complementary with copra on Santo and even out the volatility in prices from copra. Higher incomes are earned from kava and, for some households, off-farm activities. There are limits to household resources, especially labour, that can force choices and allocation of resources across activities.

While the project identified household cattle production as the biggest constraint to industry development, increasing production or productivity in this sector would have direct benefits for other chain actors including services (e.g. transport, fencing material) and abattoirs (increased throughout), which can also generate employment and government revenue. Increased throughout can also be expected to benefit beef consumers in both formal and informal markets.

Social impacts

Increased cattle productivity provides households with greater marketing options of their cattle to meet their livelihoods objectives (e.g. income generation, household savings and expenditure, social cohesion, obligatory ceremonies, nutrition, weed control). The sale or

provision of cattle into ceremonies and rural butcheries may lead to an increased consumption of locally produced, leaner beef products than imported (often less healthy) tinned meat alternatives consumed by households. The impact of increased household incomes on the purchase and consumption of processed foods and drinks is a common theme across Vanuatu and requires further research. Increased cattle sales will result in increased household incomes available for better health outcomes, improved access to education, and opportunities for re-investment in farming or other income generation activities.

The collection of gender disaggregated data enabled the project team to understand and evaluate the impacts of project activities on the livelihoods of men and women separately through the longitudinal monitoring of 45 households over the duration of the project. Research and communication activities targeted to females were implemented through the project women's group. The main social impact of the project has been the empowerment of women that participated in project women's group's activities. These women now have the confidence to communicate and contribute to discussions at the household and community level. These women will now be in position to train other women. The participation of women in household and farm planning decisions is essential to ensure the systems meet the livelihoods objectives of the entire household in the future.

Environmental impacts

The project had no direct impacts on the environment. However, it has recommended strategies to increase productivity, which would be associated with decreased greenhouse gas emissions per unit of output. The project clearly demonstrates overgrazing as a result of high stocking rates, and this inevitably contributes to weed encroachment and reduced productivity. A reduction in stocking rates coupled with improved grazing management should increase productivity and reduce weed burdens in future. These issues are recommended for future research in the proposed Phase 2 project.

8.4 Communication and dissemination activities

Field days, site visits and local events

- February-2017 - Farmers (20) visited the forage evaluation trial in progress at VARTC
- October-2018 – Farmers, government officers and students (90) attended a project field day at VARTC
- February-2019 – Farmers (115), government officers, external reviewers, ACIAR and project staff attended a project field day held in Sara village, East Santo

Presentations and meetings

- ACIAR High Commission and Policy Advisory Council – March-2018, Port Vila
- DARD Extension Officers – July-2019, VARTC
- Fiji Prime Minister meeting – June-2017, UQ
- Vanuatu Prime Minister meeting – June-2018, UQ
- Reports to LIWG meetings (2016 to 2018)
- Presentations to Dept. Livestock officers annual retreat (2016 to 2019)

Mass media

- Television Blong Vanuatu, Vanuatu Broadcasting and Television Corporation
- February-2016 (inception workshop)
- September-2016 (office lunching)
- February-2017 (farmer field day VARTC)

- October-2018 (farmer field day VARTC)
- Radio Vanuatu, Vanuatu Broadcasting and Television Corporation
- Communication for VARTC field day, October-2018
- Communication for Sara field day, January-2020
- Other interviews by Keith Antfalo
- Vanuatu Daily Post /
- ‘Improve cattle farmers and increase market access’ (https://dailypost.vu/news/improve-cattle-farmers-and-increase-market-access/article_3dde260a-0dc1-5816-88f2-664493172748.html)
- ‘New project to improve beef cattle production on Santo’ (https://www.vilatimes.com/2018/01/09/new-project-to-improve-beef-cattle-productivity-on-santo/)
- ‘Women take on Bisnis Blong Buluk project’ (https://dailypost.vu/news/women-take-on-bisnis-blong-buluk-project/article_a0d34702-bff8-5034-a8af-2f319e9eba54.html)
- ‘Empowering women through farmer to farmer knowledge transfer’ (https://dailypost.vu/news/empowering-women-through-farmer-to-farmer-knowledge-transfer/article_a8dca1e5-f97c-503d-bb8c-3a69f1524a30.html)
- Other online sources
- Bisnis Blong Buluk Facebook (https://www.facebook.com/bisnisblongbuluk/)
- Livestock research in Vanuatu gives better insights into cross-cultural issues (https://www.crawfordfund.org/news/news-livestock-research-vietnam-gives-better-insights-cross-cultural-issues-february-2018/)
- Bisnis Blong Buluk and MAD technology (https://www.youtube.com/watch?v=Q_JD_a38mcc)
- Jean Pierre Niptik video (https://www.facebook.com/groups/DailyPostGroup/permalink/1387500401449667/?__tn__=CH-R)
- Country Profile : Vanuatu beef industry (http://www.asiabeefnetwork.com/library/)

9 Conclusions and recommendations

9.1 Conclusions

To describe the economic, policy and social settings within which smallholder cattle farmers operate and their livelihood objectives and strategies

Cattle have an important role in social cohesion, community nutrition, income generation and savings for smallholder households in rural Vanuatu. The social, policy, market and biophysical environment within which smallholder cattle farmers operate is similar between Santo and Malekula and is likely to be similar across the country. As such recommendations based on research undertaken in the East Santo Area Council are likely to be transferable to smallholder cattle farmers in other parts of Vanuatu. Whilst women have limited direct hands-on involvement in cattle management practices they contribute to household and farming decision making. The project developed a strategy for empowering women to contribute to household planning and decision making, and this model should be scaled out in other projects and programs.

To sustainably increase beef production of smallholder households through change in on-farm management practices

Productivity indicators (calving rate, annual liveweight gain) of smallholder cattle systems in Vanuatu would suggest significant opportunity exists to increase productivity. Low productivity is largely a function of over-stocking resulting in nutrient deficits for reproduction and growth of cattle, with increased weed ingress further declining the productivity of the existing pasture resource. Whilst factors such as diet quality and internal parasites were unlikely to be affecting productivity, access to drinking water and to sound fertile bulls, coupled with limited management (i.e. grazing management) of existing pastures were likely to constrain productivity. The project and participating farmers identified a number of grass and legume lines that perform better than established lines and demonstrated high annual liveweight gain from cattle grazing these introduced lines. However, pasture improvement requires significant inputs and requires a long timeframe to realise a return on investment with a more sophisticated approach required to maintain the improved pasture base; such programs may also limit the opportunities for future diversification. Lower cost interventions such as reducing stocking rates, through culling of unproductive females, improved management of the existing pasture base, strategic use of legumes and improved husbandry practices are strategies that may be more feasible for smallholder farmers compared to a large pasture improvement program. It is concluded that an increase in farmer capacity to develop and implement cattle farming management plans, within the context of the entire farm, with access to the required inputs is the first important step in increasing productivity in the smallholder cattle sector in Vanuatu. This process would require on-going mentoring by technical experts with appropriate communication and facilitation skills.

To increase the returns to smallholder cattle farmers through whole-farm and cattle enterprise economic analysis, business training, and marketing interventions

Beef cattle are a major mainstream economic activity for rural households in parts of Vanuatu like the East Santo Area Council. There is considerable scope for smallholders to increase incomes through improved cattle production systems, but a diverse range of households will choose a diverse range of cattle production systems. Most households will retain low-input/low-output systems. A limited number will commit the labour and capital to make the transition to being high-input/high-output commercial farmers, which can take up

to 10 years. However, there are numerous other options to expand herds or productivity that have significant a range of income effects, as modelled in this project.

Thus, beef cattle provide an important and flexible activity that households can use to support livelihoods in combination with other activities. Cattle are particularly complementary to the other major activity of copra, which is more volatile. Large, shorter term (i.e. 3 to 5 year) increases in incomes are possible from other activities (kava and off-farm work). There is no evidence that higher productivity beef cattle production detracts from traditional activities and, indeed, may boost food supply for ceremonies through increased numbers and culling rates.

Given the diversity of households, livelihood systems and objectives, influential organisations (government, development agencies, and researchers) should resist trying to impose systems on households, but to provide technical, logistical and knowledge support for farmers to make their own decisions.

To create pathways to sustain and extend project outcomes and impacts beyond the scope of the current project

The research capacity of local team members was developed largely through hands-on action-learning approaches which were considered more appropriate than more theoretical activities. This included the engagement of farmers in research, training, and extension activities, of which farmers were active participants. The engagement of the Livestock Industry Working Group through attendance of the Chair at project annual meetings, and the NZ MFAT funded programs extended project outputs beyond the scope of the current project. Engagement of EDF-11 was less successful due to the arrival of the program team in-country relatively late in the current project. The project was recognisable amongst cattle farmers due to strong ‘branding’ (Bisnis Blong Buluk) and an active presence in the mainstream and social media. The participation of partner organisation officers in project activities was significantly lower than anticipated and certainly lower than encountered in most ACIAR projects. This is a result of the generally small number of officers employed by these organisations, resulting in heavily over-committed staff often called away on other activities at short notice. As a result, capacity was built in project employed staff and farmers but less so amongst government officers who play an essential role in sustaining project outputs. It is likely that project employed staff would be employed by some of these organisations at the end of the project. In conclusion, the project increased capacity of staff and created a small footprint from which further engagement may be built. However, it is unlikely that this on its own would be sufficient to sustain the projects outcomes without continued project support.

9.2 Recommendations

There are no quick wins or easy interventions to increase the productivity and profitability of smallholder cattle production systems in Vanuatu. The introduction of animals with improved genetics, large scale pasture improvement programs and infrastructure upgrades are unlikely to be sustainable without an increase in the capacity of farmers and support agency staff, structures that facilitate access of these resources to smallholder farmers and ensuring smallholder farmers have the land and labour resources to accommodate the significant step-changes into their existing systems. A more incremental approach is recommended involving upskilling of farmers in both technical, business and planning skills and more efficient utilisation of the existing resource base with strategic inputs. It is within this context that the project makes the following recommendations for future research and development initiatives,

1. Undertake research to:
    a. Develop methods that build the capacity of smallholder (men and women) cattle farmers to develop and implement cattle farming management and business plans

(within the context of the whole farm). This would include development of communication strategies required to facilitate this process.
   b. Identify the causes of low reproduction rates in smallholder cattle herds and develop technical packages for grazing management, weed control and water supply on smallholder cattle farms.
   c. Investigate the link between household income and expenditure on processed foods, and associated relationships with non-communicable diseases in rural communities in Vanuatu.
   d. Investigate private agribusiness models that may facilitate farm improvement by smallholder cattle farmers in Vanuatu (e.g. specialised pasture renovation business, cattle marketing assessments, water infrastructure).
2. Continue to implement gender specific capacity building activities (developed within the current project) across a wide range of projects and programs, with a view to the institutionalisation of such approaches across organisations operating within Vanuatu.
3. Continue to engage farmers through activities such as farm mapping, market valuations of cattle, cattle herd monitoring, pasture evaluations, field days, mentoring. Increased resourcing to build capacity of government officers to facilitate these activities.
4. Update existing farmer extension and training materials with new information (e.g. prices, chemicals, practices, species). The existing materials remain technically sound and generally require updating of specific information and transferring to other forms of communication (e.g. digital sources available from existing web sites).
5. Investment in VARTC to improve resources to undertake research and also to supply farmers with inputs to assist them with their far improvement plans:
   a. Establish VARTC as a forage distribution centre with vegetative and seed material, and responsibility for training.
   b. Establish VARTC as a source of cattle from which smallholder farmers may be able to buy or lease young bulls of improved genetics.
6. Continue to develop the research capacity of officers within the Vanuatu Agriculture Research and Technical Centre, Department of Industry and Department of Livestock including:
   a. Specific capacity in pregnancy diagnosis in cattle is critical for any policies requiring an assessment of the pregnancy status of cows.
   b. Formal participation of officers through tertiary education institutes in the Pacific or Australia (e.g. M. Phil., PhD, Grad. Cert.).
   c. Develop the communication and facilitation skills of the technical expertise that currently resides within the partner organisations.
7. Review the current state of the abattoirs and consider the feasibility of investment in upgrades to maintain export accreditation and/or the acquisition of mobile slaughter units.
8. Whilst the project did not intend to develop policy some relevant recommendations include:
   a. Strategies to increase productivity of the existing herd rather than large scale herd expansion, including a revision of the existing policy regarding the slaughter of unproductive females.
   b. Review the appropriateness of turn-off through the formal sector as an indicator for development programs; the informal sector is an important part of the national cattle value chain, and cattle/farmers engaged in these chains may be productive and

profitable. It may be appropriate to consider productivity or farm improvement indicators in monitoring and evaluation frameworks.

c. Determine the existing and potential land resources available to support the current and any future expanded cattle population.
d. Review existing and proposed government programs (e.g. cattle restocking, establishment of government farms).
e. Co-funding models of farm investment may be feasible and encourage farm improvements that result in increased on-farm production.

9. Future research projects should consider the placement of project employed field staff within the village/community areas within which the project will be operating. This will foster more in-depth relationships with the farmers.
10. A stakeholder workshop should be held to disseminate the above recommendations to policy makers and representatives of other funding agencies working within the cattle sector in Vanuatu. This would provide an opportunity to introduce how the Phase 2 project will undertake research related to the above recommendations.

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11 Appendixes

11.1 Appendix 1. Situation analysis, livelihoods analysis, and engagement of women

11.2 Appendix 2. On-farm and on-station production research activities

11.3 Appendix 3. Farm economics and marketing trials

11.4 Appendix 4. Engagement, capacity, and impact pathways

11.5 Appendix 5. Vanuatu country profile (Pacific Beef SRA)