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prepared by	Tamsin S Barnes, University of Queensland
co-authors/ contributors/ collaborators	TOMAK-MAF National Pig Production Research and Development Coordinator - Olavio Morais TOMAK - Jose Barros, Patrice Charpentier, Richard Holloway, Lewti Hunghanfoo, Jenny Ikelberg, Alfons Urlings MAF - Joanita Bendita da Costa Jong Research Consultant - Colin Cargill University of Queensland - Christopher Parke Charles Sturt University - Joanne Millar
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Contents

1 Acknowledgments 5

2 Executive summary 6

3 Introduction 7

4 Objectives 8

5 Methodology 9

5.1 Preliminary activities 9
5.2 Growing pig trials round one 11
5.3 Interim workshops and project variation 13
5.4 Growing pig trials round two 13
5.5 Sow trials 14
5.6 Extension materials 15
5.7 ASF-related activities 15
5.8 Farmer and technician perceptions 16

6 Results and Discussion 17

6.1 Preliminary activities 17
6.2 Growing pig trials round one 18
6.3 Interim workshops and project variation 25
6.4 Growing pig trials round two 26
6.5 Sow trials 33
6.6 Extension materials 34
6.7 ASF 35
6.8 Farmer and technician perceptions 41
6.9 Final activities 45
6.10 Challenges encountered during feeding trials 45

7 Impacts 48

7.1 Scientific impacts 48
7.2 Capacity impacts 48
7.3 Community impacts 48
7.4 Communication and dissemination activities 49

8 Conclusions and recommendations 52

8.1 Conclusions 52
8.2 Recommendations 52

9 References.....55
9.1 References cited in report.....55
9.2 List of publications produced by project.....55

10 Appendixes..... Error! Bookmark not defined.
10.1 Appendix 1: Baseline survey questionnaire..... **Error! Bookmark not defined.**
10.2 Appendix 2: Roles and Responsibilities agreement..... **Error! Bookmark not defined.**
10.3 Appendix 3: Training activities..... **Error! Bookmark not defined.**
10.4 Appendix 4: Growing pig round one protocols..... **Error! Bookmark not defined.**
10.5 Appendix 5: Income from pork sales..... **Error! Bookmark not defined.**
10.6 Appendix 6: Sow trial protocols..... **Error! Bookmark not defined.**
10.7 Appendix 7: Feeding sows..... **Error! Bookmark not defined.**
10.8 Appendix 8: Example crop calendar..... **Error! Bookmark not defined.**
10.9 Appendix 9: Nutritional analyses..... **Error! Bookmark not defined.**
10.10 Appendix 10: Water quality testing..... **Error! Bookmark not defined.**
10.11 Appendix 11: Market Price Summary..... **Error! Bookmark not defined.**

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2 Executive summary

Historically, pigs have been the second most numerous livestock species raised in Timor-Leste. They are important in traditional ceremonies and represent the greatest contributor to monetary income from livestock. The most common pig raising system has been a free-roaming scavenger system, but some pigs are raised in semi-confined or confined systems. Availability of feed is a key constraint, especially in the dry season. African Swine Fever (ASF) was detected in Timor-Leste in September 2019, while the project was underway, and has caused the deaths of at least 50,000 pigs.

The initial aim of the project was to identify husbandry practices that could be practically applied by smallholder pig farmers in Timor-Leste to enable them to improve pig production. After the arrival of ASF, measures to reduce disease risk were also prioritised.

Research demonstration trials conducted in the municipalities of Bobonaro and Baucau demonstrated that smallholder farmers can raise pigs cost-effectively using simple models that are feasible in the Timor-Leste context having been developed together by the project team, technicians and farmers. Several diets using primarily locally-grown ingredients resulted in moderate to good growth rates and return on labour invested by the farmer that easily exceeded the daily agricultural wage when combined with other good husbandry practices (suitable housing, basic biosecurity measures, free access to water, vaccination against CSF, regular anti-parasitic treatment). Nipple drinkers were successfully introduced and enabled farmers to more easily provide a continuous supply of clean water. Most research was conducted with growing pigs, but the sow trial indicated that these findings were also directly applicable to piglet production.

Rice bran, corn and fresh high-protein leaves (leucaena/moringa/sesbania/gliricia) formed the basis of most of the successful diets. The addition of a small proportion of dried fish was cost-effective and resulted in highest growth rates. However, the use of golden snails or tofu waste were also viable alternatives to enhance protein content. Snails can be successfully raised in on-farm snail ponds but the need for intermittent additions of snails means this option is most viable in areas where snails have already invaded local rice paddies. Although only trialled at one site, leaf silage appeared to be a good alternative to fresh leaves and could be a time-saving alterative to daily collection of fresh leaves during the dry season. Although pigs grew well on the commercial diet, it was not a cost-effective complete diet at current prices nor was availability reliable. However, diets trialled that included a small proportion of commercial as a supplement to local ingredients were cost-effective.

The biosecurity measures introduced to manage ASF following the initial outbreak were also largely successful in combination with public awareness sessions. As ASF in Timor-Leste moves from an epidemic to an endemic situation widespread and reinforced education on how to reduce the risk of disease will be essential to enable communities to raise pigs safely.

In the future, the husbandry and biosecurity models developed under this project, in conjunction with working with biosecurity-aware farmers, could be expanded to produce piglets for carefully managed restocking programs as a response to African Swine Fever. Scaling out of the technician training provided in this project on both husbandry and disease prevention, including the use of the resources developed by this project, would enable technicians to provide higher quality support to farmers raising pigs.

The demonstrated potential to raise pigs cost-effectively on local diets could lead to the development of appropriately regulated slaughterhouses and meat shops in local centres, processing pigs in a safe and welfare-friendly manner to supply fresh pork to the local community. Convenient and reliable market access may encourage farmers to turnover their pigs more rapidly, providing additional options to the existing cultural market for interested farmers.

3 Introduction

At the time of the 2015 census, livestock were kept by the majority (87.2%) of households in Timor-Leste (Direcção Nacional de Estatística, 2018). Pigs were the second most numerous livestock species following chickens and the national population was estimated at 419,169 (Direcção Nacional de Estatística, 2018). These data, and descriptions of typical husbandry below, were representative of the pig population at the start of this project in early 2018. However, African Swine Fever (ASF) entered the country in 2019 and was first reported on 27th September (OIE, 2019). As a result, the status of the country's pig population changed dramatically during the last six months of the project. Mortalities were estimated to have exceeded 50,000 nationally by March 2020 and the pig population almost wiped out in some municipalities (pers. comm. Joanita Bendita da Costa Jong, National Director, Veterinary Directorate, Ministry of Agriculture and Fisheries [MAF]). The current situation is largely unknown and changing rapidly.

The most common pig production system in Timor-Leste is a free-range scavenger system, but some pigs are raised in confined smallholder semi-intensive and intensive systems. Women play an important role in pig production and marketing and ownership of pigs can contribute to woman's social standing. Pigs are an important source of household monetary income and maybe sold as piglets or retained as an investment for sale when funds are required. Older pigs are required for ceremonial purposes such as funerals; in these circumstances the seller has considerable power in price setting (Bettencourt et al., 2015; Cargill, 2017).

Pig production systems in Timor-Leste are extremely low input/low output. However, prior to the start of this project, it was considered there was the potential to improve the efficiency of smallholder pork production in Timor-Leste if it was possible to (i) identify balanced cost-effective diets that are available throughout the year, (ii) train farmers in basic pig husbandry and (iii) improve the fresh pork market (Cargill, 2017). With the introduction of ASF, effective biosecurity that is practical in the smallholder system became another requirement for successful pig production.

The Ministry of Agriculture and Fisheries identified a set of development objectives in their Strategic Plan 2014 – 2020 (MAF, 2012) which included improving rural income and livelihoods and reducing poverty, improving household food and nutrition security and supporting the transition from subsistence farming to commercial farming.

At the time of development of this project, Australia's aid program aimed to improve livelihoods by diversifying Timor-Leste's economy via several avenues including increasing agricultural productivity and marketability (DFAT, 2015). The East Asia and Pacific region was the Australian Centre for International Agricultural Research's (ACIAR) highest priority region with Timor-Leste identified as a main country program (ACIAR, 2014). A larger ACIAR project, "AH/2012/065: Investigating and improving pig health and husbandry in Timor-Leste" had been in the development phase for several years. Although there had been some setbacks, this project was expected to start in 2018.

To'os Ba Moris Diak (TOMAK) is an Australian Government program that aims to engage rural Timorese families in profitable agricultural markets and to improve household food security and nutrition. For the two years following its commencement in 2016, support had been crop focussed. However, a scoping study of pig production development opportunities was conducted in 2017 (Cargill, 2017). Following this, TOMAK decided to trial supporting smallholder pig production.

The mutual interests of TOMAK and ACIAR led to a decision to collaborate on this short research activity that aimed to identify husbandry practices that could be practically applied by smallholder pig farmers in Timor-Leste to enable them to improve pig production. The expectation was that findings from this project could be scaled out through the TOMAK project and further research would follow as part of the larger ACIAR project.

4 Objectives

The overall aim of the project was to identify husbandry practices that can be practically applied by smallholder pig farmers in Timor-Leste to enable them to improve pig production.

More specifically the objectives were to:

1. Understand current pig husbandry practices
2. Identify what changes in practice are feasible, particularly in relation to improving
    a. pig diets
    b. piglet and grower health and survival
3. Conduct small trials or research demonstration experiments to assess modified husbandry practices
4. Provide relevant farm-based training in basic pig husbandry to farmers and other stakeholders

5 Methodology

An overview of project activities from March 2018 to April 2020 is shown in Figure 1.

5.1 Preliminary activities

5.1.1 Review of current husbandry practices and possible feeds

A desktop review of existing literature on husbandry practices and possible feed sources in Timor-Leste was undertaken primarily in March-April 2018 but updated when additional material was identified.

5.1.2 Interviews, focus group discussions and/or field trips to address major knowledge gaps

The municipalities of Bobonaro and Baucau were identified as target sites for the project. These locations were chosen because the TOMAK program had regional offices in Maliana and Baucau and the pig populations were relatively large, estimated in 2015 at 49,161 and 42,313 in Bobonaro and Baucau, respectively (Direcção Nacional de Estatística, 2018).

A familiarisation visit was conducted in February-March 2018. Key activities were meetings with relevant TOMAK and MAF personnel, visits to and discussions with farmers about their pig raising.

In April 2018, field visits to Baucau and Bobonaro were undertaken. Crop calendars of currently and potentially available feedstuffs were developed. Samples of some potential feedstuffs were collected, dried and sent to Universitas Nusa Cendana, Kupang, West Timor for nutritional analysis. Several additional samples were also analysed during the first phase of the project. A full-day farmer workshop was held in each municipality.

5.1.3 Inception workshop

A two-day workshop was held in Dili with representatives from MAF and TOMAK National, Baucau and Bobonaro offices, universities/polytechnics and other ACIAR projects. The first day involved a series of presentations on various aspects of pig production and associated challenges identified in Timor-Leste. The second day focussed on planning project activities.

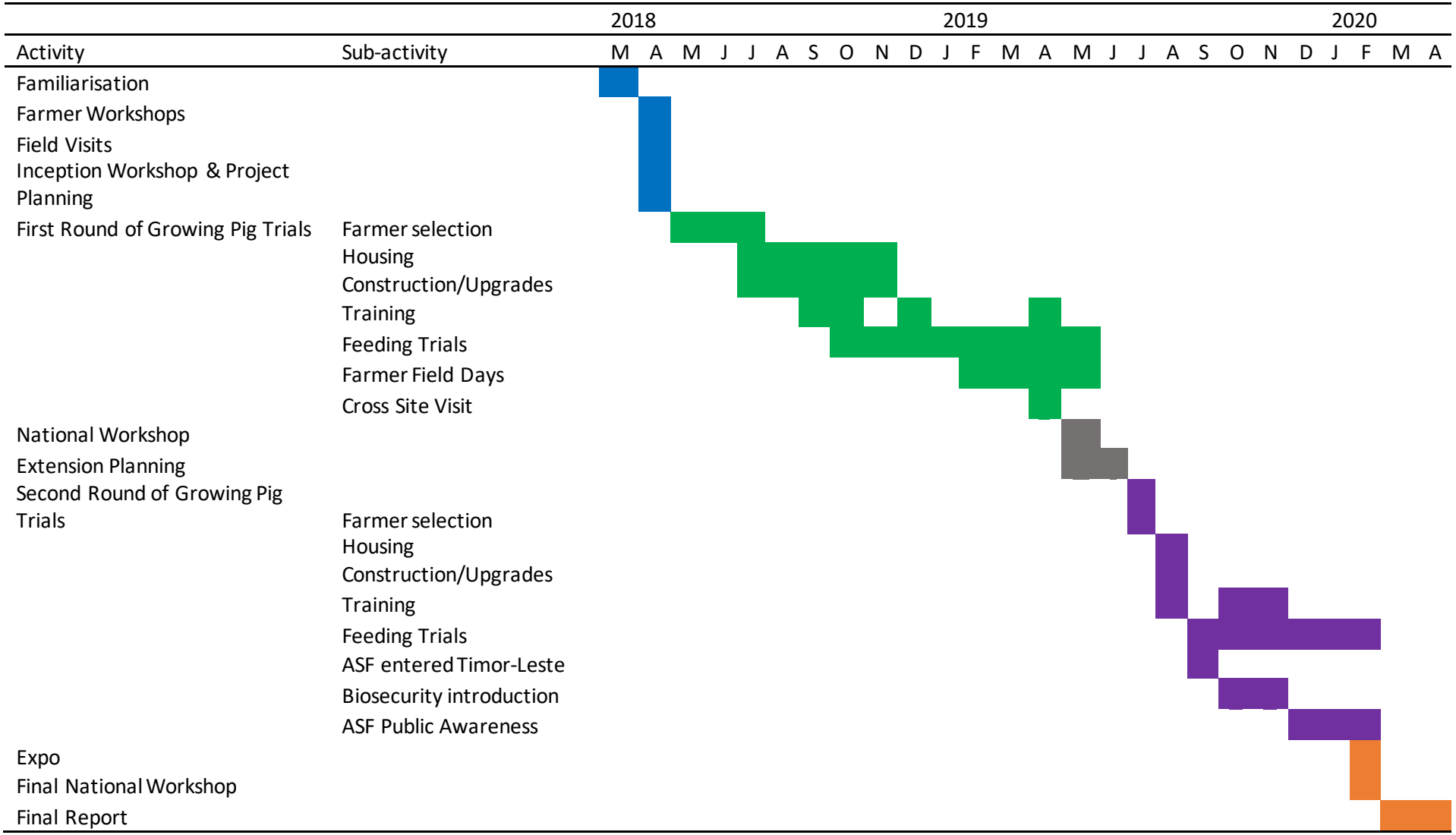

Figure 1: Timeline of project activities

5.2 Growing pig trials round one

5.2.1 Farmer selection

Potential farmers in Baucau and Bobonaro were visited and assessed against a set of selection criteria drawn up in the inception meeting: individual/family farmer i.e. not a group, currently raising confined pigs, really interested in developing a pig raising business, farmer household legal owner of land and pig pen, able and willing to keep detailed records, easily access for visits and to market, enthusiastic technical staff, food surplus, sufficient land for crop production for pig feed, in a TOMAK suku without an existing demplot, not currently receiving other support for pig production, water accessible all year, willing to sign a TOMAK-MAF-Farmer agreement. A gender balance was also considered in the selection process.

Subsequent activities were conducted with each of the eight selected farmers, with support from five livestock and six veterinary technicians (one pair per administrative post, plus one extra veterinary technician in Maliana).

5.2.2 Baseline survey

A baseline survey of the eight trial farmers was conducted in August 2018. Baseline data were collected, using the Ona mobile data collection platform, on farmer demographics, pig husbandry practices, purchases and sales and associated challenges. See Section 10.1 – Appendix 1 for the questionnaire. A survey of a broader population of farmers was originally proposed as part of this project. However, a survey of this nature was conducted during a similar timeframe by ACIAR John Alright Fellow, Alipio de Almeida whilst enrolled in a higher research degree at the University of Sydney. Consequently a decision was made not to duplicate survey activities, rather to focus time and resources on the trials.

5.2.3 Housing

Housing upgrading/construction of grower pig pens was undertaken between July and December 2018. Each pen was designed in consultation with the farmer and associated technicians to meet pig husbandry and welfare requirements and the local situation.

Water tanks and additional pipes were installed as required to try and ensure continuous availability of water. Water quality testing was conducted at each site by the Ministerio Das Obras Pubicas.

5.2.4 Market price survey

A market price survey was conducted on several occasions in each of Baucau and Maliana markets to obtain an indication of market prices of possible ingredients for pig diets and the variation in availability.

5.2.5 Feeding trials

Grower pig feeding trials were conducted between October 2018 and May 2019. Prior to commencement agreements were made on roles and responsibilities. Piglets, feed supplies (excluding fresh leaves), technical support and monitoring were provided by the project team. The farmer was to care for the pigs according to the protocol and the technicians were to visit weekly, weigh and check the pigs. Upon completion, farmers were to keep or sell half the pigs, with the remaining half being sold and funds returned to the project. There was a separate agreement for each farmer, signed by the farmer, their Xefe de Suku, their veterinary technician, their livestock technician, the project team leader, TOMAK team leader and the National Veterinary Director (Section 10.2 – Appendix 2).

To identify possible diets, a spreadsheet developed by the South Australian Research and Development Institute, that showed the expected digestible energy in MJ/kg and percentage crude protein (% CP) for a given combination of ingredients, along with the deficit from the desired content of 12MJ/kg and 16% CP was adapted to the needs of the project (available from http://tomak.org/resources/).

Golden snails (*Pomacea canaliculata*), a pest in some of the rice growing areas of Bobonaro, were identified as a possible cheap source of high quality protein at sites where they were available locally as their inclusion in pig diets in Indonesia has resulted in good growth rates (Syahputra et al., 2014).

Preliminary diets were proposed for each farmer based on the crop calendars compiled by the agronomist. The spreadsheet was then used as an interactive tool with farmers and technicians to modify the diet to balance use of available/potentially available ingredients at each site and nutritional requirements. During the course of the trial, the diet fed at several sites was changed when growth was poor and/or ingredients ceased to be available. All changes were made following consultation among the project team, farmers and their supporting technicians.

All farmers and technicians were trained in feed formulation, record keeping and other routine trial activities and technicians were trained on pig husbandry and health and conduct of post mortems (see Section 10.3 Appendix 3). Protocols for starting the trial and for the routine activities for technicians and farmers are in Section 10.4 Appendix 4. Briefly, a group of five piglets, ideally all males, was sourced for each farmers. Piglets were castrated and vaccinated prior to transport to the trial sites. There they were tagged, weighed, treated with ivermectin and a long acting antibiotic and photographed. Farmers looked after the pigs, checking them at least three times a day, providing a constant supply of water, a main feed twice a day and fresh leaves at lib, cleaning the pen at least daily and keeping detailed records. Technicians visited weekly to check and weigh the pigs, check the feed supply was sufficient until the next visit and identify if the farmer had any concerns. After each visit, technicians sent updated data to the project WhatsApp group for review by the project team. Any concerns were followed up through this group. Farmers also contacted technicians if any of the pigs showed any signs of illhealth. Pigs with ongoing health-related issues were removed from the trial and managed separately. The technicians discussed all concerns with the project co-ordinator who provided advice and/or discussed further with other members of the project team, as required.

Monitoring visits to each site in both municipalities were conducted monthly. When required, additional guidance and training were provided during these visits. Data on time involved in the growing pig trial activities and farmer perceptions of the trial were also gathered during these visits.

Growth curves were plotted and average daily gain (ADG) calculated for each diet used at each trial site. Farmer and technician feed chart data were used to estimate the approximate quantity of each ingredient fed. Very basic economic analyses, estimates of feed cost per kg live weight gain for each diet fed at each site, were conducted for two scenarios, assuming feed was bought at the market at a typical market price and assuming all feed that could be grown at home was valued at half the typical market price. When a pig was removed from the group or died, it and the feed it was assumed to have eaten prior to removal/death were excluded from the analyses.

During the course of the trials, farmer field days were held at five project sites and a cross-site visit conducted whereby the Baucau technicians visited all the Bobonaro trial sites and vice versa.

5.2.6 Snail ponds

Snail ponds were constructed at two sites. Ponds of approximately 3m x 3m x 0.6m were dug and lined with concrete. They were walled (0.5 – 1m), netted and surrounded by rice husks to prevent escape of snails and shaded to prevent excessive temperatures. Ponds

were stocked with mature snails and the population topped-up as required. Snails were fed with fresh leaves, rice bran and pig manure.

5.2.7 Silage

Silage with a high forage tree leaf content was identified as a potential solution to the challenge of providing high quality feed during the dry season. Towards the end of the first round, batches of each of two silage recipes were prepared as proof of concept at a silage training session (see Section 10.3 Appendix 3).

5.2.8 Sale of pigs

Based on the agreement of the proceeds from the sale of half the pigs at each trial site being returned to the project at the end of the trial, farmers were encouraged to identify buyers for at least some of their pigs after they reached the target weight of 50 kg. Sale of some pigs into the pork market was facilitated by the project team.

5.3 Interim workshops and project variation

Originally the project was to be completed by the end of June 2019. Workshops presenting the findings of completed activities were conducted in Baucau, Bobonaro and Dili in May 2019. A project variation in the form of a costed extension was proposed in June 2019 with additional funds being made available by both ACIAR and TOMAK.

5.4 Growing pig trials round two

5.4.1 Farmer selection

The second round of growing pig trials was restricted to Bobonaro because of logistic constraints. The target number of farmers was seven, including all those from the first round able and willing to continue. Additional farmers were recruited from areas close to existing farmers, to minimise demands on logistics, using the same set of selection criteria as used in round one. Ideally new farmers would also have attended one of the farmer field days held in round one.

5.4.2 Housing

Initial housing upgrades/construction were conducted using similar principles to round one. However, using their experiences from the first round, the technicians were able to drive this process with support from the project team. Any required maintenance was also done on pens used in round one.

A nipple drinker set up consisting of two nipples installed at different heights connected to one water container was installed in each pen.

Following the ASF outbreak in September 2019, a corrugated roof sheeting fence was also constructed around each trial pen/pig house (see Section 5.7).

5.4.3 Feeding trials

The trials were conducted in a similar manner to round one. Agreements on roles and responsibilities were signed. Initial/refresher training was provided to all farmers and technicians. The diet selection process differed in this round. Two diets were planned for each site with pigs being fed on the first diet for about two months, then the second diet until the end of the trial. Diets that resulted in cost effective moderate to good growth rate were prioritised, along with modifications to meet with seasonal availability. Diets including snails or silage were also selected as these promising ingredients had not been fully incorporated in diets in round one. A commercial feed diet was also included for

comparative purposes. As with round one, some modifications to diets were required due to lack of availability of ingredients or poor performance.

Analyses were conducted as for round one and technicians were trained to perform these analyses using Excel (see Section 10.3 Appendix 3). Some additional economic analyses were also conducted. These were conducted for four scenarios: feed valued at market price and pigs sold into the pork market, feed valued at market price and pigs sold for cultural purposes, feed valued as home-grown and pigs sold into the pork market and feed valued as home-grown and pigs sold for cultural purposes. The total cost of feed valued at market price was estimated using assumptions based on data from the market price survey for bought feed costs. Half that estimate was used for feed valued as home-grown for those ingredients that farmers could grow but the full market price was used for ingredients for this scenario that the farmer could not grow (e.g. dried fish). The value of piglets at the start of the trial was estimated at $65 for piglets with a starting weight of 6 – 8 kg and $70 for those with a starting weight of 9 – 11 kg, based on estimated feed costs for a sow fed as described in Section 5.5 on a diet of 45% rice bran, 20% milled corn, 30% fresh leaves (leucaena/sesbania/gliricidia) and 5% dried fish for one full reproductive cycle, raising a litter of seven piglets and weaning at 28 and 40 days respectively. The value of pigs sold for pork was assumed to be $4:50/kg based on income received from sale of several pigs into the pork market (see Section 10.5 Appendix 5). The value of pigs sold for cultural purposes was assumed to be $6/kg based on income received from sale of several pigs for cultural purposes and estimates of pig values provided by several farmers, technicians and other members of the project team. These data were used initially to estimate feed costs per kg liveweight gain for each diet/trial combination and profit (excluding labour) for each trial site over the duration of the trial. Then the total time spent on trial pig related activities (e.g. feeding, cleaning, mixing dry mix, gathering leaves, collecting snails and milling corn) was incorporated to estimate the farmer's return on investment per day of labour over the duration of the trial. This was then compared to the standard agricultural wage of $5/day.

5.4.4 Snail ponds

Inclusion of snails in the diet had shown promise in one diet in round one of the growing pig trials. One snail pond had been successfully established in that round, but another pond further from a reliable source of snails had failed. One of the new farmers was also located close to a source of snails and converted an old fish pond into a snail pond as described in Section 5.2.6.

5.4.5 Silage

During round one, two different silage recipes had been successfully made in small quantities and had been either moderately or highly palatable to pigs. During the second round, the plan was to trial silage that could be fed with rice bran as the only other ingredient at two sites, as the first diet on one and as the second diet on the other. There was also a plan to trial a leaf-only silage that could be used a replacement for ad-lib fresh leaves in the dry season when fresh leaves are in limited supply.

5.5 Sow trials

Trials were conducted with one sow belonging to each of three trial farmers who were involved in round one of the growing pig trials. The sow trial protocol is described in detail in Section 10.6 Appendix 6. Briefly, a suitable sow pen was constructed or modified from an existing pen for each sow. A nipple drinker was installed in each pen. Two trial sows were fed a modification of one of the most promising diets identified in round one of the grower pig trials (45% rice bran, 20% milled corn, 30% fresh leaves (leucaena/sesbania/gliricidia) and 5% dried fish). One sow, belonging to a farmer with a snail pond replaced the dried fish with twice the weight of fresh snails. The quantity of

feed provided varied with the stage of the reproductive cycle (see Section 10.7 Appendix 7 for more detail). A creep box was provided at farrowing time. Sows were body condition scored by the technicians during their weekly visit and piglets were weighed at birth and each subsequent visit. Average daily gain was calculated for each piglet from birth until the end of the trial.

Economic analyses were conducted using a similar approach to that used in Section 5.4.3. Total feed costs were estimated, then the total time spent on sow and piglet-related activities was incorporated to estimate the farmer's return on investment per day of labour over the duration of the trial. This was then compared to the standard agricultural wage of $5/day.

5.6 Extension materials

A good husbandry practices manual for pig production in Timor-Leste was developed. In the first phase sections were written on husbandry, particularly housing, welfare of pigs and feeding using locally available ingredients. During the second phase the manual was expanded to include information on a broad range of diseases likely to be important in Timor-Leste, including both African and Classical Swine Fever and some basic guidelines on biosecurity and restocking.

An interactive diet formulation spreadsheet developed by the South Australian Research and Development Institute that showed the expected digestible energy in MJ/kg and percentage crude protein (% CP) for a given combination of ingredients, along with the deficit from the desired content of 12MJ/kg and 16% CP was adapted to the needs of the project.

A biosecurity-focussed poster on how to protect pigs from infectious diseases was developed.

All these materials are available from http://tomak.org/resources/.

5.7 ASF-related activities

African Swine Fever (ASF) was first reported in Timor-Leste on 27th September 2019 (OIE, 2019). The report referred to multiple outbreaks in Dili from 9th September 2019 onwards. However, the project team became aware of large numbers of pig mortalities in several municipalities including Bobonaro and Baucau by mid-October.

5.7.1 Bobonaro

Basic biosecurity measures were introduced on all trial farms in October. These consisted of a corrugated roof sheeting fence surrounding the pig pen(s), boots for farmers and technicians to be kept inside the fence, hand sanitiser/soap to clean hands before entry to the fence, overalls for the technicians and Virkon for disinfection using sprayer and/or bucket and brush, A one-day biosecurity training session was held for all farmers and technicians on 18th October (see Section 10.3 Appendix 3). The morning session covered a basic introduction to the concept of biosecurity and its fundamental role in reducing the risk of ASF, discussion on how to tailor fencing of pens on each farm to manage obstacles such as other infrastructure and waterways and assessment of the quantity of materials required for each farm. The afternoon session was a role play activity with a mock pig pen and extra fence, boots, overalls, disinfectant etc.

Trial farmers were provided with iron and nails to construct the extra fence and other required equipment (boots, sprayer, Virkon, bucket, brush, hand sanitiser/soap). Technicians were provided with boots and overalls.

Biosecurity measures were reviewed by the project team during all remaining visits (November, December, January and February) and refresher training and additional guidance provided to farmers and technicians as required.

Additional information regarding ASF was gathered from farmers and technicians during the regular farm visits and technical meetings in October, November, January and February. These discussions covered death of farmers and technicians own pigs, deaths of other pigs in the area, need for pigs and likely impact of reduced numbers of pigs, changes in attitudes and behaviour of farmers, technicians and other members of the local communities.

Public awareness sessions about ASF were held between December 2019 and January 2020.

Eighteen trial pigs, three at each of six sites, were tested for ASF using the Bionote RAPID ASFV Ag® test by the Departemento Laboratorio Diagnostico da Veterinaria, MAF. Due to the limited supply of test kits it was not possible to test all pigs.

Interviews were conducted with two Xefes de Suku covering similar topics to those discussed with farmers and technicians, impacts of ASF on their local community and to gather feedback on the public awareness sessions.

5.7.2 Baucau

The farmers and technicians from Baucau who were involved in the first round of growing pig trials were provided with biosecurity training (see Section 10.3 Appendix 3) and materials and public awareness sessions were conducted.

5.8 Farmer and technician perceptions

Semi-structured interviews were conducted with the two farmers from Baucau participating in the first round of trials in January 2020 and the seven farmers participating in the second round of trials in Bobonaro in February 2020. Farmers were asked a series of open-ended questions about the approach used to raise pigs during the trials compared to how they had previously raised pigs, any changes in practice they had adopted with their own pigs and their vision for future pig raising. They were then asked to evaluate each of the new husbandry practices and key project activities using a five-point smiley face scale and to explain the reason for their choices.

All the livestock and veterinary technicians involved in one or both rounds of trials were asked to complete a written questionnaire. Closed questions used the same five-point smiley face scale used in the farmer interviews and covered the same topics. Open ended questions covered reasons for choices of smiley faces, adoption of practices with their own pigs and future needs.

6 Results and Discussion

6.1 Preliminary activities

6.1.1 Review of current husbandry practices and possible feeds

Several additional literature sources supporting the descriptions and recommendations made by Cargill (2017) were identified but these contained little useful additional information.

6.1.2 Interviews, focus group discussions and/or field trips to address major knowledge gaps

A familiarisation visit was conducted in February-March 2018. This provided the opportunity to meet with personnel from TOMAK and MAF from the National, Baucau and Bobonaro offices. Meetings were also held with representatives from other ACIAR projects and with some staff members from UNTL. The visits to the municipalities were facilitated by Olavio Morais from MAF who was later appointed as part-time National Pig Production Research and Development Coordinator for the project. Four pig farmers in Baucau and six in Maliana were interviewed about their pig husbandry practices and associated constraints. They kept a mix of Macau, crossbred and local pigs, which were typically in poor body condition and stunted. Diets reported were of poor nutritional quality, particularly low in protein. Pigs frequently did not have free access to water and water availability on-farm was a challenge for some during the dry season. Problems with reproduction, including boar access, were frequently reported. Several farmers reported piglet mortalities due to crushing and other mishaps and mortalities of unknown causes in adult pigs.

In April 2018, the project team including the TOMAK agronomist, visited four pig farmers in Baucau and two in Maliana. In each location the agronomist determined current pig feed crop/forage tree availability for each month, and potential changes that could be made to enhance productivity. These were later used to develop trial diets for individual farmers. See Section 10.8 Appendix 8 for an example crop calendar. Nutritional analysis reports from the Universtias Nusa Cendana Fakultas, Kupang, West Timor are included in Section 10.9 Appendix 9.

Also in April 2018, the project team held a one-day workshop in both Baucau and Maliana attended by 13 and 12 farmers, respectively. Presentations were interspersed with group discussions where farmers identified challenges they faced in pig production and attempted to identify possible solutions to key challenges. Farmers prioritised lack of feed in the dry season, access to water and housing but also flagged other feed, reproduction and marketing challenges.

6.1.3 Inception workshop

A two-day project workshop was held in Dili in April 2018 with a range of stakeholders from TOMAK, MAF and universities. The challenges identified in earlier project activities were presented, discussed and validated on the first day. On the second day the group prioritised the challenges to be addressed during the course of the project. Managing feed challenges was clearly identified as the top priority and participants agreed that the focus of the project trials should be on the use of diets comprised of locally available ingredients in grower pigs in an on-farm setting. Farmer selection criteria and a selection process were defined. MAF staff from Baucau and Bobonaro suggested that targeting six and five farmers, respectively, would be realistic.

Following this, a work plan until May 2019 was developed and a Memorandum of Co-operation between MAF-TOMAK-ACIAR SRA team was drawn up and agreed upon.

6.2 Growing pig trials round one

6.2.1 Farmer selection

It was not possible to identify farmers meeting all selection criteria as no candidate farmers were food surplus. However three trial farmers were identified in Baucau (two in Triloka-Baucau and one in Larifano-Laga, two male, one female) and five in Bobonaro (one in each of Tunubibi-Maliana, Raifun-Maliana, Hataz-Atabae, Meligo-Cailaco and Goulolo-Cailaco, three male, two female) who met most of the other criteria (some did not have easy access to water or for visits/markets). The locations of the farmers are shown in Figure 2. Although the original target for Baucau had been six farmers, the team agreed not to make up the number with farmers who failed to meet more of the key selection criteria. This was a good decision as the project team and TOMAK support staff were stretched providing the level of support and monitoring that was required of the eight selected farmers.

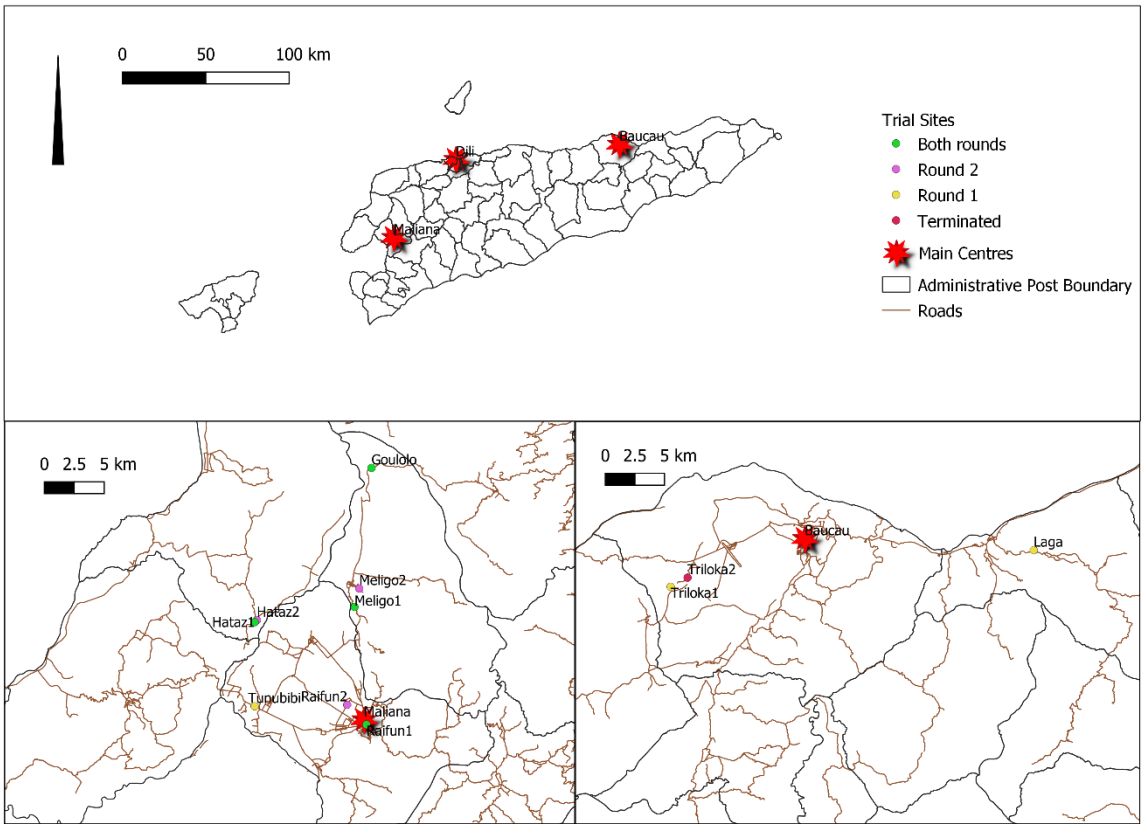

Figure 2: Map of Timor-Leste with insets showing locations of farmers from Bobonaro and Baucau involved in one or both rounds of growing pig trials.

6.2.2 Baseline survey

The baseline survey was conducted between 14th and 23rd August 2018. The five male and three female farmers ranged in age from 32 to 60 years old, mean: 46.5 years. Household size varied from one or two to nine or more, median: 6.5. The highest level of education of the household head was pre-secondary class 3 or higher in most cases (75%). The main occupations of the household head were agriculture and animal husbandry (62.5%) and government employment (37.5%). Half of the farmers had been keeping pigs for 2 – 5 years, with 37.5% keeping for only 1 – 2 years, and 12.5% keeping for more than 10 years. In addition to pigs, all farmers kept chickens, 62.5% kept goats, 25% cattle, 25% buffalo, 12.5% horses, 12.5% sheep, and no farmers kept ducks.

Most farmers kept both native and cross-bred pigs (75%) with the others keeping just native or just cross-bred pigs. The total number of pigs raised by farmers at the time of

the survey ranged from 2 to 58, median 7. Most farmers (87.5%) had a least one sow and/or gilt but only 37.5% had a boar. Most farmers (62.5%) kept some or all of their pigs confined in a pen all the time, 37.5% farmers kept some or all of their pigs tethered and 25% farmers had some free-roaming pigs. All farmers kept pigs for their own cultural purposes and to sell, while 50% also kept them for home consumption and 25% kept them to give to family/friends/other people.

No farmers had bought or acquired any pigs in the 12 months prior to the survey, but 62.5% farmers had sold one or more pigs in that timeframe. Most farmers who had sold pigs (60%) had sold weaners for either $50 or $100. One farmer had sold a gilt for $250 and a castrated male for $700 and another famer had sold four unbred sows for $650 each. Sales were usually direct to other farmers, but one farmer had sold pigs live in the market and to a trader.

Most household members were involved in pig raising in most cases and in all cases at least two household members were involved. Most farmers (75%) spent one or two hours looking after the pigs, with the other 25% spending less than half an hour per day. Most farmers (75%) fed their pigs twice a day. In most cases both men and women were involved in getting the pig feed (75%), preparing the feed (62.5%), feeding the pigs (62.5%), providing water (75%), cleaning the pigs (50%), building the pig house (50%), caring for piglets (62.5%), deciding about selling (75%) and determining sale price (75%). However, men only were more likely to mate the pigs (75%), treat sick pigs (62.5%), contact the veterinary technician (75%) and repair the pig house (50%).

All farmers fed household scraps and most (87.5%) fed some other feed produced by the household. Most farmers (87.5%) also bought some feed from the municipal, administrative post or suku market. Bought feed was either crops or produce, with no farmers buying commercial feed.

Farmers provided non-free-roaming pigs with water either once or twice a day. Water was usually sourced from the tap (75%), but other sources included pond (25%), ground water (12.5%) and purchased water (12.5%).

Clinical signs noted by farmers when pigs had been sick within the last 12 months included diarrhoea, respiratory signs, itching, weight loss, fever, skin lesions and loss of appetite. All farmers indicated that they would seek assistance from MAF technicians when pigs were sick but half would also try treating without assistance. Most farmers (62.5%) had their pigs vaccinated by MAF technicians and treated for parasites within the last 12 months.

No farmers used biosecurity measures such as cleaning shoes before visiting pigs, using a foot bath or controlling vectors such as rodents or flies. Confined pigs were not in contact with pigs belonging to other farmers, but free-roaming pigs were. Most farmers (75%) kept pig manure in a pile and only 12.5% used it as fertiliser after draining into a pit or sump.

Most (75%) farmers had at least one sow farrow in the previous two years, with 33% of these having used their own boar, 50% bringing another boar to the sow and 17% taking the sow to another boar.

Most (87.5%) farmers reported feed access as a challenge when raising pigs. Other challenges reported were space (25%), health concerns (37.5%) and water access (12.5%).

Half of the farmers had received previous support for pig raising from either MAF or a non-government organisation. In most cases (75% supported farmers) this was in the form of training.

6.2.3 Housing

Housing upgrading/construction progressed at very variable rates on different farmers but all were completed in December 2019. All pens had a basic concrete structure, but differed in roofing (iron or thatch) and flooring (concrete, sand or rice hull bedding). New free-standing pens were built at four sites whereas at the others existing housing was modified. The costs of construction/modification varied, but the materials for a simple single pen suitable for five pigs weighing up to 50 kg typically cost US$190 – 230.

All pens initially had a water trough, but nipple drinkers were installed in some pens later in the trial. At first these were not available in Timor-Leste but were sourced from Indonesia when some farmers were experiencing problems with pigs defecating and lying in the troughs.

Water quality results are reported in Section 10.10 Appendix 10 - Table 13. Total hardness was above the World Health Organisation guideline at seven sites and ammoniacal nitrogen levels at four sites. Seven sites had a non-zero total coliform and/or *E. coli* count. All other parameters measured were within the guideline at all sites and no evidence of illhealth due to water quality was noted at any site during the trials.

6.2.4 Market price survey

The results from the market price surveys are reported in detail in Section 10.11 Appendix 11 - Table 14 and Table 15. These results were used to make assumptions about feed prices for the economic analyses. Most ingredients were not sold by weight, rather by the sackful (variable in size and fullness), pile (variable in size/number of items), container (variable in size) or item (variable in size). This meant that it was only possible to get a rough indication of prices per kilogram.

6.2.5 Feeding trials

Grower pig feeding trials were conducted between October 2018 and May 2019. The start time for each farmer was determined by the timing of completion of housing upgrading/construction and the availability of piglets. Trials were completed successfully with seven of the eight farmers. The trial was stopped after a few weeks with one farmer due to poor compliance.

A starting diet was agreed upon for each site. This diet was used throughout the trial at three sites, whereas one or more ingredient was changed once at three sites, and twice at one site. The first diet change at Meligo 1 was made because of poor growth and the limited local availability of palatable leaves. The other diet changes were made when taro and cassava ceased to be available in Bobonaro. These ingredients were replaced with corn and/or pumpkin that had become available. The composition of each diet along with an estimate of its energy and protein content is shown in Table 1. Initially pigs were fed 5% body weight per day. If a group of pigs consistently ate all the feed this was increased to 5.5% and in some cases up to 6% per day.

Most diets resulted in moderate to good growth rates and at all sites exceeded those normally observed by participating farmers (Table 1). The highest growth rates (426 and 450g/day) occurred at the Laga site (one diet fed for the duration of the trial – 40% rice bran, 15 % milled corn, 10% pumpkin, 10% coconut, 20% fresh leaves and 5% dried fish) and at the Meligo 1 site using the third diet (35% rice bran, 20% corn, 10% pumpkin, 5% dried fish and 30% fresh leaves). Diets using tofu waste liquid but with no animal protein also resulted in good growth (210 and 230 g/day at Raifun 1). Sites using cassava and/or taro in the earlier diet and milled corn and/or pumpkin in the later diet (Raifun 1, Meligo 1, Goulolo and Tunubibi) mostly had markedly higher growth rates after the change, consistent with the higher protein content of those ingredients. The two farmers using dried sago noted that palatability was relatively low or variable and growth rates for diets

including dried sago were generally lower. The quality of rice bran was sometimes an issue with farmers reporting reduced palatability when it was coarser.

Prices assumed for market and home-grown values of feeds are shown in Table 2. The estimated feed costs per kg live weight gain ranged from US$1.50 - $2.53 assuming home-grown value and from US$2.50 - $4.20 assuming market value (Table 3). In all cases these costs were less, and at the home-grown value markedly less, than expected income from sale into the pork market ($4:50/kg based on income received from sale of several pigs into the pork market, see Section 10.5 Appendix 5) or $6/kg for cultural purposes (based on income received from sale of several pigs for cultural purposes and estimates of pig values provided by several farmers, technicians and other members of the project team). These findings suggested potentially good return on investment particularly as labour invested was not excessive, ranging from 50 min to 2 hours 20 min/day. Farmers spending in more time per day were those who had to travel further to pick fresh leaves and/or gather snails on a regular basis, two activities that could be reduced by planting suitable trees nearby and breeding snails in a snail pond.

A mix of leucaena, sesbania, glircidia and moringa leaves were included in all diets, with the mix depending upon a balance of which could be readily gathered by the farmer and which were palatable to the pigs.

Initially two farmers tried feeding dried leaves mixed with the other ingredients, whereas the others provided fresh leaves ad libitum that they either picked every day if relatively close by or every two to three days if a longer trip was required. The dried leaf option was not successful, pigs ate very little of the combined feed and growth rates were low, so was discontinued and the dried leaves were replaced with fresh leaves. These brief phases at the start of the trial at two sites were excluded from the ADG calculations.

The palatability of fresh leaves varied, with findings mostly but not entirely consistent between sites where the same leaves were fed. Leucaena was consistently highly palatable to pigs and available at most sites but not all sites. However, because of the risk of mimosine toxicity it could not be provided in large quantities (more than ~ 15% of the total diet). Moringa leaves were the next most palatable, but only available at three sites and usually not in large quantities. Gliricidia leaves were readily available at all sites, but were either not eaten or not eaten well by most pigs, except at one site. This was surprising and disappointing given it had provided highly palatable in Indonesia (pers. comm. Colin Cargill). However, a wide variability in palatability to sheep among Gliricidia provenances has been reported (Larbi et al., 1993). Sesbania was available at most sites but was usually not very palatable, so eaten only in small quantities by some pigs.

It was only possible to feed golden snails at one site located relatively close to rice paddies where snails were present as a pest. Even at this site is was not possible to include them consistently in the diet as the source paddies were not accessible after heavy rains and the snail pond was not established until late in the trial.

Farmers used two different strategies when feeding the trial pigs, driven largely by the combination of ingredients in the diet. Some farmers, particularly those with multiple fresh ingredients (e.g. pumpkin, taro, coconut, tofu waste liquid) prepared the main feed from scratch at each feed by weighing each ingredient separately and then mixing. Other farmers, whose diets were primarily of dry ingredients, mixed up batches of “dry mix” including all the dry ingredients (e.g. rice bran, milled corn, dried sago) which they kept stored in plastic containers for between three days and two weeks.

There were some challenges with record keeping by both farmers and technicians so the weekly sharing of data via the WhatsApp group and the monthly monitoring visits were critical to enable issues to be identified, discussed and resolved in a timely fashion. Some of the technicians also struggled with the basic feed calculations and sometimes failed to identify when their calculations were wildly wrong (e.g. advising a larger amount of an ingredient to three compared to five pigs, calculations out by a factor of ten due to decimal point issues). The limited numeracy skills of technical staff meant that far more detailed

supervision of their weekly calculations was required compared to what had been anticipated prior to the start of the project. It was hoped that the regular monitoring and checking meant that pigs generally received the required quantity of feed and that the amounts were correctly recorded so that the estimations of the total amount of each ingredient fed at each site were reasonably reliable.

The five farmer field days were attended by trial farmers, neighbouring farmers, project and other technicians. Each was run by the hosting farmer with support from their technicians and the project team.

Four pigs died during this first round of the trials, two at one site and one at each of two other sites. Two deaths occurred within a few weeks of the start of the trial. In these cases the causes of death were thought to be a haemorrhagic gastric ulcer and an intussusception, both possibly predisposed to by a pre-existing parasite burden. The two later deaths were thought to be due to a systemic infection, possibly classical swine fever, and complications following prolapsed anus. One pig with diarrhoea and inappetance did not respond well to initial treatment and was removed the trial. All pigs that developed other clinical signs e.g. itchiness, diarrhoea, conjunctivitis responded quickly to treatment.

Originally piglets were all to be sourced from one relatively large farm in Hera, near Dili and were to have been of similar age, weight and breed when the trial was started at each site. However, due to lack of supply, it was only possible to use macau pigs from this farm at four sites with more variation in age and weight than desired. Pigs for the remaining three sites came from two further sources including one trial farmer. These pigs were all crossbred and were markedly lighter for their age than the other pigs (Table 3). There are therefore several limitations to the findings from this trial: use of different diets at different sites, between site variations in genetics and prior management of the pigs, and differences in management between trial sites despite a standard protocol.

Table 1: Composition of diets used at each site in round one of the growing pig trials and associated average daily gain. The sites are referred to by suku followed by a number (1 or 2) where more than one site was involved in that suku during either round of the trials. A, B and C refer to sequential diet changes at a given site. ADG – average daily gain, CP – crude protein, DE – digestible energy.

Ingredient	Triloka 1	Laga	Hataz 1	Tunubibi A	Tunubibi B	Raifun 1A	Raifun 1B	Meligo 1A	Meligo 1B	Meligo 1C	Goulolo A	Goulolo B
Rice bran	35	40	25	40	40	40	40	35	35	35	30	30
Maize/corn	0	15	15	15	20	0	15	0	0	20	15	15
Cassava	5	0	0	10	0	0	0	10	10	0	10	0
Sago	0	0	20	0	0	0	0	0	0	0	10	10
Taro	5	0	0	0	0	15	0	20	20	0	0	0
Pumpkin	10	10	0	0	5	0	0	0	0	10	0	10
Snails	0	0	5	0	0	0	0	0	0	0	0	0
Tofu waste liquid	0	0	0	0	0	20	20	0	0	0	0	0
Dried fish	0	5	0	5	5	0	0	0	5	5	0	0
Coconut	10	10	0	0	0	0	0	0	0	0	0	0
Fresh leaves	35	20	35	30	30	25	25	35	30	30	35	35
DE (MJ/kg)	11.8	13.55	12.45	13.35	12.9	11.7	11.85	13.05	13.05	12.15	13.05	11.95
CP	14.45	15.6	14.05	15.4	16.4	13.3	13.9	12.55	14.45	16.65	12.6	14
ADG g/day	230	426	87	210	224	210	310	33	140	450	90	166

Table 2: Prices assumed for each ingredient for market and home-grown scenarios used for estimation of cost per kg live weight gain.

Price (kg)	Market Price	Home-grown Price
Rice bran	$0.40	$0.20
Milled corn	$1.00	$0.50
Cassava	$0.50	$0.25
Sago	labour only	labour only
Taro	$0.70	$0.35
Pumpkin	$2.00	$1.00
Snails	labour only	labour only
Tofu waste	$0.00	$0.00
Dried fish	$4.25	$4.25
Coconut (piece)	$0.10	$0.05
Fresh leaves	labour only	labour only

Table 3: Comparison of pigs, trial duration, labour and feed costs per kg live weight gain at each trial site. LW – live weight

	Triloka 1	Laga	Hataz 1	Tunubibi	Raifun 1	Meligo 1	Goulolo
Breed	Macau	Crossbred	Macau	Macau	Macau	Crossbred	Crossbred
Age at start (weeks)	12	12	10	10	10	13	13
Duration (days)	149	111	210	182	208	208	208
Average starting weight (kg)	16	8	16	24	21	6	6
Average finishing weight (kg)	53	55	35	65	72	50	26
Number of pigs at finish	3	5	5	5	3	4	5
Labour	38	28	58	41	31	23	68
Cost/kg LW gain - market value	$3.00	$2.50	$4.20	$3.79	$3.16	$3.35	$3.32
Cost/kg LW gain - home-grown value	$1.50	$1.56	$2.10	$2.53	$1.58	$2.10	$1.66

6.2.6 Snail ponds

Snail ponds were constructed at two sites, one in Hataz and one in Goulolo. The Hataz pond was largely successful but was not fully established until near the end of round one. The site was relatively close to rice fields where snails were present in large numbers so it was relatively easy for the farmer to gather the initial snails and to top up as required, except following heavy rain. The other site was not successful. Set up was delayed because of lack of availability of sufficient water in the dry season. This problem was later overcome by pumping water from the irrigation channel. However, the site was far from a source of snails and the initial population died within two months of set up, possibly due to high water temperatures. Given these challenges, it was decided that it was not practical to continue to try and establish a snail population at that site.

6.2.7 Silage

Towards the end of round one, a single batch (~ 10kg) was made of each of two silage recipes, one in Baucau and one in Maliana. The Baucau recipe was 45% gliricidia, 10% sweetpotatoes, 10% sweetpotato vines, 10% sesbania, 10% moringa, 5% leucaenca, 5% rice bran, and 5% milled corn. The Maliana recipe was 50% gliricidia, 15% rice bran, 10% taro, 10% cassava, 10% sesbania, 5% moringa. EM4 was added to both recipes at 300ml per 10kg. After the 14-day fermentation period, the Baucau recipe was highly palatable to the pigs tested and the Maliana one moderately so. Nutritional analyses suggested that both had good protein (15.6 and 17.4%) and energy content (16.4 and 16.9 MJ/kg) so had potential either as a complete diet or as a key ingredient of a mixed diet (See Section 10.9 Appendix 9). This was investigated further in round two (Section 6.4.5).

6.2.8 Sale of pigs

Four trial pigs were slaughtered, butchered and sold, three near Maliana market and one near Baucau market. The carcass was sold by piece for $7/kg, with the head and offal sold separately. The average income from the sale was $4.48/kg live weight. Further details are reported in see Section 10.5 Appendix 5 - Table 12. Several other pigs were sold live soon after completion of the trial for prices ranging from $200 to $400. Full details of these sales, including weight at sale and expected use of the pigs are not available, but it is likely that these pigs will have been kept by buyers for future use for cultural purposes.

6.3 Interim workshops and project variation

Originally the project was to be completed by the end of June 2019.

Municipal workshops were held in both Baucau and Maliana in May 2019. Results of the round one of the trials were shared and discussed. The workshops were attended by members of the local authority, municipal MAF staff and participating farmers. Unfortunately heavy rain in Baucau leading up to and on the day of the workshop meant that participants from further afield were unable to attend. Consequently two mini-workshops of a similar nature were held in Laga, attended by an administrative post delegate, a local livestock technician and 13 local farmers, and in Triloka, attended by three Xefe de Aldeia, the secretary of the suku, three other suku delegates and at least 20 farmers.

A two-day meeting was held in Dili immediately after the municipal workshops. The workshop was attended by about 40 people including several directors from MAF national (including the diagnostic laboratory facility) and municipal MAF sections, all project technicians and several laboratory technicians, several TOMAK staff including the program leader and both regional managers, and representatives from other ACIAR projects, Unital, and several other agencies. The first day focussed on presentation of project activities and results interspersed with videos of farmers' perspectives of project

activities prepared by TOMAK's Communication Specialist, Lewti Hunghanfoo. On the second day Colin Cargill gave an overview of piglet production systems. This was followed by group discussions to develop recommendations for future research activities, development of extension materials and marketing opportunities. Ideas were shared and discussed with other groups then the workshop closed.

The extension to project was agreed upon in June 2019. The end date was revised to the end of March 2020. The extra aim was to conduct additional research demonstration experiments (~ 4 groups of pigs/2 diets per group, and 2-3 sows) in Bobonaro.

6.4 Growing pig trials round two

6.4.1 Farmer selection

Four of the five farmers from Bobonaro were able and willing to continue with round two. The farmer who did not continue was unable to do so because of family commitments outside Bobonaro. Three new farmers were selected to participate, two male and one female from Hataz-Atabae, Meligo-Cailaco and Raifun-Maliana. Again these farmers were not food surplus and the female farmer was illiterate, but her children were able to keep the required records. The locations of the farmers are shown in Figure 2.

6.4.2 Housing

Housing upgrades were completed much more efficiently and quickly in round two compared to round one, reflecting the enhanced capacity of the livestock and veterinary technicians to provide direct support to the farmers under the guidance of the project team. New free-standing pens were built at two of the new sites and existing housing was modified at one site. All had concrete floors, two had iron roofs, one thatch.

During the course of the trial, several issues were encountered with the housing. Most of the concrete floors became damaged after a relatively short period of time and this was exacerbated by natural rooting behaviour of the pigs. It is likely this problem was exacerbated by the use of too thin a layer of relatively poor quality concrete possibly due to suboptimal combinations of ingredients and/or silty sand. The quality and durability of concrete observed elsewhere e.g. houses, other buildings was also often poor, reflecting a broader issue of short-term cost saving behaviour. Both sand floors did not drain as well as expected. Again, this was considered to be an issue of quality of materials as the sand used was silty rather than pure, prone to clagging and variable in consistency. Two farmers had experience with both sand and concrete floors and noted advantages and disadvantages to both.

Concerns were raised about the capacity to thoroughly clean and disinfect a pen following an outbreak of ASF. Although theoretically a concrete floor should be more readily disinfected, the frequent issues with damaged concrete leading to holes in the floor meant in some ways this uneven surface including exposed organic material would be harder to manage than a sand floor where the top layer of sand could be readily removed and replaced. The farmer who used rice hull bedding in his pig pen in round one elected not to use it in round two because of the risk of contamination.

Nipple drinkers were used in preference to water troughs in round two. These generally worked well though some farmers experienced difficulties in securing leak-free connections to pipes between the water container and the nipples. It was observed that farmers were generally more compliant with continuous provision of water via the nipple drinker than they had been in round one when water was provided in troughs that pigs often urinated and/or defecated in soon after cleaning.

6.4.3 Feeding trials

Grower pig feeding trials were conducted between September 2019 and February 2020. The start time for each farmer was determined by the timing of completion of housing upgrading/construction and the availability of piglets. The changeover from first to second diet occurred at most sites in late November to early December. There was some variation due to availability of ingredients and diet performance. The composition of each of the nine diets fed is shown in Table 4. Ingredients used in one or more diet were rice bran, milled corn, snails, dried fish, tofu waste, commercial feed, fresh leaves and silage. The diet consisting of 45% rice bran, 20% milled corn, 5% dried fish fed as a dry mix, with fresh leaves fed ad lib representing 30% of the diet (RB/C/F/L) was trialled on two sites as the first diet and two sites as the second diet. The original plan had been to trial the most promising diet from round one from Bobonaro (similar to RB/C/F/L with 10% rice bran replaced with pumpkin) at two sites in this round and RB/C/F/L at two sites as both were expected to be promising. However, due to the timing of the trials, it was not possible to source sufficient pumpkin so it was decided to include extra replicates of RB/C/F/L.

The average daily gain of each group of trial pigs for each diet, along with the overall average for diets fed at more than one site are shown in Table 5. Feeding RB/C/F/L resulted in consistently good growth rates across the four sites (ADG range 271 – 457 g/day, overall average 326 g/day) with higher rates when fed as the second diet. Fresh leaves were replaced with leaf silage for the second diet at one site with excellent results (ADG 482 g/day). A similar diet to RB/C/F/L with the dried fish replaced with snails (RB/C/S/L) was trialled as a first diet at one site and second at another site. ADGs were variable, 97 g/day and 271 g/day. At the first site 10% rice bran was replaced with 10% commercial diet for the second diet with an increase in ADG to 250 g/day. ADG was relatively low with the diet containing 20% tofu waste (RB/C/T/L, 157 g/day) and this reduced further later in the trial when the farmer reduced the frequency of making tofu, then stopped altogether. The growth rate was very low with the silage/rice bran diet as the trial pigs ate very little of this diet. The diet of commercial feed alone resulted in consistently high growth rates across the two sites where it was trialled (415 and 417 g/day).

Estimates of the feed costs used for the market price and home-grown values are shown in Table 6 and estimated costs per kg live weight gained for each diet are shown in Table 7. For most diets, even under the market price scenario, the cost per kg live weight gained was notably lower than the expected sale price per kg live weight of $4.50 for pork and $6 for cultural purposes. Despite the relatively low ADG, the diet with the tofu waste had the lowest cost per kg live weight gain, whereas the commercial diet, with high ADG had one of the highest costs per kg live weight gain.

Profit and return per day of labour scenarios were considered for each site for the duration of the trial, i.e. across both diets, due to the complexity of assuming values for partially-grown pigs under different scenarios at the time of the change in diet. Estimates of overall profit, excluding labour, are shown in Table 8 and estimates of return per day of labour are shown in Table 9. The amount of time farmers spent on average per day looking after their pigs was quite variable, ranging from about 40 minutes to 2.5 hours per day. Farmers spending more time were those with snail ponds, as collecting snails to top up the snail population on a regular basis was time consuming, and those who had to travel further to gather fresh leaves. If pigs could be sold at $6 per kg live weight into the cultural market, the farmers at each site would have a greater return per day of labour than the agricultural labour rate of $5 per day if sourcing feed at both market and home-grown prices. Returns were also expected to be better than the agricultural labour rate at most sites if sold at $4:50 per kg live weight for pork. Trials with the poorest return were Raifun 2 where growth rate was good, but commercial feed was fed as the second diet and Raifun 1 where the cost of feed per kg live weight gain was low, but growth rates were also low, particularly when the tofu waste was unavailable.

The inclusion of a pure commercial feed diet provided a useful baseline as to the average daily gains that could realistically be achieved with the local or cross-bred pigs included in the trials. However, sourcing the commercial feed was challenging as it was only intermittently available in Maliana, so on one occasion feed produced by a different company had to be sourced from Dili and transported from there to the trial site. Complete nutritional information was not provided on the labels of sacks from either company.

Table 4: Composition of diets used in round two of the growing pig trials and sites where they were fed as first or second diet. C – corn, Com – commercial feed, CP – crude protein, DE – digestible energy, F – dried fish, L – fresh leaves, LSil – leaf silage, RB – rice bran, S – snails, Sil – silage, T – tofu waste.

Ingredient	RB/C/F/L	RB/C/F/LSil	RB/C/Com/L	RB/C/S/L	RB/C/S/Com/L	RB/C/T/L	RB/C/L	Sil/RB	Com
Rice bran	45	45	35	45	35	40	45	25	0
Milled corn	20	20	20	20	20	15	25	0	0
Snails	0	0	0	5	5	0	0	0	0
Tofu waste	0	0	0	0	0	20	0	0	0
Dried fish	5	5	0	0	0	0	0	0	0
Commercial diet	0	0	15	0	10	0	0	0	100
Fresh leaves	30	0	30	30	30	25	30	0	0
Leaf silage	0	30	0	0	0	0	0	0	0
Silage	0	0	0	0	0	0	0	75	0
DE (MJ/kg)	13.7	13.7	13.5	13.8	13.1	11.9	14.4	11.5	
CP (%)	16.2	16.2	14.6	15.2	15.8	13.9	13.5	15.9	16-18
First diet	Hataz 2/Meligo 2		Raifun 2	Hataz 1		Raifun1		Goulolo	Meligo 1
Second diet	Meligo 1/Goulolo	Meligo 2		Hataz 2	Hataz 1		Raifun1		Raifun 2

Table 5: Average daily gain of each group of trial pigs for each diet. First/second diet, trial site and breed of pigs also included. Where a diet was used on more than one site average performance is also included. Detailed composition of each diet is shown in Table 4. C – corn, Com – commercial feed, CP – crude protein, DE – digestible energy, F – dried fish, L – fresh leaves, LSil – leaf silage, RB – rice bran, S – snails, Sil – silage, T – tofu waste.

Diet	ME (MJ/kg)	CP %	Average daily gain (g/day)	1st/2nd	Site	Breed
RB/C/F/L	13.7	16.2	271	1st	Hataz 2	cruza
RB/C/F/L	13.7	16.2	457	2nd	Meligo 1	cruza
RB/C/F/L	13.7	16.2	267	1st	Meligo 2	cruza
RB/C/F/L	13.7	16.2	308	2nd	Goulolo	local
RB/C/F/L - average			*326*			
RB/C/F/LSil	13.7	16.2	482	2nd	Meligo 2	cruza
RB/C/Com/L	13.5	14.6	191	1st	Raifun 2	cruza
RB/C/S/L	13.8	15.2	97	1st	Hataz 1	macau
RB/C/S/L	13.8	15.2	271	2nd	Hataz 2	cruza
RB/C/S/L - average			*184*			
RB/C/S/Com/L	13.1	15.8	250	2nd	Hataz 1	macau
RB/C/T/L	11.9	13.9	157	1st	Raifun 1	macau
RB/C/L	14.4	13.5	93	2nd	Raifun 1	macau
Sil/RB	11.5	15.9	42	1st	Goulolo	local
Com		16-18	415	1st	Meligo 1	cruza
Com		16-18	417	2nd	Raifun 2	cruza
Com - average			*416*			

Table 6: Prices assumed for each ingredient for market and home-grown scenarios used for economic analyses.

Ingredient	Market Price	Home-grown Price
Rice bran	$0.40	$0.20
Milled corn	$1.00	$0.50
Snails	labour only	labour only
Tofu waste	$0.00	$0.00
Dried fish	$4.25	$4.25
Commercial diet	$1.20	$1.20
Fresh leaves	labour only	labour only
Leaf silage	$0.12	$0.12
Silage	$0.33	$0.33

Table 7: Estimated feed cost per kg live weight gained for each diet trial. Where a diet was used on more than one site average performance is also included. Detailed composition of each diet is shown in Table 4. C – corn, Com – commercial feed, CP – crude protein, DE – digestible energy, F – dried fish, L – fresh leaves, LSil – leaf silage, LW – live weight RB – rice bran, S – snails, Sil – silage, T – tofu waste.

Diet	Market Price $/kg LW	Home Price $/kg LW
RB/C/F/L	$1.69	$1.14
RB/C/F/L	$2.92	$1.98
RB/C/F/L	$1.92	$1.30
RB/C/F/L	$2.10	$1.43
RB/C/F/L - average	*$2.16*	*$1.46*
RB/C/F/LSil	$3.08	$2.12
RB/C/Com/L	$2.11	$1.42
RB/C/S/L	$2.77	$1.39
RB/C/S/L	$2.58	$1.29
RB/C/S/L - average	*$2.68*	*$1.34*
RB/C/S/Com/L	$2.64	$1.66
RB/C/T/L	$1.11	$0.55
RB/C/L	$3.55	$1.77
Sil/RB	$5.13	$4.39
Com	$2.91	$2.91
Com	$4.68	$4.68
Com - average	*$3.80*	*$3.80*

Table 8: Estimated profit (excluding labour) for each trial under four scenarios: market price feed and sale for pork, market price feed and sale for cultural purposes, home-grown price feed and sale for pork and home-grown price feed and sale for cultural purposes

		Profit			
		Market Price		Home Grown	
Trial	Trial duration (days)	Pork	Culture	Pork	Culture
Hataz 1	147	$98	$357	$233	$492
Hataz 2	140	$246	$572	$424	$751
Raifun 1	140	$9	$197	$111	$298
Raifun 2	144	-$22	$376	$21	$419
Meligo 1	101	$242	$651	$330	$739
Meligo 2	145	$347	$790	$553	$996
Goulolo	125	$184	$470	$283	$569

Table 9: Estimated return per day of labour for each trial under four scenarios: market price feed and sale for pork, market price feed and sale for cultural purposes, home-grown price feed and sale for pork and home-grown price feed and sale for cultural purposes

				Income/day labour			
				Market Price		Home Grown	
Trial	Trial duration (days)	Labour (days)	Hours/day	Pork	Culture	Pork	Culture
Hataz 1	147	31.1	1.7	$3	$11	$7	$16
Hataz 2	140	44	2.5	$6	$13	$10	$17
Raifun 1	140	17.6	1	$0.30	$6	$4	$10
Raifun 2	144	14.2	0.8	-$2	$26	$1	$30
Meligo 1	101	8.5	0.7	$29	$77	$39	$87
Meligo 2	145	24.3	1.3	$14	$33	$23	$41
Goulolo	125	25.8	1.7	$7	$18	$11	$22

6.4.4 Snail ponds

The farmer with the snail pond set up in round one maintained the snail population successfully throughout round two and the new farmer who converted the fish pond successfully established a snail population. Although snails bred well in both ponds, the population was not sufficiently large to be self-sustaining for feeding the trial growing pigs plus in one case a trial sow and the farmer's own four pigs. Both farmers continued to collect additional snails intermittently. It is highly likely that a much larger population of snails could be kept in ponds of the size used in this trial, but how many snails would be required to have a population that could sustainable feed a given number of pigs has not been established.

6.4.5 Silage

The silage recipe used for as the first diet at one of the trial sites was 40% gliricidia, 20% leucaena, 20% rice bran, 15% milled corn and 5% cassava combined with EM4 at 300ml/10kg. The silage was made in October and the choice of ingredients was determined largely on availability towards the end of the dry season. All leaves used in the diet were old leaves from the previous rainy season. This silage was not palatable to the young trial pigs so their second diet was introduced early. It was however palatable to the farmer's own mature pigs.

Due to the difficulty in accessing large quantities of leaves during the dry season, particularly leaves of the more palatable forage trees (leucaena, moringa and sesbania) and the leaves being old, it was decided to delay further silage trials until there was fresh growth of leaves following the start of the rainy season. Unfortunately the 2019 dry season was long and harsh and fresh leaves were not available until December.

By the end of the dry season, the team had prioritised leaf-only silage over the more complete-diet silage as it was seen as being a viable alternative to spending an extended period each day in the dry season gathering fresh leaves. Two different recipes were trialled at one site. The first recipe completely avoided gliricidia and consisted of 60% leucaena and 40% sesbania. The second recipe was 50% leucaena, 30% sesbania and 20% gliricidia. Both recipes were highly palatable to the trial pigs and their growth rate was very good when on the diet including leaf silage (Table 5). Further batches of the second recipe were made and fed until the end of the trial. This recipe was preferred by the farmer as gliricidia was the most readily available leaf, and the 60% inclusion of leucaena in the first diet, equated to ~20% of the overall diet, so higher than preferred in relation to the risk of mimosine toxicity. A third leaf-only silage recipe of 60% leucaena, 40% gliricidia was made at another site. The gliricidia content was high because of the lack of availability of other leaves. Unfortunately this recipe was not palatable to the trial pigs when fed both separately and mixed with the other feed ingredients.

It is unfortunate that the timing and location of the second round of growing pig trials, and associated lack of sweetpotato and sweetpotato vines, meant that it was not possible to evaluate the Baucau recipe made as a proof of concept in the first round which showed promise in terms of palatability and nutritional content. However, two leaf-only silage recipes, with no/small proportion of gliricidia, proved to be highly palatable and good growth was sustained when these pigs were swapped from fresh leaves to leaf-only silage while keeping all other diet ingredients the same. These recipes should be readily adoptable by many farmers as ingredients are readily available and apart from the EM4 require time but not monetary input. The two key challenges are the need to maintain proper anaerobic storage and to plan ahead so that silage is made in sufficient quantity and frequency for what will be required in two weeks' time. The latter point did prove challenging during the trial with farmers and technicians clearly struggling to plan two weeks ahead.

6.5 Sow trials

The trial with just three sows was badly impacted by the ASF outbreak.

One sow belonged to a farmer without a boar and plans to transport the sow to another trial farmer's boar had to be cancelled because of risks associated with pig movement.

Another sow was already mid-lactation at the start of the trial. She had lost some condition during early lactation but returned to good condition within about a month of weaning. She was pregnant and in good condition when she died from ASF (see Section 6.7.3).

The trial with the third sow was very successful. She was ~ 6 weeks pregnant at the start of the trial. She produced a litter of seven piglets, one was stillborn, two were deformed and died within two days and the remaining five were healthy. The piglets grew very quickly and the sow remained in good body condition throughout. Surprisingly the piglets did not use the creep box provided. Ideally they would have been weaned after 4 weeks when they weighed ~ 8kg but the farmer did not have any housing available within the biosecurity fence. They were weaned after 85 days and the sow was mated five days later. Their final weights were measured at 100 days. The average weight was 33 kg and average daily gain from birth was 325g/day (Figure 3). This compares extremely favourably to pigs used in round two that were of similar age at the start of the trial but typically weighed ~ 7kg.

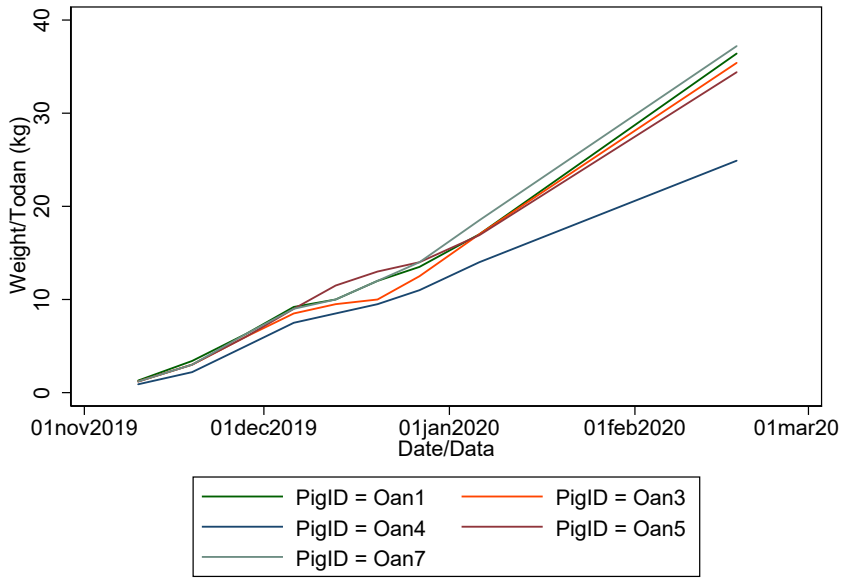

Figure 3: Average daily gain of five piglets in sow trial from birth to 100 days

The total feed costs for the sow from mating until the next mating and for the litter until 100 days old were estimated at $488 and $711 under the home-grown and market price scenarios, respectively. Total labour was estimated at 16.7 working days. With the 33 kg pigs valued at the pork price of $4.50/kg the return on investment per day was $15.30 under the home-grown feed scenario and $1.85 under the market price scenario. With the 33 kg pigs valued at the cultural price of $6/kg the return on investment per day was $30.15 under the home-grown feed scenario and $16.70 under the market price scenario.

While it is unfortunate that it was only possible to gather complete data for one sow, the results are very promising. The sow remained in good condition throughout lactation, the piglets grew rapidly and the under most scenarios the return on investment for the farmer markedly exceeded the daily agricultural wage of $5/day. The litter size was small, with only five healthy piglets. Had the litter size been larger, the return on investment would be expected to be higher, although the cost of feed during lactation would have been somewhat higher, there would have been minimal change to other parameters and this would likely have been outweighed by the value of one or more additional piglet. The situation in this case could also have been made much more profitable if the farmer had been able to wean the piglets at an earlier age (e.g. 28 – 40 rather than 100 days), and shorten the reproductive cycle of the sow by enabling her to come into oestrous and be re-mated several weeks earlier.

6.6 Extension materials

A good husbandry practices manual for pig production in Timor-Leste was developed and is now available in both Tetun and English. Soft copies have been provided to MAF and universities. It is hoped that it will be a useful resource for technicians, students and their teachers, and of course farmers who wish to improve their pig raising. It is just a starting point for improved smallholder pig production in Timor-Leste, and as new knowledge is acquired by other researchers and practitioners, it is hoped that it will be updated, improved and recirculated to key stakeholders.

The manual, interactive diet formulation spreadsheet, and biosecurity-focussed poster are available from http://tomak.org/resources/

6.7 ASF

6.7.1 Project activities

Bobonaro

The biosecurity training session in Maliana was attended by one or more representatives from six of the seven trial sites and six of the seven technicians.

All farmers and technicians constructed an extra fence around their trial pig pen and in some cases additional pens and set up an area just inside the door to store other equipment required to follow recommended biosecurity measures. The cost of iron and nails required to fence in one growing pig pen ranged from $64 to $82. Costs were higher for farmers with additional pens e.g. $135 and $180 to fence 4 and 5 pens, respectively. Other materials such as bamboo, wood and *gliricidia* for living fencing were gathered locally by farmers. Smaller fences were typically completed in less than one day by two or three people with the larger fences being constructed over two to four days.

Most farmers had other pigs. To minimize risk of introduction of ASF, these would all have been penned and pens included within the extra fence. However this was beyond the scope of support available from project funds and although some farmers changed the management of their other pigs, none constructed additional extra fencing. Other pigs were variously penned within the fence, tethered within the fence, penned outside the fence, tethered outside the fence or free-roaming with most farmers having other pigs managed using two of these alternative practices.

Public awareness meetings were conducted at Cailaco Agricultural School in November, in Hataz, Goulolo and Raifun sukus in December and Meligo and Holsa sukus in January. These sessions were attended by farmers and representatives of the local authority. Information was delivered orally with the aid of a flip-chart with ample time allocated for questions and discussion.

All samples tested for ASF had negative results.

Baucau

Two separate on-farm biosecurity training sessions were conducted for farmers involved in round one and their respective technicians. Materials to set up biosecurity measures were provided as for the Bobonaro farmers.

Public awareness meetings were conducted in Triloka and Laga sukus in February. Attendance and content were similar to the Bobonaro sessions.

General

A poster “OINSÁ MAK ITA BELE PREVENE MORAS DA’ET BA ITA NIA FAHI” was developed. After extensive input from a range of stakeholders, a final version has been produced and a laminated copy was provided to all participants at the Maliana Expo and the Final Project Meeting. It is available at http://tomak.org/resources/ and electronic copies have been shared with all collaborators/interested parties.

6.7.2 Pig mortalities in areas where trial farmers and technicians are located

The cause of death was not investigated for any of the mortalities listed below. However, it is extremely likely that the majority of deaths, particularly those occurring in large numbers in a relatively small area, will have been due to ASF.

Bobonaro

At the time of the October visit to Bobonaro, there appeared to have been limited incursion of ASF to the area. Free-roaming pigs were frequently seen on and close to the road. One farmer reported that a neighbour had 6 pigs die in September (Hataz), another said some pigs had died in the neighbouring suku, but none in their own suku (Meligo). One of the Cailaco-based technicians had visited a farmer with a dead pig, but he did not do a post mortem as the owner wanted to eat the pig. The technician said that farmers do not usually contact them when their pigs die. At the time of the visit he had heard that many free roaming pigs had died in the Cailaco area along with some penned pigs. One week later many pigs were dying in his own suku. The farmer from Goulolo was not aware of any dead pigs in his area. One of the Maliana farmers said she was not aware of dead pigs in her area, but a Maliana-based technician advised of some deaths near their house.

The situation had changed dramatically by the mid-November visit to Bobonaro. Very few free-roaming pigs were observed during travel to Bobonaro or to the trial site locations. Since the October visit, farmers from Hataz indicated that at least 1000 pigs had died in their aldeia alone and that one farmer had lost ~100 pigs, with only one surviving. A neighbour of one of the farmers had started confining his pigs and they were still alive. These farmers expressed concerns about social jealousy (discussed further in Section 6.7.4). One of the Meligo farmers reported that all the free-roaming pigs in their neighbourhood had died, with only some penned pigs surviving. The other thought at least 200 pigs had died in their area and that no free-roaming pigs remained alive. The farmer from Goulolo said many free-roaming pigs had died in their area. Neither of the Maliana farmers were aware of deaths in their neighbourhood but the some pigs continued to die near one of the Maliana-based technicians.

In most areas there was little change apparent between November and January visits to Bobonaro. The Goulolo farmer was aware of pigs continuing to die in Bilimau, but not many pigs remained. One of the Meligo farmers was aware of ongoing deaths in their aldeia but about 4km away. One of the Meligo-based technicians stated that some people around Meligo had penned their pigs when other pigs were sick and they survived, but then when the rain came they thought the rain would have washed the disease away so they let them out and they have since died. Pigs belonging to neighbours of the other Meligo farmer became sick and died in late December. The infection then spread to the trial farm (see Section 6.7.3). Both Maliana farmers were not aware of any deaths in their neighbourhoods. But another of the Maliana-based technicians said only ~15 of ~ 1000 pigs remained in his aldeia.

Baucau

The ASF situation was only discussed with the two Baucau farmers on one occasion, in January 2020. The farmer from Triloka thought that only a small number of pigs (<50) had died in the suku since the start of the outbreak, although many pigs died in Vemasse in September and Caisido in October and November. Most pigs in Triloka are tethered because of a tara bandu against free-roaming pigs. The farmer from Laga reported that a huge number of pigs had died in the area since October, but some pigs in pens were still alive.

6.7.3 ASF at trial sites

Bobonaro

At the time of the October visit, one Meligo farmer had one free-roaming sow become sick and die and one of the Hataz farmers had a pregnant gilt die within hours of becoming sick. One Cailcao-based technician reported that his pigs were sick.

Several trial farmers had had losses among their own pigs between the October and November visits. The first Hataz farmer had another pig become sick but it recovered. The second Hataz farmer had 4 of 5 of their free-roaming pigs die and one young pig had become sick but recovered. All of the free-roaming pigs belonging to the Goulolo farmer died, approximately 50 in total including 5 sows and one boar. One of the Maliana farmers had a sow and two of four piglets die, but this sow had been in poor condition for some time so is most likely to have died from other causes. One of the sick pigs belonging to the Cailaco-based technician died, but the other recovered.

At the time of the January visit, most farmers had not suffered any further losses to their own pigs. However, the boar belonging to one of the farmers from Meligo became sick on 3rd January and died 4 days later. The boar was tethered in a basic pen outside the biosecurity fence. This farmer also had four mature pigs tethered within the fence, five trial pigs in the trial pen and a trial sow in the trial sow pen. Progressively all pigs became sick, dying 3-4 days after first showing clinical signs. All pigs were dead by 25th January. This farmer was particularly diligent in applying the recommended biosecurity measures when entering the fenced area. However, during the main part of the outbreak in November-December, people had placed dead pigs in disused water tanks (from Indonesian times) up the hill behind their house. There had been no deaths in the area for a while, but after the rains started in December their neighbour's pigs became sick and died. It is possible that the rains washed a large load of virus down the hill. Furthermore, the farmer was unable to keep stray dogs away from their property and sometimes observed them with parts of pig carcasses.

Overall, five of seven trial farmers incurred losses among their own pigs (1 – 50 pigs) that were likely to be due to ASF, but only one trial farmer had any mortalities among the trial pigs penned within an extra fence and managed with extra biosecurity measures.

Baucau

The farmer from Laga incurred some early losses due to ASF. One pig died suddenly in early November shortly after he found part of a pig carcass in the water tank. He thinks this might have been a deliberate action from a jealous farmer (discussed further in Section 6.7.4). Four of the second round to TOMAK pigs died shortly thereafter but his remaining three pigs survived, two lost appetite for a few days and the other showed no clinical signs. The farmer was away for several weeks around this time, so had missed the initial biosecurity training held in Triloka, had not introduced any biosecurity measures and was not able to provide further details about the mortalities. The Triloka farmer has not experienced any mortalities since the arrival of ASF.

6.7.4 Reported consequences of ASF

A variety of consequences and concerns regarding ASF were raised during regular visits to farmers, discussions with technicians and interviews with Xefes de Suku.

Managing cultural needs of pigs when not available – thoughts early in ASF outbreak

During the October visit, farmers shared their thoughts about managing cultural obligations if they did not have pigs. Most farmers and technicians indicated they would both pay a high price and travel far to buy a pig if they did not have one when needed for cultural purposes.

One of the Maliana farmers stated that pigs are required for the ancestors to ensure good fortune, so not providing pigs would bring bad fortune.

One of the Hataz farmers said if he had no pigs for a ceremony that he was hosting for which he required two big pigs, he would need to barter or sell cattle to buy pigs and would consider going to Atambua in West Timor if required. Alternatively, a relative might be able to provide a pig, in which case he would share the exchange of cattle and buffalo

with the relative. If both pigs were provided by the relative, he would still host the ceremony, but the relative would receive all the exchanged goods. As cultural host he needs to provide big pigs, if he was unable to provide big pigs, or others participating but not hosting the ceremony provided bigger pigs he would lose face.

The other Hataz farmer stated that pigs are required for funerals and if they did not have a pig when required for such a purpose they would need to seek from elsewhere, even far away and even if only available at a very high price.

Two individuals said they might try and bargain with the cultural ceremony host to bring cash or tais instead if they were unable to source a pig.

Pigs are also slaughtered and their spleens read on certain occasions e.g. if a family member is sick the cultural host will examine the spleen, discuss with ancestors and provide guidance. Similar offerings are also associated with preparations for and closing of important ceremonies.

In some places there is a tara bandu to minimise the number of animals required for culture e.g. four pigs were previously required but more recently this has been reduced to one.

Managing cultural needs of pigs when not available – during ASF outbreak

Trial farmers and technicians had either not needed pigs or had been able to provide a pig for cultural purposes between the start of the outbreak and the final interviews.

However both Xefes de Suku noted cultural impacts in their communities due to the lack of pigs. One indicated that people would communicate with cultural organisers and discuss alternatives that they might bring instead of pigs. If it were not such a widespread problem they could go to neighbouring sukus, but in this case there was a need to consider bringing other species of livestock. In contrast the other Xefe indicated that based on discussions among families, they should not bring pigs now or substitute with alternatives, rather they should hold the debt "on their shoulders" and provide pigs in the future.

Economic consequences

Both Xefes de Suku reported economic impacts of ASF in their communities, specifically lack of funds for household needs and to pay tuition fees. The Meligo farmer who lost all their pigs due to ASF had a potential buyer for them, someone who was building a new traditional house nearby. They had hoped they could have sold all their pigs for ~ $7,000. One of the Maliana-based technicians has lost income from her boar because she will not hire it out because of the risk of disease.

Personal consequences

Trial farmers who have lost pigs in the outbreak all stated that they were very sad. The Goulolo farmers who lost a large number of pigs were pragmatic about their losses, they have learnt a lesson about good management and from their involvement in the project they have become aware of better ways to raise pigs, otherwise they might have continued to raise pigs in the same way and suffered further losses. The Hataz farmer who lost several pigs was sad because of their deaths and the loss of money. He wants to continue to raise pigs particularly for cultural needs, but will keep them confined. The other Hataz farmer who lost the pregnant gilt was particularly upset as this was the first pregnancy among his pigs in at least two years. He likened the loss of a pig to the loss of a family member and said his children had been crying. However, he was very positive and committed about continuing to raise pigs in the future. The Meligo farmers who lost all their pigs and trial pigs were visibly devastated during the period when their pigs were dying. Later on the husband said he tried to imagine the loss was in a game, like gambling, and that they needed to forget and move on. They had been concerned that

the project team might not trust them anymore and not come and visit them again after their pigs died.

Those who have not lost pigs have also been distressed. Early in the outbreak one of the Maliana-based technicians said she could not sleep as she was so worried about her pigs becoming affected as several had already died in her neighbourhood. Some farmers reported to the technicians that they were scared while most of the pigs in their area were dying.

Changes in attitudes and behaviour

Following on from the biosecurity training, some of the technicians stated they had changed their practices regarding their own pigs e.g penning previously tethered pigs, complete change of clothes, stopping visiting their pig pen and having other members of the family look after their pigs, not allowing others to visit their pigs.

Social jealousy, whereby successful farmers' efforts may be sabotaged by others, has been previously raised as a concern for development activities in Timor-Leste, although a farmer survey had indicated this was not an issue (TOMAK, 2018) As noted in Section 6.7.3, one farmer was worried that his neighbours were jealous because his pigs were alive and all their pigs had died, even though they thought he was crazy for using iron for fencing for the pigs rather than using for roofing. He thought they may throw a carcass over the fence because it is not fair that his pigs are alive and theirs are not. Around the same time, the Laga farmer found part of a pig carcass in the water tank beside his pig pen and after that his pigs started to die, despite remaining healthy when neighbours pigs had died. The farmer believes his neighbours were jealous that his pigs were alive and that he was getting support so threw the meat in. Reports of such behaviour really highlight the challenge of supporting farmers as ASF moves from an epidemic to an endemic situation in Timor-Leste.

During the initial outbreak the Xefes reported that community members had panicked, they had no idea what to do and that they had hoped for support from MAF but none had been received. Initially they did not know what had killed their pigs but had a better understanding after the community awareness meetings.

Attitudes towards and opportunities for eating pork have changed among trial farmers and technicians. Several are concerned of the risk of disease transmission e.g. will eat pork at a cultural ceremony, but not bring pork home or will not eat pork from other sources but would eat from own pigs that are known to be healthy. Some said they would eat pork from a freshly slaughtered pig, but not one that had died. One of the trial farmers who have a good understanding of the disease said they were frightened to eat pork. Opportunities for eating pork have reduced, so those farmers and technicians still happy to eat pork have had limited opportunity to do so. Many would traditionally have slaughtered a pig for New Year celebrations, but due to the scarcity they ate alternatives e.g. chicken, goat, fish, dog or snake.

Pig and pork sales and prices

Farmers' and technicians' comments on pig and pork sales and prices were variable. A Maliana-based technician commented that those who needed to sell, or thought they did would get low price, but those with good healthy pigs that people come wanting to buy could get a high price. This was consistent with mixed observations from others. The Triloka farmer sold piglets in January for $100 which he would usually have sold for $85-90. In February he sold four of his TOMAK supported pigs weighing ~50 and ~70kg for $250 and $350, respectively. In Bobonaro, some were aware of pigs being sold at higher prices than usual e.g. a small live pig for sale for cultural purposes for $200 compared to previous price of $80-100, whereas others were aware of pigs being sold at a low price e.g. a big pig for $80-120. Several were not aware of pigs being bought or sold in their

neighbourhood and/or had not seen pigs for sale in the market suggesting that it was hard to find pigs and that people remained worried about disease risk.

Some reported pork being sold very cheaply in areas of Bobonaro e.g. $2-3 for a large piece compared to the usual price of $7/kg. This was consistent with the observations of many colleagues who had seen cheap pork for sale by the roadside in several different municipalities. The Triloka farmer advised that the price of pork in Baucau market had not changed.

Keeping pigs in the future

All but one of the trial farmers are keen to continue to raise pigs despite the risk of ASF. The Meligo farmers who lost all their pigs and trial pigs were unsure. Without further support, they thought they might try raising just one or two for their own cultural purposes, rather than to try and make money as it would be hard for them to start again on their own and they were frightened the pigs might die again, wasting their time and money.

Some trial farmers were aware of others wanting to keep pigs again for cultural needs but had not yet restocked as pigs were not available. Others indicated that some farmers are too scared to keep pigs again at the moment. One of the Maliana-based technicians thought people would be willing to keep pigs again, but that they were worried about disease and do not understand. She said people in the community were asking if the disease was still there or had gone.

Similarly, the Xefes stated that members of the communities were very worried about the disease coming back, they had suffered terrible losses and were worried that if they re-engaged they would have further losses. Some were willing to purchase again, but others were frightened. People have generally lost interest in buying pigs in the market, even if the price is low. However, there was a common hope is that the virus would be eliminated from the community, the pigs would be safe and then farmers would be ready to raise again. A similar point was raised during the discussion at the Expo, with one participant wanting to know when the disease would be gone.

6.7.5 Lack of public awareness and need for ASF communication

Public awareness about ASF appears to be extremely low. All participants at the public awareness sessions were unaware of ASF prior to the sessions and did not know why their pigs had died. Some people thought of the mass pig deaths as a “natural punishment”. It was challenging to explain about ASF at these sessions because of the basic lack of understanding of disease. There is no word in Tetun for virus or bacteria, so the ASF virus was explained using the word for parasite (“kutu”), which people are familiar but as something visible to the naked eye, then likened to a very small parasite.

Despite the challenges, the Xefes said that the public awareness sessions were beneficial to sukus especially committee members as they received information on how they can manage the problem in the community. They recognised the need to manage panic and inform and educate people about coming back to pig raising activities. One disadvantage was that it was a one-off activity and changing behaviour takes time and reinforcement. They indicated that more information about how to recover from the disease and re-engage in pig raising is required, rather than just information about the disease per se. They suggested frequent coverage on community radio and other media and the provision of posters and pamphlets at Sedes de Suku.

Trial farmers were also very positive about the public awareness meetings. They felt that other members of the community now understood why their pigs had died, and why those in pens, particularly the pigs at the trial sites were more likely to be alive but that they had not been provided with “special medicine” as part of the trial. The Hataz farmer who had been concerned about jealous behaviour from neighbours was no longer concerned. However, several were disappointed at the timing of the sessions, they were too late as many farmers had already lost their pigs.

6.8 Farmer and technician perceptions

6.8.1 Farmers

Semi-structured interviews were completed with nine trial farmers. In some cases other members of the family who had been involved in the trial were also present and their comments were also incorporated when responses to open-ended questions were summarised.

Farmer responses to closed questions are summarised in Table 10. Most farmers were very positive about the trial housing, nipple drinker, diets and biosecurity measures.

Regarding the housing, they commented that the pigs were safe and protected. Specifically they would not be hunted, attacked by dogs, get lost, were protected from contamination, disease, rain and sun and would not destroy plants belonging to others. Also that they had everything they need in the pen, grew more quickly in clean pens and there was no risk of damage to legs from tethering. However, compared to pigs free roaming, there was a need to spend time cleaning the pens.

The benefits of the nipple drinker were that pigs had constant access to clean water and it saved time compared to using a water trough which required repeated cleaning and refilling when the water got dirty. One farmer initially thought the idea of the pigs sucking on the drinker was crazy but was very happy when he saw the pigs using it. Another commented that some water was wasted when pigs played with the nipple drinker.

The main comments regarding the trial diets related to saving time spent gathering firewood and cooking by feeding dry uncooked feed and to the rate of growth of the pigs. Several farmers noted that in just a few months pigs were reaching the size they were used to them growing to in one to four years. The farmer who used the leaf silage was very positive, noting that because of the improved palatability he was able to feed a broader range of leaves. He stated that he would be prepared to make a large batch (100 – 200 kg) before the dry season so that he would not need to travel far each day to get fresh leaves. The farmer with the trial sow that farrowed noted that she looked much healthier than his other sows during lactation and he thought that it would be possible to have more than one litter per sow per year using that diet. Disadvantages included the need to buy some feeds in the diets, lack of availability of some ingredients during the dry season and that some activities such as picking leaves, chopping ingredients like taro and pumpkin used in the first round and collecting snails were time consuming. One farmer commented that it might be hard for other farmers to adopt the trial diets because of the need to weigh pigs and calculate feeding requirements.

A few comments arose regarding comparisons between the first and second diets. One farmer was very positive about the swap from fresh leaves to leaf silage as it meant they could feed a broader range of leaves, rather than just leucaena which was the only leaf his pigs would eat fresh. One farmer who used the commercial feed as the second diet liked using it because it took less time than preparing the first diet of mixed ingredients and the pigs grew well, but she indicated she would prefer to use the diet of local ingredients going forwards because the commercial diet is expensive and hard to find. The farmer whose first diet included dried fish and second included fresh snails but was otherwise identical, commented that growth after the swap was still good, though a little slower, and that he would prefer to use the snails in the future because the dried fish is relatively expensive and not always readily available, except at the border market.

Most farmers were very positive about the biosecurity measures, primarily because their pigs were alive and healthy whereas other pigs in their suku had died. One farmer said his neighbours thought he was crazy but he was just pleased his pigs were alive. The farmer who lost her pigs due to ASF and one other farmer were concerned that the measure were not sufficiently secure. One farmer commented that when he had limited time he found it hard to pay attention to all the biosecurity measures.

Some farmers have adopted some of the husbandry practices introduced by the project. Those who used to have some free-roaming pigs were keeping all their pigs confined in some way by the end of the project. One farmer who had a very basic set of pens invested over $1000 and built a much larger pig house and another farmer who used to tether his pigs had built simple pens for all his pigs.

Only two farmers have installed nipple drinkers for some of their own pigs. Supply of water was raised as an issue by several farmers. These included problems with accessing bore water and tap water only being available for short periods each day. This had not been a concern when keeping free roaming pigs as they had found their own water and pens did not need cleaning.

Most farmers changed the diets they fed their own pigs, from cooked feed to dry mix using similar ingredients to the trial diets when available.

With the exception of one farmer who later built an extra pen within the biosecurity fence, only farmers with other pig pens included within the biosecurity fence where those with adjoining pens that were incorporated into the original fencing design.

Farmers generally indicated they wanted to continue to raise pigs in the future using methods similar to those used in the trial, including using gilts from the second round of trials for breeding and buying a boar. Several stated that they were keen to continue to seek advice from the technicians. One farmer noted the need for equipment and consumables such as the nipple drinker and appropriate disinfectant to be made available in Maliana.

6.8.2 Technicians

All eleven technicians involved in either just the first round, or both rounds completed the questionnaire. A few questions were not applicable to some of the technicians from Baucau. The technicians' responses to closed questions are summarised in Table 11.

The technicians were generally very positive about the trial husbandry practices and project activities. Several indicated that they had adopted some of the trial practices with their own pigs. They were positive about the WhatsApp group because of the ease of sharing and discussing information but noted that not all technicians has access due to lack of smartphone. The farmer field days were useful because they provided the opportunity for farmers to share their experiences in pig raising with other farmers and community members, the cross-site visit because it enabled them to compare different farms and the monitoring visits because they enabled identification and correction of any data recording issues and implementation of changes in response to problems. They felt the benefits of the municipal and national workshops and the Expo were the sharing of project results with the community, local authorities and the MAF National Directorate. The technicians indicated they were keen to continue to improve their capacity and improve their education in a range of animal health-related aspects.

Table 10: Farmers' (n = 9) responses regarding usefulness of project practices and activities. Farmers did not respond when they had not used the practice or been involved in the activity

Question						Number of respondents
How beneficial was the trial pig housing?	0 (0)	0 (0)	2 (22.2)	1 (11.1)	6 (66.7)	9
How beneficial was the nipple drinker?	0 (0)	0 (0)	0 (0)	3 (37.5)	5 (62.5)	8
How beneficial were the trial diets?	0 (0)	0 (0)	1 (11.1)	2 (22.2)	6 (66.7)	9
How beneficial were the trial biosecurity measures?	0 (0)	1 (11.1)	1 (11.1)	2 (22.2)	4 (44.4)	9
How useful was the feed formulation training?	0 (0)	0 (0)	1 (11.1)	3 (33.3)	5 (55.6)	9
How useful was the record keeping training?	0 (0)	0 (0)	0 (0)	4 (44.4)	5 (55.6)	9
How useful was the silage making training?	0 (0)	1 (11.1)	1 (11.1)	5 (55.6)	2 (22.2)	9
How useful was the biosecurity training?	0 (0)	0 (0)	1 (12.5)	2 (25)	5 (62.5)	8
How useful were the farmer field days?	0 (0)	0 (0)	2 (28.6)	0 (0)	5 (71.4)	7
How useful were the weekly visits by the technicians?	0 (0)	0 (0)	0 (0)	3 (33.3)	6 (66.7)	9
How useful were the monthly monitoring visits?	0 (0)	0 (0)	0 (0)	1 (11.1)	8 (88.9)	9

Table 11: Technicians' (n = 11) responses regarding usefulness of project practices and activities. Farmers did not respond when they had not used the practice or been involved in the activity

Question						Number of respondents
How beneficial was the trial pig housing?	0 (0)	0 (0)	1 (9.1)	3 (27.3)	7 (63.6)	11
How beneficial was the nipple drinker?	0 (0)	0 (0)	1 (9.1)	2 (18.2)	8 (72.7)	11
How beneficial were the trial diets?	0 (0)	0 (0)	1 (9.1)	2 (18.2)	8 (72.7)	11
How beneficial were the trial biosecurity measures?	0 (0)	0 (0)	1 (9.1)	4 (36.4)	6 (54.5)	11
How useful was the initial pig husbandry and health training?	0 (0)	0 (0)	1 (9.1)	3 (27.3)	7 (63.6)	11
How useful was the feed formulation training?	0 (0)	0 (0)	1 (9.1)	2 (18.2)	8 (72.7)	11
How useful was the record keeping training?	0 (0)	0 (0)	0 (0)	3 (27.3)	8 (72.7)	11
How useful was the first post mortem training?	0 (0)	0 (0)	0 (0)	5 (45.5)	6 (54.5)	11
How useful was the silage making training?	0 (0)	0 (0)	0 (0)	5 (45.5)	6 (54.5)	11
How useful was the biosecurity training?	0 (0)	0 (0)	0 (0)	4 (36.4)	7 (63.6)	11
How useful was the second post mortem training?	0 (0)	0 (0)	0 (0)	3 (27.3)	8 (72.7)	11
How useful was the WhatsApp group?	0 (0)	0 (0)	1 (9.1)	4 (36.4)	6 (54.5)	11
How useful were the farmer field days?	0 (0)	0 (0)	1 (9.1)	5 (45.5)	5 (45.5)	11
How useful was the cross-site visit?	0 (0)	0 (0)	2 (18.2)	4 (36.4)	5 (45.5)	11
How useful were the monthly monitoring visits?	0 (0)	0 (0)	0 (0)	3 (27.3)	8 (72.7)	11
How useful was the regional workshop in Maliana in May 2019?	0 (0)	0 (0)	0 (0)	4 (57.1)	3 (42.9)	7
How useful was the national workshop in Dili in May 2019?	0 (0)	0 (0)	0 (0)	3 (30)	7 (70)	10
How useful was the Expo and presentation in March 2020?	0 (0)	0 (0)	0 (0)	2 (28.6)	5 (71.4)	7

6.9 Final activities

6.9.1 Maliana Expo

A Pig Expo was held in Maliana on 21st February 2020. The event was very well run and showcased the wonderful collaboration between TOMAK and MAF personnel that has underpinned the success of this project, and the excellent results that have been achieved. The key project findings were presented in the morning and all trial farmers each received a certificate of participation. Then in the afternoon participants visited a series of stands. Each stand was run by a technician-farmer pair who prepared materials for the stand and provided practical information to the participants. The project-related stands covered housing, nipple drinkers, biosecurity, diets, silage preparation, butchering and pork dishes. One trial pig was used for butchering and pork dishes, with all remaining meat sold on-site. A 65 kg trial pig was also exhibited and sold for $300. There were additional stands from MAF about Newcastle Disease vaccination, the Fleming Fund on anti-microbial usage and resistance and the local agricultural shop.

The Expo was attended by 132 individuals including representatives from the local authority (administrative post and several sukus), MAF national and municipal (Bobonaro and Baucau), TOMAK national and municipal (Bobonaro and Baucau), Mercy Corps, Fleming Fund, World Vision, JICA, trial farmers (Bobonaro and Baucau), other farmers and students.

6.9.2 Final National Meeting

The final meeting was held in Dili on 27th February 2020. Key project findings and recommendations for the future were presented. This stimulated robust and useful discussion. The workshop closed after presentations of certificates and photo taking. There were ~ 46 participants including representatives from MAF national and municipal (Bobonaro and Baucau), TOMAK national and municipal (Bobonaro and Baucau), DFAT, universities (Instituto Politécnico Betano, Universidade Nacional Timor Lorosa'e, Unital), AI-Com, Sustainable Agriculture Productivity Improvement Project, Fleming Fund and University of Sydney.

6.10 Challenges encountered during feeding trials

Poor road conditions meant that travel times to municipalities and then to individual farmers were very long, particularly during the rainy season. This was a challenge for both the monitoring visits and the delivery of feed and other materials. There was a marked improvement in the Dili-Baucau and Dili-Maliana roads during the course of the project and some improvements in the local roads. However, the limited infrastructure will continue to be a constraint for farmers wishing to sell pigs for the foreseeable future, particularly during the rainy season.

Despite the simple nature and small scale of the trials planned, it was not possible to adhere completely to the protocols agreed upon. There was difficulty sourcing similar groups of healthy piglets for growing pig trials. Pigs from the initial source had various health problems and those sourced locally were stunted which resulted in a great deal of between site variation in the pigs at the start of the trials. This was much less of an issue in the second round as some of the trial farmers were able to provide piglets and, even including those sourced from elsewhere, there was much less between site variability. However, these piglets were already stunted, typically weighing ~ 7kg whereas the piglets from the sow trial of the same age weighed ~ 33kg. This early stunting would be expected to have long-term consequences and means that the true potential average daily gain that could be attained by feeding trial diets is likely to be significantly greater than that seen.

The limited and seasonal availability of feedstuffs put a strain on logistics support and meant that some diets needed to be modified during the trial. Ivermectin was not continuously available in both municipalities during round one which meant that the parasite control aspect of the trial protocol could not be followed completely. Cultural commitments of farmers meant that some farmers were on occasion away from their pigs for several days. Although training of more than one household member helped with this issue to some extent, there were periods of time at most sites where the protocol was not completely followed with the more time-consuming activities such as gathering fresh leaves being most likely to be skipped.

The limited education of technicians and farmers, particularly poor numeracy skills, presented challenges regarding feed calculations and data recording. Without the regular discussions through the WhatsApp group and monthly monitoring visits, farmers and technicians would have been unable to follow the protocol, particularly modifying the feed quantities as pigs grew, with sufficient reliability for data to have been sufficiently accurate to be able to trust the results of the analyses. These concerns were validated when the team visited the two farmers whom TOMAK had continued to support for a further round of piglets but who were not included in the round two growing pig trials. These farmers had had some, but fewer, visits from the technicians and were to follow the same protocol and use the same diets as round one. However the farmers and technicians had struggled without the additional support, and had not been correctly increasing feed as the pigs had grown, so they grew more slowly. At one site, they had also not managed to adapt to the lack of availability of one ingredient and had just stopped including it, rather than seeking an alternative ingredient and/or adjusting the quantities of the other ingredients. On a more positive note, the technicians involved in both rounds of trials were much more confident and capable during the round two. Furthermore, one of the farmers involved in round two was an illiterate widow. She managed the practical aspects of the protocol extremely well, and with some additional support from the technicians two of her children leant to keep reliable records.

Prior to the start of the trials, several farmers did not have constant access to water, either on a day-to-day basis, or during the dry season. Provision of tanks and additional polypipe largely resolved this but water supply for both drinking and cleaning remained an intermittent issue at some sites through both rounds. For example in Laga the community water supply was only available every 4 – 5 days and in Goulolo it was necessary to buy a tankful of water during the dry season. This reflects a more systemic need for the continuous supply of clean, fresh water to individual households. Without ready access to water, even medium-scale pig raising is not practical.

Limited in-country diagnostic facilities and the challenge of transport of animals/samples to existing facilities meant that full investigation of the deaths occurring during the trials could not be conducted. With the recent arrival of ASF, the need for improved diagnostics has increased, particularly the need to distinguish ASF and CSF. Hopefully the ACIAR-funded “Improved animal health surveillance in Timor-Leste” SRA will support improvement of such facilities.

National government budget issues meant that some technicians’ salaries were delayed for several months on at least two occasions during the course of the project. Despite this, the technicians remained committed to undertaking project activities.

Farmers found it challenging to sell pigs at the end of the trial, noting that live pig sales were usually of piglet or large adult pigs for immediate use for cultural purposes. Although sale for cultural purposes eventually attracted higher prices, this market is somewhat fickle in that farmers might wait for a considerable time for passing buyers to express an interest in purchase and consequently continue to invest in feed for the pigs. In contrast, sale into the pork market in the main centres gave immediate return on investment albeit at a typically lower price than sale for cultural purposes. This may be a viable option for farmers close to main centres particularly if local slaughterhouses can be established, but

the challenge of transporting pigs from more rural areas reduces the likelihood of this being viable for those from further afield until road infrastructure improves.

7 Impacts

7.1 Scientific impacts

A short communication has been published in One Health (https://www.sciencedirect.com/science/article/pii/S2352771420301221) reporting on the successes and challenges encountered in managing the risk of ASF in the latter part of this project. It is hoped that making the findings available will benefit those researching into and managing ASF in other areas where pigs are of great value and resources are limited such as Nusa Tenggara Timur, Indonesia and Papua New Guinea.

7.2 Capacity impacts

For the duration of the project the in-country project coordinator, Olavio Morais, continued to broaden his knowledge on pig production, develop leadership and management skills and experience. He also received support from ACIAR Launch Funding to attend and present at the "Regional Symposium on Research into Smallholder Pig Production, Health, and Pork Safety" held in Hanoi, Vietnam in March 2019, providing the opportunity to further enhance his knowledge and meet with like-minded researchers. He has already been able to apply his new knowledge and skills to other aspects of his role in MAF and will continue to do so in his future role as a key member of the ACIAR-funded "Improved animal health surveillance in Timor-Leste" team.

The municipal veterinary and livestock technicians have improved capacity and knowledge in pig husbandry and health through both formal training sessions and practical hands-on experience. Consequently they are already able to provide a better service to other farmers than prior to the project. They are also empowered through easy communication via WhatsApp with other members of the project team who can provide advice on challenging issues.

7.3 Community impacts

7.3.1 Economic impacts

Economic analyses from both the growing pig and sow trials indicate that the use of our proposed model for smallholder pig raising can result in significant profit for the farmer, regardless of whether pigs are sold for cultural purposes or slaughtered and sold as pork. The latter finding indicates that there is the potential to develop a sustainable local pork market.

The reasonable successes in reducing the risk of ASF seen with the simple, closed-herd smallholder pig raising model incorporating basic biosecurity measures combined with improved public awareness indicates that raising of pigs by smallholder farmers may remain viable in Timor-Leste despite the arrival of ASF. As such, the potential economic impacts of being unable to sell pigs to obtain funds for household needs and tuition fees, and the risk of indebtedness arising from inability to provide pigs for cultural purposes may be lesser than currently anticipated.

7.3.2 Social impacts

Project farmers have reported time saved as they no longer cook feed for their pigs, so time can be used for other activities. Trial pigs have gained weight faster and are in better condition than equivalent pigs raised using traditional methods. The feeding and husbandry practices advocated in the trials also appear to be cost effective, so there is the potential for improved livelihoods for farmer households through the capacity to produce

more pigs in a given time, the availability of better quality pigs for household cultural needs and from increased income from selling pigs.

The close relationship between the core project team and veterinary and livestock technicians, and conduct of farmer field days and the Expo has enabled the delivery of good husbandry practices to a broader group of farmers in Baucau and Bobonaro, beyond those directly involved with the project. The field days were run by farmers with support from their technicians and the project team, thereby empowering the trial farmers to advise other farmers in their local communities. The Expo stands were each run by a farmer-technician pair and again empowered them to provide advice to a broader group.

Since being exposed to the model for smallholder pig raising adopted by this project, three groups (two in Maliana and one in Los Palos) have submitted and been successful in obtaining government grants to raise pigs using this model. One was established prior to completion of the project and the others were in the set up phase. If these are successful, further uptake is likely, however the challenge of ASF and need for excellent biosecurity to reduce risk do reduce the likelihood of success.

Two volunteer organisations interested in supporting improved pig raising elsewhere in Timor-Leste contacted the project team while the project was ongoing. They were provided with advice and extension materials, as applicable. There is thus the potential for these and other similar organisations to enable a broader group of farmers to benefit from project findings.

The reasonable successes in reducing the risk of ASF seen with the simple, closed-herd smallholder pig raising model incorporating basic biosecurity measures combined with improved public awareness indicates that raising of pigs by smallholder farmers may remain viable in Timor-Leste despite the arrival of ASF. As such, the potential social impacts of being unable to provide pigs for cultural purposes may be lesser than currently anticipated.

7.3.3 Environmental impacts

There is the potential for a positive environmental impact through reduced firewood consumption with farmers using uncooked rather than cooked feed. Keeping confined rather than free-roaming pigs can also facilitate use of pig waste as fertiliser for crops and forage trees, as well as improve hygiene and the environment around farmers' houses.

7.4 Communication and dissemination activities

International

Project activities and preliminary findings were presented by Olavio Morais at the "Regional Symposium on Research into Smallholder Pig Production, Health, and Pork Safety" held in Hanoi, Vietnam in March 2019.

Tamsin Barnes shared insights from project activities regarding ASF at the "Regional African Swine Fever Socioeconomic and Livelihood Impact Analysis (ASF-SELIA) Forum" held in Canberra in March 2020 and is a member of the ASF-SELIA Community of Practice.

National

One of the project sites was visited by the Australian Ambassador, a specialist in agricultural development and food security from DFAT Canberra, and several national and local government officials as part of an official visit to TOMAK sites and activities in Maliana.

A two-day meeting was held in Dili in May 2019, at the end of the first phase of the project (see Section 6.3).

A one-day meeting was held in Dili in February 2020, at the end of the project (see Section 6.9.2).

Extension materials have been produced: a manual for technicians, a diet formulation spreadsheet and a biosecurity-focussed poster (see Sections 5.6 and 6.6). These materials are available at http://tomak.org/resources/

Municipal

Five farmer field days were held between February and May 2019 (see Section 5.2.5).

Municipal workshops were held in both Baucau and Maliana in May 2019 followed by two mini-workshops in Laga and Triloka (see Section 6.3).

Information about project activities was shared at a Baucau municipal MAF harmonisation meeting attended by about 40 people, including representatives from local and international agencies, farmer associations and MAF personnel. Subsequently one of the local agencies shared this information with community members.

A detailed progress report was provided at Bobonaro quarterly coordination meeting in December 2019 and briefer updates have been given regularly at municipal quarterly coordination meetings led by the President of the local authority in both Maliana and Baucau.

Nine public awareness meetings on ASF were held between December 2019 and January 2020 (see Section 6.7.1).

A Pig Expo was held in Maliana on 21st February 2020 (see Section 6.9.1).

Olavio Morais was interviewed about ASF and project activities on Maliana Community Radio in January and February 2020.

Social media

The project featured on the TOMAK Facebook page at inception and following the visit by the Australian Ambassador and on the TOMAK Twitter feed after the final meeting.

Project collaborators and project team

Monthly updates have been given by Olavio Morais to staff of the Veterinary Directorate, with additional updates provided to the Director General of Livestock and Veterinary as required. The project WhatsApp group has also been a great success enabling project team members to keep up-to-date with and provide input into project activities that they have not been directly involved with. Exchange of photographs and videos through this group has been very beneficial for the diagnosis and management of problems such as sick pigs. The WhatsApp group has continued to be used since the project has officially ended enabling municipal technicians to receive ongoing support from project team members.

Other projects

Project team members have regularly met or communicated by other means with project personnel from other current[1] and future[2] ACIAR projects and the Fleming Fund project on anti-microbial resistance. This had ensured that project teams are aware of each other's activities and knowledge exchanged.

ASF-specific communication

[1] "Evaluating opportunities for smallholder livestock-keepers in Timor-Leste"

[2] "Improved animal health surveillance in Timor-Leste" and "Developing a regional African swine fever socioeconomic and livelihood impact analysis fund"

Subsequent to the ASF outbreak, project team members have been in contact (in-person, written, email) with several other stakeholders involved in ASF management in Timor-Leste. These have included representatives from the Department of Agriculture, Australia, Department of Foreign Trade and Affairs, Australia, and the Market Development Facility. For the latter, team members have provided technical input into the development of a suite of ASF communication materials which they are co-ordinating.

8 Conclusions and recommendations

8.1 Conclusions

This project has demonstrated the potential for smallholder farmers to raise pigs cost-effectively using local diets and simple models that are feasible in the Timor-Leste context having been developed together by the project team, technicians and farmers. Several diets using primarily locally-grown ingredients resulted in moderate to good growth rates and return on labour invested by the farmer that easily exceeded the daily agricultural wage when combined with other good husbandry practices (suitable housing, basic biosecurity measures, free access to water, vaccination against CSF, regular anti-parasitic treatment). Most research was conducted with growing pigs, but the sow trial indicated that these findings were also directly applicable to piglet production.

Rice bran, corn and fresh high-protein leaves (leucaena/moringa/sesbania/gliricia) formed the basis of most of the successful diets. The addition of a small proportion of dried fish was cost-effective and resulted in highest growth rates. However, the use of golden snails or tofu waste were also viable alternatives to enhance protein content. Snails can be successfully raised in on-farm snail ponds but due to biosecurity reasons and the need for intermittent additions this option is only recommended in areas where snails have already invaded local rice paddies. Although only trialled at one site, leaf silage appeared to be a good alternative to fresh leaves and could be a time-saving alterative to daily collection of fresh leaves during the dry season.

Although pigs grew well on the commercial diet, it was not a cost-effective complete diet at current prices nor was availability reliable. Until such feed can either be made locally or imported at a cheaper price it cannot be recommended as a complete diet for smallholders. However, diets trialled that included a small proportion of commercial as a supplement to local ingredients were cost effective, so in the current situation it can be recommended as a supplement, and may be of particular use in the dry season.

Nipple drinkers were successfully introduced and overcame challenges of dirty troughs. They enabled farmers to more easily provide a continuous supply of clean water. Although not available in Timor-Leste at the start of the project, they can now be purchased in Dili, but not in local centres.

The measures introduced to manage ASF following the initial outbreak in September 2019 were also largely successful. In addition to farmer and technician training and the introduction of basic biosecurity measures, improved public awareness was essential to reduce disease pressure and jealous behaviour going forward.

8.2 Recommendations

8.2.1 Future farmer-orientated pig programs

Future government and development project-supported farmer-orientated pig programs should use the husbandry and biosecurity model that has been effective in this project. However there is need to adapt the model from a research to a real-life context e.g. manage increasing amount of feed without weekly weighing, feeding approximate quantities rather than precise weighing of ingredients, adapting diets to meet availability of ingredients while retaining adequate energy and protein. While these modification may seem basic, each of these aspects proved challenging for trial farmers and technicians so their capacity to adapt should not be taken for granted.

Given the extensive mortalities due to ASF, there will be a need for new stock once through cleaning and disinfection followed by spelling of affected areas has been completed. This opens up the opportunity for a farmer-orientated program supporting

piglet production. Trial farmers, who have already developed a good understanding of the pig raising model and the need for biosecurity, would be excellent candidates for such a program. If provided with a boar, a key factor currently limiting reproduction at many sites, and ongoing advice on nutritional management throughout the reproductive cycle, these farmers have the potential to play a key role in careful restocking the pig population in their local areas.

8.2.2 Enhanced technical capacity

Despite the small number of veterinarians in Timor-Leste, there is a widespread network of veterinary and livestock technicians. Scaling out of the technician training provided in this project on both husbandry and disease prevention, including the use of the resources developed by this project would enable technicians to provide higher quality support to farmers raising pigs. Our experience has shown that one-off training sessions are not sufficient, rather that follow-up reinforcing sessions combined with hands-on experience are essential.

The development of small local artificial insemination facilities with a small number of boars run by trained technicians/farmers could reduce the reproductive constraints reported by many farmers that have been exacerbated by the arrival of ASF. The insemination of fresh boar semen by artificial insemination has helped overcome reproductive constraints elsewhere where sow numbers are too low for farms to keep their own boar.

8.2.3 Market development

The demonstrated capacity to raise pigs cost-effectively for sale into the pork market opens up the opportunity for the development of appropriately regulated slaughterhouses and meat shops in local centres to process pigs in a safe and welfare-friendly manner and supply fresh pork to the local community. Convenient and reliable market access would encourage farmers to turnover their pigs more rapidly, rather than retaining all for the somewhat fickle cultural market. As a result, farmers would be more likely to develop a more business-like approach to their pig raising and thereby a more regular income. It would be useful to identify whether there is a market for premium products in either urban or rural areas.

Greater availability of pig feeds and other materials would also benefit those moving towards more business orientated pig raising. If commercial feed can be imported and a local supply chain established to deliver products reliably and more cheaply this could then become a cost-effective and convenient option for some farmers. The same rationale could also apply to other high quality protein feed sources such as soy bean products. Nipple drinkers and disinfectants effective against ASF also need to be available locally for farmers to purchase.

8.2.4 Future management of ASF

As ASF in Timor-Leste moves from an epidemic to an endemic situation widespread public awareness will be essential to enable communities to raise pigs safely to meet cultural needs. In addition to training of MAF personnel, public awareness could be raised through face-to-face sessions, videos, community radio, posters, leaflets and other media. To be effective the messages will need to be reinforced regularly and consistent across all formats. They will also need to provide detailed guidance on carcass disposal, disinfection, restocking and biosecurity to reduce risk of future mortalities. Pigs should only be used for restocking if they test negative for ASF. If the island of Atauro continues to remain free of ASF, this could be a source of clean stock.

The apparently lower incidence of ASF in sukus with a tara bandu against free-roaming pigs to reduce crop damage, suggests that this approach to reducing the free-roaming pig

population may be worth exploring with the lia nain (cultural leaders) in individual communities.

8.2.5 Future research

There are several avenues for future research in addition to those that have or are about to commence.

Research demonstration trials to evaluate the effectiveness in the local context of disinfection and restocking processes encompassing biosecurity measures and ASF testing would give confidence to local communities to return to pig raising.

Case studies that follow up with trial farmers, to ascertain the extent to which they have continued to use practices adopted in the trials, whether involvement in the project has resulted in any livelihood changes and whether they have shared information and experiences more broadly, would be useful to obtain insights into the likely future impact of the project.

Development and evaluation of locally-based cost-effective protein-vitamin-mineral supplement that could be added to a diet of home-grown ingredients could increase growth rates that can currently be achieved with such diets.

If reliable marketing opportunities can be developed, this would open up the potential for medium-sized pig farms, which would make development and evaluation of housing-husbandry model for medium-sized pig farms suitable for T-L environment a research priority.

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