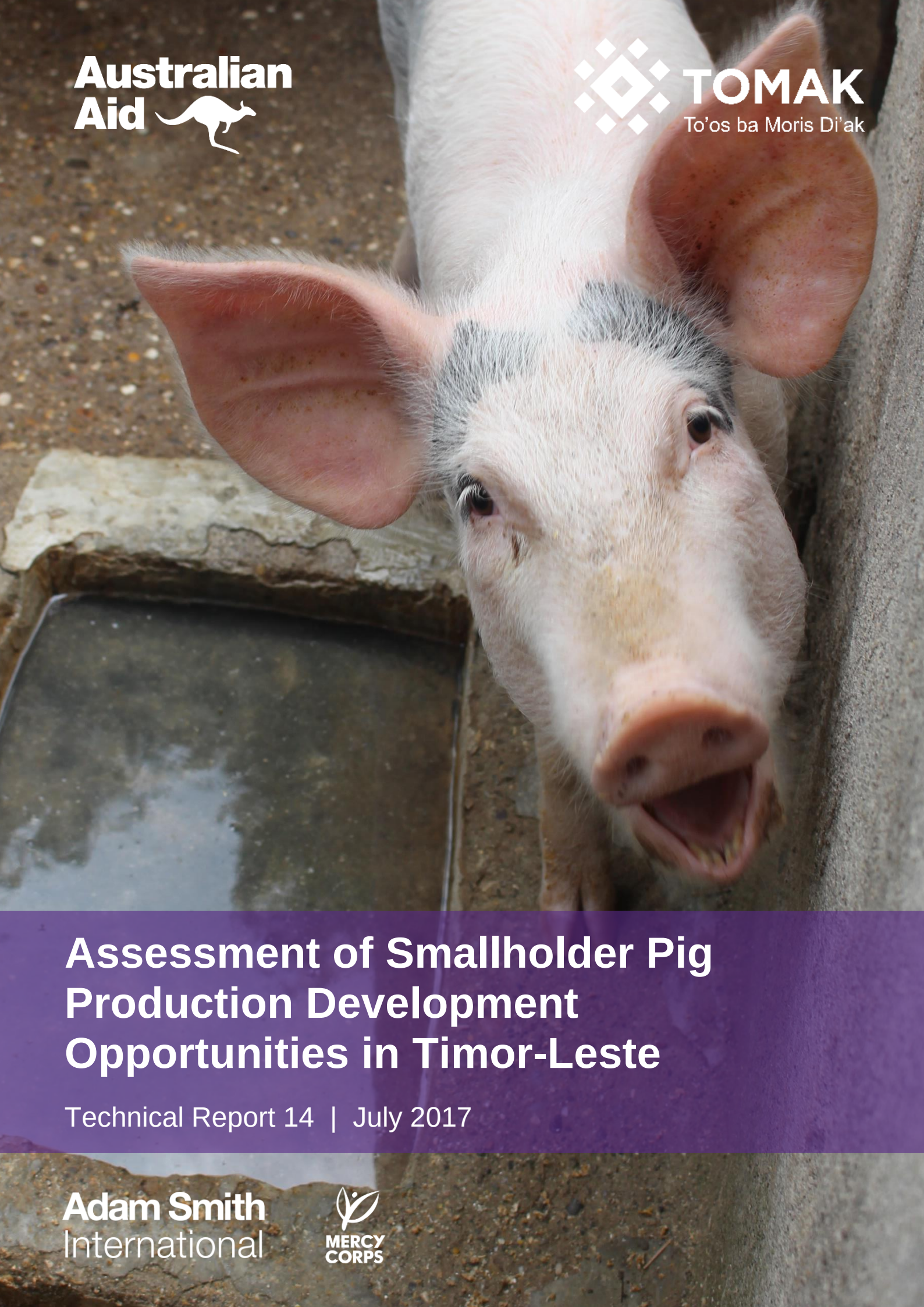

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TOMAK
To'os ba Moris Di'ak

Assessment of Smallholder Pig Production Development Opportunities in Timor-Leste

Technical Report 14 | July 2017

Adam Smith International

MERCY CORPS

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Abbreviations & acronyms

ACIAR	Australian Centre for International Agricultural Research
CP	Crude protein
CSF	Classical Swine Fever
DE	Digestible energy
FCR	Feed conversion ratio, the number of kilograms of feed required to produce 1kg of meat
GIZ	German Society for International Cooperation (orDeutsche Gesellschaft für Internationale Zusammenarbeit)
MAF	Timor-Leste Ministry of Agriculture and Fisheries
RDE	Research Demonstration Experiment
TOMAK	To'os ba Moris Di'ak (Farming for Prosperity) Program
WEE	Women's economic empowerment

Executive summary

TOMAK (To'os ba Moris Di'ak or Farming for Prosperity) is a A$25 million, 5-year agricultural livelihoods program funded by the Australian Government in Timor-Leste. Its goal is to ensure rural households live more prosperous and sustainable lives.

Pigs were included on an initial list of potential value chain activities for TOMAK for a range of reasons, including their importance as a source of income for most rural households. While the main reason for owning livestock in Timorese society is to fulfil social obligations, pigs tend to play an economic role as a source of funds when families need cash for payment of school fees and other necessities. However current production systems in the country are extremely low input/low output, and the potential for moving to a higher input/higher output model is not sufficiently well understood.

The report reviews current pig production practices including breeding, feeding, housing and animal health regimes, and identifies key technical and social production constraints. It also includes an assessment of the potential for improving productivity and developing a viable smallholder commercial industry. The research team visited families in several villages in Bobonaro and Baucau municipalities, and held discussions with local field staff from the Ministry of Agriculture and Fisheries (MAF). These field trips were augmented by discussions with MAF senior staff and animal production consultants in Dili, and a review of reports and published articles covering pig production in Timor-Leste, SE Asia and the Pacific Island Nations.

The two major restraints to efficient smallholder pork production in Timor-Leste are the lack of cost-effective diets and the lack of a stable and efficient fresh pork market. Other restraints include the lack of a guaranteed supply of quality breeding stock; limited understanding of how to manage reproduction and mating practice; inadequate knowledge and understanding of pig nutrition, diet formulation and the importance of water in the pig's diet; sub-optimal housing; and poor knowledge of biosecurity, health, and health control policies, especially the presence of internal and external parasites. Housing is particularly important as pigs will respond and grow more efficiently when provided with an optimal environment. Constant temperatures and a dry environment are especially important for younger pigs.

The report identifies key opportunities for improving production, with emphasis placed on developing balanced and cost-effective diets based on readily available (local) feed ingredients and assessing options for meeting dietary protein requirements with imported feed sources. The key dietary ingredients are carbohydrates, protein – including a source of essential amino acids, such as lysine and methionine – minerals and vitamins. As part of the review, an assessment of available feed sources was made and each ingredient costed in terms of MJ/kg of digestible energy (DE) and the percentage of crude protein. A variety of diet options were costed and are presented in Section 3.2. Data presented in the report suggests the cut-off for a cost-effective diet is below $0.40/kg.

Establishing a reliable market chain is the other essential step and the most obvious market to develop is the fresh pork market. Although such a market already exists in an informal and unstructured way, it does not provide a reliable supply of product and lacks the necessary infrastructure to support the sale of fresh pork. If these limitations can be overcome there would certainly be value in developing pilot projects in the municipalities of Bobonaro and Baucau. The projects could be designed to validate balanced cost-effective diets as well as the potential for a fresh pork industry.

While there are MAF technical staff who appear to have a sound knowledge of pig husbandry and feeding, the husbandry skills of farmers would need to be improved as part of any potential project. It is recommended that if a decision is made to commence a smallholder pig production project, that a participatory approach be taken to design interventions and involve families. This ensures that the families' pig husbandry skills are significantly improved as the project proceeds.

Full report

1. Introduction

TOMAK (To'os ba Moris Di'ak, or Farming for Prosperity) is a A$25 million, 5-year agricultural livelihoods program funded by the Australian government in Timor-Leste. Its goal is to ensure rural households live more prosperous and sustainable lives. TOMAK will achieve this through parallel and linked interventions that aim to:

- Establish a foundation of food security and good nutrition for targeted rural households;
- Build their capacity to confidently and ably engage in profitable agricultural markets.

The primary target area comprises inland mid-altitude areas that have some irrigation capacity. This zone includes around 70-80 suku, located mainly in the Maliana basin (including most of Bobonaro); the eastern mountain regions (including large parts of Baucau and Viqueque) as well as parts of Lautem and Manatuto; and Oecussi. The program will initially focus its activities in 66 suku in Baucau, Viqueque and Bobonaro municipalities.

TOMAK will develop an early focus on selected value chains that have the strongest market potential and offer the best economic returns for farmers. Through a series of studies, four value chains have been identified and assessed for initial development efforts. These include mung bean, groundnut, red rice and shallot.

Pigs were included on the initial list of potential value chain activities for a range of reasons including: their importance as a source of income for most rural households; existence of a strong and established market; opportunities for import substitution (Timor-Leste current imports pig meat); the nature of smallholder pig production which tends to be a backyard activity that utilises 'surplus' household labour; the relative rapid investment/ production cycle; and strong potential for promoting women's economic empowerment (WEE) as women are fundamentally involved in pig production activities.

Current production systems are extremely low input and extensive: pigs are generally not penned and are left to scavenge, supplemented with household scraps; and very few if any animal health treatments are provided. Growth rates are low, and mortality/ morbidity rates high. Despite being an attractive development option, the potential for moving from a low input/low output model to a higher input/higher output model based on improved feeding are not sufficiently well understood to proceed to scale-up at this stage.

This study[1] assesses whether there are viable models (technically, financially and socially) for developing more intensive smallholder pig production systems, providing a basis for farmers to move from subsistence to semi-intensive small-scale commercial production. Identifying a balanced ration that is cost-effective will be a key part of the challenge.

The objective of the study was to review current pig production practices, assess the potential for improving productivity and provide recommendations for TOMAK's investment in the sector.

The initial task was to review pig production data and conduct field assessments in two target municipalities, Bobonaro and Baucau. This included a review of outcomes and sustainability of the recently closed GIZ pig production project, along with other smallholder pig production development activities in the region including several that have been funded by ACIAR. The research then investigated current smallholder pig production practices, including breeding, feeding, housing and animal health regimes, and identified key technical and social production constraints. The varied role of women and men in traditional pig production systems was also explored, especially with regard to husbandry, feeding and marketing.

The second key task was to identify opportunities for improving production through improved husbandry skills, using interventions and training based on proven technologies and practices. The key husbandry skills included feeding, housing, breeding and animal health control. Particular emphasis was placed on identifying a balanced

[1] Conducted by Dr Colin Cargill, Pig Production Specialist, May-June 2017.

and cost-effective ration for smallholder farmers, based on readily available (local) feed ingredients. Assessing options for meeting dietary protein requirements was a key part of this assessment.

The final task was to outline a proposed production model for adoption by households that is technically sustainable and financially and socially viable. This included an assessment of Government (MAF) and/or the private sector to provide critical infrastructure and animal production and health inputs.

2. Livestock production in Timor-Leste

2.1. The importance of livestock production

Livestock play a major role in Timorese society. According to the 2015 Population and Housing Census, 87% of households in Timor-Leste own livestock. Ownership of pigs and chickens is the highest at 71.5% for both animals, an increase of 4.5% from 2010 (Bettencourt et al, 2015). In contrast, ownership of goats and cattle had increased from below 10% in 2010 to 22.5% and 26% respectively in 2015.

The main reason for owning livestock in Timorese society is to fulfil social obligations and to provide a source of income. Pigs along with goats, cattle and buffalo are required for ceremonial occasions such as weddings, funerals and other important events.

A secondary reason for animal production is to provide meat for human consumption. However it is not an important part of the average human diet with 7% never eating meat and only around half the population (54%) eating meat once per week. Only 8% of the population eat meat three or more times each week (Bettencourt et al, 2015).

Pigs also play an economic role as a source of funds when families need cash for payment of school fees and other necessities. Many households will continue to feed a pig long after it has reached its maximum body weight to provide a reserve of funds for when money is required. In this way, the pig is similar to having money in an account at the local bank, but not as secure.

In a survey of three administrative posts it was found that 31.3% of households (range 3.4 to 55.6) reared pigs for self-consumption and 52% of households (range 34 to 77) reared pigs for sale (Bettencourt et al 2015).

The total number of pigs in Timor-Leste increased from 330,435 in 2010 to 419,169 in 2015, an increase of more than 25%. However, in households that owned pigs the number of pigs/household was only 2.9, an increase of 0.2 (7%) from 2010, suggesting that the increase in pig numbers was due mainly to an increase in the number of households owning pigs. The figure of 2.9 pigs/household was also lower than for chickens (6.3), cattle (4.3) and goats (3.4). Urban households also had marginally fewer pigs/household (2.5) compared with rural households (2.93).

Bobonaro, Dili and Baucau municipalities have the highest pig populations (Appendix 1 Table 1). However in terms of the number of pigs per household, Covalima, Lautem and Bobonaro are the highest (>3.3), while Baucau, Ermera and Aileu are the lowest (<2.4). The cause of this variation is not immediately clear and may warrant further study. It may indicate lack of feed resources, reduced access to health control programs, more severe climatic conditions, or other limiting factors.

2.2. Current pig production systems in Timor-Leste

Two distinct pig production systems were identified during this study. The most common system used is best described as a free-range scavenger system. The other systems observed are best described as smallholder semi-intensive and intensive systems.

2.2.1. Free-range scavenger pig production system

Free-range scavenger systems are essentially a low care, low input system where pigs may have access to shelter at night, but are allowed to roam and scavenge for food during the day. Pigs may also be fed small amounts of high-energy feed, such as cassava or sweet potato, and even vegetable scraps when available.

However, feeding is irregular and often undisciplined and pigs generally suffer both energy and protein deficiencies. While pigs are generally fed daily, they tend to be a low priority for some households and may be left to find their food on days when more important events are taking place. Water is seldom provided on a regular basis and none of the farms visited provided water for their pigs day and night.

The scavenger system also provides low welfare for pigs as they are usually inadequately housed and husbanded. They tend to carry large burdens of internal parasites, which reduces their viability and capacity to grow. Free-range scavenger systems generally provide inferior welfare to that enjoyed by pigs in the wild.

Free range pigs also damage crops, may cause soil erosion and are often a source of zoonotic diseases (i.e. diseases that can transfer to humans) such as Cysticercosis and Trichinosis.

2.2.2. Semi-intensive pig production system

In semi-intensive production systems, pigs are confined inside a house with access to an outside run or pen. The pigs are fed and sleep in pens inside the house with drinking water provided in the outside pens where they are encouraged to urinate and defecate. A key advantage is that inside pens tend to remain clean and dry. The most important aspect of both semi-intensive and intensive systems is that the pig must be supplied with all its food and provided with water at all times.

One very simple semi-intensive system, which was part of the GIZ project, was observed on the field trip in Baucau. However most of the GIZ project sites were using a small intensive system with pigs housed in individual pens inside a house, with no access to an outside pen.

The semi-intensive system is a viable option for smallholder pig production as it is possible to provide pigs with a good standard of housing and access to outside runs or small paddocks planted with high protein pasture (ACIAR Project AS1/1998/054; Mahalaya et al, 2014).

In some parts of the world farmers use a free-range semi-intensive system where pigs are provided with small houses, or huts, set in paddocks planted with pasture. Pigs are fed a balanced diet, but they also have access to pasture and can root or dig the soil for worms.

2.2.3. Intensive pig production system

Intensive pig production is a term usually used to describe large-scale commercial pork production where farms may house several hundred to thousands of pigs. However, as mentioned above the majority of the GIZ project sites were set up as small intensive production systems with 1 to 2 pigs per pen inside a house with an iron or thatch roof. Two examples of larger intensive systems were visited in Hera. In both cases, the farmers were struggling to maintain production due to difficulties in obtaining a balanced cost-effective diet for their pigs.

Both intensive and semi-intensive pig farming requires stockpersons to have good husbandry skills and a good knowledge of nutrition, housing and reproduction.

2.3. Gender

Women's engagement in the pig value chain is high in Timor-Leste, with women retaining moderate to high control over pig production enterprises and use of income. This was evident in at least 50% of the households visited in this assessment, where women were seen to play a significant role in feeding and managing the pigs. Women also tend to have responsibility for selling pigs at local and municipal markets. In Bobonaro, one man interviewed, who had established a piggery with his son, stated that he was waiting for his sister to set a price for the pigs before he sold them.

For many women in Timor-Leste, pigs are their most significant asset and considered both an economic and socio-cultural safety net. Traditional cultural practices, ceremonies and marriage exchange often require women within a family to contribute a pig, while it is more typical for men to provide cows. Having pigs can raise a woman's social standing and status, and can provide a safety net for women to engage in different economic activities.

Women also have much lower ownership of land in Timor-Leste than men. Pig rearing comparative to other agriculture or livestock activities requires less land and can be undertaken close to the family home. Closeness to home provides women with the ability to manage competing productive and reproductive workloads, while reducing personal safety concerns in walking to and from fields to care for livestock. Proposed changes to move households from a free-range scavenger system to a small commercial semi-intensive or intensive system may require additional labour and this may impact on women's workload. It is recommended that this be taken into consideration in the design of any future initiatives.

2.4. Current markets for pigs in Timor-Leste

The two most common markets identified were the sale of piglets at weaning and the sale of older pigs aged one to three years for ceremonial purposes. There were reports also of local markets where pork is sold at around the same price as beef, which is currently $7/kg. However, as the price has increased over the last few years, the availability of pork in local markets has decreased. In Dili, local production must also compete with imported frozen pork, which is currently being sold in supermarkets for around $5/kg. Prices as low as $3.50/kg were quoted and if that is the case it makes it virtually impossible for local production to be competitive. At least some of the pork available in Dili comes from Portugal where the current price for fresh pork at the farm gate is around $US2.00 with the price in supermarkets between US$6-8.00/kg.

It may require changes to the current policy for the import of pork into Timor-Leste to allow a pig industry to be developed.

2.4.1. Sale of pigs at weaning

The majority of farmers interviewed during the field investigations sell pigs at 8 to 12 weeks of age, immediately following weaning. This is a relatively efficient and cost-effective way of marketing pigs as it means that the farmer only has to recover the cost of feeding and housing sows. The cost of feeding growing pigs is born by the purchaser. Although it was difficult to confirm, it seemed that most of the sales were to other households who planned to feed the pig and hold it as an investment until they needed money for a significant purpose. Prices varied considerably in different locations, ranging from $300 for 2 month-old weaners in Loes, down to $90 - $150/pig for 8 to 12 week-old weaners in Bobonaro and Baucau.

2.4.2. Sale of mature pigs

As noted earlier in the report, many households either breed or purchase pigs, which they keep as a form of investment that they cash in when money is required. However, this is a relatively uneconomic way to manage pigs as once the pig reaches its mature weight its value will not increase and the cost of feed and housing becomes a debt against the future sale price of the pig. The longer the pig is kept, the lower the overall profit margin.

3. Constraints to efficient smallholder pig production

3.1. Breed and genetics

Breed is an important consideration before embarking on the development of local smallholder pig production in Timor-Leste. During the field trip three types or breeds of pigs were identified.

3.1.1. Macau pigs

The most productive breed recorded was the macau, which was originally imported from Indonesian West Timor. According to local sources the macau is a duroc x landrace cross or possibly a duroc x large white cross. The evidence available suggests that the progeny from these pigs are relatively hardy with superior growth rates. Based on conversations with several families, they are able to grow to around 80kg liveweight within 6 to 8 months when fed diets containing approximately 12 to 13% protein. If fed a balanced diet with a digestible

energy (DE) of 12 KJ/kg and 16% crude protein, which also contains a good source of lysine and methionine such as animal protein, progeny should be able reach 80 to 90 kg within 5-6 months.

Based on field observations, this appears to be a promising breed on which to base smallholder pig production in Timor-Leste.

3.1.2. Macau x local cross

Some households visited had crossed macau pigs with local or native pigs with encouraging results. The crossbred pig seemed to retain the ability of local pigs to survive on lower protein diets, reaching a maximum weight of 60 kg at around 8 months of age. However, care will need to be taken when selecting local sows to be mated with macau boars as the larger heavier piglet may lead to dystocia problems at parturition.

3.1.3. Local or native pigs

Local or native pigs are extremely hardy and can survive very low standards of husbandry. However they have low production potential and may only reach 40-50kg in 8 – 10 months. Although the pork is considered more flavoursome than European breeds, they are relatively inefficient for pork production with a feed conversion ratio (FCR) of up to 6:1[2].

3.1.4. Selection of breeding stock

Irrespective of the breed/s selected, it is important that farmers understand the key traits to look for when selecting animals for breeding from their small herds.

The best animals to be retained as sows and boars are the fastest growing pig(s) from the largest and fastest growing litters. Pigs with longer bodies should also be preferred to shorter-bodied pigs. Faster growing larger pigs tend to have superior genetics and are needed to build a viable herd.

While the temptation will be to sell fast growing pigs as weaners or as older pigs for meat, it must be resisted until a stable herd is established.

3.1.5. Hybrid breeds

The term hybrid refers to the hybrid-crossbred pigs used in intensive pig production in the key pork producing nations of the world. While they are highly efficient if provided with optimal husbandry and housing and fed high specification diets, they do not survive or grow efficiently when fed low specification diets and housing and husbandry is sub-optimal. It is generally agreed that these highly efficient converters of protein to meat should only be introduced into production systems when nutrition and housing are optimal and the husbandry skills of farmers is already high.

3.2. Nutrition and availability of ingredients for diets

Before committing funds to developing smallholder pig production, an assessment of available feed sources must be undertaken. This will enable the most cost-effective and balanced diets to be formulated. Providing pigs with balanced diets containing optimal levels of energy and protein, underpinning the production of quality pork at a reasonable market price, is essential. The key dietary ingredients are carbohydrates, protein (including a source of essential amino acids, such as lysine and methionine), minerals and vitamins. The main sources of lysine and methionine are animal protein and soybean products. Once smallholder pig production reaches maturity, diet specifications can be tailored more accurately to the age of the pig and whether it is a growing pig or a mature sow or boar, as well as the stage in the reproductive cycle.

[2] Feed conversion ratio (FCR) is the number of kilograms of feed required to produce 1 kg of meat.

3.2.1. Carbohydrates or sources of energy

While cereal grains are used as the basis of pig diets in many pork producing countries, these are not available in Timor-Leste. In many tropical countries sweet potato, cassava, maize, taro and similar crops are used as the basis for diets. Rice and rice products can also be used as a source of energy.

A list of the major sources of carbohydrates available in Timor-Leste is presented in Appendix 2A Table 1. The relative cost of each ingredient in terms of digestible energy (DE) is presented in Appendix 2B Table 1. The cheapest energy sources are rice hulls and rice bran.

There are questions regarding some of sources identified relating to supply and particularly availability throughout the year, and the list is by no means complete. Other ingredients have special requirements, such as cassava, which needs to be dried or cooked to remove the risk of cyanide poisoning, and sweet potato and soybean, which both need to be cooked or processed to remove anti-trypsonases.

3.2.2. Protein supply for pigs

Protein is the other important constituent of pig diets. Because pigs are omnivores they require a source of the essential amino acids lysine and methionine, which are essential for efficient growth and reproduction. As noted above, the main source is animal protein. Alternative sources are soybean products, and more expensive synthetic sources are also available.

However, it is possible to grow pigs without access to optimal levels of essential amino acids, but a lower growth rate and feed conversion ratio will result.

Local sources of protein for pigs are presented in Appendix 2A Table 2. The relative cost of each ingredient in terms of crude protein (CP) is presented in Appendix 2B Table 2.

Similar to energy sources, there is a range of crops available with a crude protein content that is in excess 15%. The cheapest sources are copra, soybean, rice bran and sago.

Soybean would make an excellent source of protein on which to build diets, but there is a query about local production and the effect of disease on yields. Soybeans are also associated with a few other problems. They contain a great number of anti-nutritional factors that reduce digestibility and hence affect growth, productivity and profitability, even if fed to mature pigs. They require careful heat treatment to remove the anti-nutritional factors as over-cooking can result in denaturation of the useful proteins. Optimal processing conditions are required to obtain a balance between protein quality and reduction of anti-nutritional factors. A secondary problem is that soybean proteins can cause inflammation in weaned pigs. Inclusion rates in weaner diets must be less than 10%. Soybean curd and other by-products from the processing of soybean can also be a valuable source of nutrients.

Included in the list is dried fish, which is used as a successful source of animal protein in pig production worldwide. While local availability and cost is problematic at present, it may be possible to develop a dried fish product for pig diets as a new venture for the local fishing industry. This would need to be associated with the development of a supply chain so that dried fish is available in centres where smallholder pig production is being developed.

Another possible source of protein for animals is pasture legumes and tree legumes (Appendix 2 Table 3). The most efficient way to make use of pasture legumes is by developing a foraging husbandry model for pigs, where pigs forage pasture during daylight hours. Legume fodder trees also make effective live fences and branches can be lopped to provide a vegetable protein supplement for the pigs (ACIAR Project AS1/1998/054; Mahalaya et al, 2014; Soplanit et al, 2014).

During field trips and visits to markets a wide range of vegetables were also noted. Although they vary in carbohydrate and protein levels, depending on the species, vegetable waste can prove a valuable and cheap source of nutrients. It is used successfully as a source of food to supplement pig diets in a number of Asian countries.

3.2.3. Other nutrient requirements for pigs

A balanced diet for pigs also needs a supply of minerals and vitamins but these are generally supplied through the ingredients used as sources of energy and protein. A popular source of minerals in many Asian and Pacific nations is banana trunks and vegetable waste. Vegetables and green leaves are also a good source of vitamins.

3.2.4. Other sources of nutrients for pig diets

Several other strategies for obtaining high quality nutrients are discussed in section 4.1.2. These include forage pasture and legume fodder trees as well as use of imported commercial pellets and meat meal. The cost per unit of energy and protein for commercial pellets, meat meal and soybean meal has been calculated in Appendix 2B table 3.

3.2.5. Considerations for selecting ingredients of pig diets

One of the most important considerations is the availability of the crop selected as a feed source. If it is not available in Timor-Leste all year, then a substitute needs to be found for the months that it is in short supply or unavailable.

It is also important that crops selected as a food source are easy to cultivate, harvest, store and process for pig feed. The price per unit of protein or energy unit will determine those that are most suitable (Appendix 2B Tables 1-3).

Preparing and processing diets which can be stored is also more efficient than preparing feed for the pig every day.

3.2.6. Water

A reliable supply of good quality clean water is also essential. Pigs require access to water 24 hours a day. Several studies confirm that while intake over 24 hours varies significantly between pigs, pigs will consume water both day and night.

Recommended daily amounts of water for pigs to maintain physiological metabolic activity are:

- 25 kg pig - 3 to 5 litres/day.
- 45 kg pig - 5 to 7 litres/day.
- 65 kg pig - 7 to 9 litres/day.
- 85 kg pig - 9 to 12 litres/day.
- Boars & Sows - 12 to 15 litres/day.
- Lactating sows - 20 to 25 litres/day.

However, the best practice is to provide pigs with continuous access to clean water.

Water is also required for cleaning the concrete floors of piggeries, especially when pigs are confined to pens 24 hours a day. If pigs are given access to outside runs where they can defecate, the amount of water required for cleaning will be reduced.

3.2.7. A range of diets being used in Timor-Leste

The digestible energy targets for hybrid growing pigs in intensive farming systems are between 13-15MJ/kg, with levels of 13-14 MJ/kg for dry and lactating sows. In less sophisticated systems an acceptable target is between 12-13 MJ/kg.

Similarly, protein requirements for hybrid pigs range from 16% for weaned pigs down to 14% for older growing pigs and 13% for adult pigs. An acceptable target for smallholder production systems is around 12-14% crude protein in diets.

Several diets based on local ingredients that were being used on farms visited during the study are recorded in Appendix 3A.

While all the diets supplied more than the target level of digestible energy (12-13 MJ/kg), protein content varied from below the target of 12-14%, to well above. The ranges calculated for digestible energy were from 13.3-15.6 KJ/kg and ranges for protein were from 9-16.5%. Most diets however had protein levels between 12-15%, which was considered adequate for the pigs and the conditions. Only two of the six diets contained animal protein – one contained 11% dried fish and another contained 2%. One of the GIZ project diets contained 12% soybean. Pigs fed this diet were moderately well grown and in medium body condition.

Unfortunately only one of the smallholder farmers visited was able to provide an accurate costing for every ingredient in the formulation he was using, which included yellow and white corn, dried leucaena leaf, copra (or coconuts), rice hulls, dried fish, mung beans and sago (Appendix 3B Table 1).

The cheapest diet was produced at the University Field Station and was costed at $0.39/kg. It also met the dietary specifications of an optimal diet for young pigs. The only deficiency was that it lacked a source of the essential amino acids lysine and methionine.

One diet used in a small commercial pig farm in Hera claimed to feed only corn, which meant the protein level of the diet was below 10%. However, the pigs looked healthy and are likely to have been receiving a higher level of protein than this from some other source. Lactating sows were being supplemented with commercial pellets imported from the Philippines but unfortunately specifications for the pellets were not listed on the bags and the company failed to reply to subsequent email requests for information.

3.2.8. Economics of feeding pigs in Timor-Leste

It is important to understand the cost structure of feeding pigs as nutrition accounts for 70 to 80% of the daily cost for of producing pork.

The average feed intake of a hybrid commercial sow is around 3 kg/day over 12 months. Based on this figure it is estimated that a 150kg to 180kg Macau sow will eat between 2.0 and 2.5 kg/day over the same period. This is based on an average of two farrowings/year, which is possible but requires validating.

Using an average sow feed intake of either 2.0 or 2.5kg/day, and a feed cost of $0.40 and $0.50/kg, the cost to produce one weaner pig ranges from $14.60 to $38.00, depending on number of pigs weaned/sow/year (Table 1). The full costing for producing weaners is tabulated in Appendix 4.

Table 1: Cost of producing weaner pigs based on daily feed intake for sows, cost of feed/kg and number of pigs weaned/sow/year.

Sow daily feed intake (kg/day)	Total yearly feed (kg)	Cost of feed ($/kg)	Cost of sow feed for one year ($)	Pigs weaned/sow/ year	Cost of each piglet weaned ($)
2.0	730	0.50	365	12	30.41
2.0	730	0.50	365	16	22.81
2.0	730	0.50	365	20	18.25
2.0	730	0.40	292	12	24.33
2.0	730	0.40	292	16	18.25
2.0	730	0.40	292	20	14.60
2.5	912	0.50	456	12	38.00
2.5	912	0.50	456	16	28.50
2.5	912	0.50	456	20	22.80
2.5	912	0.40	365	12	30.41
2.5	912	0.40	365	16	22.80
2.5	912	0.40	365	20	18.25

Similarly, the cost of feeding a growing pig from weaning to sale at 80kg can be calculated depending on the feed conversion ratio (FCR), which is the amount of feed in kg required to produce 1 kg body weight. As an example if the FCR is 5 and the cost of feed is $0.50/kg, then the pig will eat 5x80kg = 400kg feed @ $0.50/kg and cost $200.00 to produce. When we add the cost of rearing the pig to weaning (Table 1), the total cost of the pig at the sale weight of 80kg ranges from $218.25 to $238.00.

As the carcase weight of a pig after slaughter is approximately 75% of its liveweight, the carcase of an 80kg pig will weigh about 60 kg (75% of 80kg) dressed. Hence, the production cost of the carcase is approximately $3.63/kg ($218.60/60) to $3.98 ($238/60). If the FCR is reduced to 4 by providing balanced diets, permanent water, optimal husbandry and housing, and improved parasite control, then the amount of food required to reach 80kg is reduced to 320kg @ $0.50/kg or $160.00. In this case, the fresh pork costs around $2.97 to $3.30/kg.

If the cost of feed can be reduced to $0.40/kg and the FCR remains at 4, then the cost of producing a 60kg carcase falls to between $2.37 and $2.64/kg. In this scenario, the cost of a pork carcase is well below $3.00/kg.

A butcher interviewed in Dili stated that he would need to be able to buy live pigs at less than $3.00/kg to be able to butcher and sell fresh pork at a profit, and below the cost of imported frozen pork. The latter generally sells for around $5/kg.

Example: Rearing and selling pigs for profit

Below is an example of how pigs can be reared and sold for a price which allows a butcher to sell fresh pork at a profit (below the cost of imported frozen pork), and still provides profit to the farmer.

If a farmer can produce 20 pigs/sow/year, and the feed cost is below 40 cents/kg and the FCR is 4 or lower, then the cost of producing an 80kg pig will be between $142.60 and $146.25. This translates to around $1.80/kg liveweight. If the pig is then sold for $2.50 to $3.00/kg liveweight, then the profit per kg is between $0.70 and $1.2 or $56 to $96/pig. The profit/sow/year would be between $1,120 to $1,920. This compares with the current price for a weaner pig, which is around $90 to $120 at a profit of $60 to $90/pig.

3.2.9. The economics of growing and retaining pigs after they reach maximum weight

The sale price for 1 to 3 year old pigs weighing around 80 to 90 kg was quoted at between $600 for a one-year-old pig, up to $800 for an older pig, and up to $1,200 for what was considered to be a superior older and larger pig.

Farmers did not seem to realise that once the pig reaches a maximum weight of around 80 to 90 kg, it stops growing and laying down muscle (meat). Hence keeping a pig and continuing to feed it once it has reached maximum weight means that the outlay for feed is not being compensated for through increased growth and an increased financial return. In fact the reverse applies: the longer a farmer keeps the pig, the greater the accumulated cost of feeding the pig will be and the lower the profit. Unless feed is virtually free, it is similar to having money in the bank and receiving no interest while paying bank fees. As the pig consumes more food without a significant increase in body weight, the FCR will continue to rise. For example, a pig that could have been sold for 80 kg at 8 months with an FCR of 5 will have eaten 400kg food. If the pig is kept until 12 months, the FCR will increase to around 8, and the pig will have eaten 240 kg of extra feed. If the feed costs $0.50/kg then this represents an extra cost of $120 with no increase in value.

It should be noted that these are hypothetical figures that need to be validated. However the example is given to demonstrate the deficiencies in the current management and marketing system.

3.2.10. Alternatives methods for feeding pigs

Several other alternatives could be considered for feeding pigs in Timor-Leste. These include silaging materials to increase protein levels, diluting commercial diets with cheap locally available ingredients, as well as improving fish production to create dried fish for pig feed. Importing products such as commercial pellets, meat meal and soybean meal is another possibility if the import price is cheap enough.

3.3. Production issues to be considered

3.3.1. Pig husbandry and management

Before attempting to improve smallholder pig production, consideration must be given to improving farmer understanding of pig housing and management and improving their husbandry skills. Smallholder farmers must develop a basic understanding the pig's needs as once animals are fully confined, the farmer becomes totally responsible for the health and welfare of the animal. This includes regular feeding, access to water, and providing an optimal environment.

3.3.2. Pig housing

The key factors associated with optimal housing include managing extremes in temperature, protecting pigs from sunburn and sunstroke, providing a warm dry environment for piglets and a safe place for sows to farrow away from predators. Confinement and housing are also an important part of biosecurity and preventing cross infection between pigs, as well as between pigs and humans and other animals. Examples of the value of confining free-range village pigs come from Papua (Indonesia) and Laos where confinement was used to limit outbreaks of Classic Swine Fever (CSF) in pigs and the transmission of Cysticercosis from humans to pigs.

3.3.2.1. Temperature requirements for pigs

Young pigs under 2 months of age are particularly sensitive to fluctuating temperatures. They survive and perform best when the diurnal variation is less than 2^{o}C. While the recommended target temperatures for piglets during the first two weeks is 28 to 30°C, in practical terms as long as it is above 24°C and the diurnal variation is less than 3°C, the environment can be regarded as satisfactory.

The recommended target temperatures for pigs older than 2 weeks and less than 8 weeks is 25 to 28°C or < 3°C in 24 hours, and 24-28°C or < 4°C in 24 hours for weaned pigs up to 10 weeks.

Using creep boxes in the farrowing pen is one of the most effective ways to provide optimal temperatures for piglets (Appendix 7). The creep box is placed in the corner of the pen before farrowing and piglets are placed inside the box as soon as the sow has suckled them. The piglets will then decide when they need to use the box for warmth. The box provides a warm dry environment and maintains a more even temperature as it also eliminates air movement. If electricity is available a small light can be hung inside the box for extra warmth but this is not essential.

3.3.3. The value of increasing piglet survival and viability

Based on observations and conversations with families raising pigs, pre-weaning mortalities appear to vary from <5% to greater than 40%. One would assume that even higher mortality rates are occurring in free-range scavenger pigs.

Providing a warm dry environment for new-born piglets will increase piglet survival and provides one of the most immediate and effective opportunities to increase production and income.

Example: Improving care of pigs and piglets

If a sow farrows 1.8 litters/year and averages 8 pigs/litter, she has the potential to produce 14 (8 x 1.8) pigs/year. If the piglet mortality before weaning is 40%, which is common in low care systems, the sow will only produce 8-9 pigs/year. If the mortality can be reduced to < 10%, then the sow will produce 12-13 pigs/year. This translates to 55%-60% more pigs for sale/year, with no additional feeding costs. Pigs sold/sow/year is one of the most important indices for measuring the efficiency of pig production.

3.3.4. Other housing tips

It is also considered best practice to separate pigs from their dung to prevent reinfection with parasites and enteric bacterial diseases. An easy practical way to do this is to divide the pen into two sections. Pigs are fed and given access to water in one section, where they will also usually defecate and urinate. The other section remains dry and can be covered with dry grass to provide a warm dry area for sleeping. The wet area can be regularly cleaned without compromising the welfare of the pig.

3.3.5. Reproduction

During the field-trip the majority of male pigs observed had been castrated at a young age – few entire males were noted. Lack of a boar can be a major problem in smallholder pig production as it is uneconomic for every family to own a boar. However, easy access to boars of suitable quality is essential if sows are to breed.

A number of models can be considered but they all have biosecurity issues. The two most common are that one family in a community owns a boar and rents its services to other families for a service fee of one piglet per mating. The other is for the community to erect a communal boar station where one or two boars are housed. Families take their sows to the station when they are ready to be mated. However, it is important that families understand that when their sow has clinical signs of disease they refrain from using the boar until the illness has been investigated.

The simplest way to bring a sow into oestrous is to pen her beside a boar immediately after weaning, and she will usually mate within 5 to 7 days.

Other important issues are knowing how to detect when a sow is in oestrous and ready to mate and understanding the reproductive cycle of sows. The latter is very easy to remember as the gestation period is 3 months, 3 weeks and 3 days (114 $\pm$ 3 days). If sows are weaned at 6 weeks and rested for 3 weeks before mating it is possible to produce 2 litters/sow/year. Weaning at 8 weeks has the potential to produce 1.9 litters/sow/year.

3.3.6. Health control and disease prevention

A list of diseases and parasite infections known to be present in Timor-Leste is provided in Appendix 5. Other diseases recorded as part of diagnostic sampling include several bacterial infections and Sarcoptes mites, the cause of sarcoptic mange. The bacterial infections recorded include *Staphylococcus* spp., *Salmonella* spp and *Streptococcus* spp. However, as few disease investigations result in laboratory analysis, the actual prevalence of bacterial diseases is unrecorded.

The morbidity rate in pigs, quoted in a study by Lacacio, is 35% with a mortality rate of 29.8%. However, the cause of morbidity and mortality is not defined.

The major disease known to be present is Classical Swine Fever (CSF), with a claimed vaccination rate of 28.4%. This is well below the 75% vaccination rate required to be effective.

Confinement, age segregation and good biosecurity are used in many pork-producing nations to limit disease and reduce reliance on antibiotics. Purchase of pigs should be limited to farms or herds free from major health problems. Although data is lacking for Timor-Leste, good hygiene, optimal housing, isolation of age groups and using strict confinement systems can control many of the so-called production limiting diseases. These include most major enteric and respiratory bacterial diseases and parasites.

Confining and isolating pigs from free-range scavenger pigs has been successful in both Laos and eastern Indonesia in preventing CSF in the confined pigs and limiting outbreaks of the disease. This provides a strong argument for confining pigs in Timor-Leste.

Although CSF can be an important disease when outbreaks occur, parasites are just as important and are often the major health issue affecting smallholder production systems. Instituting a parasite control program is an essential part of the initial planning and development of pork production. Parasites reduce growth rates and increase mortality in growing pigs, but can be controlled using commercial Anthelmintics or natural therapies such as papaya fruit fed daily and betel nut fed once weekly.

3.4. Building a reliable market chain

Along with identifying a range of cost-effective balanced diets, establishing a reliable market chain is an essential step in building a smallholder pig project. Without a reliable market that is able to provide adequate remuneration for the pigs produced, no livestock production project will attract long-term participants. The smallholder pig producer must be able to feed pigs economically, and recover feed and labour costs at market to be viable.

3.4.1. Current markets

As previously noted, the two most common markets identified were the sale of piglets at weaning and the sale of older pigs aged 1-3 years for ceremonial purposes.

In discussions with local MAF Officers, neither of these markets appears to have great potential, although given current prices demand would appear to be much greater than supply. Part of the problem for larger pigs is that they are usually needed for a special event, such as a funeral, when the buyer has a limited time frame to obtain the pig. This gives the vendor considerable leverage in setting the price.

3.4.2. Other possible markets

3.4.2.1. Fresh pork

The most obvious market to build on is the fresh pork market, which already seems to exist at an informal and unstructured level. Discussions with MAF officers in Baucau indicated that fresh pork is occasionally available for sale in Baucau, but not on a regular basis. Other reports from a veterinarian and a local butcher in Dili suggest that some pigs are slaughtered locally and carcases sold as fresh pork.

A survey of three administrative posts in Bobonaro municipality (Bettencourt et al, 2015) recorded that 31.3% households raised pigs for self-consumption, with the percentages across the three areas ranging from 3.4% to 55.6%. This data suggests that the consumption of pork between households varies considerably. A wider survey (Bettencourt et al, 2015) recorded that 54% of the population eats meat only once a week, and only 8% eat meat more than twice weekly. What is unknown is whether, if given an opportunity to consume meat, including pork, people will increase their consumption. This would need to occur if development of a fresh pork market was to be successful.

3.4.2.2. Processed products

Products such as *Babe Se'i*, which is smoked barbequed pork, have proven to be very popular in Kupang (Timor Barat Indonesia). According to an ACIAR project (SMAR/2007/195) report, this product was responsible for significantly increasing the consumption of pork over a period of three years. Ventures such as this could provide on-going demand for fresh pork and could help stabilise a developing fresh pork market.

In many western countries, a major part of promoting fresh meat is through developing easy recipes for households to use that increase the variety of flavours and styles of presentation. However, this technique is more applicable to increasing a market for fresh meat once it has been established.

4. Building a smallholder pig production project

The two most important issues that need to be resolved are improved pig nutrition, and developing a reliable market chain.

4.1. Issues needed to be solved before commencing a project

4.1.1. Ensuring the availability of balanced cost-effective diets

The key factor to consider and satisfy before commencing the project is ensuring that reliable and economic sources of energy and protein are available. The lists provided in Appendix 2 provide a basis of further investigation, which should include detailed assessment of availability and obtaining accurate figures on costs of each crop or ingredient in terms of cost/unit of energy and cost/unit of protein.

The range of ingredients listed in Appendix 2A (Tables 1, 2 and 3) provide enough scope for a balanced diet to be formulated, as demonstrated in several of the diets recorded in Appendix 3A and 3C.

Encouraging families to grow new and existing crops to provide ingredients for their pig diets is a more sustainable and cost-effective way of feeding pigs than purchasing all ingredients. Most of the crops listed can be grown in Timor-Leste on small parcels of land and many can be harvested over time or as required.

The specifications for diets need not be as rigorous as quoted in modern pig feeding manuals, but should approach around 12MJ/kg of digestible energy and 12 to 14% protein as a minimum standard.

The final diets will be a compromise between price and specifications in terms of energy and protein. A range of possible diets based on local ingredients, as well as imported soybean meal, commercial pellets and meat meal are presented in Appendix 3C.

One strategy would be to use the cheapest source of energy and protein available. In the sample diets presented, replacing rice bran with rice hulls in local diets will reduce the cost from around 41 cents to 35 cents/kg. However, this results in sub-optimal protein levels (12%).

Combinations of maize, rice hulls, copra meal, dried fish, pumpkin and leucaena leaf also produced cost-effective diets from $0.31 to $0.38/kg (Appendix 3 Table 1A-1D). If soybean meal can be imported for around $1.00/kg, then diets based on soybean and rice hulls could also be cost-effective and sufficient in protein. This would also have the advantage of providing essential amino acids.

Another possible strategy would be to use 10% imported meat meal as a source of protein in a diet with 20% maize, 20% rice bran and 30% rice hulls. Protein level for this diet is adequate and it is marginally cost-effective if the price of meat meal is between $0.80 to $1.00/kg. Substituting maize with an extra 10% of rice bran and rice hulls provides a similar result. If all the maize and most of the rice bran is replaced with rice hulls, the diet will be both cost-effective and contain adequate levels of protein.

In another proposed diet, meat meal was used to supplement a marginally cost-effective, but low protein diet, as used in the GIZ project. The diet contained both dried fish and copra meal and maize and rice bran. Rice bran was replaced in the sample diet with rice hulls to reduce cost, and 2% fish and 8% copra meal replaced with meat meal to increase protein levels. Adding 10% meat meal increased protein by 2% protein and using rice hulls reduced cost to from $0.41 to $0.36/kg (Appendix 3 Table 4A).

Using local fruit and vegetable waste, such as pumpkin and banana, with imported meat meal could also be promising (Appendix 3C Table 4C). Even at a price of $1.80/kg for the meat meal, the diet was marginally cost-effective ($0.40/kg) and provided adequate protein and essential amino acids.

A first step should be to test the performance of pigs fed some of the sample diets so that they can be fine-tuned.

4.1.2. Alternate feed sources to consider

4.1.2.1. Pastures and fodder trees

A number of high protein pasture grasses and fodder trees listed in Appendix 2A (Table 3) could provide a cheap source of vegetable protein once they are established. Although the long dry season may mean that there will be insufficient pasture growth for much of the year to allow continuous foraging, species such as *Centrosema spp* are used for foraging pigs in a number of Asian countries with an extended dry season. Stylo has also been used to replace other sources of protein in pig diets (Phengsavanh and Lindberg, 2013).

It would be wise to seek information on pasture establishment and production from various cattle projects before proceeding. One advantage of pastures and fodder trees is that they enhance the efficiency of confinement systems where pig diets are supplemented with high protein species (ACIAR project AH/2007/106; Bienvenu et al, 2014).

4.1.2.2. Feeding pigs to value add to crops

In Bobonaro municipality, rice production and pig production occur in the same villages and some farmers already grow rice and produce pigs. Rice also provides other products, such as rice bran and rice hulls, that are valuable ingredients in pig diets.

Many examples can be found around the world where pig production developed as a way of value adding to crops and other livestock systems. These include pig production based on cereal grains, using pigs to consume waste products from cheese and butter production in the dairy industry, and using pigs to value-add to waste product from tofu production.

Growing crops such as cassava, maize, and rice to feed to pigs, rather than buying ingredients to supply energy, could provide more cost-effective diets. The pig industries of Australia, Europe and North America were built on this approach.

4.1.2.3. Silaging root crops with green leaf material

Silage has been used as the basis for feeding pigs in both Vietnam and Indonesia, and has increased the level of protein normally found in diets based on root crops. Farmers tend to favour the use of silage over having to cook diets based on sweet potato and cassava as they can work hard for 2-3 days and make sufficient silage for several weeks, as opposed to having to cook root crops each day. However, silage making does increase the amount of labour required and it may be necessary to add a secondary source of energy as the volume of silage that can be consumed is limited in growing pigs (ACIAR project AS1/1998/054).

4.1.2.4. Diluting commercial diets with local produce

A procedure that has been widely used in ACIAR projects (LPS/2006/149) in various Pacific Island Nations is to formulate diets using from 10-25% of imported commercial pellets as an ingredient along with locally available ingredients. Rather than feed pigs entirely on the pelleted commercial diet, the pelleted ration is diluted with local ingredients such as corn, cassava, leucaena leaves, coconuts and copra meal, and other local crops. Adding small amounts of meat-meal or fishmeal at an economic level, rather than at the recommended level, will also improve the quality of the local diet. Examples are provided in Appendix 3C Tables 3A-3E and 4A-4E.

4.1.2.5. Increasing fish production

Some of the diets being used by farmers in Timor-Leste also contained dried fish, which varied in price from $2.50-5.00/kg. Unfortunately dried fish is not a viable commodity at present as supplies would seem to be insufficient to sustain an expanding pig industry. However, it may be worth investigating the feasibility of establishing a dried fish industry, or even a local fishmeal industry, as a new industry developed to supply

fledgling pig and poultry industries. A reliable supply of dried fish for pig diets would certainly enhance the viability of a smallholder pig project.

4.1.3. Developing markets

As outlined in section 3.4, it is essential to develop viable alternative markets if a smallholder pork industry is to become a sustainable reality.

4.1.3.1. Fresh pork market

The most promising market that would ensure the viability of a smallholder pig industry is probably the fresh pork market, making pork available to families on a daily basis at an affordable price. This may require a survey of consumers to determine the acceptable price for a kilo of pork in the local market.

4.1.3.2. Changing the mindset of smallholder families

Several issues need to be solved before a reliable fresh pork market could be a reality.

In discussions with several interested parties, including an established pig farmer, a senior veterinarian, a local butcher and senior bureaucrats, the existing mindset of many families currently rearing pigs will need to be changed. Currently smallholder families tend to sell a single pig at weaning to another family who will grow the pig to full size and keep it until they need money for some event or activity. Sometimes the family with a sow will also grow one or two pigs to full size, which they will also keep until the money is required. What is required is a new mindset. Smallholder pig producers will need to be prepared to embark on a new production system, where they provide superior nutrition, housing, management and health control and produce significantly more pigs from one sow. Hence, instead of having 6-12 pigs to sell per year, they may have 15-20 pigs to sell or grow out to 60 to 80kg liveweight for slaughter.

4.1.3.3. Providing facilities and training to make it happen

For this change in pig production and management to occur, local facilities will need to be provided for slaughtering pigs and butchering the carcase, and a market for selling pork to consumers established. One possibility would be to investigate the feasibility of erecting a local slaughterhouse in key rural municipalities where pig production occurs. A person trained in butchering and processing, and retailing fresh meat, would be essential to ensure the success of such a venture. A similar model is used in other Asian countries and was used in Australia to supply fresh meat to local communities, before large abattoirs became economic. However, this approach would require significant Government support to build the facilities, train butchers, and provide inspection services that maintain health and hygiene standards of both product and facilities.

While the government has funded simple facilities for slaughtering animals in most districts previously, they were apparently constructed without understanding the essential requirements for a slaughterhouse, such as access to water and a sound knowledge of hygiene.

Access to material and data from slaughterhouses can also provide valuable disease prevalence data for animal health authorities to enhance field surveys.

4.1.4. Developing farming models for pig production

Once nutrition and marketing issues have been resolved, the proposed farming models need to be evaluated for sustainability and acceptance by participating families.

Several farming models are used around the world for improving the productivity of smallholder pig production. These are mainly a mix of either small intensive systems or small semi-intensive systems similar to those described in section 2.2.

The definition of an intensive system is that the pigs are housed continuously in a pen inside a house. All activities, such as eating, drinking, sleeping and defecating take place in the same pen. This makes daily cleaning and removal of dung essential. The only practical way to separate pigs from their dung in intensive systems is to build a slatted system where a third of the pen is covered with slats over a drain that is

approximately 400 cm deep. Dung and urine will fall through the slats into the drain, which is flushed regularly with water to keep it clean. This adds significantly to the cost of construction and water use.

In semi-intensive systems, the pig is housed in an inside enclosure but also has access to an outside pen or run. Mostly the pig eats, drinks, defecates and urinates in the outside pen and sleeps in the inside pen. If the pig is fed a dry mash or pellets, it may be fed in the inside pen. The floor of the inside pen can be covered with dried grass or rice straw to improve welfare.

While both systems can be equally successful, semi-intensive systems tend to have several advantages for smallholder households. Regular cleaning is not as important and water usage is reduced if the outside pen has a sloping floor, which allows water, dung and urine to flow into a drain. This area will also be cleaned naturally when it rains. The inside pen remains dry and provides a warmer sleeping environment for the pig. The other major advantage is that the outside run can open into a small paddock, or large pen, planted with pasture and fodder trees to form living fences. In systems that are more sophisticated, the pigs can have access to several pens planted with pasture through which pigs rotate. A diagram of a model developed in Indonesia is illustrated in Appendix 6.

5. Suggested methodology for developing a pig production project

Several development and research models have been used for developing smallholder pig production in rural communities across Asia and Africa. Models that have applied participatory approaches to design interventions, and involved families in small research extension experiments, have proved very successful in rural communities in Indonesia. These communities previously practiced a free-range-scavenger pig production system similar to the prevailing situation in Timor-Leste, and the farmers generally had limited animal husbandry skills.

5.1. Steps in building the project

5.1.1. The initial step

The initial step is to invite families who already own at least one sow with piglets to join the project. Once a group of families has been recruited in a community, the project team should meet with the families to outline the aims and expected outcomes from the project. The preferred breed in Timor-Leste is the Macau, but it may be worth including families with Macau x local pigs as well as local pigs in a pilot program.

Families should be involved in designing the project and also in negotiating an agreement between the project team and the families. The agreement should include the responsibilities accepted by each group and the financial arrangements for various activities, which includes the cost of feed ingredients for nutrition experiments that are required to develop a series of balanced and cost-effective diets; labour and infrastructure costs for erecting buildings and preparing diets; as well as other costs that may be incurred. The level of subsidy may vary according to the activity, from 40% supplied by the family and 60% provided by the project, to a 70/30 split with only 30% supplied by the project. Subsidies should be withdrawn after a set period (e.g. a maximum of three years).

5.1.2. Initial training

Families should be given initial training on the nutritional requirements of pigs, as well as in preparing balanced cost-effective diets. Training should include key husbandry skills, housing concepts, managing pigs through the breeding cycle and growing phase, and the basics of health and welfare.

A novel idea applied successfully in ACIAR projects AS1/1998/054 and AH/2007/106 was to use Research Demonstration Experiments (RDE) as part of the learning process. An RDE is an experiment that combines the transfer of skills and known concepts with an assessment of how applicable a particular concept is for the community involved, and how likely it is to solve a particular set of problems. A good example of an RDE was

validating the benefit of using a boar to promote oestrous in sows after weaning. It is a known fact that placing sows in close proximity to a boar immediately following weaning will improve both the chances of oestrous occurring and the intensity of the oestrous. An RDE was run in two villages where the first, third, and subsequent odd-numbered sows were housed next to a boar post-weaning, and even-numbered sows were housed 50m away and out of sight of a boar. Families were involved in managing the RDE and recording the data so that they could observe the value of the practice and how best to manage it in a village where not all farmers owned a boar. The data collected not only validated the practice but also confirmed that it worked effectively with native pigs in a village environment. The RDE became a learning experience for farmers, while at the same time developed and validated a best-practice approach for pig reproduction in the village.

An RDE can also produce unexpected results; as well as validating a known fact. For example, data from the the ACIAR RDEs also demonstrated that litter size was increased when sows were housed next to a boar, a finding that had not been confirmed previously in studies in commercial pig production. The concept of RDEs also guarantees that a genuine participatory approach is taken. For example, it was used very successfully to introduce concepts of diet preparation. Participating families undertook RDEs where they compared growth rates achieved using two different diets. As a result, they developed a sound practical understanding of feeding and nutrition of pigs.

5.1.3. On-going support

It is important to employ dedicated project technicians who are well trained and experienced in pig husbandry, health and welfare. Preferably they would be seconded from MAF but could also be employed by the project. The role of the dedicated project technicians is to mentor and work with families and regularly visit the project sites under their care. Specialists should also be involved in regular visits to project sites and be prepared to spend time discussing progress and problems with families.

MAF already employs technicians with a sound understanding of pig husbandry and these people could be used to build an effective extension pig husbandry service. If these technicians were seconded to the project, they could become a valuable asset in the future for both MAF and the community, as the project develops.

Families should be involved in all project reviews and planning sessions and given the opportunity to visit other families in the group to compare experiences.

Once the project is about to commence, consideration should be given to working with Government to develop a local slaughterhouse where the pigs produced in the project can be butchered and marketed as clean fresh pork. Such a facility could serve as a model for other rural communities in the future.

As the project proceeds, field days at selected sites could be used to extend the ideas and developments made by the project families and the project team.

If the project proves successful, selected farmers would become a valuable resource for training other families and extending the success of the project.

6. Summary

There is potential for expanding and improving the efficiency of smallholder pork production provided the current limitations can be solved.

6.1. Major limitations

6.1.1. Lack of balanced cost-effective diets available to smallholder families

While there is a wide range of feed resources available, cost and supply problems tend to make the production of pigs for slaughter for fresh pork uneconomic. However, several strategies are available to reduce the cost of diets and reduce cost of production.

Strategies to consider are:

- Growing crops such as corn and cassava on farm to feed to pigs, which is a form of adding value to crop production;
- Developing pig production based on rice production – similar to grain-pig and sweet potato-pig production in other countries;
- Including forage crops and fodder trees as a source of protein, especially where pigs can forage the pasture to supplement protein and amino acid intake;
- Purchasing commercial pellets, meat meal and soybean meal to obtain higher quality protein, and diluting these ingredients with local ingredients to reduce cost;
- Investigating the use of vegetables and vegetable waste as a cheap source of energy and protein;
- Investigating the feasibility of establishing a dried fish industry to provide high quality protein for a pig and poultry industry.

6.1.2. Lack of markets and infrastructure for fresh pork

Currently there is no formal fresh pork market that guarantees a reliable supply of product. This is essential if smallholder pig production, based on the sale of fresh pork, is to become viable.

Targets and strategies to consider include:

- Producing fresh pork with a farm gate price of around $1.80 - $2.00/kg liveweight with a profit margin of around $1.00/kg. With a target cost for producing an 80kg pig of just under $150, this translates to a profit $1.00/kg or $80/pig;
- Producing a minimum of 16 pigs/sow/year at a return of $1,280 /sow/year;
- Developing a model for a small-scale slaughterhouse in project areas;
- Training butchers and assisting them to establish outlets for the sale of fresh pork;
- Advising and supporting Government on the establishment of a reliable inspection service to ensure adequate hygiene and quality standards for product, slaughter facilities and markets.

6.1.3. The way ahead

If these limitations can be overcome there would be merit in developing pilot projects in the municipalities of Bobonaro and Baucau. These projects should be designed to validate balanced cost-effective diets as well as the potential for a fresh pork industry.

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Appendices

Appendix 1: Distribution of pigs across municipalities in Timor-Leste

Table 1: Distribution of pigs across municipalities of Timor-Leste

Municipality	Households	Pigs	Pigs/Household	% Pigs
Aileu	6,402	14,555	2.3	3.5
Ainaro	8,516	22,761	2.7	5.4
Baucau	18,976	42,313	2.2	10.1
Bobonaro	14,338	49,161	3.4	11.7
Covalima	10,343	39,604	3.8	9.4
Dili	17,038	43,993	2.6	10.5
Ermera	14,660	31,537	2.2	7.5
Lautém	9,856	35,442	3.6	8.5
Liquiçá	9,802	26,112	2.7	6.2
Manatuto	5,815	18,804	3.2	4.5
Manufahi	7,442	25,092	3.4	6.0
SAR of Oecusse	10,913	29,003	2.7	6.9
Viqueque	12,348	40,792	3.3	9.7

Lowest populations

Highest populations

Appendix 2A: Available sources of carbohydrates, protein for feeding pigs

Table 1: Sources of carbohydrates available for pigs in Timor-Leste (Figure quoted is average of several reference sites such as Feedipedia)

Resources	Availability	DE MJ/kg	CP
Rice bran	Not available year round	20	14
Rice hulls	Not available year round	16	4
Maize		18	8
Cassava	Needs to be dried or cooked	16	4
Sweet potato	Lack of availability	12	5
Banana Fruit	Define availability	31 (ripe/green)	3
Banana leaf	Define availability	17	7
Soybean hulls	Supply problems due to disease	18	13
Mung beans	Limit to 10% diet	15	24
Brewers grain dried	Max 10% in diet	20 – 24	28 – 30
Brewer's yeast	Local source only	15	60

Table 2: Protein sources for pigs in Timor-Leste (Figure quoted is average of several reference sites such as Feedipedia)

Resources	Availability	DE MJ/kg	CP
Rice bran	Not available year round	20	14
Rice hulls	Availability uncertain	16	4
Sweet potato vines	Freshly harvested / availability?	14	16
Sago	Availability needs defining	11	15
Leucaena	Recommended 10% of diet (limit 15%)	4	25
Peanuts	Expensive source of protein	14	43
Soybean	Must be heat treated – local disease probs	19	38
Soybean meal	Can be imported if price is right	20	50
Soybean hulls	Supply problems due to disease	18	13
Cassava Leaf	Fresh or dried	7	28
Mung beans	Limit to 10% diet	15	24
Pumpkin	Need feasibility survey but widespread	5	16
Coconut	Availability localised	16	20
Copra	Availability localised	12	22
Brewers grain dried	Max 10% diet	20 – 24	28 – 30
Brewer's yeast	Localised source	15	50
Dried fish	Need feasibility survey	3	60

Table 3: Forage and foliage sources of protein for pigs in Timor-Leste

Resources	Availability	DE MJ/kg	CP
SP + pasture silage	Increase labour	8 – 13	12 -14
Legume pasture *Puerasia cephaloides* *Centrosema sp* *Calopogonium sp* *Stylosanthes guianensis*	Need to survey what is available and what grows well in TL.	 3 – 5 3 – 5 3 – 5 3 – 5	 12 – 20 15 – 25 13 – 24 12 – 18
Fodder trees *Leucaena* *Gliricidia sepium* *Erythrina variegate*	Need to survey what is available Fresh or as dried meal Wilting may improve intake Least palatable for pigs	 4 – 5 4 – 5 2 – 3	 24 – 36 18 – 30 25 – 35

Appendix 2B: Cost of energy and protein based on unit cost per commodity

Table 1: Cost of ingredients in terms of price/unit of DE

Resources	DE MJ/kg	Cost/kg	Cost/MJ DE
Rice hulls	16	0.30	0.02
Rice bran	20	0.50	0.025
Maize	18	0.52	0.03
Soybean	19	0.80	0.04
Sago	11	0.50	0.045
Cassava	16	1.00	0.06
Mung beans	15	1.00	0.07

Table 2: Cost of ingredients in terms of price/unit of protein

Resources	CP	Cost/kg	Cost/Unit Protein
Copra	22	0.20	0.01
Coconut	20	0.20	0.01
Soybean	38	0.80	0.02
Rice bran	14	0.50	0.035
Sago	15	0.50	0.035
Soybean hulls	13	0.50	0.04
Mung beans	24	1.00	0.04
Dried fish (Baucau)	60	2.50	0.04
Dried fish (Dili)	60	5.00	0.08

Table 3: Cost of imported ingredients in terms of cost/unit of protein

Resources	CP	Cost/kg	Cost/Unit Protein
Soybean at different quoted prices			
Soybean meal	51	0.80	0.016
Soybean meal	51	1.00	0.02
Soybean meal	51	1.50	0.03
Commercial pellets at different prices			
Commercial pellets	16	0.70	0.05
Commercial pellets	16	1.00	0.06
Commercial pellets	16	1.50	0.09
Meat Meal at different prices			
Meat Meal	55	0.60	0.011
Meat Meal	55	0.80	0.015
Meat Meal	55	1.00	0.014

Appendix 3A: Diets being used in pig production projects and private farms

Table 1: Specifications of diet used in Liabote MAF Project

Ingredient	Proportion in diet	DE (MJ/kg)	CP
Nutrient requirement		**12.8**	**16.2**
Rice bran	30	20	14
Cassava	5	16	4
Maize	60	18	8
Banana	**5**	31	3
Diet specifications	**100**	**19.2**	**9.4**
Total daily intake	**1855**	**35.5**	**173.4**
Difference between required and offered		**+6.4**	**-6.8**

Comments: Pigs fed this diets were poorly grown and very lean

Table 2A: Specifications of GIZ project diet

Ingredient	Proportion in diet	DE (MJ/kg)	CP
Nutrient requirement		**12.8**	**16.2**
Rice bran	17	20	14
Cassava	3	16	4
Maize	57	18	8
Soyabean	12	19	38
Dried fish	11	3	60
Diet specifications	**100**	**16.75**	**18.22**
Total daily intake	**1855**	**31.07**	**338.0**
Difference between required and offered		**+3.95**	**+2.02**

Comments: Pigs fed this diet were moderately well grown and in medium body condition.

Table 2B: Specifications of GIZ project diet with 6% less fish meal

Ingredient	Proportion in diet	DE (MJ/kg)	CP
Nutrient requirement		**12.8**	**16.2**
Rice bran	20 (+3)	20	14
Cassava	3	16	4
Maize	57	18	8
Soybean	15 (+3)	19	38
Dried fish	5 (-6)	3	60
Diet specifications	**100**	**17.7**	**16.2**
Total daily intake	**1855**	**32.9**	**300.1**
Difference between required and offered		**+5**	**0.0**

Table 3: Specifications corn diet used on private farm at Hera

Ingredient	Proportion in diet	DE (MJ/kg)	CP
Nutrient requirement		**12.8**	**16.2**
Maize	100	18	8
Diet specifications	**100**	**18**	**8**
Total daily intake	**1855**	**43.4**	**138.4**
Difference between required and offered		**+5.2**	**-8.2**

Comments: Pigs were well grown and in good condition. They appeared very healthy but although the manager claimed they only received corn, there were bags of commercial pellets on the farm that had been imported from the Philippines.

Table 4: Specifications of diet developed at University Field Station

Ingredient	Proportion in diet	DE (MJ/kg)	CP
Nutrient requirement		**12.8**	**16.2**
Rice bran	55	20	14
Cassava leaf	8	7	18
Maize	22	18	8
Leucaena leaf meal[a]	15	4	25
Diet specifications	**100**	**16.12**	**14.4**
Total daily intake	**1855**	**29.9**	**271.8**
Difference between required and offered		**+3.32**	**-1.55**

Comments: Pigs fed this diet were moderately well grown and they were in fat condition.

[a] Leucaena leaf meal is dried leucaena leaves and has slightly higher DE and protein values to fresh leaves.

Table 5A: Specifications of Baucau GIZ-MAF project diet using copra meal

Ingredient	Proportion in diet	DE (MJ/kg)	CP
Nutrient requirement		**12.8**	**16.2**
Dried fish	2	3	60
Rice bran	25	20	14
Leucaena	5	4	25
Maize	40	18	8
Mung Beans	10	15	24
Copra meal	5	12	22
Sago	13	11	15
Coconut fresh	0	16	20
Diet specifications	**100**	**16.00**	**14.60**
Total daily intake	**1855**	**29.66**	**270.8**
Difference between required and offered		**+30.2**	**-1.6**

Comments: Pigs fed this diet were well grown but their body condition varied from thin to moderate. There was evidence of sarcoptes mites and they may have been afftected by internal parasites.

Table 5B: Specifications of Baucau GIZ-MAF project diet using coconut instead of copra meal

Ingredient	Proportion in diet	DE (MJ/kg)	CP
Nutrient requirement		**12.8**	**16.2**
Dried fish	2	3	60
Rice bran	25	20	14
Leucaena	5	4	25
Maize	40	18	8
Mung Beans	10	15	24
Copra meal	0	12	22
Sago	13	11	15
Coconut fresh	5	16	20
Diet specifications	**100**	**16.2**	**14.5**
Total daily intake	**1855**	**30.0**	**269.0**
Difference between required and offered		**+3.4**	**-1.7**

Appendix 3B: Cost of diets being used in pig production projects and private farms

Table 1: Cost of Baucau GIZ-MAF project diet using copra meal

Ingredient	% in diet	Cost $/kg	Cost/100kg
White and yellow corn	40	0.52	20.80
Leucaena leaf dried	5	-	-
Coconut (copra)	5	0.20	1.00
Rice hulls	25	0.30	7.50
Dry fish	2	2.50 (5.00 Dili)	5.00 / 10.00
Mung beans	10	1.00	10.00
Sago	13	0.50/block	6.50
TOTAL	**100**		**$50.30 / $55.80**
Price/kg			**$0.50 / $0.56**

Table 2: Cost of the University Field Station diet

Ingredient	% in diet	Cost $/kg	Cost/100kg
Rice bran	55	0.50	27.50
Cassava leaf	8	-	0
Maize	22	0.52	11.44
Leucaena leaf meal	15	-	0
TOTAL	**100**		**$38.94**
Price/kg			**$0.39**

Table 3: Cost of diet used in Liabote MAF Project

Ingredient	% in diet	Cost $/kg	Cost/100kg
Rice bran	30	0.50	15.00
Cassava	5	0.20	1.00
Maize	60	0.52	31.20
Banana	5	-	-
TOTAL	**100**		**$47.20**
Price/kg diet			**$0.47**

Table 4A: Cost of GIZ MAF Project Diet

Ingredient	% in diet	Cost $/kg	Cost/100kg
Rice bran	17	0.50	8.50
Cassava	3	0.20	0.60
Maize	57	0.52	29.64
Soyabean	12	0.80	9.60
Dried fish	11	2.50 / 5.00	27.50 / 55.00
TOTAL	**100**		**$75.84 / $103.34**
Price/kg Diet			**$0.76 / $1.03**

Table 4B: Cost of GIZ MAF Project Diet

Ingredient	% in Diet	Cost $/kg	Cost of 100kg of Diet
Rice bran	20 (+3)	0.50	10.00
Cassava	3	0.20	0.60
Maize	57	0.52	29.64
Soyabean	15 (+3)	0.80	12.00
Dried Fish	5 (-6)	2.50 / 5.00	12.50 / 25.00
TOTAL	**100**		**$64.74 / $77.24**
Price/kg Diet			**$0.65 / $0.77**

Appendix 3C: Example diets using a range of local and imported products

Table 1A: Diet based on maize, rice bran, copra meal, dried fish, pumpkin and leucaena leaves

Ingredient	% in diet	DE (MJ/kg)	% CP	Cost $/kg	Cost $/100kg
Nutrient requirement		**12.8**	**16.2**		
Maize	35	18	8	0.52	18.20
Rice bran	30	20	14	0.50	15.00
Copra meal	13	12	22	0.20	2.60
Dried fish	2	3	60	2.50	5.00
Pumpkin	10	3	16	0.00	0.00
Leucaena leaf meal	10	4	25	0.00	0.00
Diet specifications	**100**	**14.62**	**15.16**		
Cost/100kg					**$ 40.80**
Cost/kg					**$ 0.41**

Table 1B: Table 1A diet with rice bran replaced with rice hulls to reduce cost from 41 cents to 35 cents/kg. However, protein is only 12%

Ingredient	% in diet	DE (MJ/kg)	% CP	Cost $/kg	Cost $/100kg
Nutrient requirement		12.8	16.2		
Maize	35	18	8	0.52	18.20
Rice hulls	30	16	4	0.30	9.00
Copra meal	13	12	22	0.20	2.60
Dried fish	2	3	60	2.50	5.00
Pumpkin	10	3	16	0.00	0.00
Leucaena leaf meal	10	4	25	0.00	0.00
Diet specifications	**100**	**13.42**	**12.16**		
Cost/100kg					**$ 34.80**
Cost/kg					**$ 0.35**

Table 1C: Table 1A diet with 15% rice bran and 15% rice hulls which reduces cost from 41 to 38 cents but provides almost 14% protein.

Ingredient	% in diet	DE (MJ/kg)	% CP	Cost $/kg	Cost $/100kg
Nutrient requirement		12.8	16.2		
Maize	35	18	8	0.52	18.20
Rice bran	15	20	14	0.50	7.50
Rice hulls	15	16	4	0.30	4.50

Ingredient	% in diet	DE (MJ/kg)	% CP	Cost $/kg	Cost $/100kg
Copra meal	13	12	22	0.20	2.60
Dried fish	2	3	60	2.50	5.00
Pumpkin	10	3	16	0.00	0.00
Leucaena leaf meal	10	4	25	0.00	0.00
Diet specifications	**100**	**14.02**	**13.7**		
Cost/100kg					**$ 37.80**
Cost/kg					**$ 0.38**

Table 1D: Table 1B diet with 10% maize replaced with 5% copra meal and 5% leucaena leaves to provide a low cost diet with almost 14% protein

Ingredient	% in diet	DE (MJ/kg)	% CP	Cost $/kg	Cost $/100kg
Nutrient requirement		12.8	16.2		
Maize	25	18	8	0.52	13.00
Rice hulls	30	16	4	0.30	9.00
Copra meal	18	12	22	0.20	3.60
Dried fish	2	2	60	2.50	5.00
Pumpkin	10	3	16	0.00	0.00
Leucaena leaf meal	15	4	25	0.00	0.00
Diet specifications	**100**	**12.42**	**13.71**		
Cost/100kg					**$ 30.60**
Cost/kg					**$ 0.31**

Comment: These examples demonstrate how it is possible to reduce the cost of a diet while maintaining adequate levels of energy and protein.

Table 2A: Sample diet using 20% imported soybean meal ($1.50/kg) to replace dried fish and reduce copra meal to 5%. Diet is high in protein and energy but not cost-effective.

Ingredient	% in diet	DE (MJ/kg)	% CP	Cost $/kg	Cost $/100kg
Nutrient requirement		**12.8**	**16.2**		
Maize	25	18	4	0.52	13.00
Rice hulls	30	16	4	0.30	9.00
Copra meal	5	12	22	0.20	1.00
Soybean meal	20	20	50	1.50	30.00
Pumpkin	10	3	16	0.00	0.00
Leucaena leaf meal	10	4	25	0.00	0.00
Diet specifications	**100**	**14.05**	**18.4**		
Cost/100kg					**$ 53.00**
Cost/kg					**$ 0.53**

Table 2B: Sample diet using 20% imported soybean meal ($1.00/kg) to replace dried fish and reduce copra meal to 5%. Diet is high in protein and energy but not cost-effective.

Ingredient	% in diet	DE (MJ/kg)	% CP	Cost $/kg	Cost $/100kg
Nutrient requirement		**12.8**	**16.2**		
Maize	25	18	4	0.52	13.00
Rice hulls	30	16	4	0.30	9.00
Copra meal	5	12	22	0.20	1.00
Soybean meal	20	20	50	1.00	20.00
Pumpkin	10	3	16	0.00	0.00
Leucaena leaf meal	10	4	25	0.00	0.00
Diet specifications	**100**	**14.05**	**18.4**		
Cost/100kg					**$ 43.00**
Cost/kg					**$ 0.43**

Table 2C: Sample diet using 10% imported soybean meal ($1.00/kg) to replace dried fish and increase copra meal to 15%. Diet is high in protein and energy and cost-effective.

Ingredient	% in diet	DE (MJ/kg)	% CP	Cost $/kg	Cost $/100kg
Nutrient requirement		**12.8**	**16.2**		
Maize	25	18	4	0.52	15.60
Rice hulls	30	16	4	0.30	9.00
Copra meal	15	12	22	0.20	3.00
Soybean meal	10	20	50	1.00	10.00
Pumpkin	10	3	16	0.00	0.00
Leucaena leaf meal	10	4	25	0.00	0.00
Diet specifications	**100**	**13.8**	**15.6**		
Cost/100kg					**$ 37.60**
Cost/kg					**$ 0.38**

Comment: Diets 2A to 2C demonstrate how expensive imported ingredients can be diluted with local ingredients to reduce cost while maintaining protein and energy levels.

Table 3A: Sample diet using 25% commercial pellets ($0.80) as a source of protein and energy with 20% rice bran – the diet is adequate in protein but only marginally cost-effective. However it will supply a range of minerals, vitamins and amino acids.

Ingredient	% in diet	DE (MJ/kg)	% CP	Cost $/kg	Cost $/100kg
Nutrient requirement		12.8	16.2		
Maize	15	18	8	0.52	7.80
Rice bran	20	20	14	0.50	10.00
Copra meal	10	12	22	0.20	2.00

Ingredient	% in diet	DE (MJ/kg)	% CP	Cost $/kg	Cost $/100kg
Banana	10	31	3	0.00	0.00
Pumpkin	10	3	16	0.00	0.00
Leucaena leaf	10	4	25	0.00	0.00
Commercial pellets	25	14	16	0.80	20.00
Diet specifications %	**100**	**15.2**	**14.6**		
Cost/100kg					**$39.80**
Cost/kg					**$0.40**

Table 3B: Sample diet using 25% commercial pellets ($0.80) as a source of protein and energy with 20% rice hulls – the diet is low in protein but cost-effective. However it will supply a range of minerals, vitamins and amino acids.

Ingredient	% in diet	DE (MJ/kg)	% CP	Cost $/kg	Cost $/100kg
Nutrient requirement		12.8	16.2		
Maize	15	18	8	0.52	7.80
Rice hulls	20	16	4	0.30	6.00
Copra meal	10	12	22	0.20	2.00
Banana	10	31	3	0.00	0.00
Pumpkin	10	3	16	0.00	0.00
Leucaena leaf	10	4	25	0.00	0.00
Commercial pellets	25	14	16	0.80	20.00
Diet specifications %	**100**	**14.4**	**12.6**		
Cost/100kg					**$35.80**
Cost/kg					**$0.36**

Table 3C: Sample diet using 20% commercial pellets ($0.80) as a source of protein and energy with 20% rice bran – the diet is adequate in protein and marginally cost-effective. However it will supply a range of minerals, vitamins and amino acids.

Ingredient	% in diet	DE (MJ/kg)	% CP	Cost $/kg	Cost $/100kg
Nutrient requirement		12.8	16.2		
Maize	20	18	8	0.52	10.40
Rice bran	20	20	14	0.50	10.00
Copra meal	10	21	22	0.20	2.00
Banana	10	31	3	0.00	0.00
Pumpkin	10	3	16	0.00	0.00
Leucaena leaf	10	4	25	0.00	0.00
Commercial pellets	20	12	16	0.80	16.00

Diet specifications %	**100**	**15.5**	**14.2**		
Cost/100kg					**$38.40**
Cost/kg					**$0.38**

Table 3D: Sample diet using 20% commercial pellets ($1.00/kg) as a source of protein and energy with 20% rice bran – the diet is adequate in protein but not cost-effective.

Ingredient	% in diet	DE (MJ/kg)	% CP	Cost $/kg	Cost $/100kg
Nutrient requirement		12.8	16.2		
Maize	20	18	8	0.52	10.40
Rice bran	20	20	14	0.50	10.00
Copra meal	10	21	22	0.20	2.00
Banana	10	31	3	0.00	0.00
Pumpkin	10	3	16	0.00	0.00
Leucaena leaf	10	4	25	0.00	0.00
Commercial pellets	20	12	16	1.00	20.00
Diet specifications %	**100**	**15.5**	**14.2**		
Cost/100kg					**$42.40**
Cost/kg					**$0.43**

Table 3E: Sample diet using 50% commercial pellets ($1.00/kg) as a source of protein and energy with 25% rice bran and 15% copra meal – the diet is high in protein but not cost-effective. Even at $0.70/kg for pellets the cost of the diet is $0.51/kg.

Ingredient	% in diet	DE (MJ/kg)	% CP	Cost $/kg	Cost $/100kg
Nutrient requirement		12.8	16.2		
Rice bran	25	20	14	0.50	12.50
Copra meal	15	12	22	0.20	3.00
Leucaena leaf	10	4	25	0.00	0.00
Commercial pellets	50	12	16	1.00	50.00
Diet specifications %	**100**	**14.2**	**17.3**		
Cost/100kg					**$65.50**
Cost/kg					**$0.66**

Comments: If the cut-off for a cost-effective diet is below $0.40/kg, then the price of commercial pellets for feeding pigs has to be less than $400/tonne. If used at the 20%, the cost needs to be less than $800/tonne. The quoted price for commercial pellets in Dili is $0.70/kg or $700/tonne.

Table 4A: Table 1B diet with rice bran replaced with rice hulls to reduce cost, and 2% fish and 8% copra meal replaced with meat meal ($0.80/kg) to increase protein levels. Adding 10% meat meal increased diet by 2% protein and 01 cent cost.

Ingredient	% in diet	DE (MJ/kg)	% CP	Cost $/kg	Cost $/100kg
Nutrient requirement		**12.8**	**16.2**		
Maize	35	18	8	0.52	18.20
Rice hulls	30	16	4	0.30	9.00
Copra meal	5	12	22	0.20	1.00
Meat meal	10	10	55	0.80	8.00
Pumpkin	10	3	16	0.00	0.00
Leucaena leaf meal	10	4	25	0.00	0.00
Diet specifications	**100**	**13.4**	**14.7**		
Cost/100kg					**$ 36.20**
Cost/kg					**$ 0.36**

Table 4B: Table 4A with meat meal costing either $1.00 or $1.50/kg. Based on these calculations, meat meal will need to be imported at less than $100 - $120/tonne to be cost-effective.

Ingredient	% in diet	DE (MJ/kg)	% CP	Cost $/kg	Cost $/100kg
Nutrient requirement		**12.8**	**16.2**		
Maize	35	18	8	0.52	18.20
Rice hulls	30	16	4	0.30	9.00
Copra meal	5	12	22	0.20	1.00
Meat meal	10	10	55	1.00/1.50	10.00 / 15.00
Pumpkin	10	3	16	0.00	0.00
Leucaena leaf meal	10	4	25	0.00	0.00
Diet specifications	**100**	**13.4**	**14.7**		
Cost/100kg					**$ 38.20 / $43.20**
Cost/kg					**$ 0.38 / $0.43**

Table 4C: Sample diet using 10% imported meat meal ($0.80/$1.00/kg) as a source of protein, with 10% rice bran and 20% rice hulls and 20% vegetables – the diet is adequate in protein and very cost-effective if meat meal less than $1.50/kg. Even at $1.80 it is marginally cost-effective.

Ingredient	% in diet	DE (MJ/kg)	% CP	Cost $/kg	Cost $/100kg
Nutrient requirement		12.8	16.2		
Maize	15	18	8	0.52	7.80
Rice bran	10	20	14	0.50	5.00
Rice hulls	20	16	4	0.30	6.00
Copra meal	15	21	22	0.20	3.00

Banana	10	31	3	0.00	0.00
Pumpkin	10	3	16	0.00	0.00
Leucaena leaf	10	4	25	0.00	0.00
Meat meal	10	12	16	0.80/1.00/1.80	8.00/10.00/18.00
Diet specifications %	**100**	**14.5**	**16.6**		
Cost/100kg					**$29.80/31.80/39.80**
Cost/kg					**$0.30/ $0.32/ $0.40**

NOTE: Using local fruit and vegetable waste, such as pumpkin and banana, imported meat meal at $1.80/kg is still cost-effective in providing essential amino acids.

Table 4D: Sample diet using 10% imported meat meal ($0.80/$1.00/kg) as a source of protein and energy with 20% rice bran and 30% rice hulls in place of vegetables – the diet is adequate in protein and marginally cost-effective.

Ingredient	% in diet	DE (MJ/kg)	% CP	Cost $/kg	Cost $/100kg
Nutrient requirement		12.8	16.2		
Maize	20	18	8	0.52	10.40
Rice bran	20	20	14	0.50	10.00
Rice hulls	30	16	4	0.30	9.00
Copra meal	10	21	22	0.20	2.00
Leucaena leaf	10	4	25	0.00	0.00
Meat meal	10	12	16	0.80 / 1.00	8.00 / 10.00
Diet specifications %	**100**	**15.0**	**15.8**		
Cost/100kg					**$39.40 / $41.40**
Cost/kg					**$0.39 / $41**

Table 4E: Sample diet using 10% imported meat meal ($0.80/$1.00/kg) as a source of protein and energy with 20% rice bran and 30% rice hulls – the diet is adequate in protein and marginally cost-effective.

Ingredient	% in diet	DE (MJ/kg)	% CP	Cost $/kg	Cost $/100kg
Nutrient requirement		12.8	16.2		
Maize	0	18	8		
Rice bran	30	20	14	0.50	15.00
Rice hulls	40	16	4	0.30	12.00
Copra meal	10	21	22	0.20	2.00
Leucaena leaf	10	4	25	0.00	0.00
Meat meal	10	12	16	0.80 / 1.00	8.00 / 10.00
Diet specifications %	**100**	**15.0**	**16.0**		
Cost/100kg					**$37.00 / $39.00**
Cost/kg					**$0.37 / $39**

Comments: Using local fruit and vegetable waste, such as pumpkin and banana, imported meat meal can be a cost-effective commodity for providing essential amino acids – even at $1.80/kg. If a more traditional diet based on rice bran and rise hulls is used, the price will need to be less than $1.20/kg. otherwise the meat meal will have to be reduced to 5% of the diet.

Appendix 4: Estimated feed costs for producing 6-week old weaners pigs

Table 1: Amount of feed required to feed sow for one year and the cost of producing one 6-week old weaner pig

Average daily intake (Kg)	Total feed yearly feed intake	Number of pigs/sow/year	Amount of sow feed/piglet
2	730	20	36.5
2.5	913	20	45.7
2	730	16	45.6
2.5	913	16	57.1
2	730	12	60.8
2.5	913	12	76.1

Table 2: Cost of producing weaner pigs if feed costs $0.40/kg and average feed intake of sow is 2.0kg/day

Pigs/sow/year	Amount of feed /piglet produced	Cost feed/kg ($)	Cost/piglet ($)
20	36.5	0.40	14.60
16	45.6	0.40	18.24
12	60.8	0.40	24.32

Table 3: Cost of producing weaner pigs if feed costs $0.40/kg and average feed intake of sow is 2.5kg/day

Pigs/sow/year	Amount of feed /piglet produced	Cost feed/kg ($)	Cost/piglet ($)
20	45.7	0.40	18.28
16	57.1	0.40	22.84
12	76.1	0.40	30.44

Table 4: Cost of producing weaner pigs if feed costs $0.50/kg and average feed intake of sow is 2.0kg/day

Pigs/sow/year	Amount of feed /piglet produced	Cost feed/kg ($)	Cost/piglet ($)
20	36.5	0.5	18.25
16	45.6	0.5	22.80
12	60.8	0.5	30.40

Table 5: Cost of producing weaner pigs if feed costs $0.50/kg and average feed intake of sow is 2.5kg/day

Pigs/sow/year	Amount of feed /piglet produced	Cost feed/kg ($)	Cost/piglet ($)
20	45.7	0.5	22.85
16	57.1	0.5	28.55
12	76.1	0.5	38.05

Table 6: Cost of producing weaner pigs if feed costs $0.75/kg and average feed intake of sow is 2.0kg

Pigs/sow/year	Amount of feed /piglet produced	Cost feed/kg ($)	Cost/piglet ($)
20	36.5	0.75	27.38
16	45.6	0.75	34.20
12	60.8	0.75	45.60

Table 7: Cost of producing weaner pigs if feed costs $0.60/kg and average feed intake of sow is 2.5kg

Pigs/sow/year	Amount of feed /piglet produced	Cost feed/kg ($)	Cost/piglet ($)
20	45.7	0.75	34.28
16	57.1	0.75	42.83
12	76.1	0.75	58.08

Appendix 5: Disease and parasite prevalence as recorded by the National Directorate of Veterinary Services

	Prevalence	INTERNAL PARASITES	Prevalence
CSF	**42**	**Strongyloides ransomi**	**21**
Aujeszky's Disease	31	**Coccidiosis**	**19**
		Ascaris suum	**16**
BLOOD PARASITES		Trichuris spp	4
Eperythrozoanosis	25	Hyostrongylus rubidus	2
Porcine Babebiosis	18	Oesophagostomum dentatum	1
Porcine Theileriosis	9	Physocephalus spp	1
		Stephanuris dentatus	1
EXTERNAL PARASITES		Metastrongylus spp	0.5
Sarcoptes scabiei	Observed	Emeria spp	0.5
Porcine Babebiosis	18	Strongyloides papillosus	0.2
Porcine Theileriosis	9	Capillaria spp	0.15
		Trichstrongylus spp	0.1
EXTERNAL PARASITES		Globocephalus spp	0.1
Sarcoptes scabiei	Observed	Macracanthorhynchus	0.1

Other diseases recorded as part of diagnostic sampling include several bacterial infections and Sarcoptes mites which cause mange. The bacterial infections recorded include *Staphylococcus* spp., *Salmonella* spp and *Streptococcus* spp.

However as few of the field disease or diagnostic investigations result in submission of tissues to the laboratory, the actual prevalence of bacterial diseases is unrecorded.

Appendix 6: Design of a rotational foraging developed in Indonesia

The foraging system consisted of 8 large pens approaximately 3 - 5 metres x 8 – 10 metres planted with high protein forage pasture.

Pigs were moved (rotated) to fresh pasture when 50% foliage had been eaten in a laleken.

Laleken 1		Laleken 5
Laleken 2		Laleken 6
Laleken 3		Laleken 7
Laleken 4		Laleken 8

Figure 1: Pigs foraging pasture grass in a laleken.

Appendix 7: Design of a creep box

Figure 1: Wooden creep box in corner of farrowing pen (left). Simple creep box (right).

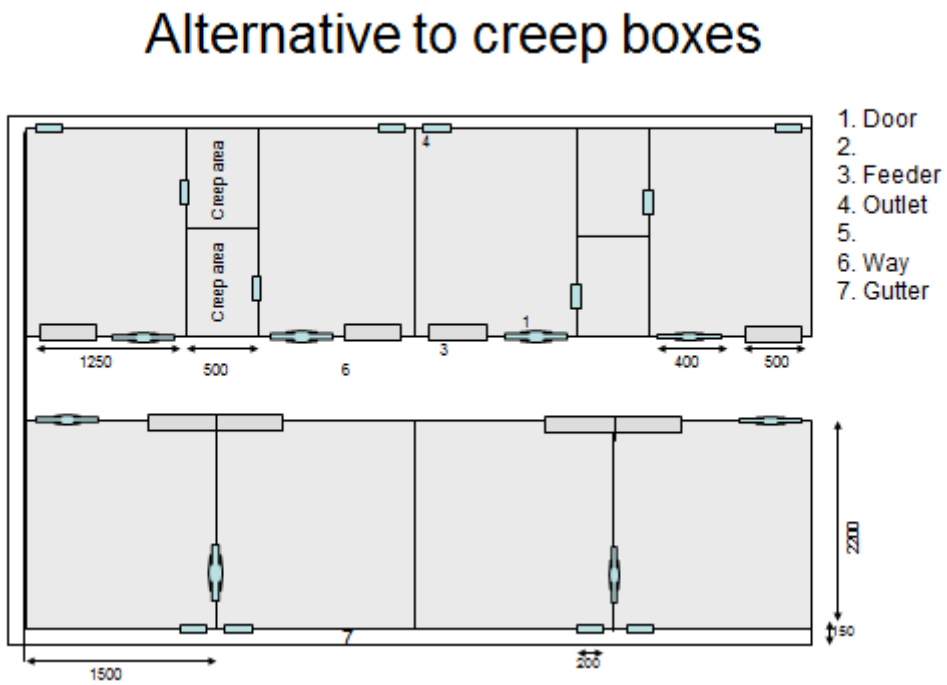

Figure 2: Design of intensive pig house with creep boxes cinstructed between farrowing pens.

Appendix 8: Personnel interviewed and farmers visited

Government		
Antonino do Karmo	National Director for Livestock & Veterinary, MAF	Dili
Joanita Vong	National Director for Veterinary, MAF	Dili
Domingos Gusmão	National Director for Livestock, MAF	Dili
Olavio Morais	MAF Veterinary	Dili
Aleixo Soares	Chief of Department for Livestock, MAF Bobonaro	Maliana
Januario	Chief of Department for Livestock, MAF Baucau	Baucau
Carlito	Dean of Agriculture Faculty, UNTL	Dili
Acacio Guterres	Lecture, UNTL	Dili
Yuliati	Lecture, UNTL	Dili
Acacio Amaral	Lecture, UNTL	Dili
Private Sector		
CJ	Talho Moris butcher shop	Dili
Aniceto Rozario	Pig producer	Hera
Smallholder producer		
Students	UNTL Students	Hera
Filomena Dos Santos	Private	Loes, Suku Uatuboro
Manuel Correia	MAF Beneficiary	Loes, Suku Uatuboro
Leopoldina dos Santos	MAF Beneficiary	Kailaku, Suku Meligu
Maria Mota	MAF Beneficiary	Kailaku, Suku Meligu
Adelina Abosiga	MAF Beneficiary	Kailaku, Suku Meligu
Santina Barreto	MECAE Beneficiary	Maliana, Suku Tapo M
Maria Imelda	MAF Beneficiary	Maliana, Suku Odomau
Bernadino Araujo	MAF Beneficiary	Maliana, Suku Odomau
Adriana dos Reis Morreira	MAF-GIZ Beneficiary	Baucau, Suku Mulia
Benancio da Costa	MAF Beneficiary	Baucau, Diwake
Lorenço da Costa	Private	Baucau, Suku Triloka

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