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Final report

project

Improvement and Sustainability of Sweetpotato-Pig Production Systems to Support Livelihoods in Highland Papua and West Papua, Indonesia

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2 Executive summary

High poverty levels in rural areas and the reported high prevalence of Cysticercosis infections in humans and pigs were the major reasons for developing this project. The dominance of pigs and sweetpotatoes (SP) had also been identified as a major contributing factor to childhood malnutrition in both regions where pigs outnumbered other livestock by more than 30 to 1 and accounted for 84% of farm income.

Significant technical improvements to SP production and pig-raising had already been delivered by an earlier ACIAR project (AH/1998/054) in the Baliem Valley (BV). However, a range of health and production problems needed to be resolved before the full benefits of more efficient pig production model could be captured.

Two workshops, one for crops and one for livestock production, were held in 2008 to consider the issues that had been identified and to record other potential issues. Participants were drawn from Australian agencies, National, Provincial and Regency Government agencies in Indonesia, Universities (University of Papua, Gajah Mada University and Udayana University) and NGO's. The key project partners were the South Australian Research Development Institute (SARDI) (Australia), International Potato Centre (CIP) (International) and Papua Assessment Institute for Agricultural Technology (BPTP) (Indonesia). Close links were developed with other national, provincial and regional government agencies (Research Institute for Legumes and Root Crops - ILETRI and Research Institute for Livestock - Balitnak), Indonesian Universities (University of Papua, Gajah Mada University and Udayana University), Australian Universities (Adelaide and Queensland) and NGOs (World Vision Indonesia - WVI and Oxfam).

The overall aim of the project was to increase food security and human health by improving SP production, storage and processing; improving the productivity of pig production by reducing disease risks to humans and pigs; and developing options to diversify production from the dominant SP-pig system.

The defined objectives were:

- to enhance smallholder returns from sweetpotato production;
- to improve pig production efficiency and reduce human and pig health risks in existing and modified pig confinement systems;
- to develop options to diversify smallholder production systems to take advantage of the increased range and quantity of feeds available;
- to increased skills and income of farmers and to develop, deliver and evaluate training and extension initiatives for the transition of smallholder pig-sweetpotato systems from subsistence to small enterprises in the highlands of Papua and West Papua Provinces.

Separate project teams, with relevant scientists and technicians from local, national and international institutions, were developed for each objective. Project teams were given specific tasks to design and execute participatory action research at community and district level. All research was conducted “on-farm” with one sili (household) in each selected village invited to participate. Regular meetings attended by the farmers and project team members enabled capacity building at all levels and outcomes to be relevant and understood and accepted. An annual review and planning workshop was held each year at which results were presented and assessed and future work planned.

The initial step was to complete a socio-diagnostic survey, in consultation with local government agencies and community groups that included representatives from churches, women, youth and local leaders. Data on SP cultivation and harvest, pig production and other livestock, and the social and cultural issues influencing the lives of the people were collected. A workshop was held to review the data and to review the current knowledge of pig diseases, including endoparasites and parasitic zoonoses, and to establish priorities.

Following a second socio-diagnostic survey designed to identify other crops and livestock already being grown and produced by farmers, a workshop to review options for diversifying smallholder cropping and livestock production systems was held

A series of publications containing the information generated during the project was also planned for the final phase of the project.

One of the major outcomes for SP production was a list of the most productive varieties that can be grown in each region. Salosa, Pattipi, Sawentar, Helaleke, and Worembai were recommended for both areas but several others performed well in one or other of the regions.

Mounding and adding green manure was also shown to be beneficial in increasing SP in the AV. However, there was no beneficial effect in the BV where soil fertility is higher and mounding is universally practiced. Several methods for storing root crops were assessed but the traditional method of storing roots in the ground as a standing crop proved the most effective. Lack of equipment and electricity in villages limited the development of SP processing and techniques were limited to roasting and boiling. Technologies developed had to be simple and applicable to both regions. A series of training programs that demonstrated how to integrate the processing of SP with other vegetable crops were developed.

A Pig Confinement System (PCS) developed in a previous project (AH/1998/054) was adapted to the farming system used in the AV. Pigs are confined overnight in houses with a dry area for sleeping and wet area for food and water, and given access to high protein pasture in small paddocks during the day. The pigs are fed diets based on ensilaged or cooked SP roots and leaves supplemented with high protein pasture grass and golden snails or fish offal. Pigs are also fed either betel nut once weekly or papaya fruit daily to control endoparasites. Pigs husbanded in this system have been shown to grow 6 to 10 times faster than pigs husbanded in the traditional scavenger systems.

Endoparasites were the most prevalent disease recorded in both areas. Species identified were Hyostrongylus spp, Strongyloides spp, Gnathostoma, Ascarids, Globcephalus, Macracanthorhyncus, Oesophagostomum spp., Metastrongylus (lung worm) and Stephanurus (Kidney worm). Trichinella antibodies were detected in only one pig but IgG antibodies to Toxoplasma gondii were found in 55% of pigs. Although Cysticercus cysts were not found in pigs in either location, cysticercii were observed in a majority of pig carcases examined at the local market in Wamena (BV) on five occasions.

The disease control potential of a PCS was measured by comparing 50 pigs husbanded in a PCS with 50 pigs husbanded in the traditional free-range scavenger system over a period of 18 months. The prevalence of most species of endoparasites decreased dramatically in PCS pigs, while increasing in free-range pigs. Similarly the prevalence of antibodies to *C. cellulosae*, Trcihella spp and *T.gondii* in pigs husbanded in a PCS declined during the same period while increasing in free-range pigs. These data validate the benefits of using the PCS model to reduce the prevalence of endoparasite burdens in pigs and reduce the risk of enzoonotic parasites in pork.

The prevalence of pigs infected with *Streptococcus suis* was higher in BV (50%) than AV (30%), and although there was little difference between the prevalence of infection in PCS pigs and non-PCS pigs (38% v 42%), the prevalence of pigs positive on 3 or more consecutive occasions was 50% greater in PCS pigs. This suggests that a carrier pig state may be more likely in confined pigs than non-confined pigs.

A list of crops suitable for climate, altitude and soil types was prepared by team agronomists, giving preference to high protein crops that grew well at higher altitudes. Demonstration plots of each crop were grown to enable comparisons between crops. Farmers in the BV chose red beans, pigeon peas, and soybean and farmers in the AV chose peanuts, string beans and pigeon peas. Strawberries were also selected by the project team for both regions.

Soybean proved to be the easiest to grow and farmers tended to consume 50% and sell 50% for 15,000 IDR/kg (US $1.30). String beans were less successful and pigeon pea was the least favoured. Strawberries were the most successful and most favoured of all the new crops and project farmers now grow these crops without financial support. The expansion of strawberry production in the BV is now being sponsored by the Regency Government.

Monogastric species (rabbits and village poultry) were selected as these species eat the same crops as humans and pigs. They also require little land and the meat is eaten by all religious groups.

Day-old chicks (Kampung Unggul Balitnak – a hybrid strain of village chicken] were purchased and reared until they were 4 months old and then distributed to project farmers. Birds commenced laying at between 7 and 8 months of age and produced well for a further 9 months. Eggs were consumed by families or sold locally for 5,000 IDR/egg (US$ 0.43). As meat from hybrid village chickens is preferred to imported poultry meat, the current price for a full grown bird ranges from 350,000 to 500,000 IDR (US$ 30.00 to 43.00), compared with imported chicken meat which sells for 35,000 to 45,000 IDR/kg (US$ 3.40 to US$ 3.90). Prices are expected to decrease as supply increases. The major challenge for the farmers and project team was to locate cost effective feed sources. As a solution farmers were encouraged to grow corn, soybeans and legumes.

Twelve does and 8 bucks were purchased and 2 does and 1 buck given to each of 4 villagers. Farmers were supported in building rabbit hutches and diets were formulated on local ingredients. Diets contained combinations of SP roots, carrots, and corn, and green leaves according to availability. Green leaves and water \were provided daily, and supplemented with whole corn cobs 2-3 times/month. Families can produce up to 40 rabbits per annum for home consumption, or for sale as live rabbits in local markets.

Rabbits and chickens were also distributed to the Rural Training Centre (World Vision Indonesia) in Wamena (BV) and the Manokwari Agriculture Extension Academy (AV), to enable students and staff to gain skills in village poultry and rabbit production. This was considered a valid step in capacity building.

Extension material, using experience and outcomes from the project, was written in three formats. The first format was produced for Extension Officers, NGO Technicians, students and farmer-trainers and contained the basic information required to establish a pig, poultry or rabbit farming systems, or grow one of the crops, as well as the basic concepts that underpin the methodology. The second format was aimed at farmers, their families and NGO technicians and written in a concise, factual and easy to follow style. Both were supported by photographs and diagrams as appropriate. The third format was a series of one page information sheets using photographs and drawings or cartoons with minimal words to present the information contained in format 2.

Training modules were developed for pig, rabbit and poultry production, SP cultivation, strawberry production, legume crops and storage and processing of products. Over 300 individual men and women from 18 villages in BV and 329 individual men and women from 11 villages in AV participated. Some chose only strawberries and pigs, while others chose multiple crops, as well as rabbits and/or poultry.

The final project activity was an extension workshop to develop plans for on-going extension activities after the project ended. The workshop was attended by local and provincial government extension services, Manokwari Agricultural Extension Academy (STPP), and selected NGOs.

The multidisciplinary approach taken by the project team, which included farmers in all stages of planning and review, proved to be a successful methodology for improving SP and pig production and establishing new crops and livestock production systems. The key outcome from the project was the development of a model for moving farmers from subsistence to small commercial production unit.

3 Background

High poverty levels, as measured by World Bank indicators for health, income and access to services, was a major reason for developing this project in the highlands of Papua (P) and West Papua (WP) Provinces.. For example in 2008, 9/10 people had no access to sanitation, 8/10 did not have electricity and 6/10 children under five were malnourished. The prevalence of Cysticercosis infections in humans and pigs was also the highest in Indonesia.

The dominance of pigs and sweetpotatoes had been identified as a major contributing factor to childhood malnutrition in both regions and in the Baliem Valley (BV), pigs outnumbered other livestock by more than 30 to 1 and accounted for 84% of farm income. One of the main reasons for the dominance of pigs was that they are extremely important for ceremonial and social activities and sweetpotatoes (SP) provided the basic food for humans and pigs. Although much had been written about pig production on the island of New Guinea, productivity in most regions was low and inefficient (Hide 2003).

The high levels of poverty and dependence on the SP-pig system were the main justifications for an earlier ACIAR project (AH/1998/054) in BV, in which significant technical improvements to SP production and pig-raising had been developed. However, a range of health and production problems needed to be resolved before the full benefits of more efficient pig production model could be captured.

The major outcomes from the first project were:

- development of sustainable pig diets based on SP roots and vines, supplemented with a range of other materials including ensilaged roots and vines, fish offal and golden snails, which resulted in village pigs growing 6 to 10 times faster;
- a modified management system for sows and boars that increased production from 1 litter/sow/1.5 years (3 pigs produced/sow/year) to 1.5 litters/sow/year (9 pigs produced/sow/year);
- a pig confinement system based on small paddocks (lalekens) sown with high protein forage pasture with pigs reaching 50 kg liveweight within 6 to 8 months compared with 15 to 24 months previously.

Although farm incomes were increased by 1 to 3 million IDR ($130 to $400) per month, other factors continued to contribute to poverty and malnutrition in the region:

- the importance of the SP-pig system culturally limited opportunities for diversification of both cropping and animal production;
- the risk of malnutrition (calorific insufficiency) was increased by uneven availability of SP throughout the year and lack of diversity in available crops associated with vitamin and nutrient insufficiency;
- pig diets based on SP alone proved too bulky to deliver nutrients to faster growing pigs;
- the risk to pig production at village level by epidemics of classical swine fever (first diagnosed in 2005) and by mortalities associated with *Streptococcus suis*;
- the risk of zoonoses, especially cysticercosis, trichinosis and possibly *Streptococcus suis* was increased by the proximity of pigs and humans in the traditional Sili or household;

A major contributing factor in the success of the first project was the participatory methodology used by the project team. Farmers, along with local government agencies, and NGO's, were included in all stages of experimental planning, execution, and assessment of results. The farmers were also paid for their time and labour, if they

followed protocols agreed to by all partners. They were also invited to participate in the regular project team meetings and send delegates to the annual project review workshop.

While this model worked well for the initial project, it became obvious that a wider base of expertise was required, other than local agencies and NGOs, to solve the problems identified during the initial project.

Two workshops were conducted in 2008 to consider the issues that had been identified or flagged. One workshop considered issues related to crop production and diversification, and the other considered pig production and health, the risks to human health, and diversification of animal production. Participants were drawn from Australian Universities and research agencies, national, provincial and regency government agencies in Indonesia, Universities (University of Papua, Gajah Mada University and Udayana University) and NGO's.

The workshops affirmed the use of the successful research and development strategies developed in the first project but also incorporated successful aspects of other ACIAR projects which have demonstrated early impact. Priority was given to working with end-users (the farmers of Papua and West Papua) to develop new technologies and practices, and demonstrate that, within the limits of a research project, there is measurable impact. Priority was also be given to ensuring that planning and implementation of the research was carried out in close collaboration with the research and development agencies at all levels of Government in Indonesia.

The key project partners selected were the South Australian Research and Development Institute (SARDI), the International Potato Institute (CIP) and the Papua Assessment Institute for Agricultural Technology (BPTP), but close links were developed with other national, provincial and regional government agencies [Research Institute for Legumes and Root Crops (ILETRI) and Research Institute for Livestock (Balitnak)], Indonesian Universities (University of Papua, Gajah Mada University and Udayana University), Australian Universities (Adelaide and Queensland) and NGOs [World Vision Indonesia (WVI) and Oxfam].

4 Objectives

The overall aim of the project was to increase food security and human health by improving SP production, storage and processing; improving the productivity of pig production; reducing disease risks to humans and pigs; and developing options to diversify production from the SP-pig systems.

Objective 1: Enhance smallholder returns from SP production in the highlands of Papua and West Papua Provinces, Indonesia

Objective 2: Improve pig production efficiency and reduce human and pig health risks in existing and modified pig confinement systems appropriate for the highlands of Papua and West Papua.

Objective 3: Develop options to diversify smallholder production systems to take advantage of the increased range and quantity of feeds available, increased output of manure from pigs and increased skills and income of more productive farmers.

Objective 4: To develop, deliver and evaluate training and extension initiatives for the transition of smallholder pig-sweetpotato systems from subsistence to small enterprises in the uplands of Papua and West Papua Provinces.

5 Methodology

General Approach:

Separate project teams, under the leadership of one of the three partners (SARDI, CIP and BPTP), were developed using relevant scientists and technicians from local, national and international institutions. While SARDI had overall responsibility for delivering outcomes across all objectives, CIP had prime responsibility for objective 1, SARDI objective 2 and BPTP objective 3. BPTP and World Vision were the main extension partners with input from the CIP Indonesian Project Manager, Dr Sukendra Mahalaya. However, the Institute for Agriculture Extension (STPP) in Manokwari WP was added later.

Each project team was given specific tasks to design and execute participatory action research at community and district level. All research was conducted "on-farm" with one sili[a] or household in each selected village invited to participate in the project. The key members of the household were included in all stages of planning, assessment and reporting results. Regular meetings attended by the farmers and project team, enabled capacity building at all levels and outcomes to be relevant understood and accepted. An annual review and planning workshop was held each year, at which results were presented and assessed and future work planned.

[a]*sili includes the head of the household, his wife or wives and several related males and females including grandparents and children.*

5.1 Objective 1

Enhance smallholder returns from sweetpotato production in the highlands of Papua and West Papua Provinces.

The initial step was to design a socio-diagnostic survey in the Arfak region of West Papua in consultation with local government agencies and community groups that included representatives from churches, women, youth and local leaders to gather data on SP cultivation and harvest and social and cultural issues influencing the lives of the Arfak people.

A workshop was held to review relevant technology that was available throughout SE Asia and the Pacific for post-harvest storage and processing SP and other commodities into flour. Participants included key people involved in the current provincial programs looking at SP processing, as well as Research scientists from the Root Crop and Sago Research Centre (UNIPA), ILETRI (Malang), and University of Adelaide.

A screening process based on length of growing period, yield and chemical analysis for macro- and micro- nutrients and dry matter content was developed locally. This process was used to screen existing collections of SP varieties (collected from the highlands of Papua and West Papua) for the characteristics required for processing. The screening process methodology was used to select several suitable varieties from those already identified as superior varieties. The aim was to select species suitable for processing and include them in future trials so that the best varieties could be blended with higher-protein legume flours to improve nutritive value.

Note: Although the trials evaluating selected varieties continued, after consultation with several families it was agreed to abandon flour production as the Dani and Arfak people do not have a culture of baking, and do not have the equipment required.

Trials were conducted over two seasons at each site, and SP varieties were evaluated for yield, pest resistance, water content, flavour, texture, and nutrients quality.

The pro-vitamin A carotenoid beta-carotene was analysed in coloured sweet potato and in processed products using high-performance liquid chromatography (HPLC) in the grain quality laboratory of Associate Professor Daryl Mares at Adelaide University. As a back-up for local diagnostic capability, and mineral macro- and micronutrients analysis, SP varieties were analysed for P, K, S, Ca, Mg, Na, Fe, Mn, B, Cu, Mo, Co and Ni using inductively coupled plasma optical emission spectrometry (ICPOES), N using a nitrogen analyser which can be used to estimate total protein content and Se using ICP mass spectrometry at the Waite Analytical Services laboratory, located at Adelaide University.

Recipes that would increase shelf life and provide a more balanced nutritional product were developed. A protein level in the range 20-25% was set as a suitable target.

Although the project was not involved in the development of small-scale processing operations at community level, CIP and ILETRI provided independent technical advice based on relevant post-harvest technologies pioneered in China and East Java. CIP and ILETRI contributed to all of the post-harvest processing activity.

5.2 Objective 2:

Improve pig production efficiency and reduce human and pig health risks in existing and modified pig production systems appropriate for the highlands of Papua and West Papua.

The initial step was to design a socio-diagnostic survey in the Arfak region of West Papua in consultation with local government agencies and community groups that included representatives from churches, women, youth and local leaders to gather data on pig production and social and cultural issues influencing the lives of the Arfak people.

The data from the survey was used to modify and adapt the BV pig Confinement system so that it was compatible with the culture and lifestyle of indigenous communities in the Arfak Villages (AV).

A disease workshop was held to review the current situation in both regions regarding diseases in pigs, including endoparasites and parasitic zoonoses, and establish priorities. Information was drawn from reports prepared by provincial and local government human and animal health agencies, plus inputs from national and international scientists involved in the project.

Outcomes from the workshop were used to review the epidemiology of pig parasites and parasitic zoonoses in terms of the local environment with pigs being husbanded in either traditional or a modified pig confinement system (PCS). This enabled the allocation of resources to the most appropriate activities to produce sustainable results across a number of human and pig health issues.

A cohort of silis were selected and divided into 2 groups – silis that had adopted the PCS (intervention group) and those maintaining the traditional free range scavenger pig systems (non-PCS or control group). Diets in PCS pigs were supplemented with papaya or betel nut and pigs at all sites were treated with oxfendazole once. Pigs were monitored for tissue and gastrointestinal parasites using serological and coprological methods at 3 monthly intervals for 18 months. Soil samples were systematically collected from areas frequented by pigs and checked for the intensity of taenioid eggs. Tonsil swabs were also collected from the same pigs using techniques developed at UGM. The aim was to determine if prevalence and carry state for *Streptococcus suis* infection was influenced by the pig husbandry system used. Statistical associations were made to determine whether any significant differences in parasite prevalence and burden (where applicable) were observed between the intervention and control groups.

All outbreaks of mortalities in selected silis were investigated to determine cause or causes of death. The data collected was used to assess the importance of classical swine fever and Streptococcus suis infections in pigs and develop control methods which complement regional and local initiatives and policy. This last step subsequently became part of a PhD research thesis studying the prevalence and epidemiology of pig disease in the BV (Drh Widi Nugroho reported separately).

5.3 Objective 3:

Develop options to diversify smallholder production systems to take advantage of the increased range and quantity of feeds available, increased output of manure from pigs and increased skills and income of more productive farmers.

The initial step was to design a socio-diagnostic survey to identify other crops and livestock already being grown and produced by small groups of farmers. This provided an understanding of possible compatible commodities acceptable to the farmers. The data was used to select similar crops that were more nutritious or more marketable than existing crops.

The second step was to decide on a selection of crops to be introduced into the farming systems in both BV and AV. Firstly, a list of high protein crops suitable for the altitude and soil types in both locations was prepared by team agronomists. Then the opinions of farmers, extension officers and community groups were obtained and a short list of crops complied. Then a series of demonstration plots was establish to enable the project team and farmers to select crops that were suitable for the region and acceptable to farmers. For example, an area of prepared land was divided into 4 parts and areas planted with one crop (max 3 per experiment) based on expected yield/ha and compared with SP production. Data assessed included yield/ha; value as an animal feed; value as a human food; and work units required for land preparation and planting, growing, harvesting and storage and processing. Views of farmers regarding ease of planting, growing, harvesting, storage and value was obtained and overall sustainability assessed using these data. Experiments were repeated in several locations using selected crops. The most valuable crops were identified and monogastric diets developed for animal feeding trials

Cropping strategies, including mulching (with dried waste plant material), composting of large mounds (with pig manure, kitchen waste and unused plant material), intercropping with legumes and cover crops was investigated for their potential to maintain soil fertility and crop productivity, compared to normal practice (control), using a popular local SP variety. The trials were conducted at three sites in each region over two seasons at the same sites. Yield, mineral nutrients and flavour was also evaluated.

A series of focus group meetings were held to obtain the farmers views in alternate livestock production systems for each region. It was agreed that village chickens and rabbits would be the most suitable species as they were both monogastrics and ate similar diets to humans and pigs, and all cultures eat chicken meat and rabbit.

The FAO model for village rabbit production was adopted and one demonstration unit established in 2 villages in each region. Twelve does and 8 bucks were purchased and 2 does and 1 buck given to each of 4 villagers. Farmers were supported in building the rabbit hutches and were closely supervised by project field staff. All activities were monitored and problems recorded. Diets were developed using locally available crops. Rabbits were also distributed to the Rural Training Centre (World Vision Indonesia) in Wamena (PP) and the Manokwari Agriculture Extension Academy (WP), to enable students and staff to gain skills in village rabbit production. This was considered a valid step in capacity build

A village chicken production model that had been developed by SARDI scientists in other ACIAR projects in the Pacific Region was adopted for egg and poultry production and one demonstration unit established in 2 villages in each region. Two hundred day-old "improved" KUB (Kampung Unggul Balitnak) village chickens were purchased from the Indonesian Institute of Animal Production and reared (under the supervision of the Local Government Livestock Office (Dinas Peternakan)) until they were four months old. Fifteen 4 month old birds (13 females and 2 males) were distributed to farmers in two villages in both BV and AV. Birds were also distributed to the Rural Training Centre (World Vision Indonesia) in Wamena (PP) and the Manokwari Agriculture Extension Academy (WP). All activities were monitored and problems recorded. Diets were developed using locally available crops and egg weight and production recorded. .

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5.4 Objective 4:

To develop, deliver and evaluate training and extension initiatives for the transition of smallholder pig-sweetpotato systems from subsistence to small enterprises in the uplands of Papua and West Papua Provinces.

Objective 4 was added in March 2010 following a Workshop on a major extension and training initiative in West Papua funded by IFAD and Word bank through AusAID and ACIAR.

The initial step was to develop a set of materials for use as training modules for the modified SP-pig farming system developed in the BV between 2001 and 2006.

Working models of the modified farming system developed for SP-pig systems (PCS) was developed in selected villages in consultation with farmers. These models provided the opportunity to adapt the modified system to fit the requirements and land constraints in each community.

Units for individual activities associated with the modified pig-sweetpotato systems, such dunging areas, ensilaging of sweetpotato and pasture grass, growing tree cuttings, were developed at the Manokwari campus of the Agriculture Extension Academy and to the Mandiri Rural Training Centre (World Vision Indonesia) in Wamena to enable student to be trained.

Series of training modules were written by selected project team members based on experience and outcomes from the project and reviewed by other team members. The extension material consisted of two levels of information transfer. The first was a series of single or double sided pages with minimal descriptions, but suitably illustrated, to enable a basic understanding of how to establish and operate each facet of the production system, and published in a manual format with replaceable pages. The second was a book containing more detailed information including the concepts involved in each facet of production, as well as how to build, develop, operate and manage each system. The first format was aimed at farmers, their families and NGO technicians and written in a concise, factual and easy to understand language. The second format was produced for Extension Officers, NGO Technicians, students and farmer-trainers and contained the basic information required to establish a pig, poultry or rabbit farming systems, or grow one of the crops, as well as the basic concepts that underpin the methodology. Both were supported by photographs and diagrams as appropriate. A third format was produced as a series of one page information sheets using photographs and drawings or cartoons with minimal words to present the information contained in format 2.

A group of successful farmers was selected, and provided with the knowledge and skills required to train other farmers.

A series of training workshops was offered in each production system: pig production, village poultry production, rabbit production and various crop production systems.

Finally an Extension Workshop was held at the end of the project to develop plans for on-going extension activities after the project ended. Participants were invited from local and provincial government extension services, the Manokwari Agricultural Extension Academy (STPP), and selected NGOs in BV and AV.

6 Achievements against activities and outputs/milestones

6.1 Objective 1: *To enhance smallholder returns from sweetpotato production in the highlands of Papua and West Papua*

No.	Activity	Outputs/ milestones	Completion date	Comments
1.1	Plan and execute a workshop to review relevant technology and varieties available throughout SE Asia and the Pacific for post-harvest storage and processing SP and other commodities into flour and noodles	Priorities established and methodologies identified for post-harvest storage and processing that can be tested in the local environment. Initial screened list of varieties.	Original date[1]: 03/09	The Objective 1 Workshop was held in Manokwari in March 2009. Participants reviewed the project aims and amended the project plan and activities as follows with a new set of completion dates. The decisions from the workshop were: i) To complete a social diagnostic survey of communities in the AV of Manokwari Regency (*see Activity 2.*1 comments) ***Completed: December 2009*** ii) To select suitable varieties/clones for human food and pig feed ***Completed: December 2010*** iii) To determine the best land preparation and cultivation methods for sweetpotato cultivation in AV – later expanded to include BV. ***Completed in December 2012*** vi) To increase dietary diversity by supplementing with legumes and vegetables, including nutritional enhancement of SP based products ***Completed September 2013***
1.2	Select equipment for purchase and select staff for training in technology required for post-harvest storage and processing of SP	Infrastructure and equipment required for assessing SP varieties for their suitability for processing available locally	Original date: 04/09 Amended date: 09/10	UNIPA purchased equipment for analysis of SP varieties including an Atomic Adsorption Spectrophotometer and PCR equipment and the project provided funds for staff training during 2010. In return UNIPA analysed all samples submitted from project experiments and activities. Guidance is being provided by scientists from both CIP and National Agencies. ***Completed March 2012***

1.3	A screening process based on length of growing period, yield and chemical analysis for macro- and micro- nutrients and dry matter content will be developed based on technology transferred from CIP and National Agencies	The methodology for screening existing collections of SP varieties to enable the selection of varieties suitable for processing established locally	Original date: 06/10 Amended date: 12/10	Twenty cultivars were planted at 3 sites in both the BV and the Minyambouw district in the AV with 3 replications at each site. The 20 varieties were ranked according to yield, biomass above ground, dry matter and water content, thickness of storage root cortex, colour of storage root, colour of storage root flesh, tuber quality shape, uniformity of tuber shape and size, number of cracks in tuber, as well as organoleptic tests for taste, flesh colour, texture, fibrous, sweetness, and appearance. ***Completed June 2102*** ***A full report has been prepared by UNIPA***
1.4	To determine the best land preparation and cultivation methods for sweetpotato cultivation in both the BV and AV [see point iii) in comments from workshop in activity 1.1)	The most suitable land preparation and cultivation methods will be determined to increase SP yield and maximise food security in villages.	***Original date: 12/11*** ***Amended date: 12/12***	**Baliem Valley:** Patipi (9 t/ha) outperformed Salosa (5.8 t/ha) and Helaleke (4.4 t/ha) at all trial sites and in both composted and non-composted mounds. Composting mounds did not appear to make any difference to production at any of the BV trial sites and in fact production was higher for Patipi using soil mounds (11.7 t/ha) than with composted mounds (6.4 t/ha). The results for vine production were similar but vine production was higher for both Salosa (21 v 14.3 t/ha) and Patipi (21.5 v 11.6 t/ha) with soil mounds compared with composted mounds. It also appeared that composted mounds performed better in more fertile soil than less fertile soil. The data suggests that the extra labour required for composting mounds is not warranted. **Arfak Villages:** Patipi out performed Helaleke at all sites and the production of roots in composted mounds was greater (7 t/ha) than in soil mounds (6.1 t/ha) and direct planting (5.6 t/ha). However there was no difference in the production level of vines. The difference in production of roots between composted mounds and soil mounds as well as composted mounds and direct planting was also greater with Patipi than with Helaleke. Hence the data from the AM conflicts with the data from the BV and indicates that there is value in composting mounds. ***Completed May 2013.***
1.5	Plan and complete as series of trials to determine the most suitable storage methods for SP roots in both regions	The most suitable storage methods will be determined to increase food security in villages.	Original date: 06/12 New date: 11/13	The first trial completed in 2012. Leaving roots unharvested was the most successful storage method followed by storing roots in the ground covered by dry grass or sand. The trial was repeated in 2013. ***Completed December 2013***

1.6	Experiments designed to determine appropriate combinations of SP flour and noodles from different varieties (white and orange flesh) plus flour made from other commodities	Combinations of SP flour from a mix of varieties and other commodities available with improved taste and nutritive values	Original date: 12/10 Cancelled	Activity 1.4 was cancelled following the Objective 1 workshop as flour was considered not to be a useful commodity for people living in either the AV or BV. Baking is not an accepted part of the culture. Efforts were concentrated on SP storage technology and crop diversification. ***Completed September 2013***
1.7	Develop and test recipes for nutritionally balanced cooked and processed foods with increased shelf life	Recipes for nutritionally balanced cooked and processed foods snack foods with increased shelf life available for families	Original date: 12/11 Amended date: 09/13	Activity 1.5 was expanded to include processing techniques for local people as well as developing suitable recipes. ***Completed September 2013***

6.2 Objective 2: To improve pig production efficiency and reduce human and pig health risks in existing and modified pig production systems appropriate for the highlands of Papua and West Papua

No.	Activity	Outputs/ milestones	Completion date	Comments
2.1	Design social diagnostic survey in consultation with local government agencies and community groups to gather data on SP cultivation and harvest, pig production and social and cultural issues in 3 Arfak communities	Data from socio-diagnostic survey available to assist in the adaptation of the BV Pig Production system as well as selection of other crops and livestock (objective 3)	Original date[1]: 04/09 Amended date[2]: 10/09	The survey was completed in November 2009 and the data was analysed and presented to the Planning and Review Workshop in Jayapura in October 2010. ***(Completed October 2010)***
2.2	Adapt the BV pig production system to 2 to 3 communities in the Arfak Region	A modified pig production system appropriate for the Arfak region available	Original date: 04/10 Amended date: 01/11	The development of a modified pig production system for the AV was delayed to allow for a pig disease survey to be completed in May 2010. The new target date set at the Objective 2 workshop in July 2009 was 01/11 (***Completed November 2011 with 5 MBVPCS facilities operating)***

2.3	Validate modifications made to BV pig production system (PCS) in the Arfak Region	Changes to the modified pig production system validated with farmers in the Arfak region	Original date: 06/11 Amended date: 09/13	Monitoring of pigs maintained in the modified pig confinement system continued and the final models were presented at a Project Review and Planning Workshop scheduled in October 2013. However, initial responses by farmers were positive and the major problem encountered was difficulty in maintaining stands of high protein forage pasture [*Puerasia cephalpoides* (Sundeleka)]. Other high protein, including Lambiyase (*Sonchus arvensis L.*), Hamboihuy, Abris and Mengkai were trialled. Results of trials to improve cultivation of Sundeleka were disappointing as the Sundeleka appeared unable to compete with weeds in the AV. ***(completed October 2013)***
2.4	Plan and execute disease workshop to establish priorities and review the current situation in both regions for parasitic diseases in pigs, parasitic zoonoses	Review of parasitic disease and parasitic zoonoses in Papua and West Papua. Priorities established for developing improved and sustainable control programs for parasitic disease and parasitic zoonoses in pigs	Original date: 07/09 Amended date: 07/09	The workshop was conducted in July 2009 and a report was published in August 2009. The report detailed the agreement reached for activity plans required to: i) Validate the BV pig confinement system (PCS) to reduce internal parasitic burdens and the prevalence of zoonotic parasites in pigs; ii) Study the epidemiology and improve diagnostic competency of zoonotic parasites in Indonesia; iii) Increase understanding of the epidemiology and improve diagnosis of Classical Swine Fever and Streptococcal infections in pigs in Papua and West Papua. The latter was subsequently became part of a PhD project (drh Widi Nugroho) ***(Report Completed September 2009)***
2.5	Select equipment for purchased and select staff for training in immunodiagnostic and conventional parasitological techniques	Immunodiagnostic and conventional parasitological techniques established in relevant class B and C Veterinary Diagnostic Labs in each Province	Original date: 09/09 Amended date: 12/13	The process commenced with the transfer of technology from University of Queensland to Udayana University in Denpasar along with visits of staff from UQ to UNUD and UNUD to UQ. ***(Completed December 2010)*** The transfer of appropriate technology from UNUD to Maros DIC did not occur because of internal issues. Some transfer of technology from Udayana University to the Class B laboratory in Timika and Class C laboratory in Manokwari occurred and equipment purchased . ***(Completed May 2013)***

2.6	Plan and execute disease workshop to establish priorities and review the current situation in both regions for CSF and *Streptococcus suis* infections in pigs	Review of *Streptococcus suis* infections in pigs in Papua and West Papua published. Priorities established for developing improved and sustainable control programs for *Streptococcus suis* infections in pigs	Original date: 07/09	The review of CSF and Streptococcal infections in pigs in Papua and West Papua Provinces was completed and presented as part of the Objective 2 Workshop in Wamena in July 2009. Workshop participants agreed to a series of activities to establish improved diagnostic and control programs (see 2.4). A small pig disease survey was also undertaken in May 2010 with emphasis on examining pigs in the Arak Villages. Similar to the results of the 2003 survey in the BV, internal parasites were the most significant health problem in both areas in pigs and Cysticercosis was the major health risk identified for humans. ***(Completed reports available)***
2.7	Select equipment for purchased and select staff for training in immunodiagnostic and conventional bacteriological techniques for diagnosis of *Streptococcus suis*	Immunodiagnostic and conventional microbiological techniques established in relevant class B and C Veterinary Diagnostic Labs in each Province	Original date: 09/09 Amended date: 12/13	A biohazard laminar flow cabinet was purchased for the Class B lab in Timika Regency and equipment for coprological examination of faeces for parasites purchased for the Class C lab in Manokwari Regency. Technology for the diagnosis of Streptococcal and other bacterial infections was transferred from UGM to Maros and subsequently to the Class B lab in Timika, the Class C lab in Manokwari and field staff in Wamena. ***(completed September 2013)***
2.8	Cohort of silis (small holder farm units) that either have adopted the modified pig farming systems to use for validation of all disease control programs against traditional farming system (control)	Farmer collaborators selected and experimental model established to validate disease control programs in modified farming systems	Original date: 11/09 Amended date: 09/13	A cohort of silis using the PCS was selected in the BV and renovation of facilities completed. The process was delayed to enable a supplementary disease survey to be completed in May 2010 to detect any changes in pig disease patterns since the original survey in 2003. A set of control silis was also selected for future trials (2.8). The final sampling was completed in the BV in March 2013 and sampling in the AV was completed in June 2013. A review of the data confirmed that the prevalence of endoparasites infestations, based on faecal egg counts, was reduced over time in silis using the PCS whereas the prevalence increased in control silis using a free-range scavenger system. Regular monthly treatment with betel nut further reduces parasite burdens to non-impact levels. ***(Completed July 2013)***

2.9	Experiments designed to investigate methodologies aimed at reducing disease prevalence and risk in pig and human populations	Control programs for reducing disease prevalence and risk in pig and human populations validated and available for socialisation	Continuing to 09/13	The experimental design was developed and agreed to at the Objective 2 workshop in July 2009 and reviewed and amended at the Review and Planning Workshop in Jayapura in October 2010. Sampling of pigs occurred on a regular 3 monthly basis with the final sampling being completed in the BV in March 2013. Sampling in the AV will be completed in June 2013. Serological testing of pigs demonstrated that the prevalence of Cysticercosis reduced over time in pigs husbanded in the PCS whereas prevalence increased in the traditional free range scavenger pigs. ***(Completed July 2013)***
[1]*Original date: Completion date proposed in original proposal document when anticipated project start date was 1st January 2009.* [2]*Amended date: Commencement date was either amended to accommodate for an actual project start date 1st April 2009 or following the Objective 2 workshop to accommodate for increased activities agreed to by the workshop participants*				

PC = partner country, A = Australia

6.3 Objective 3: To develop options to diversify smallholder production systems to take advantage of the increased range and quantity of feeds available, increased output of manure from pigs and increased skills and income of more productive farmers

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1	Design socio-diagnostic and market survey in consultation with local government agencies and community groups to gather data on preferred crops and livestock suitable for integration into the SP-pig farming system in each region	Preferences for crops and livestock suitable for integration into the SP-pig farming system identified and determined in each Region established	3/11 New completion date 09/13	Information on preferred crops and livestock was obtained in the initial diagnostic survey in December 2009. Further information was obtained through focus groups, discussions with individual farmers, extension technicians and students from the BV and AV studying at UNIPA. Option papers on potential crops by Dr Graham Lyons and Dr Wasgito D. Purnomo from UNIPA and potential livestock by Dr Glatz (Village Chickens) and Dr Cargill (Rabbits) were prepared and discussed at the Planning Workshop in October 2011. ***(Completed October 2011)***

3.2	Diversify the range of crops available for feeding humans, pigs, poultry and rabbits	A diversified cropping management model for a village food production will be available for farmers to diversify their crop production to improve human nutrition and increase cash flow.	12/12 Amended date: 09/13	The following crops were introduced into each region: Baliem Valley: Red bean; Soybean; Pigeon pea; strawberry Arfak Villages: Peanuts; String beans, Pigeon pea; strawberry Strawberries were the most popular and successful of the new crops introduced in both regions, with pigeon peas the least popular. Farmers did not know how to make use of the pods and pigeon peas proved hard to sell. Recipes and advice on how to use the pods proved unsuccessful. Trials were also designed to investigate ways that pigeon peas can be used to provide extra protein for pigs, rabbits and poultry but again farmers were reluctant to use them. Trials were designed to determine the effect of pigeon peas on soil fertility by comparing strawberry production when corms are either planted under pigeon peas or in open spaces. Strawberry production is now expanding without project assistance and there is a strong demand for both berries and new plants. Soybean (BV) and string beans (AV) were also successful and the majority of farmers have continued planting these crops. Other successful crops were red beans in the BV and peanuts in the AV. ***(Completed June 2013)***
3.3	Development of a model for village poultry production	A housing and management model for a village poultry production system will be available for farmers to diversify their animal production and increase cash flow.	12/12 Amended date: 09/13	A housing and management model for village poultry production system was developed and was successfully trialled in both the BV and the AV. 100 day old chicks were sourced from Balitnak in Bogor and distributed to project farmers. Mortalities were minimal. A diet based on locally available ingredients was formulated and successfully tested. Housing design varied from farm to farm, and location to location, and no one design appeared to be superior ***(Completed February 2014)***
3.4	Development of a model for village rabbit production	A housing and management model for village a rabbit production system will be available for farmers to diversify their animal production and increase cash flow.	12/12 Amended date: 09/13	An FAO model for a village rabbit production system was adopted and adapted in both the BV and AV. Rabbits were obtained from Java and distributed to project farmers. A diet based on locally available ingredients was formulated and evaluated. Rabbit mortalities were a major problem in the AV where bamboo was used for housing. The bamboo became infested with the powder-post beetle (Dinoderus spp.) and rabbits died from dust inhalation and respiratory infection. As with poultry housing, designs for rabbit housing varied from farm to farm, and location to location. ***(Completed February 2014)***

6.4 Objective 4: To develop, deliver and evaluate training and extension initiatives for the transition of smallholder pig-sweetpotato systems from subsistence to small enterprises in the uplands of Papua and West Papua Provinces.

No.	Activity	Outputs/ Milestones	Completion date	Comments
4.1	Develop a set of materials for use in training modules for the modified pig-sweetpotato farming developed in the BV between 2001 and 2006.	Training materials written, reviewed and translated and printed.	8/10	Objective 4 was added in March 2010 following a Workshop on a major extension and training initiative in West Papua funded by IFAD and Word bank through AusAID and ACIAR. The initiative involved the project team in developing and evaluating a training program to extend outcomes from this project and a previous project (AH 1998/054) to a wider community of farmers. Some of the of training material was available in a set of publications developed during the final 2 years of project AH 1998/054, completed in December 2008. However the material was continually revised and amended as more understanding of farming systems in the AV was gained. ***(Completed June 2014)***
4.2	Plan and develop working models of the modified farming system developed for pig-sweetpotato systems in the BV in consultation with farmers to provide opportunity to adapt the modified system to fit the requirements and land constraints in each community.	Working models of the pig-sweetpotato farming system developed in the BV will be established in selected villages in the Arfak and other nominated regencies	12/10	Five working models of the PCS were developed in 5 villages (Unggah, Nimbiau, Sigim, Sinaitosi and Minyambouw) in the AV and modified as required. ***(Completed October 2011)***
4.3	Design and build units for individual activities associated with the modified pig-sweetpotato systems, such dunging areas, ensilaging of sweetpotato and pasture grass, growing tree cuttings, etc. on the Manokwari campus of UNIPA	Training units for individual activities associated with the modified pig-sweetpotato systems, available at Manokwari campus of UNIPA	Original date: 08/10 Amended date: 12/12	Originally plans were developed by Dr John Randa from UNIPA but the concept was not supported by his colleagues in the Animal Science Faculty. Hence UNIPA declined to accept the funding support. Following consultation with the Principal of the Manokwari Agricultural Extension Academy – STPP (which is part of KEMTAN), a working model of the PCS for training students was erected at the STPP rural campus. As STPP trains technicians for Government departments and NGO's, it was considered to be a more appropriate organisation for our purposes. The project funded scholarships for 3 students each year to complete projects related to our project aims and activities. ***(Completed March 2013)***

4.4	Trial and validate training programs for farmers in selected locations	Farmers trained in the technology and concepts involved in the modified pig-sweetpotato farming system (MBVPCS).	06/11 Amended completion date 12/13	A group of key farmers from the Arfak village of Minyambouw were trained in the crops and animal production systems being modelled and this was extended to other villages over the life of the project. In the BV we supported WVI in developing a PCS model for pigs, as well as housing models for rabbits and poultry at the Mandiri Farm Training School. These were commissioned In December 2012 and were used to train young men from outlying villages in more modern techniques for cropping and animal production. Staff from the Wamena project office, were involved in teaching skills at the Centre. A group of successful farmers was selected, and provided with the knowledge and skills required to train other farmers. Workshops were offered in each animal production system (pig production, village poultry production, rabbit production) and various crop production systems including strawberries. ***(Completed December 2014)***
4.5	Develop posters (showing boards) at all project activity sites to describe the activity and invite farmers to learn about pig, poultry, rabbit production as well as new crop production options.	Provide visual information about the project activities and encourage farmers to participate by developing their own modified farming models based on the project models.	02/13	"Showing boards" were erected at sites in both the BV and AV. As a result several farmers sort more advice on developing the PCS model for their own pig production. ***(Competed October 2014)***

7 Key results and discussion

7.1 Socio-diagnostic survey data

There were approximately 5 people/household in AV households with a range from 3 to 8. One of the most notable figures was the small number of children/family (0-2). The majority of people were aged between 15 and 45 years with few people older than 45 or younger than 15 years. This suggests that either the data is inaccurate or that few people live beyond 50 years.

The staple food in all villages was SP, followed by taro, cassava and rice.

The average household had 3 gardens/household with sizes ranging from 1,600 to 2,100 m2 of which 30 – 54% was allocated for SP.

The SP growing period was 9 to 10 months and 2 planting seasons were recorded – January to April and September to October. Harvesting occurred from August to March with a yield of 3.3 to 4.3 t/ha. Only 12% was sold in the market. Other crops grown included cassava (100% respondents), banana (96%), taro (87%) and potato (85%).

Women spent more time than men on all aspects of crop cultivation, except cutting trees and constructing fences. Women's tasks included removing grasses, burning, dividing land, planting, weeding and harvesting.

7.2 Sweetpotato production

7.2.1 Recommended Varieties

Following a series of variety selection trials in which varieties were ranked according to yield, above ground biomass, dry matter and water content, thickness of storage root cortex, colour of storage root, colour of storage root flesh, tuber quality shape, uniformity of tuber shape and size, number of cracks in tuber, as well as organoleptic tests for taste, flesh colour, texture, fibre, sweetness, and appearance, a list of recommended varieties by rank was prepared.

Varieties recommended for both regions were Salosa, Pattipi, Sawentar, Helaleke, and Worembai, varieties recommended for AV were Numfor-5, Sukuh, Dosak-1 and BB-10 and varieties recommended for BV were Ungu, Ayamurasaki, Cangkuang.

The degree of pest damage and disease was low to non-existent, and carotenoid content ranged from 0 (Nabiri, white flesh) to 226 mg/kg DW (BB-10, dark orange flesh).

7.2.2 Cultivation

Mounding and adding green manure (2 kg of green composting material to each soil mound) significantly increased production of roots in the AV, where mounding is not practiced. However in the BV, where soil fertility is higher and mounding is universally practiced, adding green manure to mounds did not increase production. However, planting shorter length vines did increase production in both areas. The major outcome from this work is that extension agencies will be advised to encourage Arfak farmers to construct mounds and add green leaf material, and to plant shorter length vine cuttings into mounds, rather than direct planting

7.2.3 Storage

Several methods for storing root crops were assessed. Methods included storing SP roots in a hole covered with dry grass or reeds (alang-alang) and then leaves with drainage to

protect the roots from rain; storing SP roots in a hole and then covered with layers of dry sand covered with leaves to keep out water – with drainage to protect roots from rain; and storing roots in the ground as a standing crop, which is the traditional method used by farmers. Other methods assessed were storing roots by hanging them above a kitchen fire, in a *noken* on the ground and covered with dry grass, again with unharvested roots as a control.

The final assessment was that storing roots in the ground as a standing crop was the most successful method. Other methods were open to damage by rodents and other pests and flooding caused by heavy rain.

7.2.4 Processing Sweetpotato

Boiling and roasting were found to be the main methods used by local people for processing SP. Leaves were also consumed after boiling. Rather than develop new technology, it was decided to adopt and adapt current technology that was simple and applicable to both BV and AV and which could include supplementing SP with other vegetables, fruits, and meats.
A series of training programs were developed for women and delivered through farmer groups, Dharma Wanita (Civil servants wives organization), church groups and students (UNIPA, STPP and WVI-Mandiri). The training programs were developed by colleagues from ILETRI and UNIPA and run at the same time as the implementation of training of trainers (ToT), and farmer-to-farmer (F2F) programs.

7.3 Pig Production and Health

7.3.1 Pig Confinement System (PCS)

A pig confinement system (PCS) developed in a previous project (AH/1998/054) was adapted to the farming system used in the AV. Pigs are confined overnight in pig houses divided into a dry area covered with dry grass for sleeping, and wet area for food and water. When released in the morning the pigs are held in a dunging area for 20 to 30 minutes and then confined in one of a number (4 or 8) of small paddocks (laleken) planted with high protein pastures during the day. Pigs forage the high protein pasture during the day and have access to water and shade. Pigs are moved to a fresh laleken when 50% of the leaf material has been consumed. The pigs are fed diets based on ensilaged or cooked SP roots and leaves supplemented with high protein pasture grass, golden snails or fish offal, and either papaya fruit or betel nut to reduce endoparasite burdens.

Pigs husbanded in this system have been shown to grow 6 to 10 times faster than pigs husbanded in the traditional scavenger systems.

7.3.2 Identification of parasites in pigs

A disease survey was completed in 2010 in both the BV and AV and helminth infections of pig were the dominant disease recorded in both areas. However the prevalence of helminth infection was significantly higher in BV. Species identified were Hyostrongylus spp, Strongyloides spp, Gnathostoma, Ascarids, Globcephalus, Macracanthorhyncus, and Oesophagostomum spp. Metastrongylus (lung worm) and Stephanurus (Kidney worm) were only found in pigs in the BV. Trichinella antibodies were detected only in one pig in BV but IgG T-gondii antibodies were found in 55% of all pigs tested. The prevalence of T. gondii IgG antibodies was significantly higher in BV (75.5%) than in AV (25%). Although Cysticercus cysts were not found in pigs in either location, cysticercii were observed in a majority of pig carcases examined at the local market in Wamena (BV) on five separate occasions.

7.3.3 The influence of the PCS on endoparasite burdens

Five PCS households were selected for study together with 5 households practicing traditional scavenging systems (non-PCS) in each region. PCS households were given assistance in constructing a confinement system which incorporated the principles underpinning the PCS, including diets that contained papaya fruits and/or betel nut. Non-PCS farmers continued to produce pigs in the traditional free range scavenger system. Individual faecal samples were collected from rectum (or off the ground if fresh and identifiable), and preserved in sodium acetic formaldehyde (SAF). Faecal samples were qualitatively examined for intestinal parasite stages by the SAF concentration technique (Marti and Escher, 1990).

The overall prevalences of internal parasites decreased dramatically in PCS pigs during the study period (A. suum 14% to 0%, T. suis 47% to 14%, Strongyle type helminths 81% to 8%, Physocephalus spp 6% to 0% and M. apri 20% to 4%), compared with increases in the number of pigs positive for parasite eggs in non-PCS pigs (T. suis 20% to 61%, Strongyle type helminths 60% to 70%, Physocephalus spp. 8% to 19% and M. apri 20% to 40%) and little change in pigs positive for A. suum (18% - 19%). These data validate the benefits of using the PCS model in reducing endoparasite burdens in pigs.

7.3.4 The influence of the PCS on zoonotic parasites

The same PCS and non-PCS households and pigs as described in 7.2.3 were used. All pigs were treated with a single dose of Oxfendazole at 30 mg/kg prior to commencement of sample collection. Blood samples were collected and serum stored at minus 200C until analysis. All serum samples were qualitatively screened for IgG antibodies to C. cellulosae, Trichinella spp. and T. gondii using Enzyme Linked Immunosorbent Assay (ELISA). The seroprevalence of pigs with antibodies against C.cellulosae decreased in PCS pigs from 18% to 14%, but increased in non-PCS pigs from 42% to 52% during the 18-month study period. Antibodies to Trichinella were not detected but the seroprevalence of T. gondii antibodies increased in both groups (from 6% to 10% in PCS pigs and from 8% to 24% in non-PCS pigs).

These data validate the benefits of using the PCS model in reducing or limiting the risk of zoonotic parasites in pork.

7.3.5 The influence of the PCS on the prevalence of *Streptococcus suis* infection

The same PCS and non-PCS households and pigs as described in 7.2.3 were used. Tonsil swabs were collected from each pig and inoculated immediately into individual vials containing 1% pepton water and placed into a cool box with ice for transfer to the Clinical Pathology Laboratory, University of Gadjah Mada. Standard techniques for culturing and isolation were used to identify *S. suis*. Approximately 40% of pigs were positive on one or more occasions and 14% were positive on 3 or more occasions. Pigs from only two (of 10) housholds (one PCS, one non-PCS) in BV and one non-PCS in AV (of 10) were negative at all samplings. The prevalence of infected pigs was higher in BV (50%) than AV (30%), as was the prevalence of pigs with 3 or more positive samples (24% v 4%). The relatively higher pig population in BV and a history of previous serious outbreaks in 2006, may explain the greater reservoir of infection in BV. Although there was little difference between the prevalence of infection in PCS pigs and non-PCS pigs (38% v 42%), the prevalence of pigs positive on 3 or more consecutive occasions was double in PCS pigs (20%) compared with non-PCS (10%). This suggests that a carrier pig state may be more likely in confined pigs than non-confined pigs.

7.4 . Diversifying cropping and animal production

7.4.1 Introduction of new crops

A list of crops suitable for climate, altitude and soil types was prepared by team agronomists and individual interviews and focus groups were used to determine farmer and community preferences. High protein crops that grew at higher altitudes were preferred. Selected new crops were grown in small plots to enable farmers to make observations before deciding. Farmers in the BV chose red beans, pigeon peas, and soybean and farmers in the AV chose peanuts, string beans and pigeon peas. The project team also decided to trial strawberries in both regions as well.

The introduction of the new crops in the BV was relatively successful. Soybean was easy to grow and was harvested at around 100 days. Farmers tended to consume 50% and sell 50% for 15,000 IDR/kg (US $1.30). Red beans were harvested around 90 days after planting and also consumed by the family or sold for Rp 5,000 to RP 10,000/bunch (US$ 0.43 to US$ 0.87/bunch). In AV, peanuts grew successfully and were harvested at between 100 and 120 days. String beans were less successful and pigeon pea was the least favoured as a food source in both regions. Strawberries were the most successful and most favoured of all the new crops in both regions. Berries can be harvested 30 and 40 days after planting in the BV and AV respectively and sold for up to 50,000 IDR/100g (US$ 4.30). Project farmers now grow these crops without financial support from the project. The expansion of strawberry production in the BV is now being sponsored by the Regency Government.

Strawberry production was increased slightly in AV when pigeon peas were grown between rows of strawberries, but not in the BV. Soils in the BV are considered to be more fertile than in the AV.

7.4.2 Diversifying animal production

Selection of species

Monogastric species (rabbits and village poultry) were selected at a focus group meeting of the project team and selected key farmers and a subsequent planning and review workshop. The main reasons for selecting these species were that they eat the same crops as humans and pigs, they require little land, and the meat is eaten by all religious groups.

Village poultry production

Birds were housed in purpose built houses with secure outside runs. The pilot model was 12.5 m2 (2.5 x 5 m) with a similar sized run. Walls were made of wood and roofs of zinc. Similar housing models were developed in AV using bamboo for walls and dried grass for roofs. The concepts and essential features included in the pilot model were explained and demonstrated to farmers. However farmers were free to adapt the plan to their own farms. Nest boxes (50 x 30 cm) were located approximately one meter above the ground and filled with dry grass. Feeders and drinkers were provided but farmers were also free to make replicas of each or design their own. Birds commenced laying at between 7 and 8 months of age and produced well for a further 9 months. The average weight of eggs was around 30 g and the eggs were consumed by families and sold locally for 5,000 IDR/egg (US$ 0.43). As meat from hybrid village chickens is preferred to imported poultry meat, the current price for a full grown bird ranges from 350,000 to 500,000 IDR (US$ 30.50 to 43.50), compared with imported chicken meat which sells for 35,000 to 45,000 IDR/kg (US$ 3.40 to US$ 3.90). No doubt prices will decrease as supply increases.

Farmers were also shown how to set eggs under broody hens to hatch and produce replacement birds.

The major challenge for the farmers and project team was to locate cost effective feed sources. Commercial pellets were available but expensive [20,000 to 25,000 IDR/kg (US$ 1.73 to $2.20/kg)]. Corn also sells for around 20,000 IDR/kg (US$ 1.73). Other available feed sources include SP roots and vines, cassava, legumes, peanuts and corn. As a solution farmers are being encouraged to grow corn, along with the newly introduced soybeans and legumes. Diet formulations were provided to enable farmers to make full use of their own crops.

Village Rabbit production

Accommodation for rabbits was based on standard FAO models and consisted of three cages (30 x 50 cm/cage), situated one meter above ground, with wooden floors and walls, and a thatched roof. A larger thatched or zinc roof (3 x 0.5 m to 4 x 0.5 m) was constructed above the cages to provide extra protection from sun and rain. Initially bamboo was used for floors and walls in AV, but the bamboo became infested with a dust borer, creating dust problems inside the cages. This resulted in several mortalities associated with dust inhalation and respiratory problems. As a result farmers have replaced bamboo with wood. Alternatively farmers can store freshly cut bamboo under water for 14 days, before drying and using, to prevent infestation with dust borers.

Simple diets developed for rabbits contained combinations of SP leaves and roots, cut sundaleka (*Puerasia cephaloides*), cabbage leaves, carrots, and corn, according to availability. Other high protein forage plants such as *Sonchus arvensis, Centrosema* spp, and *Calopogonium* spp, as well as fodder trees (*Erythrina variegata* and *Gliricidia sepium*) were also used. Farmers feed rabbits twice daily with leaf material and three times weekly with raw SP roots. Whole corn cobs are provided 2-3 times/month to help stop rabbits chewing the pen. Water is provided daily.

Families can produce up to 40 rabbits per year either slaughter the rabbits and consume the meat or sell live rabbits in local markets. Full grown rabbits sell for between 500,000 and 800,000 IDR (US$ 43.50 to US$ 70) and 3 month old kittens sell for around 350,000 IDR (US$ 30). Again prices are expected to drop as production increases.

7.4.3 Conclusions

Using a multidisciplinary approach, and including farmers in all stages of planning, proved to be a successful methodology for establishing new crops and livestock production systems in an existing sweetpotato-pig system. Childhood nutrition was improved by the introduction of high protein crops and the availability of eggs on a daily basis. Farm income was increased through the sale of crops, eggs, and meat. The success of the project was demonstrated by the fact that the majority of farmers recruited into the program between 2010 and 2011 did not require financial assistance beyond 2013.

7.5 Training and extension programs

7.5.1 Training materials

The experience and knowledge of the project team, supplemented with experience from the field trials and demonstrations, and farmers' comments and assessments, was used to write a series of extension materials as a basis for training other farmers. The extension material consisted of two levels of information transfer. The first was a series of single one page documents with minimal descriptions, but suitably illustrated, to enable a basic understanding of how to establish and operate each facet of the production system. This was published in a manual format, with replaceable pages, to allow updates to be inserted. The second was a book containing more detailed information including the concepts involved in each facet of production, as well as how to build, develop, operate and manage each system.

Limited copies were published in English but the majority were published in Bahasa Indonesian. As farmers who are not fluent in Bahasa Indonesia tend to be illiterate in their own language, it was decided not to publish the information in local languages.

7.5.2 Working models of cropping and animal production

Working models of the PCS, village poultry and rabbit production units were constructed on selected farms in each region, as well as at the Manokwri Agricultural Extension Academy and the Mandiri Rural Training Centre operated by WVI in Wamena. The former trains students in agriculture and extension and the majority of the graduates are employed by government agencies and NGO's as extensionists and technicians. The latter trains unemployed young men and women in agriculture and animal production. Demonstration crops were also established at both facilities.

"Showing boards", or billboards describing the ACIAR project and its activities were placed on the road at each location where project production systems were located. These attracted many farmers and became an important part of our extension program.

7.5.3 Farmer to farmer training modules

Training modules were developed by the local project team and reviewed by relevant project team members and consultants. These modules were then trialled with a group of farmers selected as trainers to train other farmers. Once the modules had been validated and finalised a series of Farmer to Farmer (F2F) training workshops were planned and advertised.

Modules were developed for pig production (PCS), village rabbit production, village poultry production, sweet potato cultivation, strawberry production, legume crops, and storage and processing of products. Each module consisted of 2 sessions and each session was run over 6 days (3 days/week). Groups were limited to 20 to 25 participants.

In the first (four) series of training workshops, 309 individual men and women from 18 villages in BV and 329 individual men and women from 11 villages in AV participated. Some chose only strawberries and pigs, while others chose multiple crops, as well as rabbits and/or poultry.

7.5.4 Final Extension Workshop

An Extension Workshop was held in Makassar (South Sulawesi Province) at the end of the project and plans for on-going extension activities after the project ended were formulated and agreed to by participants. Unfortunately the workshop had to be relocated outside of Papua and West Papua due to security issues. As well as the project team, workshop participants included senior extension staff from local and provincial government agencies, senior managers of animal health programs in Papua and West Papua Provinces, lecturers from the Manokwari Agricultural Extension Academy (STPP) and field technicians from selected NGOs in BV and AV.

8 Impacts

8.1 Scientific impacts – now and in 5 years

Although the project was not designed to generate significant scientific impacts, scientific progress was made in the diagnosis and control of zoonotic parasites and the cultivation of sweetpotato.

8.1.1 Control and prevention of Zoonoses

The reduction of antibodies to Cystercerii in pigs husbanded in a PCS is a novel scientific finding. This demonstrates an alternate approach to using vaccination to reduce the risk of infection in humans from eating pork. Based on the results from the project, using a PCS model in conjunction with family latrines can be expected to eliminate infection from a community.

8.1.2 Sweet potato cultivation

Planting short vine cutting material into mounds as an alternate to direct planting has already increased SP production in the AV. Provided the technology is more widely promoted by local extension staff, the impact on SP production and food security in the AV should continue.

8.1.3 Diagnosis of *Streptococcus suis* infections

The technology for isolating and identifying *S. suis* from pigs in remote areas was advanced by improved technology developed at UGM. The methodology has been transferred to provincial and regional laboratories in Eastern Indonesia. It is planned to continue this development as part of a PhD study at Roseworthy Campus of the University of Adelaide with the ultimate goal being a simple procedure for identifying *S. suis* that can be used in the field with limited resources.

8.2 Capacity impacts – now and in 5 years

8.2.1 Agricultural extension services

A major impact of the project has been in the training of extension staff and the training of farmers to train other farmers. The training programs have had a significant impact already with over 300 families (638 individuals) attending training sessions and approximately 30 potential extension officers graduating from the Manokwari Agricultural Extension Academy.

Provided local government extension agencies continue to nurture the process and support farmers adopting new practices, the impact in 5 years on both animal and crop production in both regions could be significant.

8.2.2 Analysis of vegetable crops

The purchase of Atomic Adsorption Spectrophotometer and PCR equipment with project funds enabled the Legume Research and Root Crop Research Group at University of Papua (UNIPA) to analyse crops for minerals and other nutrients. This has significantly increased the research capacity of the group and will accrue benefits for at least 10 years.

8.2.3 Control and Diagnosis of endoparasites

The transfer of diagnostic techniques for endoparasites from Udayana University to the local government laboratories in Manokwari and Wamena increased the capacity of local animal health staff to diagnose endoparasite infections and monitor control programs in all species.

The purchase of equipment for the Class C laboratory in Manokwari added to this capacity building.

8.2.4 Diagnosis of zoonotic parasites

The transfer of technology from the University of Queensland to Udayana University has improved the diagnostic and research capabilities of the Departments of Public Health and Parasitology at the University. The working relationship between Udayana University and Queensland, and more latterly Melbourne University, will continue to benefit the research and diagnostic capabilities of the research team at Udayana.

8.2.5 Diagnosis of Streptococcus suis

The field techniques for processing swabs from pigs that were developed by scientists from University of Gajah Mada, significantly increased the efficiency of the laboratory to isolate *Streptococcus suis*. This will enable a more reliable investigation of mortalities and increase diagnostic capabilities for Veterinarians located in isolated communities without direct and immediate access to a laboratory.

The purchase of a laminar flow cabinet for the Class B laboratory in Timika added to this capacity.

8.2.6 Disease diagnosis

Local animal health staff in both regions, including veterinarians, have benefited from working with a number of scientists with specific expertise in disease diagnosis and control. This has included extensive training in post-mortem techniques and collection of specimens for diagnosis. Provided staff continue to work in the regions and train new staff that are recruited, this increased capacity should be maintained.

8.2.7 Socio-diagnostic surveys

Three UNIPA students, whose families live in the Arfak region, were recruited and trained in conducting questionnaire surveys. As a result one student was employed part time as the project Arfak co-ordinator, working with Ir Triono Syahputra the local project Co-ordinator in West Papua (Manokwari).

8.2.8 English language proficiency

There have been a number of major steps taken to increase English language capacity within the project team.

Eight scientists participated in a five-day, hands-on English language writing skills workshop in Bali in July 2010, sponsored by the Crawford Fund and Udayana University.

Ir Triono Syahputra was granted a training award from the Crawford Fund for a 6 week training program at SARDI and Adelaide University in the skills required to develop, manage and review research and development projects.

Ir Isman, the project translator, was also granted a training award by the Crawford Fund to attend a 6-week English language program at Adelaide University.

A scientific writing workshop was held in Bogor in May 2013 at which 9 scientific papers, ready for submission to a journal, were completed. Seven papers were directly related to the project and were published in the proceedings of the 16thAAAP Animal Congress

2014. The other two papers have already been accepted and published in peer reviewed English language journals.

One of the most beneficial decisions made by the project leader was to employ a project translator whose task was to translate emails and reports into either English or Bahasa Indonesia. Email discussion increased significantly when emails were sent to the translator, translated into the alternate language and then emailed to all scientists and technicians involved in the project. This was particularly popular with junior scientists who used the emails to practice and improve their English language skills.

8.3 Community impacts – now and in 5 years

The major community impact has been an increase in the teenage children of project families completing High School and some going onto post-secondary studies.

The availability of eggs and strawberries in local markets has also added to the nutrients available for children.

8.3.1 Economic impacts

Although there has been significant economic impact with individual project families, this has yet to flow on to any significant community impact.

The development of strawberry production is being promoted by the Regional (Local) Government and this is expected to have significant economic impact on farmers and villages where production occurs.

It is also anticipated that as the demand for eggs and rabbit meat increases this will have wider economic impact in village communities.

8.3.2 Social impacts

Little social impact has been accrued directly from the project. However, the increased number of students completing high school and going on to post-secondary and tertiary studies is expected to have social impacts within villages. Based on data recorded for the first project, some of these students have already returned to their communities as Village Health Workers and Teachers.

8.3.3 Environmental impacts

No direct environmental impacts are expected. However, confining pigs could be expected to reduce crop damage and habitat degradation and using live fences may reduce the harvesting of firewood from forests.

8.4 Communication and dissemination activities

8.4.1 Extension materials

As reported above (7.4.3) set of publications outlining the concepts and rationale for the various cropping and animal production systems modified and developed was written by the project team and reviewed by relevant project team members and consultants. Steps on how to build or develop, as well as manage and operate each system were also included. The information was written and presented in three formats.

The first format was produced for Extension Officers, NGO Technicians, students and people who will be training farmers to train other farmers (FtF). This contained the basic information required to establish a pig, poultry or rabbit farming systems, or grow one of

the crops, as well as the basic concepts that underpin the methodology. It was supported by photographs and diagrams as appropriate.

The second format was written for farmers, their families and NGO technicians who provide technical support to farmer networks. This material was concise, factual and easy to follow and limited to single or double sided page. The material was also supported by diagrams and photographs as appropriate.

The third format was a series of one page information sheets using photographs and drawings or cartoons with minimal words to present the information contained in format 2. These were prepared by a small editorial group led by Dr Sukendra Mahalaya and Pak Yan from the Manokwari Agricultural Extension Academy.

All editions were published in Bahasa Indonesia with a small number also published in English.

8.4.2 Farmer training

Groups of farmers have been taken to strawberry growing regions in Java and others to pig, rabbit and poultry production farms in Bali and Java. The farmers selected for these field trips were those who had demonstrated entrepreneurial initiatives in establishing their own production systems.

8.4.3 Farmer training workshops

As reported above (7.4.3) a group of famers was selected to train other farmer using the materials written (8.4.1). In total 309 individual famers and their wives from 18 villages in BV and 329 individual famers and their wives from 11 villages in AM received training. Some chose only strawberries and pigs, while others chose multiple crops, as well as rabbits and/or poultry. The training sessions were divided each week between a day of class meetings, a full day practical session, and a full day field visit to a local farm.

8.4.4 Extension workshop

An extension workshop was held in Makassar in May 2015 at which plans were put in place for on-going extension activities after the project ended. This included the local and provincial government agricultural extension and animal health service, Manokwari Agricultural Extension Academy, and selected NGOs.

8.4.5 Scientific publications

A number of scientific articles were published during the life of the project. These included:

Agustina K. K.; A. T. Syahputra; L. Kossay; A. Soplanit; I B. N. Swacita; I B. M. Oka; I M. Dwinata; S. Mahalaya; I M. Putra; I M. Damriyasa; R. Traub; and C. Cargill (2014). Reducing Zoonotic and Internal Parasite Burdens in Pigs Using a Pig Confinement System. The Proceedings 16th AAAP Conference, Yogyakarta Indonesia 10th-14th November 2014 – p1225-1228.

Cargill, Colin; Sukendra Mahalaya; A.Triono Syahputra; Luther Kossay; Nakeus Muiid; Alberth Soplanit; Graham Lyons; Saraswati Prabawardani; and Phil Glatz (2014). Diversifying Village Animal and Crop Production in Sweetpotato-pig Production Systems. The Proceedings 16th AAAP Conference, Yogyakarta Indonesia 10th-14th November 2014 – p1114-1117.

Cargill, C.F. and S. Mahalaya (2015). Moving families from subsistence animal production to small commercial production using a participatory approach with a multidisciplinary team. The Proceedings 5th International Conference on Sustainable Animal Agriculture for Developing Countries (in press).

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Syahputra, Aris Triono; I Made Putra; Sukendra Mahalaya; Luther Kossay; and Colin Cargill (2014). Using Designated Dunging Areas and Feeding Papaya Fruit and Betel Nut to Reduce Parasite Burdens in Confined Pigs. The Proceedings 16th AAAP Conference, Yogyakarta Indonesia 10th-14th November 2014 – p1221-1224.

9 Conclusions and recommendations

9.1 Conclusions

The multidisciplinary approach taken by the project team, which included farmers in all stages of planning and review, proved to be a successful methodology for improving SP and pig production and establishing new crops and livestock production systems.

A list of higher yielding varieties of SP, suitable for processing was published after a series of production trails and nutritive assessments. The list provides the varieties recommended for the regions in Papua and West Papua Provinces.

Planting short vine cutting material into mounds, as an alternate to direct planting, increased SP production in both the BV and AV. This practice is already widely used in the BV. Mounding and adding green leaf material to the mounds at planting time also increased yield in the AV. Provided the technology is widely promoted by local extension staff, the impact on SP production and food security in the AV will be significant.

The pig confinement system (PCS) developed in the BV in a previous project was adapted for the AV and proved a successful model for improving the efficiency of pig production. The PCS was also shown to reduce endoparasite burdens and the risk of Cysticercosis in pigs. The latter was a novel finding and is one of the few recorded successes of using a pig management system to reduce the prevalence of zoonotic parasites in pigs. It also demonstrates an alternate approach to using vaccination to reduce the risk of infection in humans from eating pork. Using a PCS model in conjunction with family latrines can be expected to eliminate infection from a community.

New crop and livestock production systems were successfully introduced and integrated into the existing sweetpotato-pig system. The introduction of high protein crops and the availability of eggs on a daily basis had a positive effect in reducing childhood nutrition. The sale of crops, eggs, and meat from chickens and rabbits also increased farm incomes. The success of the project was demonstrated by the fact that the majority of farmers recruited into the program between 2010 and 2011 did not require financial assistance beyond 2013.

The publication of a series of extension materials and the development and validation of a model for training farmers using selected farmers as trainers (Farmer to farmer extension) will help to ensure that the outcomes from the project are disseminated widely within the regions where the project was located. The final extension workshop attended by agricultural extension providers from both provinces will increase the area of dissemination and uptake.

The key outcome from the project was the development of a model for moving farmers from subsistence to small commercial production units.

9.2 Recommendations

Several recommendations can be made based on the experience of the project team.

- A multidisciplinary approach, which involves scientists and technicians with a wide range of experience and expertise, and involves farmers and local government agencies in all stages of planning and review, is essential for a successful outcome in projects aimed at changing farming systems and introducing new forms of livestock and crop production.
- Ensuring that strong links are developed between Australian and Indonesian agencies and universities, and between national Indonesian agencies and

universities and local government agencies and NGOs in the field, is essential. This will help ensure that the flow of information and technology and expertise, from universities to local government agencies and NGOs will continue after the project has ended.

- The employment of a translator will aid significantly in capacity building within the project team. Younger inexperienced scientists tended to be reluctant to become involved in email discussions where many of the responses were in English. Once email discussions were routed through the project translator, who translated them and forwarded them in both languages to all participants, the majority of junior Indonesian scientists became more involved in discussions. The increased participation was instrumental in building a much stronger and integrated project team, as well as "special interest" sub-teams and individual personal relationships.
- When establishing projects in either Papua or West Papua, regular access to the project sites by Australian and International scientists must be negotiated as part of the MOU. Otherwise it will lead to frustration and inefficient delivery of expertise.
- Broadly based projects, such as AH/2007/106, need to include market chain development and methodology for building access to regular markets for the increased range of products that result from the project's activities. This was a noted deficiency in planning AH/2007/106.

10 References

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Slipranata, Mitra; A Triono Syahputra; Luther Kossay; Albert Soplanit; Nakeus Muuid; Sukendra Mahalaya; I Made Putra; Siti Isrina Oktavia Salasia; and Colin Cargill (2014). Isolation of Streptococcus suis in Confined Pigs versus Free Range Scavenging Pigs in Indonesia. The Proceedings 16th AAAP Conference, Yogyakarta Indonesia 10th-14th November 2014 – p 1229-1232.

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11 Appendixes

11.1 Appendix 1:

Nil