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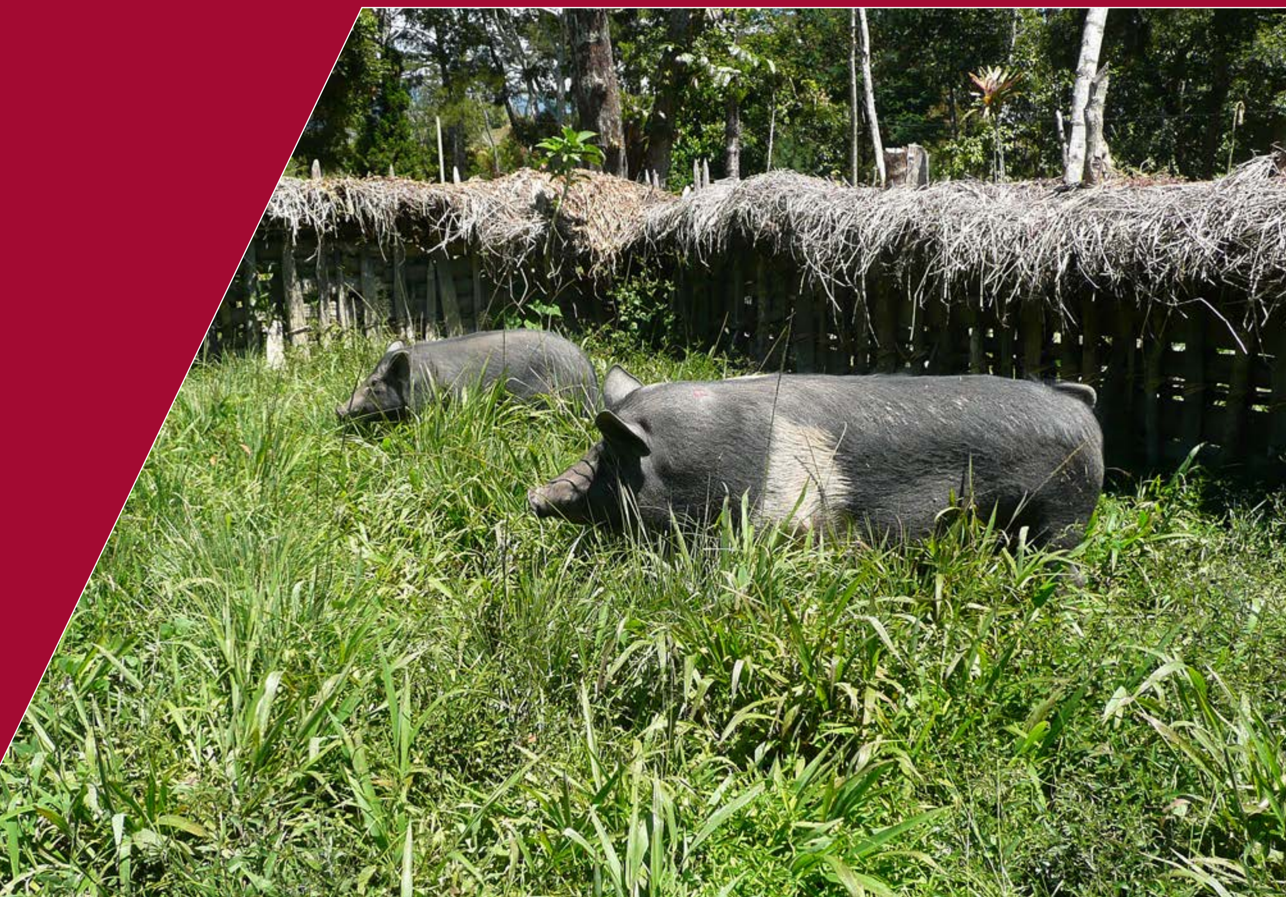
A novel approach to rural development in traditional communities



A history of the establishment of successful research and development projects in the Highlands of Papua Province Indonesia

A novel approach to rural development in traditional communities

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Contents

Introduction

This monograph describes how the first large-scale research and development projects ever to be undertaken in the Baliem Valley in the Highlands of the Indonesian province of Papua were established and conducted over a period of 15 years.

The Baliem Valley has been home to the Dani people for at least 9,000 years, but it was not until the mid-1950s that the first Europeans arrived. Prior to that time, the Dani had had little experience with the outside world, and statistical records did not exist until the recording of births was introduced in the early 1960s.

Between 2001 and 2015, ACIAR funded two major projects in the valley. The first project, AS1/1998/054: '*Poverty Alleviation and Food Security Through Improving the Sweetpotato–Pig Systems in Indonesia*' (Cargill et al. 2009), covered the years 2001 to 2008. This project concentrated on making improvements to sweetpotato production through developing new clones and improving cultivation practices, and modifying pig husbandry through improvements to nutrition, health and management. The second project, AH/2007/106: '*Improvement and Sustainability of Sweetpotato–Pig Production Systems to Support Livelihoods in Highland Papua and West Papua, Indonesia*' (Cargill et al. 2016), ran from 2009 to 2015. This project was designed to diversify both food crop and meat production with the introduction of new crops and livestock systems, and to introduce post-harvest technologies for improving human diets. The overall objective of both projects was to move farmers from subsistence to small commercial production enterprises and increase cash flow.

The International Potato Center (CIP), the South Australian Research and Development Institute (SARDI) and the Papua Assessment Institute for Agricultural Technology—Indonesia (BPTP) were the three key partners, but expertise was also drawn from universities in Australia and Indonesia, and national, provincial and local government agencies in Indonesia. CIP was the lead organisation for the first project with Dr Dai Peters (2001–2003) and Dr Colin Cargill (2003–2008) as project leaders. SARDI took on the project leadership for the second project with Dr Cargill (2009–2015) again as project leader.

While much was achieved by the project teams, this monograph is about the story of the project rather than the outcomes and achievements. It provides a model for working with communities and farmers who have had little if any education and little contact with other farming communities let alone scientists and agricultural technicians. Their main contact with the world outside the Baliem Valley was through the many Christian churches established in the valley, and to a lesser extent Islam.

1. Traditional Systems of the Dani People

INTRODUCTION

The Dani are the traditional inhabitants of the Baliem Valley, which is situated in the Highlands of the Indonesian Province of Papua. Having inhabited the valley for around 9,000 years, they have come to rely almost entirely on the cultivation of sweetpotato and husbandry of pigs for their existence. In fact, the Dani pig–sweetpotato system—which has also been referred to as a human–pig–sweetpotato system—can be regarded as a unique monoculture. While sweetpotato cultivation is unique and quite complex, pig husbandry is extremely unsophisticated.

Although the first recorded contact with the western world was an accidental forced landing of an American airplane in 1938, the first real contact was the arrival of Christian missionaries in 1954. The region was colonised by the Dutch but subsequently became part of the Republic of Indonesia in 1969. Although there have been several visits by anthropologists since the 1960s, there have been relatively few studies with a specific agricultural focus and prior to the commencement of the ACIAR project few authentic in-depth descriptions of the Dani farming system.

GEOGRAPHICAL FEATURES

According to Mahalaya (2010), the Baliem Valley follows the Baliem River and covers approximately 160 km^2 of Jayawijaya Regency in Papua Province. The total area of Jayawijaya Regency in 2001 was almost 15,000 km^2, of which about 90% was covered by forest, with only 13% devoted to farming. Wamena, the only significant town in the Valley, is 1,550 m above sea level and accessible only by air. The bulk of the urban and farming communities lie between 1,470 and 1,850 m above sea level. The valley is rimmed by much higher mountains along both sides, with the highest peak being Aditjondro (Puncak Jaya) at 4,750 m. The soils in general are developed from limestone with poor native fertility, but the majority of cultivated land is situated on clayey–loam–alluvial soil deposited by the Baliem River and its many tributaries.

The climate is described as a humid tropical climate, with a seasonal rainfall. The wettest period is from December to April, but recent recordings suggest that annual rainfall is very variable and has ranged in recent years from 1,266 mm in 1997 to 2,617 mm in 2005. Air temperatures vary little over the year with mean daily temperature being 18 °C in all months except May, when it rises to 19 °C. Mean maximum and minimum temperatures range from the mid-20s down to around 10 °C.

DANI CULTURE AND SOCIAL STRUCTURES

The traditional house or compound of a Dani community is the *sili*—a word used for the traditional house and surrounding enclosure. It also describes the social group of families living within each *sili*. The traditional layout is portrayed in Figures 1. It consists of a men's hut (*pilamo*) located opposite the entrance (*mokarai*), with one or more women's huts (*ebeae*) along the right side between the entrance and the men's house. A long building, which houses the kitchen (*hulina*) and the pig pens (*dawula*), is situated along the left side of the *sili*. The open space in the centre of the *sili* is called the *silimo*, and a pig yard (*laleken*) is attached behind the kitchen and/or the men's hut. At one end of the kitchen there may be several traditional stoves (*wulikin waganek*), which are small holes in the ground where women cook; and at the end adjacent to the men's hut there will be several small pens or even stalls. Although this is a description of the traditional layout of a *sili*, many modern *silis* do not have a *laleken* available for their pigs, and the pigs use the open space in the middle of the compound when not in the house or outside scavenging.

While the number of families or clan members living in one *sili* will vary greatly, one man will be the designated head of *sili* (*kepala sili*). The arrangement between the families in one *sili* is described as *sabokhogon*, which means 'one for all and all for one'; the term also indicates that there is no separate ownership of the sweetpotato gardens and the pigs, however the head of *sili* controls the way the gardens and pigs are used.

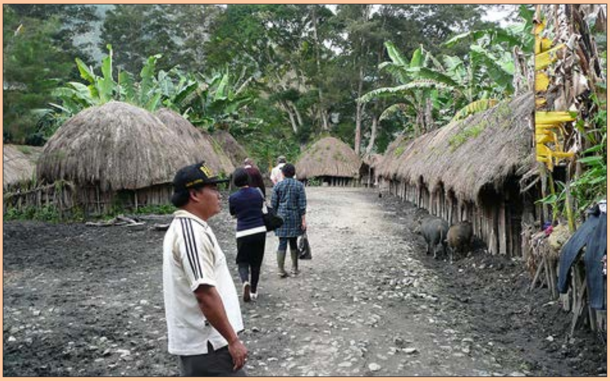


Figure 1: A typical sili with men's house at one end (centre), women's houses located along the left perimeter, and the long cook house and pig pens on the right

TRADITIONAL SWEETPOTATO CULTIVATION

Sweetpotatoes and pigs are the staple crop and livestock for all peoples across the New Guinea land mass, and the Dani are no exception. In 2001, approximately 80% of the land being cultivated by the Dani was devoted to sweetpotato cultivation. Perennial crops such as coffee accounted for about 11% and vegetables and other crops about 5% and 3% respectively.

The Dani employ different cultivation systems for the two main landscapes where sweetpotatoes are cultivated. One is called the 'valley system' (*wen-tinak*) and the other is the 'upland system' (*wen-yawu*). The cultivation systems differ not only in the position the garden occupies in the landscape, but also in the way the land is prepared. In the *wen-tinak*, the drainage system is built first, and the crop is planted in mounds. The upland system can be divided into three sub-systems: *waganak* (the higher part of the valley floor with medium slope), *enapopme* (medium to steep slopes), and *alome* (very steep and/or stony slopes). In the *waganak*, sweetpotatoes are planted in mounds built on naturally well-drained land and drained by small ditches. In the *enapopme*, drains run across the slope on the contour, and sweetpotatoes are planted in beds without mounds but with complete soil tillage. In the higher *alome*, sweetpotatoes are planted directly with dibble sticks without prior tillage. Schneider et al. (1993) estimated that up to 200 cultivars are grown by the Dani, but only 10–40 cultivars are grown in any single garden; in our surveys the figures had fallen to around 70 sweetpotato cultivars in both valley and upland areas, with 7–20 sweetpotato cultivars in a single sweetpotato garden. The farmers' explanation for this decline was that they now select higher yielding cultivars with superior taste for both human food and pig feed. A few cultivars are also reserved for use in traditional ceremonies. Because the sweetpotato is an open-pollinated plant, the Dani are able to develop new cultivars by mixing a number of cultivars in a single garden, and new cultivars with slightly different characteristics will appear over several seasons. Although they plant specific cultivars for pigs and specific cultivars for people, in practice the human cultivars may also be fed to pigs (especially poor-quality roots).

Other differences include size and number. *Silis* entirely in the valley have almost twice as many gardens as upland *silis*, and the gardens are almost double in size too. *Silis* with access to both valley and upland gardens have fewer gardens, which are smaller than valley *silis*, but they have more and larger gardens than upland-only *silis*. Valley *silis* also tend to grow two to three more varieties than the other *silis*, and this may be because the soil is more fertile. As in many cultures, the gardens are not necessarily near the *sili*. Based on surveys, families in *silis* with only valley gardens walk further to their gardens than families with only upland gardens.

Compared with upland gardens, both tilling and harvesting takes longer in the valley gardens, but the growing and fallowing periods are shorter.

Because harvesting can be carried out over long periods (10–14 months), it is difficult to estimate yield accurately. The size of the daily harvest will also vary depending on the size of the family and the number of pigs being fed each day. Most estimates put yields from the valley gardens around 10 t/ha of fresh roots and around 8 t/ha for upland gardens. One of the positives discovered during the project was that harvesting sweetpotato crops over several months proved a very efficient and successful method for storing the roots until needed for sale or consumption.

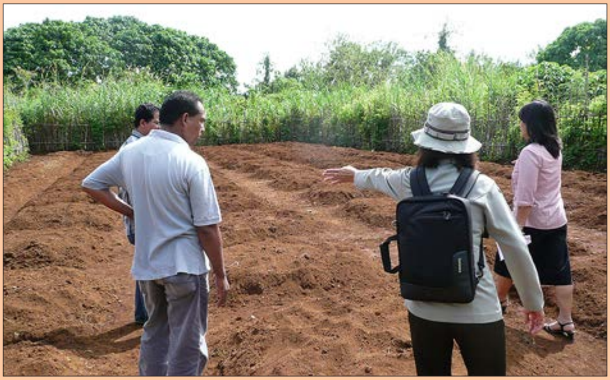


Figure 2: Sweetpotato cultivation—preparing mounds for planting in "valley style sili"

Figure 3: Growing Sweetpotato in rows in upland sili—plantings are in rows with drainage channels

TRADITIONAL PIG PRODUCTION SYSTEMS AND THE ROLE OF PIGS IN SOCIETY

The Dani's management system for pig production is usually described as extensive (Hide, 2003; Peters, 2001), but a more accurate description might be 'free-range scavenger'. Pigs are penned during the night and allowed to roam free to scavenge for food during the day. Traditionally the pigs are fed diets consisting of chopped sweetpotato roots and vines occasionally supplemented with excess garden vegetables.

Previous surveys report that there is a shortage of entire male pigs and that many *silis* do not own an uncastrated male or boar. The reason for this is that the majority of male pigs are castrated because of a belief that castration makes the male pigs grow faster. In fact, it produces a fatter pig, which is preferred in many Melanesian and Polynesian cultures, and in practice only the largest male pigs with the biggest testicles escape castration (Heider, 1970). On the surface this practice of selecting only larger and faster growing pigs as sires would be expected to improve the gene pool, resulting in superior progeny, but the lack of boars limits the opportunity for sows to mate and reduces the likelihood of sows coming into oestrous. The combination of poor diets, insufficient boars, and allowing pigs to wander over large areas, often without access to water, results in a very inefficient pig production system. Based on limited surveys, sows appear to breed only once every two to three years, and their progeny take three to five years to reach 80 to 90 kg body weight.

As described above, the traditional pigsty (*dawula*) has one stall for each pig, and because it has wooden walls and a thatched roof, it is very dark and poorly ventilated. This may explain why respiratory problems such as pneumonia were one of the major problems diagnosed and recorded by the local veterinary service.

Pig production is also highly dependent on sweetpotato production; hence the *silis* with larger, more fertile areas of land carry significantly more pigs of all classes. In a survey by Mahalaya (2010), *silis* in the valley owned 30% more pigs across all classes than the *silis* with access to upland only. Litter size was also around 10% higher in the former group. Mahalaya also calculated the ratio of pigs to people in three different *sili* locations, which ranged from 0.78 pig/person in *silis* with only upland gardens to 0.88 pig/person in *silis* with both valley and upland gardens, and 1.0 pig/person in *silis* with only valley gardens.

Figure 4: Free-range scavenger pigs

One of the negative aspects of free-range scavenger systems was highlighted in 2005 when an outbreak of classical swine fever occurred in the valley, where over 64,000 pigs were reported dead (Disnak Jayawijaya, 2007). The spread of this disease was facilitated by free-roaming pigs, but interestingly no deaths were recorded in pigs kept in modified *lalekens* developed by the project.

HUMAN AND SOCIAL CAPITAL

It was not just bigger gardens and more pigs that were features of the *silis* with access to valley land, but people as well—they had access to a larger labour pool, and because of proximity to the only significant population centre, they also had access to a much better educated and more agriculturally experienced labour pool. While *silis* with access to both valley and upland did not differ significantly from the valley-only *silis* in terms of size, and the education and experience of men, the women in these *silis* were statistically similar to their sisters in the upland *silis*. Both groups of women had less education and agricultural experience than women in valley-floor *silis*. Across all locations women represent the larger proportion of the *sili* workforce and have more experience working with sweetpotatoes. Men, on the other hand, tend to have more education and also more experience working with pigs although in the actual daily work routines, women engage more with both sweetpotatoes and pigs than men.

TRADITIONAL COOKING

While sweetpotatoes are a significant part of the Dani diet, pigs are generally only eaten at special celebrations that require a feast. While the cooking method used on these occasions has similarities to other Melanesian and Polynesian cultures, it is unique to the Dani. Ceremonial slaughter of the pig involves two men holding the pig by the arms at chest height and a third man using a traditional bow to shoot an arrow through its heart. Once the pig is dead, the carcass is bled out and cut into large chunks of unboned meat. The meat is spread out on leaves from banana and other tropical plants and left until the oven is ready. Meanwhile, polished rounded stones, collected from the river bed, are heated in a wood fire to make them ready for use. A thick layer of long dry grass is then laid on the ground to form the base and walls of the above-ground oven that will be used to cook the food. A layer of banana leaves is then spread out in the centre of the grass bed and covered with a layer of hot stones. The stones are covered in turn with more green leaves followed by a layer of meat or sweetpotato or fish. The food layer is again covered with more leaves and hot stones, and the process is repeated until all the food has been added in layers between hot stones and green leaves. The ends of the grass are then pulled up to form the walls of the oven and tied with thin vines used as twine. The oven is then left to steam and cook for several hours until the feast is ready to begin. Following the ceremonial opening of the oven, the meat is shared among the participants, but on the occasions we were present at a *batu bakar* (stone bake), the men were served the best parts of the carcass followed by the boys and finally the women and girls. The latter mainly ate roots and fish.

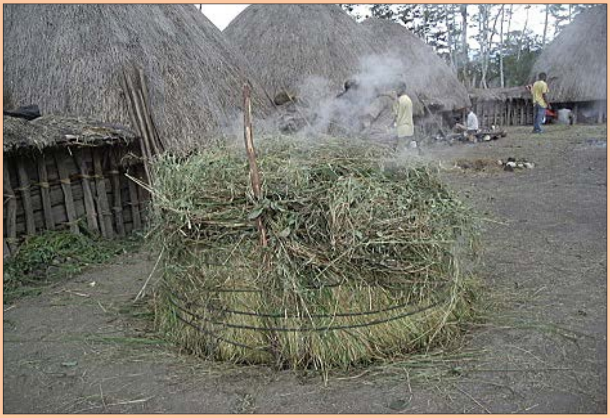


Figure 5: Cooking food in a completed "baka batu"

CULTURE AND TRADITIONS: CHANGES AND CONSTANTS

Although the design and layout of a *sili* as described above is accurate for a traditional *sili*, changes are occurring. For example, in 2006, less than 40% of the valley *silis* kept a *laleken* for pigs; instead the pigs were confined inside the house overnight, held in the centre of the *sili* during early morning and evening, and allowed to run free scavenging for food during the day. The upland *silis* kept even fewer *lalekens* than the valley *silis*. One of the reasons given for the loss of *lalekens* was the general decline in tribal warfare, meaning it was no longer necessary to keep pigs confined. It was also stated that the early missionaries had recommended that pigs be allowed to free-range over uncropped land during the day.

Another significant change in Dani culture was the disappearance of *waloleget* (places for ancestors' souls) and graveyards for ashes and bones of ancestors (*oakleget*). Many Dani villages have converted to Christianity, therefore when members of the *silis* die they are buried in the village graveyard according to Christian traditions. A survey in 2006 by Mahalaya (2010) reported that 78% of *sili* members interviewed stated they were Christian, 1% were Muslim, and 21% refused to state their religion. It is not unreasonable to expect that, with such fundamental cultural changes, a greater openness and receptivity to modern agricultural technology is possible. Such differences within the Dani community should also be considered in development planning.

While changes are occurring in Dani society, the communitarian sense of *sabokhogon* remains unchanged. This was identified in the initial project survey workshops, and repeatedly validated by subsequent surveys, and raises real problems for planning infrastructure and social support by the national and provincial governments as all social surveys and planning throughout the Republic are based on the family household unit. In fact, the number of *silis* is not available at regency or provincial level (i.e. Statistics Bureau), even though it has been collected at the village level. Nevertheless, using the *sili* as a unit of analysis is important because it is the unit through which people operate and communicate with the rest of Papuan society. Consequently, the failure to recognise the unique structure of Dani society may limit the effectiveness of social and community services delivered by regional, provincial and national governments.

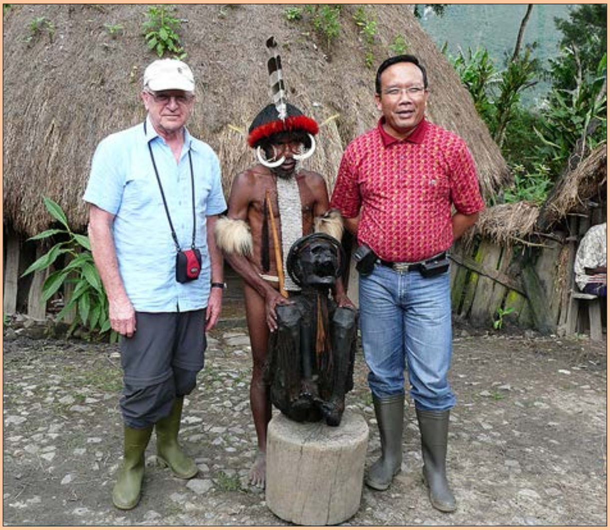


Figure 6: Dr Cargill and Professor Made Damriyasa (Udayana University) with Village Headman and mummy of ancestor

REFERENCES

Disnak Jayawijaya. 2007. *The Jayawijaya Livestock Office Annual Report 2006/2007*. Wamena: Dinas Paternakan Jayawijaya (in Indonesian).

Heider, K.G. 1970. *The Dugum Dani: A Papuan Culture in the Highlands of West New Guinea*. New York, NY: Wenner-Gren Foundation for Anthropological Research.

Hide, R. 2003. Pig husbandry in New Guinea: A literature review and bibliography. Canberra, Australia: Australian Centre for International Agricultural Research.

Mahalaya, S. 2010. *Impact evaluation of agricultural research in Papua Indonesia using the sustainable livelihood framework* (Doctoral dissertation). The University of Adelaide, Australia. Retrieved from https://digital.library.adelaide.edu.au/dspace/handle/2440/67200

Peters, D. 2003. Poverty alleviation and food security through improving human–sweetpotato–pig systems in Papua, Indonesia. In K.O. Fuglie (Ed.), *Progress in potato and sweetpotato research in Indonesia* (pp. 215–224). Bogor, Indonesia: CIP.

Schneider, J., Widyastuti, C.A. and Djazuli, M., 1993. Sweetpotato in the Baliem Valley area, Irian Jaya: A report on collection and study of sweetpotato germplasm, April–May 1993. Bogor, Indonesia: CIP.

2. A Participatory and Multi-Disciplinary Approach to Research and Development to Improve the Livelihoods of Subsistence Farmers

INTRODUCTION AND BACKGROUND

An initial scoping exercise was carried out in 1999. At the time there was little infrastructure that enabled direct access to local communities and little knowledge of the current agriculture and animal husbandry practices used in the Baliem Valley. The majority of published literature describing Papuan agriculture and animal husbandry was based on studies in Papua New Guinea (PNG) with little reference to the western end of the island.

The Baliem Valley was chosen as the preferred location for the project, first, because it was accessible by air; second, because poverty levels there were known to be high; and, third, the local farming practices were assumed to be representative of agriculture and animal production in the Highlands of the Papua Province of Indonesia. Although there were no roads into the valley, there were irregular commercial flights from Jayapura, the provincial capital, which would enable access to the project sites for national and international scientists involved in the project. At the same time, however, it was acknowledged that the isolation and lack of infrastructure would place many restrictions and limitations on developing a project that would have relevance to the other rural communities in the Highlands.

The local government administrative region that covered most of the Baliem Valley in 1999 was the Regency of Jayawijaya (Kabupaten Jayawijaya). It was centred on Wamena, which was the only organised population centre in the valley.

Besides the lack of regular flights into the valley, communities consisted of several *silis* (see Chapter 1) and tended to be isolated and self-managed with a head of village the main decision-maker. It was recognised that the scoping team lacked any understanding of current farming practices or the cultural reasons for those practices. This was compounded by the lack of a clear pathway for making contact with individual farmers and encouraging them to be part of the project. These factors would also make it difficult to recruit local staff with the necessary skills to supervise development and extension projects and gain the cooperation of the farming community.

THE FIRST STEPS

Initially it was agreed that access to the local rural communities could best be achieved through church groups and the Jayawijaya Regency Livestock Office (JLO—Dinas Peternakan Kabupaten Jayawijaya, Wamena). JLO staff were primarily non-Papuan Indonesian nationals who, in general, only had contact with community groups close to Wamena, rather than directly with individuals and the more remote villages. This meant that access to the broader local community was limited, and the problems this could cause became apparent very early in the recruitment process. In the first instance, contact was made via the JLO with farmers who were connected to a Bible school on the edge of Wamena. The school offered to provide a group of farmers as collaborators as well as facilities for on-station trials. When contact was made with the Catholic and Muslim communities, however, it became obvious that having a high-profile connection between the project and the Protestant school would mean that members of the Catholic and Muslim communities would be reluctant to be involved.

A further complication that had not been recognised was the effects of the newly instituted policy of autonomy, under which Papua was to be granted the status of an autonomous region. Further, the policy guaranteed that local government would receive increased revenues from natural resources exploitation, and hence extraordinary sums of money were being promised to local communities. The implication for the project was that it would be difficult to attract collaborators to the project unless we could provide farmers with cash payments similar to what they hoped for under the autonomy program.

These difficulties delayed the commencement of the project, and after six months no villages or farmers had been recruited into the project. The project leader, Dr Dai Peters, then decided to spend several weeks in Wamena in an attempt to make a connection with the local community. She was joined by Dr Colin Cargill, the project animal scientist and veterinarian, and together they made several excursions to villages within a 10 km radius of Wamena. These trips enabled them to observe cropping practices and pig husbandry, and speak to villagers and people they met along the way.

The appointment of Dr Peters as project leader was one of the most significant and important decisions made in the life of the project and a major factor in its ultimate success. Dr Peters was a sociologist employed by CIP, and the value of having a sociologist experienced in rural development cannot be understated. An understanding of how to observe and identify the basic social interactions in a community provided a solid basis for working with the community and developing a soundly based participatory approach for the project. Local farmers and whole villages became an integral part of the project as a result.

Dr Peters had spent several months visiting the Baliem Valley in 1997 and had gained some understanding of community structures and a rudimentary knowledge of the culture. During her visit she had focused on the traditional market where the women from villages gathered to sell their sweetpotato harvest. This prior contact with groups of women proved very useful in gaining the trust of the local people, especially women.

Figure 7: Dr Dai Peters (Project Leader 2001–03) chats with Dani Project coordinator Pak Luther Kossay

Dr Peters had also made contact with an American citizen who was the son of American missionaries and had spent many of his early years living in Wamena and attending a local school. After completing college in the United States, he had had returned to Wamena with his own family and had re-established connections with the local village of Tulem, where his parents had been missionaries. Tulem village is an area approximately 15 km from Wamena. Through this connection, the project team were able to meet with the head of village and his relatives and have preliminary discussions. During these discussions a Dani schoolteacher named Luther Kossay was identified as a possible project coordinator, along with a young man (Sangkok Kerda) whose family also had strong connections with the American citizen. The appointment of a Dani coordinator and an assistant enabled the project leaders to recruit two farmers from Tulem who agreed to be part of the project. Subsequently, with the help of the Dani project coordinator, two other families were recruited, one from Napua and one from Siepkosi. Several other farmers who were approached refused to join the project once they realised that they would not be paid money.

MOVING INTO SECOND GEAR: THE INITIAL SURVEYS

The first activities undertaken were a socioeconomic diagnostic survey and technical and observational surveys. These surveys were necessary to describe common agricultural and animal husbandry practices and to identify the constraints affecting both sweetpotato and pig production in the Baliem Valley. The older women, befriended by Dr Peters previously in the market, helped to recruit young female and male relatives who had completed several years of high school, and this group were trained as interviewers. Because of the cultural morae, men and women had to be interviewed separately by interviewers of the same sex for some issues, but could be interviewed together for others. In each village a group of locals were also interviewed as a focus group. Selected villages were visited by the interview teams under the guidance of a CIP scientist who was experienced in conducting surveys, and the Dani coordinator. The surveys included documenting the specific tasks undertaken and time spent by men and women for land preparation, planting, weeding, harvesting and the sale of sweetpotato roots, as well as housing, feeding and the sale of pigs. Time allocated to school, church, community and family activities were also recorded along with modes of transport, time spent travelling to market, market procedures and family structures.

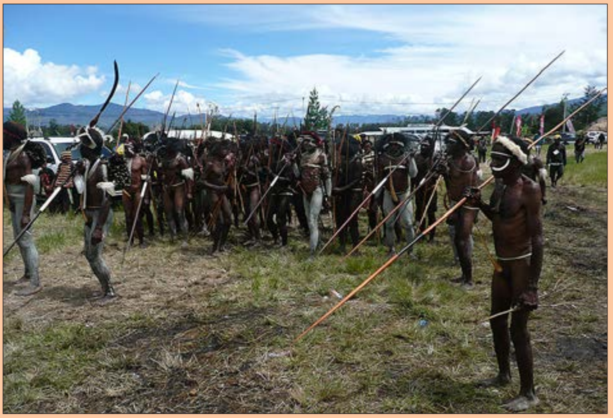


Figure 8:
Dani men taking part in Baliem Valley Festival to celebrate Dani traditions and customs

It quickly became apparent from the survey data that various tasks associated with both sweetpotato cultivation and pig husbandry were gender specific. If we needed information about feeding pigs, therefore, we needed to speak to women; and if we needed to build the pig nutrition skills of the community we needed to work alongside women. When it came to breeding pigs, it was the men who were involved. In both the cultivation and harvest of sweetpotato, and the husbandry of pigs, women played the major role. The data also confirmed that women and teenage girls allocated more time for work (42% and 40%) than men and teenage boys (34% and 35%). Sweetpotato planting and harvesting, which was mainly done by women, was the most labour-intensive activity undertaken. At the time of our survey, sweetpotato as human food had declined from 80% in previous recorded studies to around 45–50%, but its significance as pig feed had increased. Fruit and rice had replaced sweetpotato in human diets. Girls also spent 10% more time studying than boys and most communities spent significant time on church-related activities.

As described in Chapter 1, the majority of people lived in a family compound known as a *sili*, and two distinct family structures were identified. One was the traditional polygamous marriage structure, where the head man of the clan owned four to six wives and the clan lived in a single compound (*sili*) which included several related unmarried males. The other was a monogamous marriage structure where families tended to live in a less formal, but a still family-oriented compound (*sili*) structure. Pig ownership was also found to be important, and in the polygamous family structure the number of pigs owned by a woman determined her status and position in the sili.

The observational survey of pigs was undertaken at several households. *Silis* were identified in selected villages and the number and ages of pigs recorded at the initial visit, and pigs and facilities photographed. Six small pigs, weighing between 10 and 15 kg, were tagged and weighed at each selected *sili*, and three tagged pigs were treated with ivermectin (an anthelmintic) to remove parasites. The selected *silis* were visited monthly and the number of pigs present recorded and tagged pigs weighed. The same three pigs were also treated for parasites. The observational studies confirmed that internal parasites were a major limiting factor in pig production. The mortality rate in untreated pigs over a period of five months was 40%, compared with only 10% in treated pigs, and while treated pigs grew between 25 to 54 g/day, untreated pigs grew at around 20 g/day. The study also indicated that sows farrowed approximately every 15 months with an average of 5.9 pigs/litter, however in the socioeconomic survey, the number of piglets/sow was found to be only 2.4. The difference was a measure of the natural wastage that occurred in the free-range scavenger husbandry system practised.

The preliminary investigations also included a disease survey (see Chapter 4). Pigs were purchased randomly from several villages and examined clinically and post mortem. Most pigs examined were considered to be in poor condition, indicating malnutrition, but blood tests confirmed freedom from the majority of infectious diseases commonly associated with pig production. Again, the most significant health problems identified were internal parasites found in the stomach, intestines, lung and kidney—in fact most species of parasite recorded for pigs globally were present. The other significant health problem recorded was widespread ingestion of pyrrolizidine alkaloids from plants, especially in older pigs.

Based on the analysis of data from the socioeconomic, technical and observational surveys, and the pig disease survey, current cropping practices and pig husbandry practices were defined and the major constraints in both sweetpotato and pig production identified. The key limitations identified for sweetpotato production were theft and a low level of disease in vines and roots. By contrast, identified limitations in pig production were much more significant and included heavy burdens of internal parasites, suboptimal diets and irregular feeding regimes, low level of boar ownership, suboptimal housing and the widespread practice of free-range scavenger management systems.

PARTICIPATORY APPROACH: USING RESEARCH DEMONSTRATION EXPERIMENTS TO TEACH AND EXPLORE KNOWN AND NEW CONCEPTS

Because of the problems identified in pig husbandry and production, and the lack of local scientific and technical expertise available, it was decided that the most sustainable way to improve pig production would be to use a participatory approach and undertake a series of research demonstration experiments in villages. This was in preference to more formal research undertakings at field stations operated by church groups and provincial and local governments. A research demonstration experiment (RDE) was a term we used to describe experiments that combine the transfer of skills and known concepts with an assessment of how applicable a particular concept is for the community involved and how likely it is to solve a particular set of problems. A good example of an RDE was validating the benefit of using a boar to promote oestrous in sows after they are weaned. It is a known fact that placing sows in close proximity to a boar immediately following the removal of her litter (weaning) will improve both the chances of oestrous occurring and the intensity of the oestrous. An RDE was run in two villages, where the first, third, and subsequent odd-numbered sows weaned were housed next to a boar and even-numbered sows weaned were housed 50 m away and out of sight of a boar. Farmers were involved in managing the RDE and recording the data so that they could observe the value of the practice and how best to manage it in a village where not all farmers owned a boar. The data collected not only validated the practice but also confirmed that it worked effectively with native pigs in a village environment. Thus it was a learning experience for farmers, while at the same time developing and validating a best-practice approach for pig reproduction in the village. An RDE can also produce unexpected results; as well as validating a known fact, the data also demonstrated that the subsequent litter size was increased when sows were housed next to a boar, a finding that had not been confirmed previously in studies in commercial pig production. The concept of RDEs also guaranteed that a genuine participatory approach was taken by the project team when designing experiments with farmers.

The first step in this approach was a meeting between the key project scientist who had expertise in the activity under discussion, local project staff who would supervise the experiment in the villages, other scientists with knowledge to contribute, and all the farmers who had been recruited and joined the project.

The discussion began with an explanation of the concept being introduced and a description showing how the concept was practised or used by farmers in other countries or regions and noting recognised advantages and disadvantages. The aims and the anticipated outcomes from the experiment were then described, followed by discussion and questions, with input from all groups, before final agreement was made by the farmers to the proposal. Farmers whose facilities would be used for the RDE and who would be involved in the actual daily management and operation of the experiment then entered into an agreement with the project leader. The agreement included allocation of all costs associated with purchasing animals, seed and other necessary materials; the purchase and supply of any building or fencing material required; transport costs; and an honorarium for the extra work that the farmer would be required to do above his or her normal labour. In return the farmer agreed to follow the program designed by the project team and ratified at a farmer meeting.

Figure 9: Some of the 32 families who became part of the project by 2006 with Project Leader (Dr Cargill—back row 4th from R), Project Manager (Dr Mahalaya—sitting centre front); Veterinarian (drh Putra—standing left front); Dani Coordinator (Mr Luther Kossay—centre back row) and Local Project Technician (Mr Syahputra—R standing)

During the planning meetings it was not unusual for the farmers to request permission to withdraw from the group so that they could discuss concepts and ideas in their own language. This proved extremely beneficial and allowed farmers to raise concerns and question anticipated outcomes. The extra discussion usually resulted in farmers having a clearer understanding of both the technical and the practical aspects of the experiments. It is well accepted that it is easier to understand concepts in the language in which we think and are most fluent. This practice helped to ensure that the aims of the project were fully discussed with the participating farmers and their opinions on each procedure were fully canvassed.

Regular project team meetings with the farmers, the local project coordinators and technicians, the project leaders, and other scientists who had current activities in the project, were held during each visit by the international and national scientists. These meetings took place at least twice each year, although there were times when travel permits to visit the Highlands were not being issued to non-nationals for security reasons. During these periods the project meetings were held in Denpasar or Makassar, with the local project team and key farmers being flown in. The meetings reviewed the progress of each RDE and developed plans for new activities. Data generated from an RDE were presented by the relevant farmer and the relevant local project technician. This methodology provided an opportunity for the key farmer involved in the experiment to be questioned by the other farmers, and concerns and problems to be highlighted and solved. It also enabled all farmers to observe the data, which helped them to make their own decision on how to use that information according to their own situation. Once a year, all farmers were bussed to every project site to give them an opportunity to see all the project activities first hand. Overall, the methodology worked well, and only one farmer had to be removed from the project for failing to follow the agreed plans. Farmers also had the freedom to adapt concepts and farming systems to suit their own particular circumstances. This freedom to adapt was confirmed by a group of Indonesian scientists who came to inspect the project: after visiting several project sites, they commented that farmers at every site they visited had incorporated all the concepts recommended by the project team, but that each farmer had adapted the system slightly differently—consequently, each farmer owned the system they had helped validate by adapting it to suit their own location and circumstance.

The participatory approach, based on RDEs, that was used to establish the project, was a key factor in the success of the project and also a major contributing factor in the successful establishment of the project in the farming community of the Baliem Valley. Initially, in the first year of the project, only four farmers were recruited, hence activities were limited to running sweetpotato production trials comparing local and introduced varieties, and pig nutrition trials comparing balanced diets based on raw, cooked and ensilaged sweetpotatoes. By the end of that first year, several successful pig nutrition trials had been completed in three villages, with encouraging results, and once farmers from other villages saw that the pigs being fed the balanced diets on a regular daily basis grew significantly faster and looked healthier than their own pigs, many requested an opportunity to join the project. As a result, by the end of the second year, a range of RDEs were under way in 15 villages, and by the end of the third year the project team were turning away farmers from new villages who wanted to join the project. If the trials had been undertaken inside field stations, farmers would not have been able to make these observations, and it is unlikely that the project would have survived.

MULTIDISCIPLINARY APPROACH: BUILDING A MULTIDISCIPLINARY TEAM OF SCIENTISTS AND TECHNICIANS

As stated, the participatory model established in the initial phases of the first project, and used subsequently throughout both projects, was a major reason for the overall success of the two ACIAR projects (2001–2008 and 2009–2014) conducted in the Baliem Valley over the 15-year period. As the project continued and expanded, the farmers and their families became more confident about contributing to planning ideas in the knowledge that their voice would be heard and their views considered. It also proved a resource-building exercise for the farming community as many of the men and women went on to play a major role in training other farmers in the concepts and management of systems developed—this included the introduction of other crops and livestock production systems that were developed in the final diversification phase of the project.

Figure 10: Pak Wamisik explains how his new pig house works to other farmers

In addition to Dr Dai Peters, a sociologist and initial project leader, and Dr Colin Cargill, an animal scientist and veterinarian with expertise in pig production, health and welfare as well as experience working in other cultures, the original team consisted of four national scientists, plus the local coordinator and his assistant. The Indonesian national scientists were an animal nutritionist (Dr Pius Ketaren), a sweetpotato breeder (Dr Mohamad Jusuf), a local veterinarian (drh I Made Putra), and a scientist with expertise in communications (Dr Liem Mahalaya). Dr Cargill took over as project leader at the end of the third year, in 2003, when Dr Peters resigned.

As the project progressed, it became obvious that other disciplinary skills and expertise were required, and other scientists were recruited. These included an animal scientist with expertise in poultry production (Dr Phil Glatz), an epidemiologist (Dr Widi Nugroho), parasitologists (Prof I Made Damriyasa, Dr Rebecca Truab and drh Kadek Kerang Agustina), veterinary microbiologists (Prof Isrina Salasia and drh Mitra Silpranata), agronomists with expertise in legume and other crops (Dr Graham Lyons and Ir Dani Saraswati), a post-harvest specialist in sweetpotato and other crops (Ir Erliana Ginting) and extension scientists (Dr Susanto and Mr Simon Boroan). In fact, by the end of the second project in 2014, there were 32 scientists and technicians from a range of international, national, provincial and local organisations. The local team had also grown to five technical staff and included Triono Syahputra, Albert Soplanit, Luther Kossay (a local Dani school teacher), Nakeus Muiid (a Papuan university student) and Mr Isman, who became project translator.

Figure 11: Project scientists and technicians at Planning Workshop in Wamena (2008)

The lead organisation on the second project was SARDI, with key partners CIP and BPTP. Other participating agencies included the Indonesian Research Institute for Legumes and Root Crops (ILETRI) and the Research Institute for Livestock (Balitnak), Indonesian universities (Papua, Gadjah Mada and Udayana), Australian universities (Adelaide and Queensland) and NGOs (World Vision Indonesia and Oxfam). Several provincial and regional government agencies were also involved, the key ones being Dinas Perikanan dan Peternakan, Jayawijaya Regency, Dinas Peternakan and Dinas Tanaman Pangan dan Hortikultura, Papua Province, and Dinas Peternakan Kabupatan Manokwari and Dinas Tanaman Pangan dan Hortikutura, West Papua Province.

With such a diverse range of activities, it was necessary to develop specific teams to be responsible for various objectives and a diverse range of activities. Each team consisted of relevant scientists and technicians with expertise and experience that matched the specific tasks they were assigned. It was their task to design an RDE or a participatory research activity aimed to address a particular set of problems or demonstrate a known technique and adapt it to the local conditions. Additionally, all plans were discussed at full project review meetings so that farmers and other scientists and technicians had an opportunity to question and discuss ideas.

A broad multidisciplinary project team, and the additional cost of travel, communications between agencies and individuals proved to be difficult to manage but crucial to the success of project activities. As the majority of the project scientists and technicians were monolingual, email discussion of proposals and data review was also difficult. Fortunately, this problem was resolved by recruiting a bilingual translator into the team who had responsibility for translating emails and reports that could then be forwarded to all relevant team members for reading in their own language. This enabled monolingual scientists and technicians to compose an email or a report in their own language, send it to the translator who translated it into the other language and forwarded it to all relevant team members. As a result, the Indonesian scientists (especially young inexperienced graduates) were more confident in responding to reports and making a contribution to the discussion; similarly, the international scientists were able to read reports and emails composed by their Indonesian colleagues.

CAPACITY BUILDING: CREATING LOCAL HUMAN RESOURCES

It is well established that to deliver successful and sustainable project outcomes, projects must involve capacity building through developing human resources. In retrospect, the project achieved this at many levels.

Possibly the most important was building the skills and knowledge of the farmers, men and women. This was achieved by working closely with farmers and using RDEs to introduce new ideas and concepts. The experience and knowledge of the project team, supplemented with comments and assessments by farmers, subsequently formed the basis for a series of extension manuals used for training other farmers (see Chapter 6).

As well, the local project team became a competent resource for the project and a significant resource for their community at the completion of the project. As a result of their participation in the project, team members were skilled and trained in project development and management, animal and crop production, and how to transfer those skills to farmers and their families. Further, the younger scientists and technicians assigned to the project increased their skill set and learned valuable lessons from their more senior and experienced colleagues; three completed their Master's degree at Indonesian universities, and three completed their Doctorates, one in Indonesia and two at Adelaide University.

Additionally, the project enabled senior scientists to learn a great deal about how to transfer their knowledge and skills to people from a different environment and culture; they also learned how to take a holistic approach to problem-solving that enabled subsistence farmers to move to a smallholder commercial enterprise.

3. Improving Sweetpotato Production in the Highlands of Papua

INTRODUCTION AND BACKGROUND

The project commenced at the end of one of the worst droughts recorded in the Baliem Valley. Sweetpotato crops had failed, causing food shortages, and the Australian Airforce had been using helicopters to fly food drops into remote villages in the valley. Malnutrition, associated with rural poverty, had been identified as the major ongoing problem for the region.

As mentioned previously, sweetpotato has been the principal staple food for the people of this region for many centuries, and cultivation of sweetpotatoes and production of pigs are the dominant agricultural and farming activities in the Highlands. Sweetpotato is also the main food source used for pig diets and consequently both pigs and people lack an adequate and reliable source of protein in their diets.

PROJECT OBJECTIVES

One of the key objectives of the original project was to improve sweetpotato production as a means of providing a more stable food supply throughout the year for villages in the highland regions. The main research focus was to breed and select dual-purpose varieties with higher nutritive values that were drought- and frost-resistant and rich in vitamins A and E. The ultimate goal was to register these new clones for release throughout the highland areas of Indonesia for use in human and pig diets. The final selection of varieties for release and promotion would be based on the results of a number of comparative production trials in selected villages, designed in consultation with farmers, and with farmers providing labour and land. Secondary objectives, all aimed at improving yield and quality, included the adoption of technologies that would provide farmers with disease-free planting material, composting strategies to improve soil fertility, and post-harvest processing and storage methods.

PROJECT DEVELOPMENT

The project commenced with a socioeconomic survey and observational studies to collect data required to describe and characterise sweetpotato cultivation in the Baliem Valley. While more than 600 varieties of sweetpotato had been recorded by CIP between 1997 and 1999, it had previously been recorded that farmers only planted 10–40 different cultivars per plot. Musan and Tamue were the main short-season varieties and Helaleke and Hupuk the main long-season varieties that were planted consistently. Root yields ranged from 8.3 t/ha in the upland areas to 9.58 t/ha on the valley floor, and vine yields from 6.8 to 8.0 t/ha respectively. The survey data confirmed that farmers obtained planting material from disease-free 5-month-old vines grown on both new and old land and that they only purchased planting material when they decided to try out new varieties.

It was also clear from the socioeconomic survey that different varieties of sweetpotato were used for human and pig consumption. The reason for this was unclear, but the tasty and juicier varieties were used for humans, and the drier, less tasty varieties grown for pig feed. Although attempts were made to change this cultural habit and grow the same high-yielding nutritious varieties for pigs and humans, little success was achieved. The main reason given for not changing this practice was that varieties fed to pigs had little or no value in the market, whereas varieties popular with humans demanded a high price and were considered too expensive to feed to pigs. Even if there was an excess of tastier varieties, the farmers preferred to market them rather than use them to value add to their pig production. Hence, pigs appeared destined to eat varieties that were considered too dry and not tasty enough for humans; the only exception was when roots were damaged during harvest.

MANAGING THE PROJECT ACTIVITIES

The development and initial testing of new varieties was undertaken at ILETRI in Malang, Java, supervised by Dr Jusuf. Drought trials were carried out at the eastern end of Sumba Island where the wet season is limited to one to two months each year and long periods without rain can be guaranteed—hence the amount of moisture applied to crops could be strictly controlled and drought resistance assessed.

Hybridization of sweetpotato clones was also initially conducted at ILETRI in Malang. The purpose of hybridization was to create high genetic variability of the Papuan cultivars. Ten Papuan cultivars were crossed with ten improved variety/breeding lines from ILETRI and CIP. After hybridization, the F1 progenies (the first hybrids) were planted in the Baliem Valley to test for yield and root quality. At first, small plantings were made and the quality and taste of roots compared. Later, larger trials using a randomised complete block design were developed to compare the time from planting to maturity or harvest, as well as the root quality and yield.

A second series of trials, also using a randomised complete block design, with three replications, was used to compare growth patterns and productivity levels between existing Baliem Valley cultivars and the newly developed clones. The criteria used for selecting clones to test for human consumption were fresh yield, taste, colour and shape. The plantings included 15 clones from CIP, 15 clones from ILETRI (including hybridised clones) and 10 local cultivars selected by famers. The clones and cultivars were selected for their potential to produce good quality roots, their taste and moisture content, and included several with orange flesh. Twenty-five plants of each clone or cultivar were planted in the mound system commonly used in the Baliem Valley and harvested 6–7 months later.

Prior to starting any field trials, the project leader and team agronomists visited all the selected villages and met with the head of village and key villagers.

Figures 12 and 13: Sweetpotato trial plots to evaluate new varieties

The reasons for the work were explained to the headman, and his agreement to the use of land and permission to collaborate with farmers in his village obtained. Individual farmers were either nominated by the village headman or volunteered to be part of the project. Key team members then met with the nominated farmers to develop an agreement, which covered costs and work practices, and negotiate the day-to-day management of the trial. Despite this, a valuable lesson was learned about pitfalls that can occur when working within a structured village culture where a headman makes most of the important decisions. Although approval from the headman was obtained prior to meeting and negotiating with the farmers, he was never part of the subsequent discussions on the actual procedures to be followed. In one village, for example, everything went to plan until the day of harvest. Under the agreement, farmers were to assist the team to harvest the entire plot on the one day so that genuine comparisons could be made between the various production traits for each clone or cultivar being evaluated. Dani farmers traditionally store the roots in the ground as a standing crop and only harvest sufficient roots for daily home consumption and market; they never harvest the entire plot on the one day. So when our team turned up to do just that, the headman refused permission for the crop to be completely harvested in one day. Fortunately none of the other headmen stuck so rigidly to their Dani traditions.

Other trials, using different methodologies, were conducted successfully in the villages of Napua (uplands) and Tulem (valley floor). These trials were arranged as observational trials without replications using the seeds from

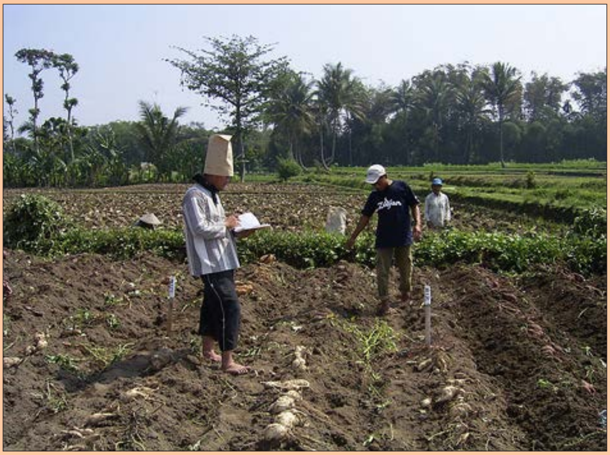


Figure 14: Harvesting the roots from a Sweetpotato trial

24 parents. The number of clones from each parent was different and depended on the number of successful seedlings that grew. Numbers varied from 25 to 300. Because sweetpotato is an open-pollinated crop, this meant that each plant became one clone and each clone possessed a different phenotype. Again, the plants were harvested after 6–7 months.

NATIONAL REGISTRATION TRIALS

Once superior clones had been selected, a series of multi-location trials was needed to collect data required for national registration. Six new superior clones of sweetpotato, plus a local cultivar Musan, were tested for drought resistance and performance at other high altitudes. The project funded trials in Bali and East Nusa Tengarra (Sumba Island), and CIP funded trials in North Sumatra, West Sumatra and Jambi Province to supplement the registration trials. Based on the results of these trials, three varieties for human consumption––Papua Solossa, Papua Pattipi and Papua Sawentar—were officially named by the President (Susilo Bambang Yudhoyono) and released in 2007. Two improved clones, together with Musan, were also registered and released nationally for pig feed. All were identified as being superior in energy and protein content, with high dry matter content.

AN UNEXPECTED OUTCOME

An unexpected outcome arising from these trials was a decision by the national government to use the new varieties to solve a food shortage problem that had occurred during 2006 in the neighbouring regency of Yahukima. The acute food shortage was caused by high rainfall, pests and poor tuber production, and had resulted in severe malnutrition and deaths. The team investigating the problem were taken by Dr Jusuf to visit one of the multiplication and demonstration trials at Holima and were very impressed with the size of the tubers and growth of the vines and overall production. Planting material was taken from the Holima plots and planted in demonstration plots in 17 locations in Yahukima. Two high school graduates were selected for each site and trained in the theory and practice of sweetpotato crop production by Dr Jusuf. As a result, food drops to villages in Yahukima ceased the following year because food supplies were deemed sufficient.

OBTAINING HEALTHY PLANTING MATERIAL

One of the problems identified during surveys, and by farmers during focus group discussions, was the need for healthy planting material. Although our surveys indicated that the prevalence of disease and pest problems was relatively low, and farmers followed practices that reduced the risk of using diseased planting material, crop failures associated with suboptimal planting material had been recorded. The use of chemical pesticides in the Baliem Valley was also banned by the national government. In order to understand the local practice, it was agreed to conduct a survey in 10 representative villages (five upland villages and five from the valley floor). The survey would collect baseline data on how planting material was collected and identify the way farmers managed sweetpotato planting material. It would also review the sweet potato cultivation practices commonly used.

Data from the baseline survey indicated that farmers usually obtained planting material from vines growing on both new and old land that were free from pest and diseases. They also tended to select fresh large-sized stems with healthy leaves. Planting material was only purchased if they wanted to plant new varieties. Most farmers used planting material from 5- month-old crops, but a small number used material from older crops. The planting material was collected by women, and apical cuttings (around 40 cm in length) were generally used and stored for three to four days prior to planting. Farmers in the upland areas planted sweetpotato in a slanting or horizontal position, whereas farmers on the valley floor planted it in an upright position. The reason given was that soil texture in the two environments varied. None of the farmers in the villages surveyed prepared special land for a multiplication plot or renewed planting material with roots; this was because planting material was always available and hence was not a constraint to production.

In consultation with farmers, it was decided to evaluate technology for creating clean planting material from existing gardens and to validate the methods in field trials. If it was demonstrated to be beneficial for the region and provided superior planting material that resulted in increased yields, the technology would be adopted.

The improved technical method for selecting planting material is called positive selection (PS) and was developed by CIP in the Philippines. It was designed to provide healthy cuttings for planting on a routine basis. This process involves selecting 20 or more healthy plants and having them tested serologically for virus. Cuttings are then taken from virus-free plants for planting in pots inside an insect-proof 'igloo' or screen-house. The resulting planting material can be then guaranteed free of virus and can be used to grow disease-free crops.

Once established, trials were designed to compare PS with current farmer practice (FS) and the data analysed. The trials were run in Napua (upland) and Siepkosi (valley floor). In the first trial, the average yield was 10.3% higher for all varieties when PS material was used than it was when FS material was used (26.0 t/ha compared with 23.3 t/ha), but the difference was only significant for Cangkuang and Musan, the fastest growing and maturing varieties. In a second trial, the average root yield from PS planting material was higher for all varieties, with an overall increase of 25%. Average root yields were also higher from trial sites in the valley floor (23.3 t/ha) than upland sites (17.3 t/ha). Nonetheless, the low level of disease problems recorded in the Baliem Valley tended to reduce the farmers' enthusiasm for adopting the more expensive and labour intensive positive selection process over their traditional methods.

Figure 15: Screen house for growing disease free planting material

Figure 16: Disease free planting material from screen house

Farmers were also introduced to rapid-multiplication techniques using micro-cuttings to provide good quality disease-free planting material quickly. The method relies on using sterile conditions and clean mother plants as the source of multiplication planting material. The key steps for success are: select healthy mother plants; use young (3–4 weeks) plants reared in a screen-house or greenhouse to avoid pests; cut the shoots weekly to stimulate the growth of new branches—the new branches are called micro-cuttings and can be used for planting. Farmers and their families were more enthusiastic about this process and many quickly adopted it into their routine practices. It was also found that planting shorter length vine cuttings also increased yield.

THE VALUE OF COMPOSTING MOUNDS

One of the issues that had to be considered in working in the Baliem Valley was the ban on the use of commercial fertilisers. Hence other ways of improving soil fertility and texture needed to be evaluated.

Initially, small trials were undertaken by one of the local project technicians (Triono Syahputra) working with local women in evaluating the use of compost in small kitchen vegetable gardens. Triono had reviewed composting methods and erected small composting boxes at several locations. The results of these trials were very encouraging, as adding compost appeared to have positive benefits both for the health of the plants and yield.

Providing sufficient composted material for an entire sweetpotato garden was a far more difficult undertaking. Discussions between team agronomists and farmers resulted in a plan to add green composting material to the mounds that were used to cultivate sweetpotato in the Baliem Valley. For comparison, the practice was also evaluated in the Arfak Mountain villages in West Papua where mounding for sweetpotato cultivation is not practised. The process used was to bury 2 kg of green composting material into each soil mound prior to planting and measure any increases in yield.

While the use of mounds, as well as adding green composting material to mounds, significantly increased the yield of roots in the Arfak villages, adding the green material to already existing mounds in the Baliem Valley had little effect on yield. Limited soil analysis had already confirmed that the texture and fertility of soil is higher in the Baliem Valley than other regions examined. Nevertheless, this was still a valuable result given that Arfak farmers could now increase yield significantly by constructing mounds and digging in green leaf material. Adding green composting material to mounds prior to planting may also help to maintain soil texture and fertility in the Baliem Valley generally.

POST-HARVEST STORAGE AND PROCESSING

In order to increase food security, several methods for storing root crops were assessed by individual farmers (mainly women) at various locations on the valley floor and in the upland areas. The methods included: storing sweetpotato roots by hanging them above a kitchen fire in a *noken* (knitted bag); storing them on the ground covered with dry grass or reeds (*alang-alang*), with a further layer of leaves to keep out rain and providing drainage to protect the roots from water; storing them in a hole and then covering them with layers of dry sand followed by leaves and again providing drainage to protect the roots; and storing roots in the ground as a standing crop, which is the traditional method used by farmers. This latter method proved to be the most successful way to store roots. The other methods were open to damage by rodents and other pests and flooding caused by heavy rain, and also required extra labour by women after harvesting the roots.

As described above, Dani people traditionally store the roots in the ground as a standing crop and only harvest what is required daily for market and home consumption. Based on observations made when visiting families in the late afternoon, boiling fresh roots in a metal container over an open fire was the most common method used for cooking. Occasionally, the vines were also added (but this was not a regular practice), and other vegetables were added if they were available, however only a minority of homes had a small vegetable garden. On special occasions, such as weddings or funerals, roots were cooked along with pig meat, fish and maybe other vegetables in a *batu bakar* or stone bake (see Chapter 1).

The fact that sweetpotato roots were often the only food eaten during the day was a major reason for the high prevalence of malnutrition in children. As a key objective of the project was to increase the nutritive level of the daily diet, the first step was to investigate sweetpotato processing. Early in the project, varieties were screened for their processing qualities and 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 protein level in the range 20–25% was set as a suitable target, and the complete data set enabled the agronomists to produce a list of recommended varieties by rank. A number of suitable varieties were identified as superior for processing, and recipes that would increase shelf-life and provide a more balanced nutritional product were developed. In all the surveys it was found that boiling was the main method used by local people for processing sweetpotato, and leaves were also consumed occasionally after boiling. Rather than develop new technology, it was decided to adopt and adapt current technology that was simple and applicable, and which could include supplementing sweetpotato with other vegetables, fruits and meats. Colleagues from ILETRI and the University of Papua helped develop recipes that were delivered to local women with the help of farmer groups, women's organisations (*dharma wanita*), civil servants' wives' groups, church groups, students from the University of Papua and Manokwari Agricultural Extension Academy (STPP), and World Vision Indonesia.

SUMMARY AND CONCLUSIONS

Although consumption of sweetpotato by the Dani people appears to have decreased over recent decades, it is still the dominant crop in the Highlands of Papua. Farmers in the Baliem Valley have also been active plant breeders, and when the first CIP scientists visited in 1997 they identified over 150 varieties that had not been previously recorded. Many of these varieties were found to be superior to other more established varieties grown in other parts of Indonesia. Selected Papuan varieties and hybrid strains from CIP and ILETRI were used to breed three new superior varieties for human consumption and two for pigs.

Over the centuries the Dani farmers have developed very sophisticated methods and practices for cultivating sweetpotato, and the project was consequently limited in what we could offer in terms of improvement and progress. For example, a number of areas explored—such as storage of roots and improving soil fertility—met with limited success mainly because the method used by the Dani was equal to or superior to proposed new methods and technologies.

Other than the new varieties developed, one of the areas where we did deliver progress was in the production of clean, healthy, viable planting material. Adapting a rapid-multiplication technique that involved propagating plants in screen-houses and using shorter cuttings from vines did improve production and was accepted enthusiastically by farmers.

Unlike their pig husbandry skills, the Dani were very capable agronomists with strong traditions in sweetpotato cultivation.

4. Improving Pig Production in the Highlands of Papua and West Papua

INTRODUCTION AND BACKGROUND

Pigs play an important social role in Melanesian communities across the South Pacific, including the eastern and western ends of the island of Papua New Guinea. The Dani people in the Baliem Valley are no exception. Feasts, at which ceremonial pigs are killed with an arrow through the heart and then slaughtered and roasted in a *bakar batu* (see Chapter 1), are extremely important for celebrating community events. The success of a feast, and that of a village headman, is measured by the number of pigs slaughtered. Hence the pig is an important status symbol in Dani culture, as well as being an integral part of their mythology and customs: the Dani people will say that "a Dani man without pigs is a man without a soul". The position of pigs in the culture means that pork is too valuable to be eaten regularly in rural communities and is kept for feasting on special community occasions. During the project, a new tradition developed where project families would make a *bakar batu* for the project team at the completion of experiments and demonstration trials in their community.

As described in Chapter 1, the socioeconomic unit of the Dani society is the *sili*—a compound where an extended family group lives together and the group own and share all resources together under the control of a headman. Most *silis* are oblong in shape with the main gate and the men's house located at opposite ends of the compound. The women's houses are built along one side, and a kitchen (or cook-house) along the other (see Figure 1). We observed that pigs were an integral part of the *sili*, housed overnight in pens at one end of the kitchen house, adjacent to the cooking area and released in the morning into the communal space in the centre of the compound where pigs, dogs and children played and defecated, exposing all three species to a mix of each other's bacteria and parasites. After pigs had been fed they were set free to scavenge over large areas of land in search of food and water.

Observational studies (see Chapter 2) were used to establish a baseline rate for growth (g/day) and pig mortalities. Just to recap, the observations involved photographing and tagging six pigs in five villages and weighing them on a monthly basis for five months. Half of the tagged pigs were treated monthly with an anthelmintic to remove internal and external parasites and mortalities recorded. The untreated pigs in the survey group grew at 15 to 28 g/day, compared with 25 to 54 g/day (mean 46 g/day) for the treated pigs. Mortality rates in untreated pigs were 40% over five months compared with only 10% for treated pigs. These observations and recordings confirmed that suboptimal growth rates and high mortalities caused by internal parasite infestations were a major production limiting problem in pig rearing.

EXISTING PIG HEALTH PROBLEMS

One of the first investigations undertaken was to obtain information about the overall health of pigs. Thirty-nine pigs were randomly selected from 10 villages and purchased for clinical and post-mortem examinations. Pigs were clinically examined and classified as emaciated, thin, average or fat, prior to being humanely slaughtered. Based on a comparison with commercial pigs in Bali and Australia, the majority were classified as either emaciated or thin. During post-mortem, however, some pigs had to be reclassified to a higher category as they had significant fat deposits in the inguinal regions and along the belly. Because of their conformation, native or village pigs will always appear thin to a western-trained eye.

As expected, internal parasitism, ingestion of toxic plants and the presence of three important zoonotic diseases were the most important findings. Pigs were serologically negative for a range of diseases found in other regions of Indonesia, such as brucellosis, leptospirosis, porcine parvovirus, *Mycoplasma hyopneumoniae*, classical swine fever ('hog cholera'), and transmissible gastroenteritis virus. A few pigs were positive for pseudorabies virus (Aujeszkey's disease) and, as noted earlier, a subsequent outbreak of classical swine fever occurred in 2005.

The range of internal parasite species that were identified was staggering and included almost every species of pig parasite recorded anywhere in the world. As the only known introduction of pigs was a one-off shipment from Bali in 1963, where many of the parasites found in Dani pigs are not present, it must be assumed that the pigs brought their parasites with them when they arrived in the Baliem Valley several centuries ago. Evidence of three important zoonoses (cysticercosis, trichinellosis and toxoplamosis), which can all be transmitted to humans by eating undercooked pork, were also found. Cysticercosis, known as pork measles, presents as cysts in the muscle and is an intermediate stage in the life cycle of the human tapeworm. It can be lethal when humans become infected from eating undercooked pork, as they often develop cysts in the brain and other vital organs. In fact we discovered subsequently that in some rural villages 60–70% of the human population have antibodies to the cysts. These findings raised some major issues for the project in that we needed to develop management and husbandry systems that would minimise internal parasite infections and prevent pigs becoming infected with human tapeworm eggs.

OVERCOMING EXISTING PIG PRODUCTION PROBLEMS

Nutrition

The initial surveys had recorded very low growth rates even in pigs that were free of internal parasites. The traditional diets fed to pigs consisted primarily of fresh sweetpotato, which was harvested daily and chopped and fed raw to the pigs either in the morning or evening, or both. Sweetpotato vines were also fed, but not on a regular daily basis. Water was not provided, and in dry seasons pigs in some villages had to travel long distances to the nearest water. It was the women's duty to feed the pigs and sometimes they were neglected for several days during important communal events, such as ceremonies and funerals. Malnutrition due to poor diet and irregular feeding was thus a major cause of slow growth rates.

The first demonstration trial undertaken was designed to investigate what would happen when pigs were fed adequate amounts of the traditional diet and provided with water at all times. The first three farmers recruited to the project agreed to feed pigs twice daily with approximately 10% of their body weight/day using a diet of uncooked sweetpotato roots and vines. Luther Kossay weighed the pigs every two weeks and then calculated the volume of feed required to provide 10% of the pig's body weight. Pigs were housed in the existing pig pens in the *sili* and fresh water was provided daily. They were treated every four weeks for internal parasites. After three months of monitoring, growth rates ranged from 54 to 126 g/day with an average of 89 g/day. This figure was about 90% higher than the growth rate achieved when treated similar weight pigs were managed in the traditional free-range system and fed in the traditional way. The result confirmed that in addition to parasites other major problems were irregular and underfeeding, lack of available water, and an undisciplined approach to caring for their animals.

The next step was to formulate a series of balanced diets based on sweetpotato roots and vines, but supplemented with other locally available crops. The project animal nutritionist (Dr Pius Ketaren) was given this task, and he designed a base diet (Wamena #1). This diet consisted of 33% cooked sweetpotato vines, 55.5% cooked sweetpotato roots, 11% cooked banana trunk and 0.5% salt. An alternative diet based on uncooked sweetpotato roots and vines was also developed to demonstrate the effect of cooking sweetpotato roots. Because ensilaged sweetpotato roots and vines had been used successfully to feed pigs in Vietnam, farmers were also asked if they would like to develop this technique in the Baliem Valley. Two diets based on ensilaging were then formulated and tested. The first (Wamena #2) contained 33% cooked sweetpotato vines, 22% cooked sweetpotato roots, 34% ensilaged sweetpotato roots and vines and 11% cooked banana trunk. The second (Wamena#3) contained similar quantities but the roots and vines were fed raw. The original silage contained 85% sweetpotato roots, 15% sweetpotato vines and 0.5 kg salt and was stored in airtight containers for a minimum of 14 days. Later, sweetpotato vines were replaced with one of the high-protein pastures that grow naturally in the Baliem Valley.

Because it was not possible to find sufficient pigs of the same weight and age to meet the requirements for statistical analysis, all animal experiments

Figures 17 and 18: Making Sweetpotato silage and feeding trials were run in at least two different locations and repeated a minimum of three times. Only two diets were compared in any one experiment to make management simpler. The data collected was averaged for each site to provide what was considered to be a valid response range for a particular diet or treatment. Pigs weighing 10 to 15 kg were obtained from farmers in the village, examined by the local veterinarian, and weighed and matched into pairs according to weight and sex. One of each pair was then randomly assigned to each treatment group. Pigs were treated for parasites using an anthelmintic and injected with long-acting oxytetracycline (a broad-spectrum antibiotic) to eliminate infection. Pigs were fed either a test diet or a control diet for a period of two weeks to acclimatise them to the experimental conditions. They were weighed again at the beginning of the trial to give the start weight. Faecal samples were collected and examined for parasite eggs at the beginning and the end of each experiment, and any pigs that developed clinical signs, or died, were examined by the local veterinarian.

As anticipated, all three diets improved pig growth rates significantly. Pigs fed Wamena #1 and #2 diets recorded growth rates from 160 to 220 g/day, and pigs fed Wamena #3 diet grew at 120 to 170 g/day.

Although these figures were well short of the potential growth rates published for native pigs in other parts of the Asia–Pacific Region, they did impress other farmers who lined up to become part of the project. Some of the project farmers also became very enthusiastic about silage, and some made their own diets of ensilaged material, adding extra fresh-cut green leaf material. The enthusiasm was not only because their pigs grew faster, but because they could work hard for a week and make enough pig feed for several months. This reduced the amount of daily labour required to successfully rear pigs.

One reason for the shortfall in pig growth rates was a lack of the essential amino acids required for efficient growth that are mainly found in animal protein. As meat meal was unavailable in the Baliem Valley, it was decided to investigate the possibility of adding fish to existing diets instead. A new diet (Wamena #6) consisting of 50% cooked sweetpotato roots, 30% cooked sweetpotato vines and 20% cooked fish offal made up of internal organs and gills was formulated and tested. Pigs fed this diet grew at 230 to 300 g/day, which was considered to be close to the maximum potential for the local pigs, however something needed to be done to increase fish production if it was to become a viable alternative. On the advice of scientists from SARDI's Aquatic Sciences Division in Adelaide, several methods for increasing fish production were explored by Albert Soplanit, a young scientist attached to the project team. The most successful method involved improving pond fertilization using dried pig dung. This was achieved by initially adding 8 kg dried dung with 12 kg sweetpotato vines to the pond, followed by 4 kg pig dung every 10 days. As a result, fish production increased by more than 200% when compared with traditional methods. While this was a valuable outcome for farmers on the valley floor, who either produced fish themselves or had access to nearby fish farms, it was of little value for farmers in the uplands.

A sustainable solution to the lack of animal protein was finally found one afternoon when the veterinarians Made Putra and Colin Cargill were walking back to Wamena after visiting nearby villages. The gutters and waterholes beside the road were filled with golden snails that had been introduced accidently to the Baliem Valley and were now prevalent. The snail is very robust, a prolific breeder, and grows rapidly. Made Putra pondered whether pigs would eat them—and to answer his question a batch of snails was collected, boiled and fed to pigs over several days. The pigs survived and appeared to find the snails quite tasty. Subsequent analysis proved the snails to be a valuable source of lysine and methionine, essential amino acids for pigs found in animal protein. When 5% snails were added to Wamena #2 diet (Wamena #9), pigs grew almost as well as those fed the fish diets. The snails could be produced next to the pig house by digging a small pond, filling it with water and adding snails and green leaf material. Snails were easily harvested by standing bamboo sticks upright in the pond, allowing the snails to attach to the stick overnight, and then stripping them from the stick into a bucket—a cost-free, low-labour source of essential amino acids for pigs.

Figure 19:
Golden snails

Figure 20: Harvesting golden snails from pond

Pig husbandry, management and housing

The major problems identified from observational surveys were that pigs were confined overnight in small pens inside a poorly ventilated house that was adjacent to the family kitchen; they had access to human, dog and pig faeces in the family compound in the morning and evening; and they were allowed to roam over large areas of land in search of food and water during the day. The free-range scavenger system also allowed pigs to damage crops and create soil erosion. One of the extra costs of a free-range scavenger system for pigs that is never included is the expense of fencing crops—but the cost of fencing crops to keep pigs out is much greater than the cost of fencing to confine pigs and keep them in.

In discussions with older people it had been discovered that prior to the arrival of European and American missionaries in the mid-20th century, pigs had been kept in *lalekens* during the day. Because the *laleken* was generally bare, with no plants to forage, the missionaries had thought it best to allow pigs to roam free during the day to search for food and water. Hence the practice of keeping pigs in *lalekens* during the day had become less common.

After wide-ranging discussions between the project team and the project families, it was decided to design a welfare-friendly management system based on the *laleken*. This time, however, the *laleken* would be planted with high-protein pasture and surrounded by fodder trees that would provide extra protein as well as shade and firewood. A number of introduced pasture grasses, including stylo, were trialled unsuccessfully, but several suitable pasture grasses and fodder trees were identified growing in the Baliem Valley. The grasses selected were *Puerasia cephaloides*, *Centrosema* sp. and *Calopogonium* sp. and the fodder trees were *Erythrina variegate* and *Gliricidia sepium*.

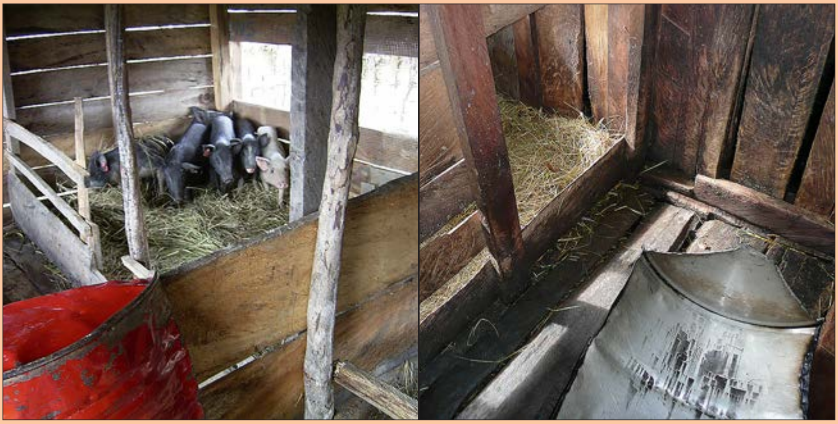
Because of the human–pig health problems that had been identified, it was agreed that the pigs must be completely removed from the family compound. New pig housing based on current recommendations for optimal pig housing was designed, and individual farmers and their families were free to adapt the layout

Figure 21: A series of lalekens for foraging

Figure 22: Pigs in laleken enjoying pasture grass

of their pig facility so long as it met the concepts agreed to in our discussions. The recommended *laleken* model had a minimum of eight small paddocks planted with pasture grass; an alternative model, which had four larger paddocks and required less fencing, was also provided. Fodder trees could also be planted along the outside fence line to provide a living fence.

The pig house was designed with a dry sleeping area covered with a layer of dry grass located in the back half, and a wet area in the front half for food troughs and water containers. Two rules the farmers were forbidden to break were: do not allow the water supply to run out and do not allow dogs to enter the *laleken*. It became a standing joke among farmers that if dog or human faeces were found in the *laleken*, Pak Luther would shoot the pigs, the dog and the farmer. Fortunately he was never called into action.



Figures 23 and 24: Photographs showing dry sleeping area and wet area for food and water

The space immediately outside the pig house was called the 'dunging area' and was covered with river stones. Pigs were held in this space for 20 to 30 minutes before moving them to a *laleken*. This practice was based on the fact that pigs tended not to defecate in their pens but to dung and urinate frequently as soon as they were let out in the morning. The stones exposed dung and parasite eggs to the hot sun and prevented pigs from digging for earthworms that might be infected with pig parasite larvae. Where stones were not available, another option was to build a wooden slatted platform over the area to prevent pigs having access to contaminated dung.

Figure 25: Dunging area covered with stones adjacent to pig house

Rather than try to set a correct stocking density for pigs in a pasture, it was decided that it would be much simpler for farmers to recommend that pigs be moved to a fresh *laleken* when approximately 50% of the foliage had been eaten. This usually allowed sufficient time for the pasture to re-establish before the pigs returned.

THE BENEFITS ACHIEVED BY FARMERS

Overall, farmers who adopted the complete package of feeding pigs with improved diets, developing a welfare-friendly *laleken*-based confinement system and building suitable housing for their pigs were very pleased with the outcomes, namely:

- Pigs reached 50 kg live weight in around six to eight months, compared with 15 to 24 months in the free-range scavenger system with traditional diets, and farmers sold around 10–12 pigs/sow/year compared with 3–5 pigs/sow/year previously.
- As well as increasing family cash flows and incomes, a household that owned two sows could recover the cost of investing in a confinement system in less than three years.
- Pigs in project *silis* were also negative for human tapeworm cysts (pork measles) whereas a prevalence of 30–80% was recorded in pigs from non-project *silis*.
- Providing pigs with optimal housing conditions and husbanding them in a welfare-friendly confinement system with access to high-protein pasture and balanced diets proved to be a cost-effective and efficient way to produce pigs in a smallholder enterprise.

5. Diversification of Horticulture and Animal Production in the Highlands of Papua and West Papua

INTRODUCTION AND BACKGROUND

Although the importance of pigs and sweetpotato in Dani culture is well recognised, the dominance of these commodities has also been identified as a major contributing factor to rural poverty.

While increasing pig production efficiency improved cash flow and family incomes in the short term, it appeared to have limited capacity for reducing rural poverty in the long term, most likely because the market for pork is limited to Christians in a community where many people with a regular cash flow are Muslim. Few Dani families have achieved the financial means to become regular pork consumers, and the lack of formal markets for pork reduces its value as a commodity.

In the socioeconomic surveys completed in 2001 and 2008, the dominance of pigs and sweetpotato was also recognised as a major factor in childhood malnutrition and human health issues as well as rural poverty. The lack of access to vegetables, meat and eggs meant that most families living in rural villages did not have sufficient protein in their diets.

Following the success of the initial ACIAR project, AS1/1998/054: '*Poverty Alleviation and Food Security Through Improving the Sweetpotato–Pig Systems in Indonesia*' (Cargill et al. 2009), a scoping exercise was undertaken in 2008 to develop a new project to redress the high poverty levels in rural areas. Two workshops were held, one for crops and one for livestock production, where scientists with a broad range of expertise and experience were gathered together to review issues already identified and to consider other potential factors contributing to rural poverty. Participants were drawn from several Australian agencies (SARDI, the Universities of Adelaide and Queensland), CIP, national Indonesian agencies and universities (ILETRI, Balitnak, the Universities of Papua, Gadjah Mada and Udayana), provincial and regency government departments, and World Vision Indonesia.

The overall aim of the project was to increase food security and human health by:

- improving sweetpotato cultivation, storage and processing (Chapter 3)
- improving the productivity of pig production and reducing disease risks to humans and pigs (Chapter 4)
- developing options to diversify production from the dominant sweetpotato–pig system.

A final objective was to increase the knowledge and technical skills of farmers and to develop, deliver and evaluate training and extension initiatives to transition farmers from subsistence to a smallholder mixed farming enterprise (Chapter 6).

DIVERSIFYING CROPPING IN A SWEETPOTATO MONOCULTURE AGRONOMY SYSTEM

It was decided to follow an informed and measured approach for selecting the new crops to be introduced into the sweetpotato monoculture.

The first step was to identify other crops already being cultivated by farmers in the region as this would provide information about the possible commodities that would be compatible with sweetpotatoes and acceptable to the farmers. The project agronomists were also asked to produce a list of high-protein crops that would be suitable for local soil types and altitudes between 1,500 and 2,200 metres.

The second step was to seek the opinions of the farmers and their families based on ease of planting, cultivating, harvesting and storing each crop, as well as their commercial value. A list of crops already being grown by some farmers, supplemented with the crops selected for the region by the agronomists, was drawn up and shared with farmer groups. Demonstration plots were planted so that families could become more familiar with the crops that had found the most favour with the community. Data assessed included yield/ha, value as an animal feed, value as a human food, and work required to cultivate and harvest the crop.

Lastly, focus groups and farmer meetings were used to draw up a list of three crops for each region. The three crops chosen by communities in the Baliem

Valley were red beans, pigeon pea and soybean. Soybeans proved easy to grow and could be harvested at around 100 days. The families tended to consume 50% and sell 50% for around 15,000 Indonesian rupiah/kg (A$1.50). Red beans were harvested at around 90 days after planting and also consumed by the family or sold for 5,000 to 10,000 rupiah/bunch (A$0.50 to $1.00). Pigeon peas were the least productive and proved less popular than the other two crops, but were still used to supplement diets.

These steps are an example of following an informed and measured process to make a community decision.

Figure 26: Project demonstration vegetable plots to enable farmers in deciding which crops to grow to increase protein intake for children and provide ingredients for pig, poultry and rabbit diets.

However, the most successful new crop grown proved to be strawberries, though little informed and measured planning was involved. The idea came about while the project leaders and the local project team were eating lunch in a restaurant where there was strawberry juice on the menu. Everybody ordered strawberry juice and one young scientist casually asked if strawberries would grow in the Baliem Valley. By the end of the meal, plans were well in train to trial the berries in the Baliem Valley. It appears that, unknown to anyone, the Baliem Valley just happens to have the right soil type, altitude and climate and is idealfor growing strawberries. Berries can be harvested 30 and 40 days after planting and sold for up to 50,000 rupiah/100g (A$5.00) in the Jayapura market.

By the end of the project, several farmers were growing all the introduced crops without financial support; however, further development and expansion of strawberry production, the most successful of the new crops, was being sponsored by the local regency Government. Project farmers were commissioned

Figure 27:
One of several women (Ibu Penina) who successfully developed a strawberry plantation

Figure 28:
Farmers and project team members inspecting a strawberry plantation with Baliem Valley in background

to produce planting material for sale to other farmers to increase production. The logistics were favourable: fruit could be picked early in the morning, taken to the Wamena Airport, flown to Sentani on the coast and be in the Jayapura and Abepura markets by late morning. One farmer has since planted over a hectare of land with strawberries and has reduced the number of pigs he produces. He reasoned that when he has a large number of pigs his relatives know he is a wealthy man, but he can grow hectares of strawberries and be just as wealthy without his relatives realising.

Figure 29: Project families were commissioned to grow seedlings for distribution to other families by local government

DIVERSIFYING ANIMAL PRODUCTION IN A SWEETPOTATO-PIG SYSTEM

A different approach was taken for selecting species to diversify animal production. Based on their experience in smallholder village animal production, the project team leadership made a decision to recommend rabbits and village chickens. Both are monogastrics and both eat the same crops as humans and pigs. This would mean that no new crops needed to be planted. Chickens and rabbits do not require large areas of land and can be successfully husbanded in simple and inexpensive backyard facilities. Introducing ruminants, on the other hand, would involve establishing pastures. Choosing rabbits and village chickens also meant that their meat would be acceptable to people of all three faiths practised in the region: Hindu, Muslim and Christian.

Introducing village chickens into smallholder pig farming

A village chicken production model, which had been developed by SARDI scientists in an earlier ACIAR project in the Pacific Region, was adapted for egg production after discussions with participating farmers. The farmers invited to participate in this venture were men and women who had been trained in pig management and demonstrated superior husbandry skills. They also agreed to build, manage and maintain the smallholder poultry enterprise according to the negotiated plan. The model adopted was a 12.5 m^2 (2.5 × 5 m) house with a similar-sized fenced run. Walls were made of wood and roofs of zinc (galvanised iron). Nest boxes (50 × 30 cm) were located approximately 1 m above the ground and filled with dry grass. Feeders and drinkers were provided, but farmers were also free to make replicas of these, or design their own.

The project purchased 200-day-old improved KUB village chickens (Kampung Unggul Balitnak) from the Indonesian Institute of Animal Production in Bogor. The chickens were reared locally until four months old in facilities supervised and owned by the local government livestock office. Fifteen birds (13 female and 2 male) were distributed to the farmers, who were visited at least twice weekly by the local project coordinators. The farmers were also shown how to set eggs under broody hens to hatch replacement birds. Each farmer was encouraged to grow corn and provided with a range of corn-based diet formulations that they could supplement with other locally grown crops.

The venture was quite successful: the birds commenced laying at around 7 to 8 months, and continued to lay for a further 9 months. It was interesting to observe that eggs were consumed by families as well as sold locally for 5,000 rupiah/egg (A$0.50). Village chickens are also valued for their meat and hybrid village chicken meat is much preferred to imported poultry meat. Meat from any excess or cull mature birds could be sold for around 60,000 to 80,000 rupiah (A$6.00 to $8.00), compared with 35,000 to 45,000 rupiah/kg (A$3.50 to $4.50) for imported chicken meat, although these prices were not expected to be maintained as more farmers commenced raising village chickens.

In order to provide the next generation of farmers with the skills required for egg and chicken meat production, birds were distributed to the Rural Training Centre (World Vision Indonesia) in Wamena and STPP. Financial assistance was also provided to build a model smallholder village poultry enterprise at each institute and teachers were trained by the local project technicians.

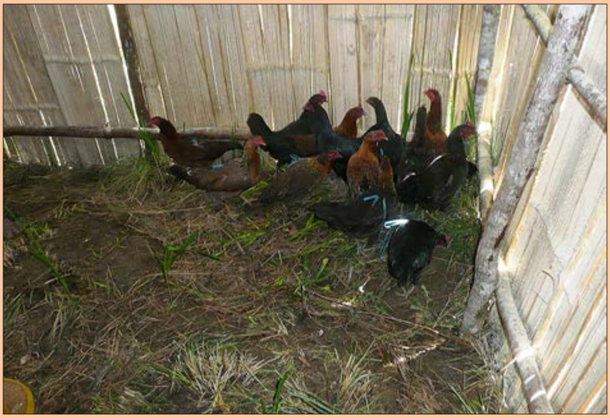


Figure 30:
Birds in outside run

Figure 31:
Egg laying boxes

Introducing rabbits into smallholder pig farming

A simple village rabbit production model developed by the United Nations Food and Agriculture Organization was adapted to suit the local environment and the farmers' needs. The model consisted of three cages (30 × 50 cm/cage), situated 1 m above ground, with wooden floors and walls and a thatched roof. A larger thatched or zinc roof (3 × 0.5 m to 4 × 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 the Arfak villages in West Papua, but the presence of a dust borer beetle caused severe dust problems and resulted in respiratory problems and deaths in rabbits. The problem was controlled by soaking cut bamboo in water for two weeks before using it in construction.

Again, farmers were invited to participate based on how well they had developed their pig husbandry skills and demonstrated an affinity for working with and managing animals. Each farmer entered into an agreement and was provided with financial assistance to build the rabbit hutch. Twelve does and eight bucks were purchased for the project, and two does and one buck were given to each family. Farmers were closely supervised by a local project technician and all activities and problems were monitored and recorded.

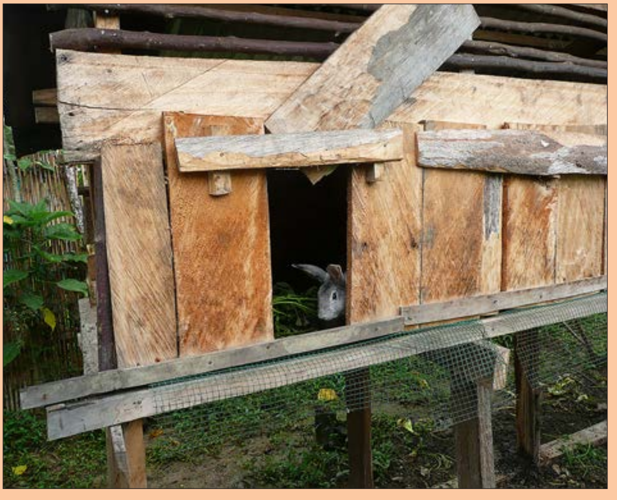


Figure 32: Rabbit hutch

Figure 33: Dr Mahalya with family in front of their new rabbit hutch

Simple diets based on locally available produce were developed for the rabbits. They contained combinations of sweetpotato leaves and roots, cut sundaleka grass (*Puerasia cephaloides*), and cabbage leaves, carrots and corn, according to availability. Other high-protein forage plants such as *Sonchus arvensis*, *Centrosema* sp. and *Calopogonium* sp. as well as fodder trees (*Erythrina variegata* and *Gliricidia sepium*) were also used. Rabbits were fed twice daily with leaf material and three times weekly with raw sweetpotato roots. Water was provided daily and the rabbits were given a whole corn cob 2–3 times a month to help stop them chewing the pen.

Families seemed to adapt to rabbit production very rapidly and a good farmer was able to produce up to 40 rabbits per year. These were slaughtered and consumed by the family, or live rabbits were sold in a local market. By the end of the project, fully grown rabbits were selling for around 400,000 to 500,000 rupiah (A$40 to $50) and 3-month-old kittens sold for around 250,000 rupiah (A$25). Again, these prices were expected to fall as more rabbits were produced and offered for sale. Rabbits were also distributed to the Rural Training Centre (World Vision Indonesia) in Wamena and STPP to enable students and staff to gain skills in village rabbit production. This was considered a valid step in capacity building.

OUTCOMES AND CONCLUSIONS

The introduction of the new crops and livestock into the existing smallholder sweetpotato and pig farming system was very successful. While the financial boost to farm income was greatest from rabbits and village chickens, strawberries further proved a financially rewarding crop for project farmers.

In accordance with the project aims, diversification of the cropping and livestock production base also contributed to reducing the risk of malnutrition in children—introducing red beans, soybeans and pigeon peas into family diets increased protein intake significantly, although encouraging children to eat at least one egg a day most likely provided the biggest boost to their diet. The task of feeding and watering hens and collecting eggs quickly became a job for the children and seemed to be one of the few opportunities they had ever had to contribute to family food production. Previously, children seemed to play little part in pig husbandry or the cultivation of sweetpotato.

While the introduced crops and livestock may never replace the pig and sweetpotato as the centrepiece of Dani farming systems, families involved in the project demonstrated a willingness to try new ventures. The new skills they acquired for sweetpotato cultivation and pig husbandry were readily transferred to other crops and livestock systems.

The pig and sweetpotato will continue to outnumber other livestock and crops for many years to come, but the results of this project demonstrate the value of diversifying smallholder village agriculture and animal husbandry to improve health and financial well-being.

6. Extension and Farmer Training Methodology Used to Increase Adoption

INTRODUCTION

The final objective of the project was to develop, deliver and evaluate training and extension initiatives that would transition farmers from subsistence to small commercial enterprises.

Although training was the last objective to be achieved, planning commenced much earlier in the life of the project so that as many families as possible could be introduced to the modified systems before the project was ended.

Reviews of the conduct of a number of similar projects suggested that unless a validated farmer training program was instituted well before the end of the project, the uptake of the technology developed by the project would be limited. It was also decided that the training program needed to be supported with printed materials, working modules and demonstration plots, and that the best outcome would be achieved if a 'farmer-to-farmer' training model was adopted.

KEY ACTIVITIES

The initial step was to develop a set of written materials using different formats to describe the key concepts that underpinned the modified animal production and cropping systems that had been developed, as well as how to establish and operate each system.

Three formats were adopted for the extension information publications. The first was a book containing more detailed information, describing the concepts involved in each facet of production, as well as how to build, develop, operate and manage each system. A separate chapter was devoted to each animal and crop production system developed. This format was directed at extension officers, NGO technicians, students and farmer-trainers. The second format comprised a series of one-page, doubled-sided documents with minimal descriptions, but suitably illustrated, which were designed for use by farmers and their families. They provided a basic understanding of how to establish and operate each facet of the production system. And the third format was a series of one-page information sheets using photographs and drawings or cartoons (with minimal words) to convey the information contained in the second format. This format was designed for farmers who could not read.

Figure 34: Project farmer explaining his modified fish production system to other farmers.

Figure 35: Project veterinarian (drh Widi Nugrohu) discussing pig health with farmers and students.

The material was written by selected project team members and was based on the experience and knowledge of the project team supplemented with experience from the field trials and demonstrations, farmers' comments and assessments, and project outcomes. Each document was reviewed by a number of relevant team members including senior scientists. As most of the primary authors were Indonesian much of the material had to be translated into English for review by the senior scientists from Australia. This created some minor problems because sometimes the original meaning was lost or varied in translation. To ensure that the original meaning and concept was maintained, the final English version was reviewed by the project leader and both versions were reviewed and compared by the Indonesian project manager who was bilingual.

Figure 36: "Team Wamena"—project manager with local project team who managed the framer training program

So that non-project families could gain some practical knowledge and understanding of each of the farming systems developed, working models of each modified animal production and cropping system were developed. These included working models of pig, rabbit and village chicken production systems, as well as demonstration plots of the key crops introduced. Originally it was proposed to establish working models in the Baliem Valley and the Arfak villages, as well as on the campus of the University of Papua in Manokwari, however because of a lack of support from the Animal Science Faculty there, the farming system models were moved to STPP, which is part of the Indonesian Ministry of Agriculture (Kementerian Pertanian). An extra training facility was also established in the Baliem Valley at the Mandiri Rural Training Centre (MRTC) operated by World Vision Indonesia in Wamena. STPP trains students in agriculture and extension, and the majority of their graduates are employed by government agencies and NGOs as extension technicians. MRTC trains young men and women from villages in agriculture and animal production. The majority of students at MRTC are young people who have left their villages and are unemployed. Demonstration crops were also established at both facilities.

Figure 37: Dr Cargill and Dr Mahalya with staff and students at the World Vision Training Facility in Wamena

A farmer-to-farmer training model was developed. This involved recruiting 'farmer trainers' who were selected from families who had joined the project during the first 10 years of operation, all of whom were successful sweetpotato farmers and were operating successful modified commercial pig production enterprises. In most cases both husbands and wives were involved as well as members of their extended families. Those who agreed to participate in a farmer-to-farmer training program were provided with the knowledge and skills required to train other farmers. The 'training of trainers' was done under the leadership of the Indonesian project manager who was experienced in communication and extension.

Once teams of competent farmer-to-farmer trainers had been trained, assessed and approved, training workshops in each production system were offered. These included pig production, using the modified pig confinement system, village egg production and small-scale commercial rabbit production, as well as sweetpotato production, strawberry production and general crop production.

'Showing boards' (billboards) describing the project's activities and key outcomes were used to promote the project itself and the opportunities available for gaining the knowledge to build and operate each system. A showing board was located on the road near some of the active project production systems and carried an invitation for passers-by to visit the farm and chat with the family.

To ensure life after the project ended, an extension workshop was held to develop plans for on-going extension activities. Participants were invited from local and provincial government extension services, STPP, and selected NGOs in the Baliem Valley and Arfak Villages.

Figure 38: Showing boards were used to spread the project's activities and outcomes to other families.

KEY OUTCOMES: WHAT WORKED AND WHAT DID NOT WORK

The most successful activity was the farmer-to-farmer training workshops conducted in the main centres at each location. Training modules used at these workshops were developed by the local project team and reviewed by relevant project team members and consultants. Once the project leadership had signed off on a training module, it was trialled with groups of farmers who had been approved as trainers to train other farmers. Then, once the modules had been validated and finalised, a series of farmer-to-farmer training workshops were planned and advertised.

Training modules were developed for the modified pig production confinement system, village rabbit production, village poultry production, sweetpotato cultivation, strawberry cultivation and production, the cultivation of legume crops, and post-harvest storage and processing of all products. Each module consisted of two sessions, and each session was run over six days (three days per week) and included several practical hands-on sessions. Groups were limited to 20–25 participants, and the only aspect that was lacking was marketing and market development.

In the first series of farmer-to-farmer training workshops, 309 men and women from 18 villages in the Baliem Valley, and 329 men and women from 11 villages in Arfak participated. Some chose only strawberries and pigs, while others chose multiple crops as well as rabbits and/or poultry.

It was interesting to note that the working models of animal production systems that were developed by individual families in each village varied in design and size, although they all incorporated the concepts that underpinned each system and maintained a relatively consistent approach to management. The variations in design and size of animal production models also proved valuable in training and exposing new families to commercial animal production as they offered a range of alternatives for them to consider when designing their own system.

Showing boards were also a great innovation and were successful in attracting new families into the project and hence they became an important part of the extension program.

The final extension workshop proved a valuable way to conclude the project as it provided an on-going interest in continuing to build on the work. This was achieved by ensuring the participation of both local and provincial government extension agencies, as well as local and national NGOs. A supplementary grant from ACIAR at the end of the project increased the likelihood of the farmer-to-farmer training workshops continuing and even being taken up by NGOs and farmer groups.

7. Summary and Conclusions

The original project was the first large-scale development project ever attempted in the Baliem Valley where the Dani Tribe have been the traditional inhabitants for at least 9,000 years.

It is only since 1954 that the Dani have experienced contact with the outside world, and a number of the families who participated in the project had never been outside of this beautiful grand valley. When we took one of the famer's wives to a review meeting in Bali it was the first time she had seen the ocean. In fact, she was so scared of the small breaking waves at Kuta Beach that she could not be enticed to prove to herself that the water was salty. A cup had to be carried to her before she would believe it.

Over the last centuries the Dani have developed a unique pig–sweetpotato system, which can be regarded almost as a monoculture that has also been described as a human–pig–sweetpotato system. As we mention in earlier chapters, the importance of pigs to a Dani was best summed up by one of the farmers themselves when he told us that "a Dani man without pigs is a man without a soul".

The project team experienced many frustrations in the early years as they tried to work out the best way into the community and to how to gain their trust. Language was also a minor problem as some farmers only had limited Bahasa Indonesia, and we discovered that the majority of Dani cannot read their own language. Even those fluent in Bahasa Indonesia and able to read Indonesian, can often only speak but not read their local language.

The adoption of a participatory approach (see Chapter 2) involving RDEs was probably the most significant key to the ultimate success of the project. This enabled the team to form solid partnerships with individual families and develop a relationship based on mutual trust and respect. Through these partnerships and the results generated from the RDEs, other participants were attracted to the project.

The outcomes, including successes and failures, are described in Chapters 3, 4, 5 and 6, the most important being the transfer of families from subsistence agriculture to small commercial enterprises. This resulted in increased cash flows that enabled families to educate children through high school and even in some cases to tertiary or post-secondary courses, as well as expand their ownership of material goods. An impact survey undertaken in 2012 found that between 80 to 90% of teenage children from families who joined the project prior to 2006 were completing or had completed high school compared with 10 to 20% for non-project families. Eight young people, including five district health workers and one veterinarian, were completing tertiary studies.

Because of the sophisticated methods and practices the Dani farmers had developed over hundreds of years for cultivating sweetpotato, the project was limited in what it could offer. An example was the method of storing roots until needed (see Chapter 3), which was superior to any storage method we could propose. It was only in the area of new varieties and developing methods for obtaining cleaner and superior planting material that we could deliver progress.

In contrast, it was in pig production that the project provided some of the best outcomes for the community. The development of a modified confinement system provided not only benefits for pigs but also health and economic benefits for the farmers and their families.

While it is accepted that other crops and livestock may never replace the pig and sweetpotato as the centre piece in Dani farming systems, families involved in the project demonstrated a willingness to try new ventures and were readily able to transfer their skills for sweetpotato cultivation and pig husbandry to other crops and livestock systems.

The introduction of the new crops and livestock into the existing smallholder sweetpotato and pig farming system was very successful. The diversification of the cropping and livestock production base contributed significantly to reducing the risk of malnutrition in children as well as economic and social benefits—introducing red beans, soybeans and pigeon peas into family diets increased protein intake but encouraging children to eat at least one egg a day probably provided the biggest boost to dietary improvement.

While the financial boost to farm income was greatest from rabbits and village chickens, strawberries and pigs also proved a financially rewarding for project farmers.

One of the most significant unplanned outcomes was that while there was uniformity in the methodology and management used on each farm, there was significant variation in design, size and ultimate place of the animal system within the overall farm operation. Much of this success could be attributed to the interactive process employed in the development of animal and cropping production models. As described previously, this approach incorporated research demonstration experiments to teach and explore known and new concepts, with ongoing and consistent feedback from individual and groups of end users. This ensured that the systems were relevant and fitted into the culture and traditional land-use customs of the community.

No doubt the pig and sweetpotato will continue to outnumber other livestock and crops in the Baliem Valley for many years to come, but the results demonstrate the value of diversifying smallholder village agriculture and animal husbandry to improve health and financial well-being.

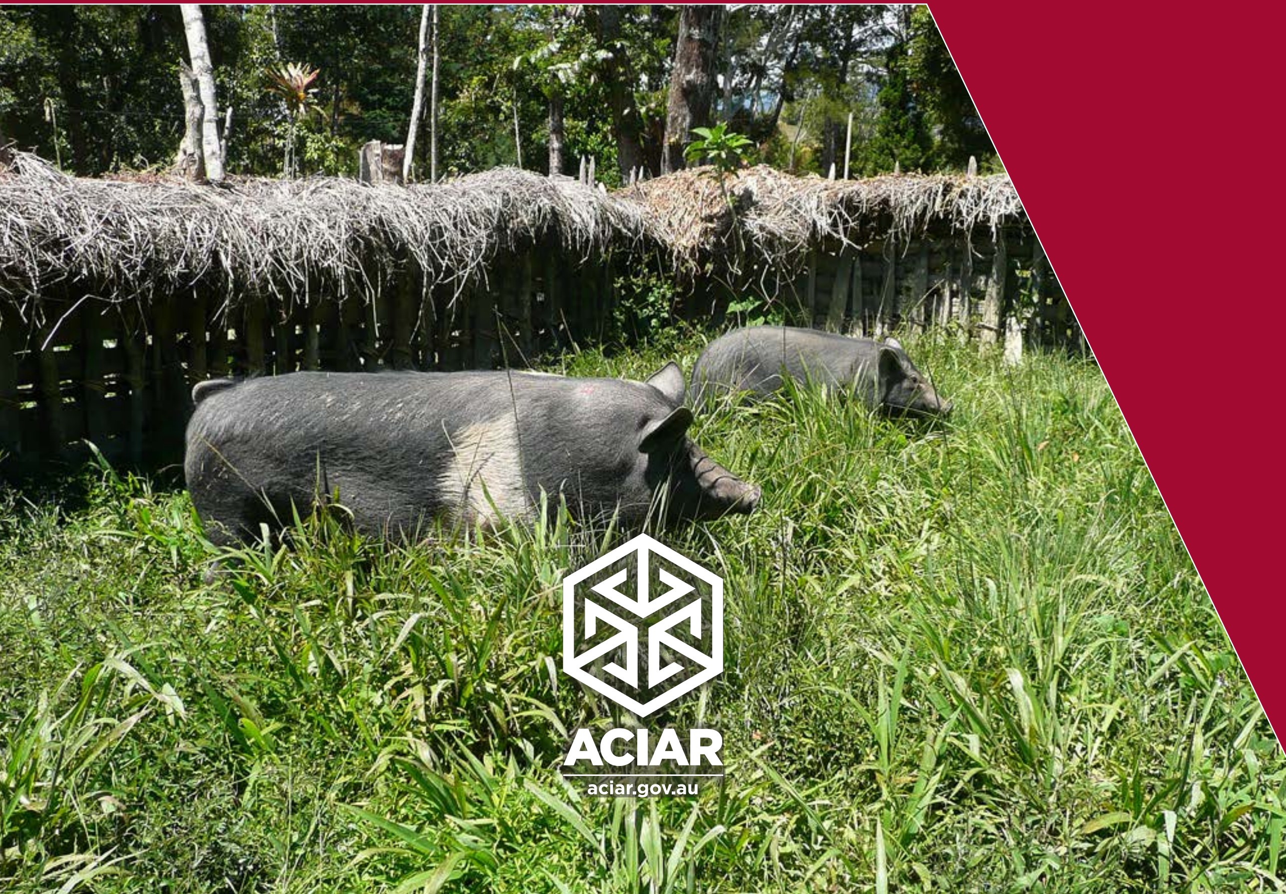
Over the 15 years of the project there was considerable bonding between the scientists, technician and farmers. The 32 scientists and technicians plus farmers involved over the life of the project included a mix of people of Hindu, Muslim, and Christian faiths, and atheists. Probably the most outstanding feature of the group was their natural respect for each other's needs and beliefs. Without actually any decision ever being made, no significant activities were scheduled for Fridays, Sundays and Hindu Feast days. It was just taken for granted that others needed their time and space. How well the project team became a family was demonstrated at the final workshop in Makassar in May, 2015. At the conclusion of the workshop, one of the senior Indonesian scientists suggested that the group pray together before saying their final goodbyes. Everyone agreed and immediately turned to one of the farmers present, Mr Paulus Muiid, who was a lay preacher in the church in his village. He was obviously considered to be the best substitute for an imam or a priest. . So together, everyone—Muslim, Christian, Hindu and others,—stood in a circle and held hands while Paulus prayed in his Papuan language. This was the final activity of the project before the team said their sad farewells after 15 years working together in the Baliem Valley—or, as the Dutch called it, "de Grote Vallei" or Grand Valley.

Figure 39: Scientists, technicians, extensionists and farmers gathered for the final workshop

REFERENCES

Cargill, C.F., Mahalaya, S., Syahputra, T. and Syahputra, T.A. 2009. Poverty Alleviation and Food Security Through Improving the Sweetpotato–Pig Systems in Indonesia [AH-1998-054]. Canberra, Australia: ACIAR.

Cargill, C., Mahalaya. S., Soplanit, A., Syahputra, A.T., Kossay, L., Muiid, N., . . . dan Ellen, A.K. 2014. Improvement and Sustainability of Sweetpotato–Pig Production Systems to Support Livelihoods in Highland Papua and West Papua, Indonesia. Canberra, Australia: ACIAR.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