Impact Evaluation of Agricultural Research in Papua, Indonesia Using the Sustainable Livelihood Framework

By

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Dedication

This thesis is dedicated to my sons: ***Rizki Caesario Maulana*** *and* ***Muhammad Kevin Andra*** *who have been providing me with never ending aspirations and inspirations. Nuhun Rob, Alhamdulillah…*

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May Allah SWT bless you all ...,,,,,,,,

Declaration

I, Sukendra Mahalaya, declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy from the Faculty of Sciences, The University of Adelaide, Australia, is completely my own work except where otherwise referenced or acknowledged.

This work has not been submitted for qualifications at any other academic institutions.

Roseworthy, 11th July 2010

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Abstract

Papua presents Indonesia with an intractable development challenge; while the province is the source of great national wealth from its extractive industries, 41% of population remains below the poverty line. Accordingly, the Papuan provincial government, with help from international donors, is enhancing community development through promoting a sustainable livelihoods strategy based on agriculture. During 2001-2006, the Australian Centre for International Agricultural Research funded a research project to improve the sweetpotato-pig systems of the Dani people in the Baliem Valley. This study evaluates the impact of this project on Dani livelihoods, and examines the value of the Sustainable Livelihood (SL) framework for the purpose of this evaluation.

Surveys with semi-structured group interviews and other Participatory Rural Appraisal techniques collected primary bio-physical and socio-economic data, both quantitatively and qualitatively. 'Before-' and 'After-project' information was collected from project participants (n = 38) and a comparison group (n = 190). The survey sample was determined using the propensity score matching method. A double difference statistical method was used to quantify the impact of the project in terms of relative changes in livelihood assets between project and comparison groups. A similar method was used to establish qualitative differences in vulnerability factors associated with sweetpotato and pig production. *Silis* – the fundamental social unit of the Dani community – was used as a unit of analysis.

Impacts of the research project on the 5 categories of Livelihood Assets include: 1) improved sweetpotato genetic diversity, higher yields, crop production efficiency and cycles and resilience against environmental stress, and less dependence on natural resource products for income (natural assets); 2) improvements in physical *sili* goods and the adoption of the pigsty-*laleken* technology (physical assets); 3) improvements in education and sweetpotato-pig husbandry skills (human assets); 4) improvements in social cohesion through the formation of *sili* organisations (social assets); 5) and improvements in the capacity of producing more sweetpotatoes and pigs, and cash incomes (financial assets). Moreover, the vulnerability factors of sweetpotato and pig production such as sweetpotato yields and pig diseases is reduced by *sili* participation in the project.

Drawing on these impacts the study proposes a number of recommendations in the context of the "policies, institutions, and processes" component of the SL framework. The proposed policies include extension of the improved sweetpotato-pig systems through farmer-to-farmer extension programmes, efficient sweetpotato-pig husbandry technical assistance from local institutions, the formation of *sili* organisations in every village, equitable agricultural training opportunity for both Dani men and women, wider access to loans from local financial institutions, on-farm multiplication of new sweetpotato cultivar cuttings, and regulations to control marauding pigs. Meanwhile, the institutions that need closer facilitated collaboration are the Jayawijaya Extension, Agricultural, Livestock, and Co-operative Offices (government organisations); and the World Vision Indonesia and the Jayawijaya Institute for Customary Discussion (non-government organisations). Furthermore, wider participation of *silis*, and the provision and continuation of training for local technical staff within the institutions should be encouraged.

The use of the SL framework elsewhere has been either as an analytical tool, as a tool impact assessment, or an overview to guide development. In this study, all these values of the SL framework are used to evaluate the impact of the project. As such it offers a more comprehensive impact evaluation with more quantification of impacts than other similar studies.

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List of Acronyms

ABS	Agricultural Bank of Sudan
ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
AIAT	Assessment Institute for Agricultural Technology (= BPTP)
AP	After Project
AUSAID	Australian Agency for International Developement
BC	Benefit Cost
BKD	*Badan Kepegawaian Daerah* (=LLI)
BP	Before Project
BPTP	*Balai Pengkajian Tekonologi Pertanian* (= AIAT)
CG	Comparison Group
CGIAR	Consultative Group on International Agricultural Research systems
CIP	International Potato Center
CRS	Catholic Relief Services
DDI	Double Difference Impact
DFID	Department for International Development
DISKOP	*Dinas Koperasi* (= JCO)
DISNAK	*Dinas Peternakan* (= JLO)
DISTAN	*Dinas Pertanian* (= JLO)
FFS	Farmer Field School
FtF	Farmer-to-Farmer
IAARD	Indonesian Agency for Agricultural Research and Development
IDRC	International Development Research Centre
IDS	Institute of Development Studies
IFAD	International Fund for Agricultural Development
IRR	Internal Rate of Return
JAO	Jayawijaya Agricultural Office (=DISTAN)
JCO	Jayawijaya Cooperative Office (= DISKOP)
JEO	Jayawijaya Extension Office (=KIPPK)
JGO	Jayawijaya Government Office (= PEMDA)
JICD	Jayawijaya Institute for Customary Discussion
JLO	Jayawijaya Livestock Office (= DISNAK)
KIPPK	*Kantor Informasi Penyuluhan Pertanian dan Kehutanan* (= JEO)
LA	Livelihood Assets
LLI	Local Labour Institute (= BKD)
LO	Livelihood Outcomes
LS	Livelihood Strategies
MMI	Metemamen Microfinance Institution
NPV	Net Present Value
PG	Project Group
PIP	Policies Institutions Processes
PRA	Participatory Rural Appraisals
PSM	Propensity Score Matching
RoI	Returns on Investment
SFR	Soil Fertility Replenishment
SL	Sustainable Livelihoods
SP	Sweetpotato
ToT	Training of Trainers
UN	United Nations
UNDP	United Nations Development Programmes
USAID	United States Agency for International Development
VC	Vulnerability Context
WB	Vulnerability Context
WCED	World Bank World Commission on Environment and Development
WVI	*Wahana Visi Indonesia*

1. Introduction

1.1. Background

Papua is a source of great wealth for Indonesia. This largest but least populated province contributes the Indonesian government around US$1.7 billion per year collected from its natural resources (BPS Indonesia 2008). The Papuan Gross Domestic Regional Product (GDRP) of US$5.5 billion earned largely through the mining and forestry sectors produces a per capita GDRP of US$2,400 which is well above the national average of US$1,500. However, this economic success has not been shared by most Papuans. In this province, 41% of the population live below the poverty line, which is defined as living with less than US$20 per month, which is more than double the national average of 17%.

The Indonesian government re-invests around US$160 million per year into the agricultural sector of Papua where 75% of the population engage in this sector, while international donors provide an extra investment of approximately US$6 million per year (BPS Papua 2008). To guide this investment is important to understand the agricultural-based livelihoods of the local people. To evaluate the impact of this investment is important to measure changes in assets – both quantitatively and qualitatively – underpinning these livelihoods.

The Dani tribe of the Baliem Valley in the Central Highlands of Papua is one of the 312 indigenous tribes and they are the biggest with about 146,000 members (BPS Papua 2008). They follow a traditional system of sedentary agriculture based on sweetpotatoes and pigs. Their subsistence economy is becoming increasingly monetised in response to regional economic growth. The Indonesian Agency for Agricultural Research and Development (IAARD) recognises that scientific intervention is needed to develop this traditional farming system so the Dani can participate in the sustainable and equitable development of the region (Darmajana 1996). To this effect, during 2001-2006 they formed a partnership with the Australian Centre for International Agricultural Research (ACIAR) for a project called “Poverty alleviation and food security through improving the sweetpotato-pig systems in Papua, Indonesia” in which ACIAR made a total investment of A$1,253,608 (ACIAR 2005).

There has been a need to justify how and to what extent the investment has benefited the Dani community, and to what degree the project has affected development processes in the region. Has the investment been worthwhile? Impact evaluation can play an important role to address such a justification (Sayce and Norrish 2006), and so it has been employed here accordingly.

Conventional economic approaches such as econometric and economic surplus which quantify the economic benefits of projects have been considered by some as "best practice" to impact evaluation (Alston et al. 1998). However, there is a growing wide recognition that purely quantitative evaluation provided by these approaches has limitations. For example, the impact of complex social interventions cannot be translated into a single number. There will also be many links between project outputs and its wider level of impacts which are not captured by economic measures (Douthwaite et al. 2003). Since then other multi-disciplinary approaches which mix quantitative and qualitative methods have evolved.

One approach that has currency is the Sustainable Livelihoods (SL) framework. The fundamental position of this framework is that to help poor people to escape from poverty one needs to understand the way in which their livelihoods are constructed, and how and why they change over time. This understanding is based on information about their livelihood assets (seen as natural, physical, human social and financial), the vulnerability of these assets to change, and the policies, institutions and processes that affect these assets (DFID 1999). As such this framework has been used for policy development and planning for sustainable and equitable community development in its early use. However, there has been a growing interest to use it as well for the purpose of impact evaluation since 2003 (e.g. Hossain et al. 2003, Hallman et al. 2003, Place et al. 2003, Bourdillon et al. 2003, and Bellon et al. 2003).

Accordingly, the research question of this study is "what were the measurable impacts of agricultural research (i.e. the ACIAR project) on Dani livelihoods and how can these impacts be evaluated using the SL framework?"

1.2. Aim

Therefore, this study aims to evaluate the impact of the ACIAR project on Dani livelihoods in Papua, Indonesia and to examine the value of the SL framework for the purpose of impact evaluation.

1.3. Structure of thesis

Chapter 2 provides an overview to impact evaluation and establishes the SL framework as an appropriate starting point for evaluating the impact of the ACIAR project. The SL framework determines what should be evaluated. This chapter also draws from the literature the double difference impact method as a statistical robust way to infer causal links between the activities of the ACIAR project and physical, social and economic variables which can be measured by survey.

Chapter 3 then sets the scene of the research study site. It provides the geographical, social and institutional context of the Baliem Valley, Papua. It then describes the genesis and structure of the ACIAR project.

Chapter 4 presents details of the methods used in this study, viz: focus group discussions to develop questionnaire; propensity score matching to identify a statistically robust sample; survey with semi-structured group interviews; participatory rural appraisal such as project timelines, seasonal calendars, wealth and well-being ranking, and matrix scoring and weighting; double difference impact to quantitatively measure estimates of the impact of the project; and t-tests for significance of the impacts.

The next four chapters, 5 to 8, present the results of the survey. These are presented in the form of manuscripts for the publication process. Chapter 5 describes the farming systems of the Baliem Valley. It updates previously published knowledge with further contextual information that was generated from the survey. It quantitatively establishes the key importance of that the traditional sweetpotato-pig production system in Dani livelihoods. Chapter 6 provides details on the vulnerability of the sweetpotato-pig production system. The vulnerability to stable livelihood can be affected by different factors in the sweetpotato and pig sub-systems. The factors themselves were defined by the Dani within participatory processes. This chapter

quantities the ecological balance between humans, sweetpotatos and pigs; the change in use of sweetpotatos and pigs from participation in the project; and ranks the significance of the various vulnerability factors.

Chapters 7 and 8 present the impact of the project in terms of change in natural and physical assets (Chapter 7) and human, social and financial assets (Chapter 8). They quantify a number of variables that were influenced by the project, that were measured and analysed in a statistically robust manner, and that logically contributed to sustainable livelihood outcomes.

At the time of submission each of the papers that constitute Chapter 5 to 8 was at various stages in the process. As each paper must read as an internally coherent, stand-alone document they contain similar background information and methods sections. As such they exist as shorter versions of Chapters 3 and 4. For the same reason the tables and figures for each of Chapters 5 to 8 have their own internal numbering system.

Chapter 9 drawn on Chapter 5 to 8 begins with summarising the measurable impacts that emerged from the ACIAR project. This is followed by discussing how that knowledge be used to provide recommendations in terms of proposed policies, involved institutions, and necessary processes in the context of the SL framework. This chapter is closed by examining the value of the SL framework, i.e. comparison with other similar uses of the SL framework in other contexts. Finally, the conclusions of the study are summarised in Chapter 10.

2. Impact Evaluation: An Overview

This chapter briefly describes impact evaluation particularly one used to examine the effectiveness of agricultural development projects in developing countries. It aims to provide understanding necessary for the study, clarify other studies that have previously been done, and justify the use of the Sustainable Livelihood (SL) framework, the Double Difference (DD) method and the mixed quantitative and qualitative methods which all work in conjunction on ensuring a quality impact evaluation. It is organised as follows: (1) The importance of impact evaluation, (2) Debate on impact evaluation, (3) Approaches to impact evaluation, (4) The SL framework, (5) The DDI method, (6) Impact evaluation using the SL framework, and (7) Conclusions.

2.1. The importance of impact evaluation

The first goal of the United Nations Millennium Development Goals calls for the eradication of extreme poverty around the world by half in 2015 (UN 2001). To answer this call, donors invest billions of dollars into poverty eradication projects mostly based on agricultural development in developing countries. For example, in 2009/10 alone the Australian Centre for International Agricultural Research (ACIAR) invested about $49 million to assist in eradicating poverty through increasing farmers' incomes in its five working regions of Papua New Guinea and Pacific Island Countries, South Asia, South East Asia, North Asia, and Southern Africa (ACIAR 2009). These huge investments, due to the scarcity of resources, increase demands for accountability and thus highlight the importance of impact evaluation.

There is agreement on the importance of impact evaluation. The following are some examples of important reasons for conducting impact evaluation:

- Impact evaluation is a basic requirement for all who are accountable in spending funds for development purposes (Sayce and Norish 2006) because it can demonstrate whether the money they spent was improving the lives of poor people (White 2006).
- Impact evaluation can justify how well development projects achieved their desired objectives and thus met donor expectations, how results compared with

alternative uses of the invested resources, and how effectively they contributed to the attainment of broad development objectives such as the Millennium Development Goals and the eradication of poverty (Bamberger 2009).

- Impact evaluation can help learn about change processes what worked and what did not and why, and thus contribute to the effectiveness of future development projects (Leeuw and Vaessen 2009).

2.2. Debate on impact evaluation

While there is agreement on the importance of impact evaluation, there is also widespread debate on the definition of impact evaluation and how impact evaluation should be done, particularly the use of appropriate methods (see White 2009 for an overview). The debate on the definition has two sides which talk about completely different things. The first side attempts to not just find out what worked and what did not, but more importantly why which leads to mapping out the causal chains from inputs, outputs, outcomes to impacts (e.g. Douthwaite et al. 2003, Springer-Heinzea et al. 2003, Douthwaite et al. 2007, White 2009).

Meanwhile, the second side focuses more on project results at a higher level, which are the effects of projects on final welfare outcomes. By such a focus, impact is defined as the difference in the indicator of interest (Y) with the intervention (Y_1) and without the intervention (Y_0), that is impact (Y) = $Y_1 - Y_0$ (e.g. Ravallion 2001, Reddy et al 2004, ADB 2006, Ravallion 2008b).

Nonetheless, the two definitions are neither right nor wrong. They are just different and they depend on the aim of impact evaluation projects whether one is interested in the project implementation process (i.e. the earlier definition) or the effect of the project which allows the attribution of the observed results to any particular investment to convincingly show the impact of the project (i.e. the later definition). However, no debate about methodology is of any use unless one first agrees which definition is being adapted (White 2009).

This study aims to evaluate the impact of an agricultural development project on the final welfare outcomes of its target community. Therefore, it adapts the later definition and uses one formulated by the World Bank, that is an evaluation that

> … assesses changes in the well-being of individuals, households or communities that can be attributed to a particular project, program or policy. The central impact evaluation question is what would have happened to those receiving the intervention if they had not involved in the project. Since we cannot observe this group both with and without the intervention, the key challenge is to develop a counterfactual – that is a group which is as similar as possible in observable and unobservable dimensions to those receiving the intervention. This comparison allows for the establishment of definitive causality – attributing observed changes in welfare to the project (World Bank 2010).

Following the adaptation of this definition, the debate on the use of appropriate methods falls into two areas. The first area is the practicability of experimental and quasi-experimental designs among those who use quantitative methods (White 2006 and 2009). The experimental designs which generate control groups using random methods are considered as a perfect counterfactual since these control groups are free from selection bias problems (Baker 2000). Critics argue that the experimental designs are simply not practicable for a broad range of development interventions especially in the field of agriculture, e.g. no one can prevent new agricultural technologies spreading into the control groups (Pearce 2002; CGIAR 2006). However, these critics are stuck with the problem of showing their alternative, the quasi-experimental designs which generate comparison groups using non-random methods can establish a valid counterfactual (comparison groups) since these comparison groups are difficult to be free from selection bias problems.

Meanwhile, the second area reflects the more general debate over the role of quantitative and qualitative methods in social science research (White 2006 and 2009). Those who use quantitative methods are criticized for their attempts to quantify the impact of complex social interventions into a single number and establish linear links between project outputs and its wider level impacts (Douthwaite et al. 2003). Such a single number and linear links cannot tell the whole story of impact (Meizen-Dick et al. 2004). On the other side, those who use qualitative methods are rejected for their analyses which fail to build on a well-designed sample of project and comparison groups (Maredia et al. 2002). Such a well-designed sample can allow statements to be made with a degree of scientific confidence about the behaviour of indicators with versus without the intervention.

Nevertheless, there has been an emerging consensus around the use of counterfactual – no matter they are established using random or non-random methods

– and a growing interest in using a mixed quantitative and qualitative methods approach (White 2008; Garbarino and Holland 2009). This leads to impact evaluation using an interdisciplinary approach which attempts to comprehensively capture the impact of projects on the life of poor people. No single discipline or expert can understand the complexity of social impacts and so an interdisciplinary approach should be done (Ashley and Carney 1999; Mackay and Horton 2003; White 2008; Garbarino and Holland 2009).

The Sustainable Livelihoods (SL) framework developed by the Department for International Development of the United Kingdom (DFID 1999) allows the implementation of an interdisciplinary approach to impact evaluation. The SL framework is a model for understanding the many interrelated causes of poverty and how to alleviate poverty. It looks at the livelihood assets of poor people (i.e. natural, social, human, physical and financial) and other internal and external factors (i.e. vulnerability context and policies-institutions-processes) which influence changes in those assets and affect their livelihood strategies used for achieving their livelihood outcomes. More details about the SL framework will be discussed later after the following sub-heading of approaches to impact evaluation.

2.3. Approaches to impact evaluation

There are a number of approaches to evaluating the impact of projects on final welfare outcomes. These approaches include economic, participatory, and interdisciplinary. They are discussed below.

2.3.1. The economic approach

The economic approach is the oldest (e.g. Griliches 1958), but still the most popular today (e.g. Raitzer and Kelley 2008; Alene and Coulibaly 2009; Palanisami et al. 2009). It is commonly employed by big organisations such as the World Bank (Leeuw and Vaessen 2009), the Consultative Group on International Agricultural Research systems (Walker et al 2008), the Asian Development Bank (ADB 2006), and the Australian Centre for International Agricultural Research (Raitzer and Lindsner 2005; Davis et al. 2008; Harding et al. 2009) for which they argue that it

allows the use of broadly acceptable quantifiable measures which can directly be related to costs showing the effectiveness of their investments.

The economic approach attempts to quantify the effectiveness of a project in terms of achieving the goal of the project. It measures an estimate of economic benefits to participants as a whole involved in the project by calculating Returns on Investment (RoI). There are two broad approaches to estimating RoI – the econometric and economic surplus approaches (Alston et al. 1998).

The econometric approach employs a production, productivity, cost, or supply function, or a total factor productivity analysis to estimate changes in productivity due to investment in a project (Alston et al. 1998). The functions incorporate a number of inputs (e.g. in a livestock production function: feed amounts, labour numbers, etc.) and uses the project effort, which is usually measured by lagged project expenditures as one of the argument in the function. The estimated project coefficient(s) (measuring marginal product) is then used to calculate the value of additional output attributable to the lagged project expenditures (assuming other inputs constant) and to derive a marginal RoI. Examples of using the econometric approach can be seen in Bredahl and Peterson (1976), Flores-Moya et al. (1978), Taylor et al. (1979), Jayasuriya (2003), Deng et al. (2005), and Alene and Coulibaly (2009). However, the wider application of this approach is constrained by its requirement of availability and good quality data (e.g. time series) which is difficult to obtain in most developing countries (Evenson and Pray 1991).

Meanwhile, the economic surplus approach calculates RoI as a performance measure used to evaluate the effectiveness of an investment or to compare the effectiveness of a number of different investments (Alston et al. 1998). To calculate RoI, the return of an investment (gain from investment – cost of investment) is divided by the cost of the investment and the result is expressed as a percentage or a ratio. This is a versatile and simple measure, that is if an investment does not have a positive ROI, or if there are other opportunities with a higher RoI, then the investment should be not be undertaken. Alternatively, the economic surplus approach may estimate RoI by using estimated economic surplus together with costs to compute Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit Cost (BC) ratio. Examples of using the economic surplus approach can be seen in Norton and Davis

(1981), Morris et al. (1994), Marasas et al. (2003), Smale et al. (2003), Raitzer and Lindner (2005), Raitzer and Kelley (2008), and Palanisami et al. (2009).

While the economic approach provides a strong performance measure to the effectiveness of projects, it fails to tell the whole story of impacts such as social processes that occurred in the projects' target communities (Douthwaite et al. 2003). The projects may achieve their goals (i.e. having a high positive RoI), but what actually happened with their target communities are unclear whether they perceive the impacts and if they do or do not then why. This is where the participatory approach comes in, which was only begun in the early 1990s (Okali et al. 1994).

2.3.2. The participatory approach

The participatory approach attempts to evaluate the impacts of a project as they are perceived by individuals, households or communities targeted by the project (Cromwell et al. 2001; Chambers 2009). As participation is at the core of this approach, all stakeholders are involved in all stages of evaluation from determining the objectives of evaluation and identifying and selecting indicators to be used to participating in data collection and analysis. Moreover, it concerns with the process of evaluation (IFAD 2002). This concern leads to the establishment of participatory approach variants such as impact pathway analysis (Douthwaite et al. 2003; Springer-Heinze et al. 2003; Doutwaite et al. 2007) and theory-based impact evaluation (Carvalho and White 2004; White and Masset 2007; White 2009) which attempts to depict impacts in more likely ways from inputs, outputs, outcomes to impacts (i.e. the causal chain of impacts). This chain tells the whole story of impacts from the beginning to the end of work, which part works best and why.

Depicting the causality of impacts requires first hand information from those who are involved in the project. Therefore, the participatory approach relies more on qualitative methods (Okali et al. 1994; Ezemenari et al. 1999). There are a number of qualitative methods used by this approach such as mapping and diagramming, ranking and scoring, and interviews (see Cramb and Purcell 2001 for the description of these methods). However, some of these methods can be quantified (e.g. ranking and scoring), and even interviews can generate quantitative data (e.g. Cramb et al. 2004).

In practice, the participatory approach also uses the basis for comparing project impacts, that is the situation "Before-After" and "With-Without" of the project (Baker 2000). Cramb and Purcell (2001) argue that if we measure changes over time and attribute these changes to the project, we need to compare the two situations because without comparing them we cannot be sure to what extent the changes are actually impacts of the project. However, the way in which this approach collects the data is somewhat different from the economic approach. For example, instead of conducting an elaborate and time-consuming questionnaire survey for collecting baseline and endline data to permit the "Before-After" comparison, this approach employs participatory techniques such as community mapping, time lines, problem ranking, and semi-structured interviews in focus group discussions as part of project planning and review to establish the past and recent status of key variables. Similarly, as it is always difficult to find an area which is sufficiently similar to the project area yet unaffected by the changes the project is engaged in to permit the "With-Without" comparison, this approach employs participatory techniques such as flow-charting and ranking-scoring in focus group discussions which draw on the detailed local knowledge and experience of farmers and field workers within the project area to identify and weight the factors (project and non-project) which have led to the changes. More details on this example can be seen at Cramb et al. (2004).

So, while the participatory approach tends to overlap more with qualitative methods, and the economic approach strongly uses quantitative methods, these two approaches actually have the same purpose, that is to provide evidence that the project being evaluated does or does not having impacts. Both also agree with the use of counterfactual, though there is difference in methods they use to collect data. Nevertheless, there has been a growing realisation since early 2000 that the use of mixed quantitative and qualitative methods may enhance impact evaluation efforts (Bamberger 2000; Gacitua-Mario and Woden 2001; Holland and Campbell 2005; White 2008; Garbarino and Holland 2009). This realisation leads to the interdisciplinary approach in impact evaluation.

2.3.3. The interdisciplinary approach

There is no single discipline or expert which can solely understand the complexity of socio-economic impacts (Ashley and Carney 1999). Therefore, an interdisciplinary approach is needed (Mackay and Horton 2003; White 2008; Garbarino and Holland 2009). This approach allows to bring together both quantitative and qualitative methods in its attempt to comprehensively capture and understand the complexity. While quantitative methods provide performance measures telling the effectiveness of a project, qualitative methods explain which part of the project works best or do not work and more importantly why. It is clear that this approach with its mixed quantitative and qualitative methods can enhance impact evaluation.

Meinzen-Dick et al. (2004) provides a good example of using an interdisciplinary approach to evaluate the impact of agricultural research in six developing countries. They show that quantitative measures of the direct impacts of new technologies on incomes and yields do not tell the whole story. Both economic and socio-cultural factors play an extremely important role in determining whether the poor adopt or benefit from new technologies. These factors together influence whether the poor receive direct and indirect benefits from new technologies. They conclude that it is crucial that impact evaluation includes a mix of disciplines and methods, and that researchers do not only focus on quantifiable impacts, but need to understand all the social factors which affect the uptake and impacts of technologies. In addition, they recommend for the future that scientists and other decision makers designing new research programmes need to understand poor people's strategies for managing risk and the importance and role of agriculture in their livelihood strategies. This recommendation fits in well with the sustainable livelihoods framework which has been growing to be used for the purpose of impact evaluation since the 2000s.

2.4. The Sustainable Livelihoods framework

The concept of "Sustainable Livelihood (SL)" was first introduced by an advisory panel of the World Commission on Environment and Development (WCED) in 1987 (WCED 1987). The panel describes SL as an integrating concept which links

SL security to basic human needs, food security, sustainable agricultural practices, and poverty. Since this introduction, the SL approach has been formalised (Chambers and Conway 1992) and a number of different SL frameworks to set out factors in a SL system and to represent relationships among these factors have been developed during the 1990s by a number of government, non-government and multilateral organizations such as the United Kingdom's Institute of Development Studies (IDS) (Scoones 1998), the United Kingdom's Department for International Development (DFID) (Carney 1998; DFID 1999), Oxfam International (Carney 1999), CARE (Drinkwater and Rusinow 1999), United Nations Development Programme (UNDP) (Singh and Gilman 1999; UNDP 1999), and later on International Fund for Agricultural Development (IFAD) (IFAD 2006). However, the most well-known SL framework is one developed by DFID (Figure 2.1).

NOTE:
This figure is included on page 13 of the print copy of the thesis held in the University of Adelaide Library.

Figure 2.1. The SL framework (DIFD 1999)

DFID commits to the task of eliminating world poverty (DFID 1998). It concerns with the voices of the poor, and believes that policies need to be pro poor, public services tailored and projects planned and carried out in ways that respond to strengths. Meanwhile, the SL approach puts people at the centre of development, builds on people's strengths, bring all relevant aspects of people's lives and livelihoods into development, takes into account how development decisions affect distinct groups of people, emphasizes the importance of understanding the links between policy decisions and household level activities, draws in relevant partners whether government, non-government, private, local, national, regional or international, and responds quickly to changing circumstances (Chambers and

Conway 1992). Therefore, DFID believes that the SL approach is the most sensible and practical way of thinking about, planning and implementing development, and that this approach is more effective in helping the poor improve their opportunities to escape from poverty.

To help understand livelihoods, the way in which livelihoods are constructed and how and why they change over time which in turn can help identify the best way of supporting the poor to escape from poverty, DFID develops the SL framework (Figure 2.1). This framework has five core components which relate with each other, viz, Vulnerability Context, Livelihood Assets, Policies-Institutions-Processes, Livelihood Strategies, and Livelihood Outcomes. It looks at livelihood assets of the poor (i.e. natural, social, human, physical and financial) and other internal and external factors (i.e. vulnerability context and policies-institutions-processes) which affect changes in those assets and livelihood strategies used for achieving livelihood outcomes. The following is the key features of the five components.

2.4.1. Vulnerability context

Vulnerability context is defined as the set of factors related to shocks, trends and seasonality issues which can have a great impact on people's livelihoods (DFID 1999). These factors are all outside people's control. They are constant realities – not just passing states – which many poor people have to deal with everyday. Examples of these factors are human health shocks, technological trends, and seasonality of prices. Moreover, vulnerability context can be influenced by society's policies, institutions and processes, exerting in turn influences on and be influenced by people's livelihood assets (see Figure 2.1). To analyse it, one can begin with understanding various groups within a target community and factors that make their life vulnerable. Once a factor has been identified as important, one can assess its relative importance compared to other factors, how widely applicable it is, what its effect on livelihoods is, and whether people have developed any way of coping with it.

2.4.2. Livelihood assets

Livelihood assets consist of five types of capital or assets, on which livelihoods are built, which include Human (H), Social (S), Natural (N), Physical (P) and Financial (F) (DFID 1999). These assets refer to not only people's possessions, but also their ability to access them. Moreover, livelihood assets partly determine people's choice of livelihood strategies. People usually require some combination of assets to achieve positive livelihood outcomes. However, a single asset can generate multiple benefits. For example, a household which has secure access to land (a natural asset) may use the land for both productive uses and a guarantee for getting a loan (a financial asset).

Human assets

Human assets represent the skills, knowledge, capacity to work and good health which together enable people to pursue different livelihood strategies in order to achieve their livelihood outcomes (DFID 1999). At a household level, they are a factor of the amount and quality of labour available which is varied according to household sizes, skill levels, leadership potential and health status. They are important in their own right as the skills, knowledge and health can help in creating sustainable livelihoods. They are also necessary to be able to make use of the other four assets.

Social assets

Social assets are the social resources upon which people draw in pursuit of their livelihood objectives (DFID 1999). These resources are developed through interactions (through work or shared interests) which increase people's ability to work together, membership of more formal groups in which relationships are governed by accepted rules and norms, and relationships of trust which facilitate co-operation, reduce transactions costs and sometimes help in the development of informal safety nets among the poor. They are also important in their own right as people may draw on them as a way to ensure that they survive in times of extreme vulnerability. For

example, they may make use of shared work groups at times of peak labour demand, or rely on neighbours following a death in the household. Moreover, social assets also have a direct impact on the other four assets. For example, relationships of trust can sometime substitute for a land guarantee for getting a loan (a financial asset). In many cases, they can be effective in improving the management of common resources (a natural asset) and the maintenance of shared infrastructure (a physical asset) because people trust each other and are willing to work together.

Natural assets

Natural assets are a term used for natural resource stocks upon which people rely (DFID 1999). These stocks vary from intangible public goods such as climate and biodiversity to divisible assets used directly for production such as land and trees. The benefit of the stocks can be both direct and indirect. For example, land and trees may provide direct benefits by contributing to income and people's sense of well-being and at the same time may provide indirect benefits such as nutrient cycling and storm protection. Moreover, natural assets are clearly important for those who derive all or part of their livelihoods from natural resource-based activities such as farming. However, its importance actually goes beyond the source of livelihoods. For example, none would survive without food produced from land (a natural asset).

Physical assets

Physical assets comprise basic infrastructure and physical goods that support livelihoods (DFID 1999). Basic infrastructure consists of changes to the physical environment which help people meet their basic needs and be more productive. It is commonly a public good, which people can either directly or indirectly pay to put it in place. Key components of infrastructure include affordable transport systems, adequate quantity and quality water supply and sanitation, affordable energy, and good communications and access to information. Moreover, the other components of physical assets include items which enhance income (e.g. transportation and communication devices, agricultural tools). Most of these items are usually owned by individuals or households. However, a few items such as larger agricultural machines

may need to be rented or they can be used as well by paying the service of using them.

Financial assets

Financial assets are the financial resources which people use to achieve their livelihood objectives and they include available stocks and regular inflows of money (DFID 1999). A common type of available stocks is savings which can be held in several forms such as cash, including bank deposits, and liquid assets (e.g. livestock, gold). These savings are usually the preferred type of financial assets as they do not have liabilities attached and usually do not entail reliance on others. However, they can also be obtained through credit-providing institutions. Meanwhile, as regards the regular inflows of money, the most common types of it are pensions and remittances. These inflows are not earned incomes, but they must be reliable, meaning they should be distinguished between a one-off payment and a regular transfer on the basis of which people can plan investments. Moreover, financial assets are important because they can be converted into other types of assets (e.g. using savings to buy land or agricultural tools) as well as be used directly for achieving a desired outcome (e.g. money can be used for purchasing food which helps ensure food security).

2.4.3. Policies-institutions-processes

Policies-institutions-processes refer to a wide range of contextual factors that have great effects on all aspects of livelihoods (DFID 1999). These factors usually relate to the services and environment created by governments, but they may also relate to local-level institutions, which are unaffected by governments, and the activities of private sector organizations. They can also be influenced by people themselves, unlikely most of the factors within the vulnerability context. Examples of these factors include central and local authority, public service delivery, legislation, governance, policy formulation and implementation, participation, institutions (regulations, interactions, laws and markets), organisations (non-governmental organisations, community-based organisations, private companies), and cultural factors which may account for unexplained differences in the way things are done in

different communities. Moreover, the policies-institutions-processes can effectively determine: (1) access to various types of assets, livelihood strategies, decision-making bodies and sources of influence, (2) the terms of exchange among different types of assets (i.e. markets), and (3) incentives to undertake certain activities or invest in particular areas. In addition, they may have direct impact on both inter-personal relationships (i.e. how different groups treat each other) and whether people are able to achieve a feeling of inclusion and well-being.

Policies

Policies refer to deliberate action designed to achieve particular goals or targets (DFID 1999). They may associate with both government bodies and other types of organization (e.g. NGOs). They can be either macro, which affects the whole country, or micro, which affects only particular sectors, districts, neighbourhoods or groups. They can also be either long-term or short-term. While determining what policies are in place, it is also important to understand what effects they have on livelihoods and how they are made and altered.

Institutions

The term 'institutions' cover two important elements: (1) organisations or agencies that operate within both the public and private sectors, and (2) the way in which these organisations function and interact each other (DFID 1999). It is important to understand the organisational density in a given area which is the number of different organizations that are concerned with a particular issue, or that influence the livelihoods of a particular group. Analysing these institutions should cover markets, which are essentially groups of private sector organisations, and conventions or legislation governing how they operate, as they have a key influence on people's abilities to pursue different livelihood strategies.

Processes

Processes refer to the ways in which policies and institutions change over time, either as a result of policies or due to other factors (DFID 1999). This can be a difficult area to analyse. One solution is to look at issues such as the nature of authority and decision-making structures, the form and quality of government systems, the extent and nature of public participation in policy and other processes, the effect of public participation, and other factors behind change.

2.4.4. Livelihood strategies

Livelihood strategies refer to the range and combination of activities and choices that people make and undertake in order to achieve their livelihood objectives (DFID 1999). One of the goals of the SL approach is to help people build up their core assets so that they have the ability and flexibility to alter their livelihood strategies over time. The more flexibility they have, the greater their ability to withstand or adapt to the vulnerability context and the policies-institutions-processes as well as the better they are to take advantage of positive opportunities to achieve their livelihood objectives. In addition, when thinking about livelihood strategies, it is important to look beyond just sources of income. Other issues to think about include the way in which people use their assets, which assets they choose to invest in, and how they manage to preserve existing assets and income rather than generating new income. These issues are easier to understand when they are analysed at the same time with livelihood outcomes.

2.4.5. Livelihood outcomes

Livelihood outcomes refer to the achievements of the outputs of livelihood strategies (DFID 1999). These outcomes should be sustainable and poverty-elimination-oriented. In many cases, people tend to have objectives that lead them to 'unsustainable livelihoods'. For example, they may aspire to make a great deal of money which might use natural resources in an unsustainable way. As regards the poverty-elimination-oriented, this means that attention should be given on results and

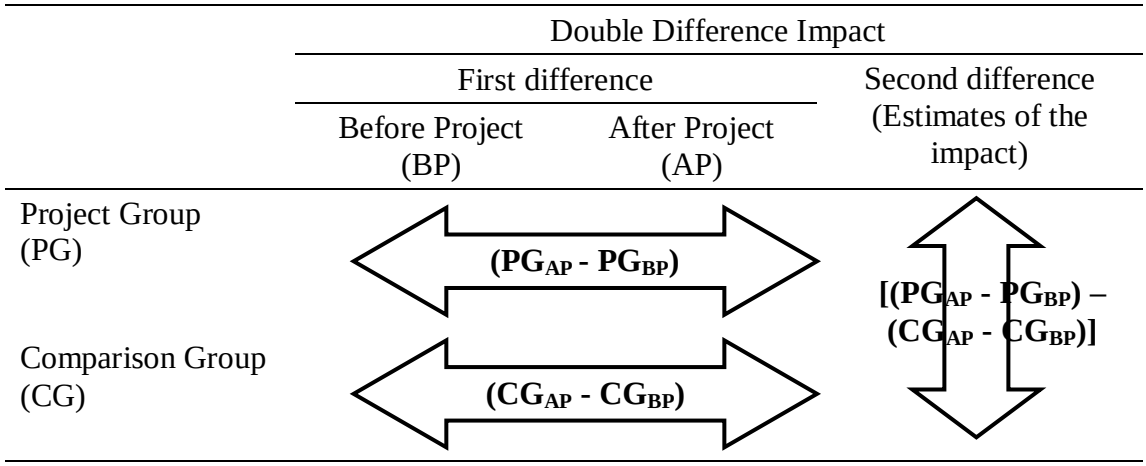
progresses that are made towards poverty elimination rather than thinking only about what people try to achieve. Moreover, as depicted in the SL framework these outcomes may be more income, increased well-being, reduced vulnerability, improved food security, and more sustainable use of the natural resource base. However, in practice people might aspire to things that fall outside these types of livelihood outcomes (e.g. better access to particular services), or they might not have objectives in all of these types of livelihood outcomes (e.g. they might not aspire to more sustainable use of the natural resource base).

To summarise all the key features above, the SL framework with its five core livelihoods is a model for understanding the many interrelated causes of poverty and how to alleviate poverty. It looks at the livelihood assets of the poor, the vulnerability context, and the policies-institutions-processes which together affect the livelihood strategies used for achieving the livelihood outcomes in order to help the poor escape from poverty. The practicability of the SL framework particularly for the purpose of impact evaluation will be discussed later after the following section of the double difference method.

2.5. The Double Difference Impact method

The Double Difference Impact (DDI) method is one of the quantitative methods developed by the World Bank to help measure estimates of the impact of intervention on final welfare outcomes (Baker 2000). It entails comparing a project group with a comparison group both before and after the intervention (Ravallion 2001). While the project group consists of those who involved in the project (i.e. participants), the comparison group in contrast consists of those who did not (i.e. non-participants). To employ this method, a baseline survey is needed before the intervention is in place, and the survey has to cover both participants and non-participants. Then at least one follow-up survey is needed after the intervention is put in place. The baseline and follow-up surveys should be comparable in terms of the questionnaire, the sampling, and the interviewing. Finally, estimates of the impact of the intervention are obtained by calculating the mean difference between the 'after' and 'before' values of the outcome indicators for each of the project and comparison

groups (first difference), and the difference between these two mean differences (second difference). The second difference is estimates of the impact of the intervention (see Figure 2.2).



Source: Adapted from Ravallion (2001)

Figure 2.2. The DDI method for measuring estimates of the impact of intervention.

The biggest challenge of employing the DDI method is to form an appropriate comparison group. While forming a project group is relatively easy, that is simply to choose all participants of the project, forming a comparison group is in contrast quite tricky which is reflected by the continuing debate on the practicability of experimental and quasi-experimental designs (White 2006 and 2009). However, while experimental designs with random methods can generate a perfect counterfactual (i.e. control group) which is free from selection bias problems (Baker 2000), these designs are not practicable for a broad range of development interventions especially in the field of agriculture, e.g. no one can prevent new agricultural technologies spreading into the control group (Pearce 2002; CGIAR 2006). Therefore, quasi-experimental designs with non-random methods are likely more appropriate.

There are a number of non-random methods used for forming a comparison group. These methods include pipeline, propensity score matching, and instrumental variables (Baker 2000; Ravallion 2001; Kapoor 2002). The comparison of these methods is shown in Table 2.1. However, in conjunction with the DDI method, the propensity score matching method is the most fruitful (Ravallion 20001; White 2006). This method attempts to find a "closest" comparison group from a sample of non-participants to the sample of program participants. "Closets" is measured in terms of

observable characteristics. Baker (2000) and Ravallion (2001) describe steps in propensity score matching as follows:

Step 1: You need a representative sample survey of eligible non-participants as well as one for the participants. The larger the sample of eligible non-participants the better, to facilitate good matching. If the two samples come from different surveys, then they should be highly comparable surveys (same questionnaire, same interviewers or interviewer training, same survey period, and so on).

Step 2: Pool the two samples and estimate a logit model of program participation as a function of all the variables in the data that are likely to determine participation.

Step 3: Create the predicted values of the probability of participation from the logit regression; these are called the "propensity scores." You will have a propensity score for every sampled participant and non-participant.

Step 4: Some in the non-participant sample may have to be excluded at the outset because they have a propensity score that is outside the range (typically too low) found for the treatment sample. The range of propensity scores estimated for the treatment group should correspond closely to that for the retained sub-sample of non-participants. You may also want to restrict potential matches in other ways, depending on the setting. For example, you may want to allow only matches within the same geographic area to help ensure that the matches come from the same economic environment.

Step 5: For each individual in the treatment sample, you now want to find the observation in the non-participant sample that has the closest propensity score, as measured by the absolute difference in scores. This is called the "nearest neighbor." You can find the five (say) nearest neighbors.

Step 6: Calculate the mean value of the outcome indicator (or each of the indicators if there is more than one) for the five nearest neighbors. The difference between that mean and the actual value for the treated observation is the estimate of the gain due to the program for that observation

Step 7: Calculate the mean of these individual gains to obtain the average overall gain. This can be stratified by some variable of interest, such as income, in the non-participant sample.

Table 2.1. Methods in quasi-experimental designs for generating a comparison group

Methods	Implementation
Pipeline	This method takes individuals, households or communities that have been selected to participate in a project, but not done yet so, and allocates them into a comparison group. It assumes that there has been no change in selection criteria and that all applicants were not ranked when they were selected. Examples: World Bank (1998), Buddelmeyer and Skoufias (2004), Galasso and Ravallion (2004), Ravallion (2008a).
Propensity score matching	This methods identifies a group of individuals, households or communities with the same observable characteristics (i.e. a comparison group) as those participating in a project using propensity scores, that are the predicted probability of participation given the observed characteristics. Examples: Rosenbaum and Rubin (1983 and 1985), Barrow (1987), Czajka et al. (1992), Friedlander et al. (1997), Heckman et al. (1996 and 1998), Heckman et al. (1997 and 1998), Dehejia and Wahba (1999 and 2002), Bryson et al. (2002).
Instrumental variables	This method, also known as statistical controls, can be used if there are variables that matter to participation, but not to outcomes given participation. These variables are used to identify a source of exogenous variation in outcomes attributable to a program recognising that its placement is purposive. They predict program participation which allows to see how the outcome indicator varies with the predicted values on other characteristics. Examples: Heckman (1997), Angrist and Krueger (2001), Leigh and Schembri (2004), Miguel et al. (2004), Terza et al. (2007).

Sources: Adapted from Baker (2000), Ravallion (2001), and Coliendo and Kopeinig (2005)

The literature discussing the use of the DDI method for evaluating the impact of agricultural intervention is enormous (e.g. Cramb and Purcell 2001; Ravallion 2001; Kerr and Chung 2002; Kapoor 2002; Feder et al. 2004; Reddy et al. 2004; Hope 2006; White 2006; Bamberger 2006; Naudet and Delarue 2007; Davis and Nkonya 2008; Nkonya et al 2008). While the main idea remains the same, that is comparing two groups before and after the project, the specific outcomes of interest vary with the context of the studies. Despite difficulties in forming the comparison group, it is clear that this method is a good means of estimating the impact of intervention, relatively easy to employ (i.e. does not require high statistical skills compared to the instrumental variables method), and somewhat cheaper without disregarding the quality of evaluation.

The next section will discuss impact evaluation using the SL framework. This framework works in conjunction with the DDI method used for measuring estimates of the impact and the mixed quantitative and qualitative methods employed to help strengthen the evaluation.

2.6. Impact evaluation using the SL framework

The SL framework has generally been used for various purposes, from planning new projects, monitoring on-going projects to evaluating completed projects (Ashley and Carney 1999; DFID 1999; Carney 2003). This framework provides researchers with a 'checklist' of issues to be considered and prioritized in their study. It also provides the advantage of allowing researchers to understand the parameters of the 'big picture,' and then narrow the scope of the study to what can have the highest impact or what is most relevant to the important stakeholders.

For the purpose of impact evaluation in particular, the SL framework is used variously. Some use this framework to help organize the main research questions (e.g. Adato and Meinzen-Dick 2002; Bourdillion et al. 2003; Place et al. 2003; Bellon et al. 2005). Some apply it as a means of broadening the understanding of poverty and drawing together the various perspectives of social and economic analysis to undertake a broader poverty impact evaluation (Ashley and Hussein 2000; Carney 2003; Hallman et al. 2003: Hossain et al. 2003; Meinzen-Dick et al. 2004). Some pick a particular component or two components of the framework to be the focus of

the study, e.g. changes in vulnerability context (Lautze and Raven-Roberts 2003; Knutsson and Ostwald 2006; Nabi et al. 2007), livelihood assets (Winters et al. 2002; Reddy et al. 2004; Hope 2006), livelihood strategies (Orr 2001; Cramb et al. 2004; Brown et al. 2006; La Rovere et al. 2006), and livelihood assets and strategies (Shah et al. 2005; Kibwage et al. 2009). However, the most common use of this framework is as a point of departure which then guides the study from the beginning to the end (Cramb and Purcell 2001; Reddy and Soussan 2003; Segers et al. 2005; Mancini et al. 2007; Babulo et al. 2008). Finally, the most important lesson taken from all these studies is that employing the SL framework requires an interdisciplinary approach and a combination of quantitative and qualitative methods as the pathway from research to impact is very long and there are so many factors interacted between them.

It is clear that the SL framework is like foundations on which the study is built. This framework cannot measure the impact of the study and it needs other methods to do so. There are various quantitative and qualitative methods used to help measure estimates of the impact. For example, Cramb and Purcell (2001) and Cramb et al. (2004) use a number of participatory qualitative methods to quantify the impact of the forage for smallholders project on livelihood strategies in Vietnam. Another example is Reddy et al. (2004) and Hope (2006) who use the DD method to measure estimates of the impact of the watershed development project on livelihood assets in India, in which the impact of the project is measured in terms of changes in all types of assets (i.e. natural, physical, human, social and financial) by comparing the beneficiaries and non-beneficiaries both before and after the project. More examples can be seen in the above studies (see the previous paragraph).

The SL framework and the DD method together with the appropriate mixed quantitative and qualitative methods work in conjunction on ensuring the quality impact evaluation. While the SL framework provides strong foundations for the study, the DD method helps measure estimates of the impact, and the appropriate mixed quantitative and qualitative methods may help explain the question “why” behind the impact.

2.7. Conclusion

Impact evaluation plays an important role in examining the effectiveness of development projects. It can demonstrate whether the money spent into the projects has improved the lives of poor people. Despite the debates on the definition of impact evaluation and the use of appropriate methods, there is an emerging consensus around the use of counterfactual, that is a group which represents the central impact evaluation question of what would have happened to those receiving the intervention if they had not involved in the project (i.e. a comparison group to the project group), and a growing interest in using a mixed quantitative and qualitative methods approach.

The SL framework and the DD method work in conjunction on ensuring a quality impact evaluation. While the framework, which is a model for understanding the many interrelated causes of poverty and how to alleviate poverty, helps show the big picture and organise the evaluation; the DD method, which entails comparing a project group with a comparison group both before and after the intervention, helps measure estimates of the impact of the project being evaluated. It is clear that the implementation of the framework and the method allows the use of mixed quantitative and qualitative methods.

3. The Study Site and the ACIAR Project

This Chapter sets the context of the study which has three components: 1) the geography of the study site; 2) the institutional environment of the study site; and 3) the ACIAR project "Poverty alleviation and food security through improving the sweetpotato-pig systems in Papua, Indonesia". Some of this material is reproduced in Chapters 5 to 8 as part of the background discussion of these manuscripts of papers to be published.

3.1. Geographical context

3.1.1. Papua Province

Papua is the largest province of Indonesia. It comprises most of the western half of the island of New Guinea and nearby islands which constitute about 22% (421,981 km2) of the total land area of the country (Papua 2010). Geographically, it lies between 00-120 S and 129-141 E.

This province has a very bio-physically and socio-culturally diverse environment. The bio-physical diversity is reflected by the division of agro-ecosystem zones ((Tucker 1987; Karafir 1988; Haynes 1989: Kepas 1990). For example, Kepas (1990) divides this province into eight main agro-ecosystem zones: tidal lowlands, freshwater swamps, coastal plains, savannahs, humid tropic forest, low mountain forests, high mountain forests, and alpine mountains. Haynes's division is relatively simpler: the lowlands and the highlands, but he further sub-groups the lowlands into (1) coastal, swap and rivers, (2) coastal plains, and (3) foothills and small valleys; while the highlands consist of broad valleys, lakeshore plains, and hill-slopes in narrow valley (Haynes 1989). Meanwhile, the socio-cultural diversity can be seen from the number of indigenous tribes and spoken languages. In this province, there are over 300 indigenous tribes (BPS Papua 2008), and almost 280 distinct spoken languages, not to mention dialects (Boelaars 1986). The bio-physical and socio-cultural diversity gives Papua a unique identity (UNDP 2005).

The province of Papua is economically a source of great wealth for the country. It contributes to the Indonesian government around US$1.7 billion per year

collected from its natural resources (BPS Indonesia 2008). The Papuan Gross Domestic Regional Product (GDRP) of US$5.5 billion earned largely through the mining and forestry sectors produces a per capita GDRP of US$2,400 which is well above the national average of US$1,500. However, these industries support less than 2% of the total working population, while 75% of the population is engaged in agriculture. The population of this province is about 2 million which constitute only around 1% of the national population. Not surprisingly, this economic success has not been shared by most Papuans. In this province, 41% of the population live below the poverty line, which is defined as living with less than US$20 per month, which is more than double the national average of 17%.

Finally, this province is administratively divided into 26 districts known as *Kabupaten* (25) and *Kota* (1) (Papua 2010). While there are so many maps showing the province, it is difficult to find one containing all the districts with a clear administrative boundary. The one presented here (Figure 3.1), which is relatively more complete, is taken from the 'Papua Needs Assessment' report by UNDP (UNDP 2005). The following will focus on one of the districts, namely the Jayawijaya District (*Kabupaten* Jayawijaya), where the study site is located.

NOTE:
This figure is included on page 27 of the print copy of the thesis held in the University of Adelaide Library.

Source: UNDP (2005)

Figure 3.1. The province of Papua, Indonesia with its 26 districts

3.1.2. Jayawijaya District

The Jayawijaya District lies on the Central Highlands of the province (see Figure 3.1). It centres to Wamena, which is only accessible by air transport (Figure 3.2). Wamena lies at an altitude of 1,550 m above sea level (asl), but other populated areas lie between 1,470-1,850 m asl. The surrounding Jayawijaya Mountains reach altitudes of 4,700 m asl (Aditjondro 1982).

Source: Mahalaya (2005)

Figure 3.2. Wamena, the capital city of Jayawijaya District, taken from the air

This district has a total area of almost 1.5 million ha. The biggest part is occupied by forest (almost 87%) and followed by arable land (13%) and settlement (less than 1%). Table 3.1 shows land use in the district.

Table 3.1. Land use in the Jayawijaya District

NOTE:
This table is included on page 29 of the print copy of the thesis held in the University of Adelaide Library.

Source: BPS Jayawijaya (2006)

The Jayawijaya District is administratively divided into 15 sub-districts known as *Kecamatan* and these sub-districts overall administrate 366 villages known as *Kampung*, which is the smallest administrative unit in the structure of the local government organisation. Figure 3.3 shows the Jayawijaya District with its 15 sub-districts. In these villages over 60,000 households which constitute the district population of almost 230,000 live and share local resources. Table 3.2 presents the population of Jayawijaya District. According to BPS Papua (2008), 91% of this population are indigenous people, while the remaining 9% are non-Papuan migrants mostly coming from South Sulawesi and Java. These non-Papuan migrants live only in Wamena; none live outside the city. From the 91% indigenous people, 64% are Dani people, while the remaining 27% are other indigenous people which constitute over 20 smaller tribes.

Table 3.2. The Jayawijaya District population

NOTE:
This table is included on page 29 of the print copy of the thesis held in the University of Adelaide Library.

Source: BPS Jayawijaya (2006)

NOTE:
This figure is included on page 30 of the print copy of the thesis held in the University of Adelaide Library.

Source: Jayawijaya Government Office (2010)

Figure 3.3. The Jayawijaya District with its 15 sub-districts

Distance from Wamena to the other sub-districts varies greatly. The shortest one is 13 km (Hubikosi) and the longest one is 110 km (Mapenduma). Two third sub-districts have distances of over 50 km. Table 3.3 shows the distance between Wamena and other sub-districts. The greatest challenge here is that road quality in many cases is poor, and that there is only limited public transport available. About 60% of roads are categorised as good or medium, and only 105 public transport (jeeps and station wagons) serving the entire districts (BPS Jayawijaya 2006).

Finally, the educational infrastructure and health services are presented in Table 3.4 and 3.5. While primary schools are available in every sub-district, junior high school is not available in three sub-districts (Kobakma, Kenyam and Mapenduma), and senior high schools is only available in four sub-districts (Wamena, Assologaima and Bolakme and Tiom). Even though teacher-student ratios are good, about one-third of children are not in schools. Moreover, while health centres are available in every sub-district, hospitals are only available in two sub-districts (Wamena and Tiom). Given the population of the district is 227,474, the ratios of doctors and nurses to the population are 1:15,165 and 1:940.

Table 3.3. The distance between Wamena to other sub-districts

NOTE:
This table is included on page 31 of the print copy of the thesis held in the University of Adelaide Library.

Source: BPS Jayawijaya (2006)

Table 3.4. The educational infrastructure in the Jayawijaya District

NOTE:
This table is included on page 31 of the print copy of the thesis held in the University of Adelaide Library.

Source: BPS Jayawijaya (2006)

Table 3.5. Health services in the Jayawijaya District

NOTE:
This table is included on page 31 of the print copy of the thesis held in the University of Adelaide Library.

Source: BPS Jayawijaya (2006)

3.1.3. The Baliem Valley and the Dani people

The Baliem Valley, which is the research site of this study, is part of and administratively managed by the Jayawijaya District – Some more background information provided here will therefore be overlapping. It is home to Dani people,

which is the target community of this study, who are the biggest tribe in the Central Highlands with approximately 146,000 members (BPS Papua 2008). The Baliem Valley and the Dani people are historically quite unique. Alua (2006) reports that the Baliem Valley was first visited by an expedition team from the American Museum of National History led by Richard Archbold in 1938, and the Dani made first contact with outsiders, missionaries from the Christian and Missionary Alliance, only in 1954. The region and the people formally became part of Indonesia in 1969 based on Law No. 12/1969 on the Formulation of the *Irian Barat* Autonomous Province and the Autonomous Regencies in the *Irian Barat* Province (Indonesia 2001).

The Baliem Valley covers approximately 160 km^2 along the Baliem River of Jayawijaya District (Figure 3.4). Soils in this valley are generally developed from limestone with poor native fertility (Schroo 1963, cited in Soenarto and Rumawas 1997), but most of the cultivated land is on Histosols and hydromorphic mineral soils like Aquepts and transitions of these main groups (Van Baal et al. 1984).

Source: Mahalaya (2005)

Figure 3.4. The Baliem Valley lies along the Baliem River of Jayawijaya District

Climatic data for this valley is limited to measurements from 1987-2006 by the Jayawijaya Meteorology Office based in Wamena (BMG Jayawijaya 2006). This

valley has a humid tropical climate with little variation in temperature across the year, while rainfall is seasonal with the wetter months from December to April and the drier months from May to November (Figure 3.5). However, variability in annual rainfall is great, ranging from 1,266 mm in 1997 (an El Nińo period) to 2,617 mm in 2005 with variability in monthly rainfall (i.e. coefficients of variation) between years ranging from 28 to 87 per cent. The 1997 drought caused food shortages and malnutrition in the Baliem Valley (Peters 2003). In response to the relatively uniform climate, there are neither planting seasons nor harvesting seasons; hence the Dani can grow sweetpotatoes in one month as favourable as in other months (Gardner and Heider 1968).

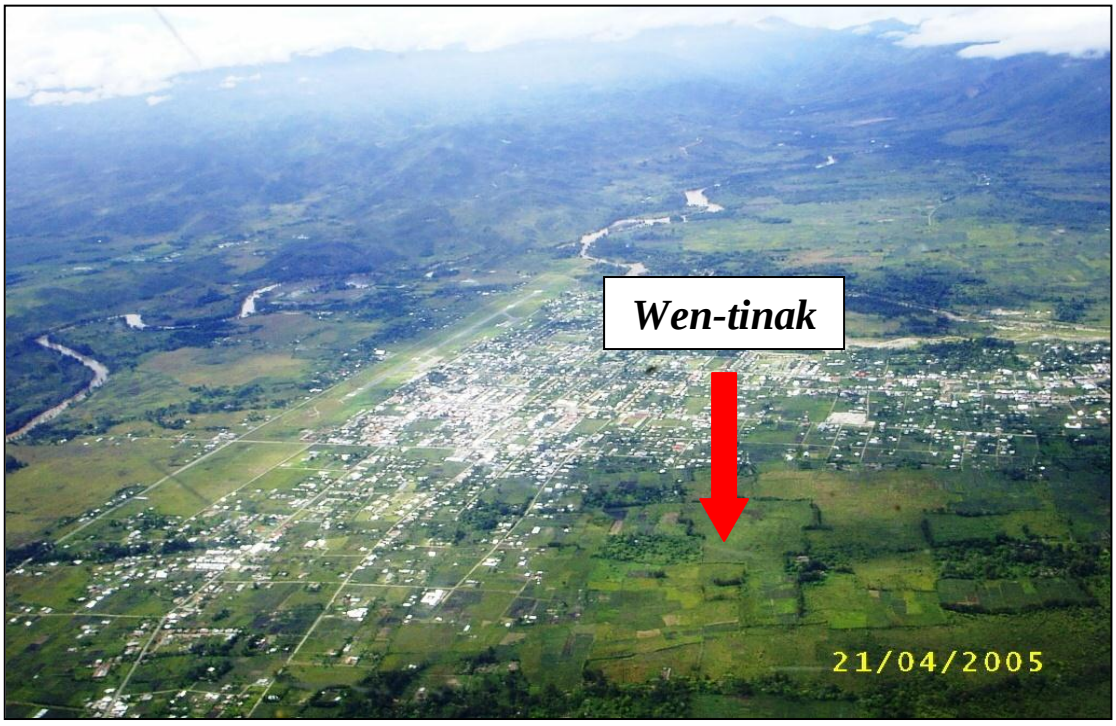
NOTE:
This figure is included on page 33 of the print copy of the thesis held in the University of Adelaide Library.

Source: BMG Jayawijaya (2006)

Figure 3.5. Mean monthly maximum (Tmax) and minimum (Tmin) temperature (^{o}C) and rainfall of the Wamena BaliemValley 1987-2006

According to Golson (1997), the Dani have likely occupied and farmed the Baliem Valley for more than 9,000 years, and have likely grown sweetpotatoes (*Ipomoea batatas*) and raised pigs (*Sus scrofa papuensis*) for several hundred years. The literature indicates that they employ two landscape-based sweetpotato cultivation systems: valley floor (*wen-tinak*) and upland (*wen-yawu*). The upland further consists of three sub-systems: the upper part of the valley floor with medium slopes (*waganak*), medium to step slopes (*enapipme*), and very step and/or stony slopes (*alome*) (Schneider et al. 2003; Achmady and Schneider 1995; Schneider 1995). Figures 3.6 – 3.9 show these landscape-based sweetpotato cultivation systems.

Indeed, their traditional farming systems are mainly based on sweetpotato and pig production. This is reflected by the dominance of these two commodities in the Jayawijaya District (Table 3.6). These systems provide a year round source of food for families, generate cash income, supply manure for soil fertility, convert low value sweetpotatoes into high value pigs, and are at the centre of the Dani's culture – all cultural traditions (e.g. marriages, conflict resolutions and funerals) always involve sweetpotatoes and pigs (Schneider et al. 1993; Peters 2003; Peters et al. 2005).



Source: Mahalaya (2005)

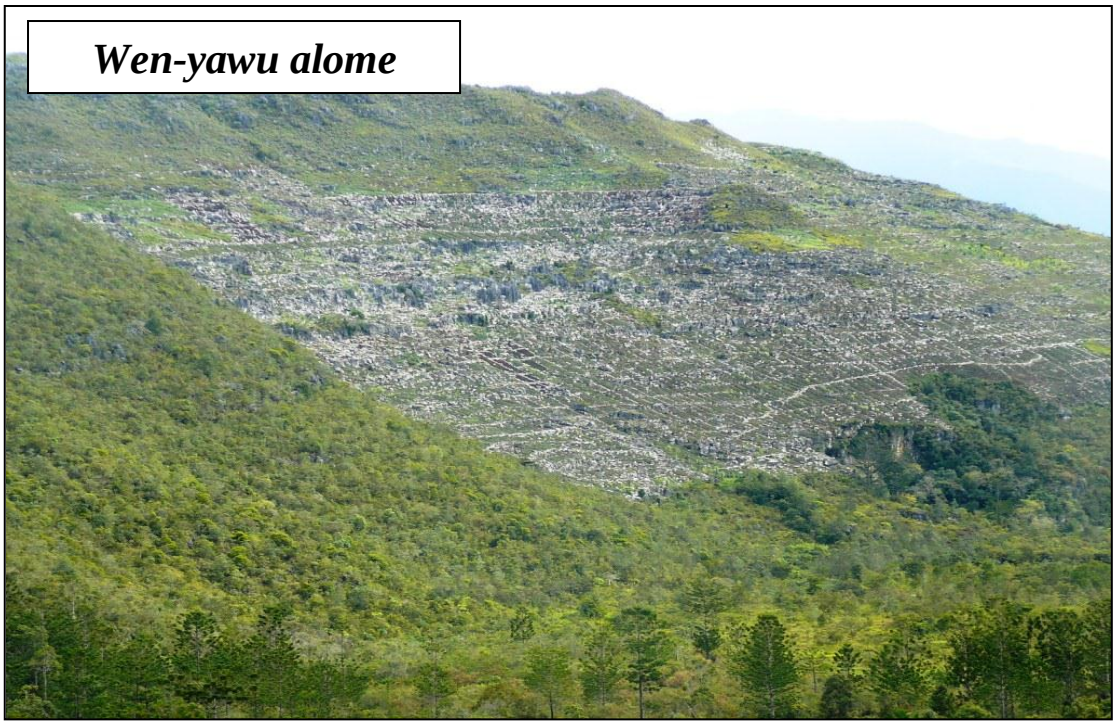
Figure 3.6. Sweetpotato cultivation systems in the valley floor (*wen-tinak*)

Source: Mahalaya (2005)

Figure 3.7. Sweetpotato cultivation systems in the upper part of the valley floor with medium slopes (*wen-yawu waganak*)

Source: Mahalaya (2005)

Figure 3.8. Sweetpotato cultivation systems in the upper part of the valley floor with medium to steep slopes (*wen-yawu enapipme*)



Source: Mahalaya (2005)

Figure 3.9. Sweetpotato cultivation systems in the upper part of the valley floor with very steep and/or stony slopes (*wen-yawu alome*)

Table 3.6. Agricultural commodities in the Jayawijaya District

NOTE:
This table is included on page 36 of the print copy of the thesis held in the University of Adelaide Library.

Source: BPS Jayawijaya (2006)

Finally, the Dani people are a socio-culturally unique community. Figure 3.10 and 3.11 show traditional and modern Dani people. They commonly speak the same language called *hubura*, but with many dialects from one place to another across the Baliem Valley. They live in traditional housing systems called *silis*. *Sili* is the word the Dani use for their traditional houses and living enclosure, but it is also take to mean the social group of families living within it. A *sili* is a living compound surrounded by wooden fencing (*leget*) (Figure 3.12 and 3.13). This *sili* consists of a

men's hut (*pilamo*) located across and facing the entrance (*mokarai*) of the *sili* area, several women huts (*ebeae*), indicating the number of wives, in the left hand side of the men hut, a long kitchen (*hulina*) in the right hand side of the men hut, an empty space (*silimo*) right in the middle of the *sili* area, and a pigs yard (*laleken*) attached behind the kitchen and/or the men hut. In the kitchen, there are several traditional stoves (*wulikin waganek*) which are small holes on the ground where women cook, and several pigsties (*dawula*) which are normally in the northern part of the kitchen adjacent to the men's hut. Each position of the *sili* components has meaning. For example, the position of the men's hut facing the entrance of the *sili* area is intended to monitor enemy attacks (Kossay *pers. comm*.).

Several Dani families will live together in the one *sili*. They describe their arrangement as "*sabokhogon*" which means "one for all and all for one" because they live and work together as one *sili* unit which is led by a chief called *kepala sili* (Lokobal et al. 2006). *Sabokhogon* also indicates there is no separate ownership in which household and farm infrastructure, gardens, sweetpotatoes and pigs are owned and shared collectively under the management of the *kepala sili* who controls access and rights for the benefit of all *sili* members.

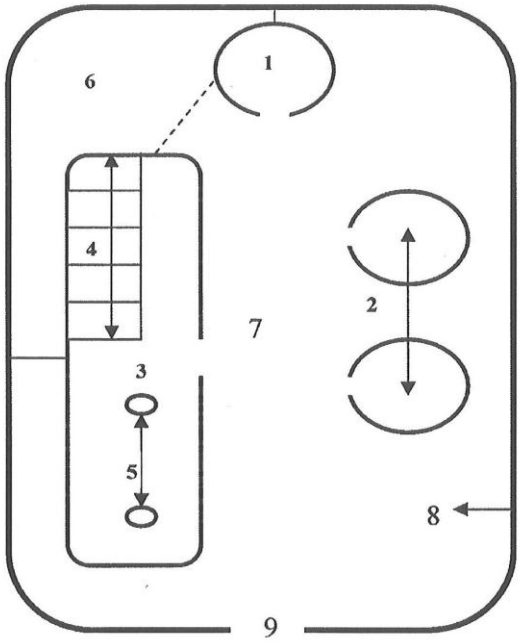
Source: Mahalaya (2006)

Figure 3.10. Traditional Dani people

NOTE:
This figure is included on page 38 of the print copy of the thesis held in the University of Adelaide Library.

Source: Mahalaya (2006)

Figure 3.11. Modern Dani people



Notes:
[1] *Pilamo* (men hut)
[2] *Ebeae* (women hut)
[3] *Hulina* (kitchen)
[4] *Dawula* (pigsties)
[5] *Wulkin waganek* (traditional stoves)
[6] *Laleken* (pigyard)
[7] *Silimo* (empty yard)
[8] *Leget* (wooden fencing)
[9] *Mokarai* (entrance)

- The number of *ebeaes* indicates the number of wives which the chief of the *sili* has.
- The number of *wulkin waganeks* indicates the number of households which lives together (*sabokhogon*) in the *sili*
- *Laleken* and *silimo* sometimes have no boundaries.

Source: Mahalaya (2007)

Figure 3.12. An illustration of a Dani *sili*

NOTE:
This figure is included on page 39 of the print copy of the thesis held in the University of Adelaide Library.

Source: Nuberg (2007)

Figure 3.13. A Dani *sili* in the Baliem Valley

3.2. Institutional context

In the Jayawijaya District, there are a number of institutions working in the agricultural sector. These institutions in general can be grouped into three organisations: (1) government organisations, (2) non-government organisations, and (3) private businesses. The following describes these organisations and how they operate in this district.

3.2.1. Government organisations

The overall government organisations working in the Jayawijaya District are managed by the Jayawijaya Government Office (JGO) (*Pemerintah Daerah Kabupaten Jayawijaya*) which is led by a chief called *Bupati* with help from a vice chief called *Wakil Bupati*. However, the operation of the JGO is controlled by the Jayawijaya House of Representatives (*Dewan Perwakilan Rakyat Daerah*). Figure 3.13 shows the organisational structure of the Jayawijaya Government Office.

In practice, these government organisations do not all engage in the agricultural sector, but only a few organisations **in bold** as showed in the 'Jayawijaya Government Offices' box (see Figure 3.14). These few organisations include the Jayawijaya Agriculture Office (JAO) (*Dinas Pertanian*) which provides services in food crop sectors (no. 2 in the box), the Jayawijaya Livestock Office (JLO) (*Dinas Peternakan*) which deals with livestock services (no. 3), the Jayawijaya Estate Crops Office (JECO) (*Dinas Perkebunan*) which looks after estate crop sectors (no. 4), the Jayawijaya Fishery Office (JFO) (*Dinas Perikanan*) which provides services in fishery sectors (no. 5), and to some extent the Jayawijaya Forestry Office (JFO) (*Dinas Kehutanan*) which looks after the forestry sector (no. 6), and the Jayawijaya Cooperative Office (JCO) (*Dinas Koperasi*) which provides services in cooperative businesses (no. 12).

In addition, there are still among others two national and provincial government organisations whose offices dealing with the agricultural sector in the district, which are not appeared in the JGO organisational structure. The national organisation is the Jayawijaya Extension Office (JEO) (*Kantor Informasi Penyuluhan Pertanian dan Kehutanan*) which helps the JGO in providing agricultural extension services, while the provincial one is the Papua Assessment Institute for Agricultural Technology (AIAT) (*Badan Pengkajian Teknologi Pertanian*) which assists the JGO in assessing new agricultural technologies before these technologies are applied in the district.

NOTE:
This figure is included on page 40 of the print copy of the thesis held in the University of Adelaide Library.

Source: Jayawijaya Government Office (2010)

Figure 3.14. The organisational structure of the Jayawijaya Government Office

3.2.2. Non-government organisations

There are 16 Non-Government Organisations (NGOs) operating in the Jayawijaya District and all are based in Wamena (Table 3.7). However, there are only two NGOs which have agricultural programmes. These NGOs are the Jayawijaya Institute for Customary Discussion (JICD) (*Lembaga Musyawarah Adat Masyarakat Jayawijaya, Yayasan M-Mula*), and the World Vision Indonesia (*Yayasan Wahana Visi Indonesia, WVI*). While the JICD is purely a local NGO, the WVI is an international supported NGO. However, these NGOs are quite similar in terms of both mainly focusing on providing health services, although they also have some agricultural programmes particularly dealing with livestock (e.g. pigs and rabbits).

Table 3.7. Non-government organisations in the Jayawijaya District

NOTE:
This table is included on page 41 of the print copy of the thesis held in the University of Adelaide Library.

Source: Jayawijaya Government Office (2010)

3.2.3. Private businesses

The other organisations which are important to mention here are agricultural-related private businesses. They include banks, cooperatives, and markets. The first two organisations may provide financial assistance (e.g. providing loans) in local

agricultural businesses, while the third organisation facilitates agricultural commodity transactions. Table 3.8 shows the availability of banks, cooperatives and markets in the Jayawijaya District.

There are only three banks operating in this district and all are based in Wamena. These banks are *Bank Mandiri*, *Bank Rakyat Indonesia*, and *Bank Papua*. The first two banks are owned by the Indonesian central government, while the third bank belongs to the Papuan provincial government. Meanwhile, the cooperatives are quite a number: 56 cooperatives in total. Most of these cooperatives are also based in Wamena (61%). Except in Hubikosi, Abenaho, Kobakma, Kenyam and Mapenduma sub-districts, there is at least one cooperative operating in the other sub-districts. However, it is not clear which cooperative providing financial assistance for agricultural businesses, but most of them particularly those operating in Wamena are government staff' cooperatives (i.e. only available for government staff). Finally, the markets are not available in 6 sub-districts (Kurulu, Gameliya, Abenaho, Kobakma, Kenyam and Mapenduma). Most of the available markets operate weekly only, and only in Wamena and Tiom they open daily.

Table 3.8. The availability of banks, cooperatives and markets in the Jayawijaya District

Sub-district	Bank	Cooperative	Market[1]
		(number)	
Wamena	3	34	3 (daily)
Hubikosi	0	0	1 (weekly)
Kurulu	0	3	0
Asologaima	0	4	1 (weekly)
Bolakme	0	4	1 (weekly)
Kelila	0	1	1 (weekly)
Gameliya	0	1	0
Makki	0	3	1 (weekly)
Abenaho	0	0	0
Apalapsili	0	2	1 (weekly)
Tiom	0	2	1 (daily)
Perime	0	2	1 (weekly)
Kobakma	0	0	0
Kenyam	0	0	0
Mapenduma	0	0	0
Total	3	56	11

Source: BPS Jayawijaya (2006); [1]Data collected from sub-district offices

3.3. Poverty alleviation and food security through improving the sweetpotato-pig systems in Papua, Indonesia

During 2001-2006 the Australian Centre for International Agricultural Research (ACIAR) funded an agricultural research project titled "Poverty alleviation and food security through improving the sweetpotato-pig systems in Papua, Indonesia" with a total investment of A$1,253,608 (ACIAR 2005). This project operated in 20 villages[1] (Figure 3.15). The International Potato Center (CIP) led this project in collaboration with the South Australian Research and Development Institute (SARDI) and a wide range of national and local institutions such as the Indonesian Agricultural Agency for Research and Development (IAARD), the Papuan Assessment Institute for Agricultural Technology (BPTP Papua), the University of Papua (UNIPA), the Jayawijaya Agricultural Office (Disperta Jayawijaya), the Jayawijaya Livestock Office (Disnak Jayawijaya) and the Jayawijaya Information and Extension Office for Agriculture and Forestry (KIPPK Jayawijaya).

The goal of this project was to alleviate poverty and increase food security of the Dani people in the Baliem Valley of Papua. This goal would be achieved by improving their traditional farming systems based on sweetpotato and pig production. Therefore, the project had the following specific objectives: (1) to analyse the existing sweetpotato-pig systems within the overall household economy to understand the types of systems being used, their importance and their major constraints, (2) to improve the production of sweetpotato to ensure a stable food and feed supply, (3) to enhance the productivity of pig growth by nutritional improvement using appropriate technology and disease management based on various levels of confinement acceptable to the Dani, (4) to enhance the efficiency of pig production by improving the management of sows and boars, (5) to strengthen the indigenous, integrated pig-raising systems by developing a *laleken*[2]-based foraging system for pigs, and (6) to increase the capacity of national scientists and local extension officers participated in the project as well as the project staff, and to improve the sweetpotato-based pig raising capacity of the Dani by developing appropriate training programmes.

[1] Assolokobal, Holima, Hubikiak, Ibele, Kelila, Kumima, Maki, Megapura, Molima, Muliama, Napua, Pisugi, Siepkosi, Sinakma, Sunili, Timia, Tulem, Wamena, Wanima, and Tulem.
[2] *Laleken* is a Dani term for a traditional fenced area to confine pigs

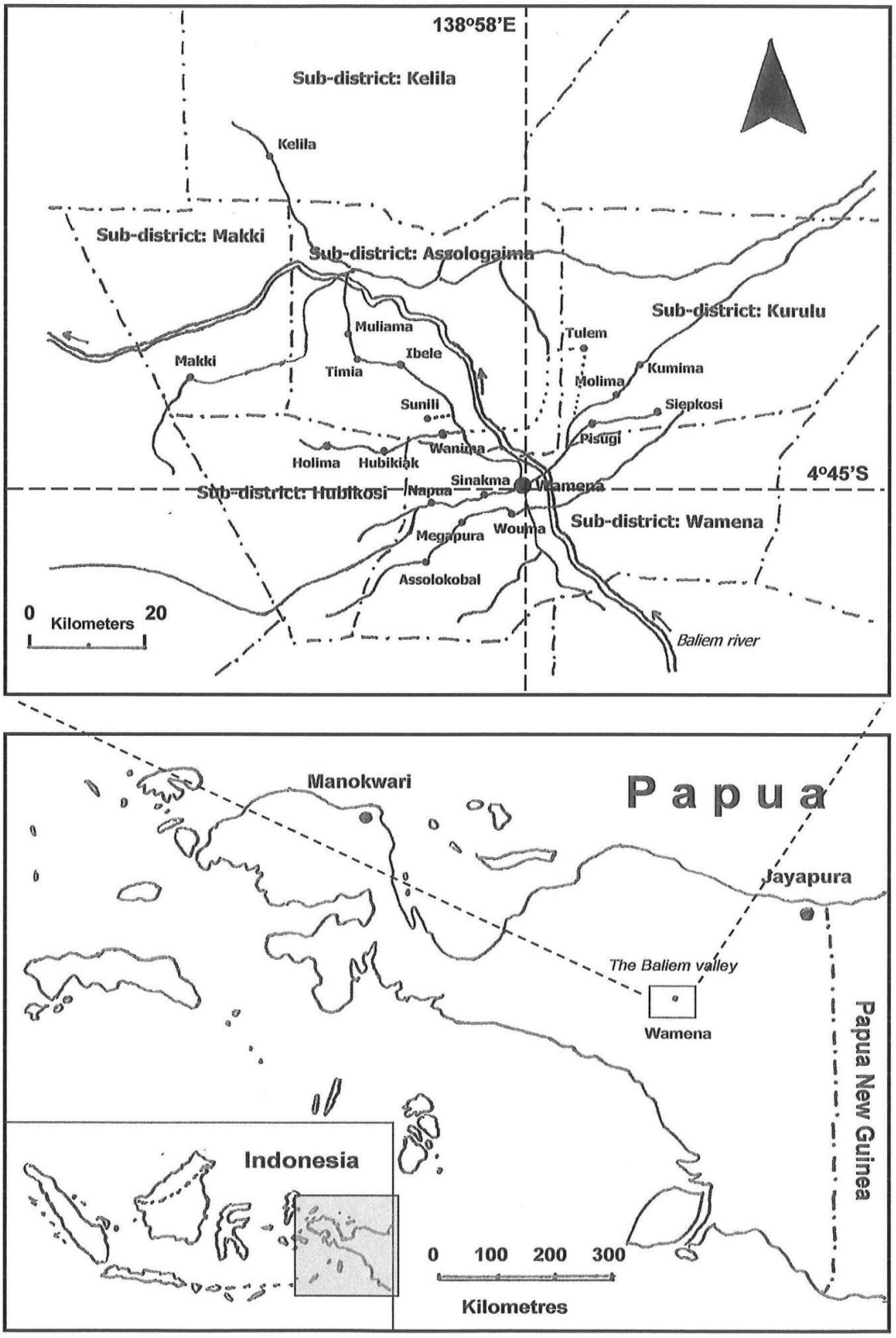


Figure 3.15. The 20 villages where the ACIAR project operated in 2001-2006

The project in general employed a participatory research approach to achieve these specific objectives. The project personnel (Table 3.9) built a close collaboration with a totally of 38 Dani *silis* (see Appendix D) working together from designing experimentation, on-farm execution, to monitoring and evaluation. Some *silis* (26%) were randomly selected in the beginning of the project, but most *silis* (74%) selected themselves by approaching the project and asking to be involved. Table 3.10 summarises a range of activities which were carried out by the project in order to achieve the specific objectives. Figures 3.16 – 3.21 show some photographs related to these activities.

Consequently, the project produced six groups of outputs in the end of the project. These outputs included (1) a summary of socio-economic studies (Peters 2003), (2) seven new sweetpotato cultivars for human food (three cultivars) and pig feed (four cultivars) with high dry matter content in roots and high protein content in leaves, (3) five sustainable nutrient-balanced diets for pigs, (4) a novel management scheme for boars and sows, (5) a modified *laleken*-based rotational foraging system for confining pigs, and (6) a significant number of national scientists and local extension officers, the project staff, and Dani farmers which have been trained according to their needs in association with the project (Cargill 2009). More details about the project can be seen at the final report written by Cargill (2009) which is downloadable from the ACIAR website.

Table 3.9. ACIAR project personnel in the Baliem Valley

Name	Institution	Position
Dr. Dai Peters	CIP	Project leader (2001-2002)
Dr. Colin Cargill	SARDI	Project leader (2003-2006)
Caecilia A. Widyastuti	CIP	Project manager (2001)
Sukendra Mahalaya	CIP	Project manager (2002-2006)
Luther Kossay	CIP	Field coordinator (2001-2006)
Yatiya Pahebol	CIP	Field assistant (2004-2006)
A. Triono Syahputra	CIP	Field assistant (2006)

Table 3.10. ACIAR project specific objectives and activities in the Baliem Valley

Specific objectives	Activities	Photographs
1. To analyse the existing sweetpotato-pig systems within the overall household economy to understand the types of systems being used, their importance and their major constraints	Socio-economic surveys in seven villages (Moai, Wanima, Pisugi, Napua, Hubikiak, Tulem, Siepkosi)	Figure 3.16
2. To improve the production of sweetpotato to ensure a stable food and feed supply	On-farm sweetpotato trials in 11 villages (Napua, Sinakma, Tulem, Pisugi, Siepkosi, Hubikiak, Holima, Muliama, Wamena, Maki, Kelila)	Figure 3.17
3. To enhance the productivity of pig growth by nutritional improvement using appropriate technology and disease management based on various levels of confinement acceptable to the Dani	On-farm nutrition trials six villages (Wamena, Tulem, Pisugi, Molima, Megapura, Assolokobal)	Figure 3.18
4. To enhance the efficiency of pig production by improving the management of sows and boars	On-farm sow and boar management trials in three villages (Napua, Wanima, Holima)	Figure 3.19
5. To strengthen the indigenous, integrated pig-raising systems by developing a *laleken*-based foraging system for pigs	On-farm *laleken* trials in seven villages (Sinakma, Siepkosi, Kumima, Wouma, Sunili, Timia, Muliama)	Figure 3.20
6. To increase the research capacity of national scientists and local extension officers as well as the project staff, and to improve the sweetpotato-based pig raising capacity of the Dani by developing appropriate training programmes	Various training in Indonesia: Wamena, Jayapura, Manokwari, Bogor, Solo, Malang, Medan; Thailand: Bangkok; Vietnam: Hanoi; China: Beijing; Australia: Adelaide	Figure 3.21

Source: Mahalaya (2002)

Figure 3.16. Socio-economic surveys

Source: Mahalaya (2005)

Figure 3.17. On-farm sweetpotato trials

NOTE:
This figure is included on page 47 of the print copy of the thesis held in the University of Adelaide Library.

Source: Mahalaya (2005)

Figure 3.18. On-farm nutrition trials using some various local resources

Source: Mahalaya (2005)

Figure 3.19. Sow and boar management trials

Source: Mahalaya (2005)

Figure 3.20. *Laleken* trials

NOTE:
This figure is included on page 49 of the print copy of the thesis held in the University of Adelaide Library.

Source: Mahalaya (2005, 2006)

Figure 3.21. Various training for Dani farmers

3.4. Conclusion

This Chapter has set the geographical and institutional context of the study site. It has also shown the ACIAR project. In summary, Papua is a very bio-physically and socio-culturally diverse province of Indonesia. This province is a source of great wealth for the country, but continues providing an intractable development challenge. The Jayawijaya District is one of the 26 districts administered by this province. In this district, the Baliem Valley becomes home to the Dani people, the biggest tribe in the Central Highlands of Papua with almost 150 thousand members. They rely on their traditional farming systems based on sweetpotato and pig production for livelihood. Agricultural services in this region are mostly provided by the Jayawijaya Government Office through the Jayawijaya Agricultural Office and the Jayawijaya Livestock Office with help from the Papuan Assessment Institute for Agricultural Technology, the Jayawijaya Extension Office, and to some extent the *Wahana Visi Indonesia* and the *Yayasan M-Mula* non-government organisations. The ACIAR project aimed to alleviate poverty and

increase food security of the Dani people through improving their sweetpotato-pig systems. A wide range of sweetpotato-pig innovations were introduced at the end of the project. The scene has now been set to understand the methods which were employed in the study, and these will be explained in the next Chapter.

4. Methodology and Methods

Chapter 2 established the SL Framework as the most appropriate starting point for understanding what impacts need to be evaluated in the Papuan context. It also introduced the DDI method as a robust method for analysing these impacts. Chapter 3 provided a comprehensive description of the geographical and project context of this study. This Chapter provides the comprehensive description of how the SL framework and DDI method were applied in practice. It begins with presenting methodology whereby step-by-step activities were performed in the fieldwork for this study. This is followed by explaining each activity in details which includes specific methods involved in it. Some appendixes are produced and attached for elaboration. Details of the organisations and personnel involved in executing the overall activities are also presented here. Some of the materials presented in this chapter are reproduced, usually in a shorter form, in the 'methods' sections of Chapters 5 to 8, which are the manuscripts of papers to be published from this study.

4.1. Methodology

Step-by-step activities performed in the fieldwork for this study are presented in Table 4.1. They include developing questionnaires, training for interviewers, sampling which includes forming project and comparison groups as well as setting base-line and end-line datasets, and collecting data through surveys and focus group discussions. While each of these activities involves a range of specific methods, these methods overall include Focus Group Discussions (FGDs), individual reviews, field-testing, semi-structured group interviews, in- and out-class training, statistical random sampling, Propensity Score Matching (PSM), and a number of Participatory Rural Appraisal (PRA) techniques such as brainstorming, preference ranking, re-call, seasonal calendars, matrix scoring and weighting, and pair wise ranking. Some of the core references where these techniques have been described are Babbie (1973), Okali et al. (1994), Baker (2000), Cramb and Purcell (2001), and Ravallion (2001). Details of the application of these methods are explained in the following description of each activity.

Table 4.1. Methodology and methods

Step-by-step activities	Approach/Method
Developing questionnaires	• Focus group discussions: Brainstorming, Preference ranking • Individual reviews • Field-testing
Training for interviewers	In- and out-class training
Sampling:	
• Forming project and comparison groups	• Statistical random sampling • Propensity score matching
• Setting base-line and end-line datasets	Re-call techniques for the base-line datasets
Collecting data:	
• Surveys (mostly quantitative)	Semi-structured group interviews
• Focus group discussions (mostly qualitative)	PRA techniques: Seasonal calendars, Matrix scoring and weighting, Pair wise ranking
Analysing data	Independent samples t-tests and Pearson correlations

4.2. Developing questionnaires

Developing questionnaires initiated the fieldwork for this study. It aimed to determine impact variables in the context of the SL framework to be evaluated as perceived by the local people. Consequently, it involved a series of FGDs involving three groups of local key informants: (1) 10 Dani women, (2) 10 Dani men, and (3) 12 officials from local government organisations (10 officials) and non-government organisations (2 officials). These FGDs were conducted on 19th, 20th, and 29th March 2007 respectively. The key informants are presented in Appendix A. The separation of Dani women and men into two different FGDs was intended to avoid the domination of men in the discussion. The first two FGDs focused on potential impact variables in the 'vulnerability context, livelihood assets, livelihood strategies, and livelihood outcomes' components, while the third FGD discussed potential impact variables in the 'policies, institutions and processes' component of the SL framework. So the five components of the SL framework were all covered by these FGDs. Moreover, brainstorming techniques were used to collect as many potential impact variables as possible, which were then re-selected by using preference ranking to determine the final set of impact variables that needs to be evaluated as perceived by

the Dani people themselves. This final set of impact variables formed the basis for developing the draft of questionnaires.

The next step was to refine the draft of questionnaires. This was done several times through individual reviews by two ACIAR project field staff, four government organisation officials, one non-government organisation official, one Dani key informant woman, and two Dani key informant men (see Appendix A) who have all provided valuable feedback. Finally, the refined questionnaires were field-tested. This aimed to identify problems when the questionnaires are being used in the field. Four *silis* from four different villages were involved in the field-testing and they all provided valuable feedback as well. The final questionnaires are presented in Appendix B.

In addition, while the fundamental unit for social data collection in Indonesia is the family household, it appeared during the three FGDs that all key informants have suggested to use *sili*, which is the fundamental social unit of the Dani people (will be discussed in Chapter 5) as a unit of analysis for this study. Consequently, this study adopts this suggestion.

4.3. Training for interviewers

Training for interviewers prepared five young Dani men (Appendix C) to carry out *sili* surveys. One ACIAR project field staff was appointed to coordinate these interviewers and manage the surveys. This training was conducted on the 8th and 9th of June 2007. In the first day, it focused on understanding the questionnaires. It was an in-class training exercise. In the second day, all interviewers visited the field for them to try interviewing some *silis* (out-class training). Each interviewer interviewed two *silis*. While the first *sili* was interviewed to complete 50% of the questionnaires (page 1-15), the second *sili* was interviewed for completing the remaining questionnaires (page 16-31). In average, each interviewer spent about 50 to 70 minutes to complete half an interview (i.e. either page 1-15 or 16-31).

An evaluation for both the in-class and out-class training was also conducted involving the five interviewers and the survey coordinator. It was held only one day after the out-class training (10th June 2007), so they were all still fresh with their experience. It aimed to make sure that all the interviewers have had the same

perceptions on the questions in the questionnaires, and that they have delivered these questions and got the answers appropriately.

4.4. Sampling

As established in Chapter 2, the application of the DDI method requires a project group and a comparison group to be compared in mean outcomes at the base-line (i.e. before the project started) and the end-line (i.e. after the project finished). The mean outcomes for this study have been established above; they are impact variables in the context of the five components of the SL framework. The following explains how these project and comparison groups are formed for this study in a statistically robust manner. It also describes the base-line and end-line datasets of the two groups.

4.4.1. Forming project and comparison groups

The project group was simply formed by choosing all collaborator *silis* involved in the ACIAR project. There are 38 *silis* in this group (Appendix D). These *silis* came from the 20 villages across the Baliem Valley where the project has operated (see Chapter 3). The extent to which they involved in the project varied; 10, 15, and 13 *silis* did only sweetpotato trials, only pig trials, and both sweetpotato and pig trials respectively. However, the project facilitated all these *silis* to visit one to another at least once a year (Cargill 2009), so after all they all had opportunities to observe everyone's trials.

In contrast, the formation of the comparison group was not straightforward. It involved two stages. The first stage involved the selection of 15 neighbour *silis* of each of the 38 project group *silis*. These 15 neighbour *silis* were *not* collaborator *silis* and randomly chosen from the list of *sili* population provided by each of the 20 village offices. This first stage resulted in a total of 570 non-collaborator *silis* (i.e. 15 non-collaborator *silis* x 38 collaborator *silis* = 570 non-collaborator *silis* in the first stage sample). Appendix E presents the 570 non-collaborator *silis* chosen randomly in the 20 villages. These 570 non-collaborator *silis* were also used to establish the current farming systems of the Baliem Valley (presented in Chapter 5).

Furthermore, the second stage involved the selection of 5 'nearest non-collaborator *silis*' of each of the 38 project group *silis* using the PSM method. 'Nearest non-collaborator *silis*' here mean that they had similar observable characteristics (i.e. the size of sweetpotato gardens and the number of pigs) to the project group *silis*. These 5 nearest non-collaborator *silis* were chosen from the list of 15 non-collaborator *silis* selected through the first stage. This second stage resulted in a total of 190 nearest non-collaborator *silis* (i.e. 5 nearest non-collaborator *silis* x 38 collaborator *silis* = 190 nearest non-collaborator *silis* in the second stage sample). Appendix F elaborates the application of the PSM method in this second stage. These 190 nearest non-collaborator *silis* formed the comparison group that was used to identify the counterfactual of what would have happened without the ACIAR project intervention (analysed in Chapter 6 to 8). The two sampling stages for forming the final 190 comparison group *silis* were intended to make the farming system based on sweetpotato-pig production characteristics of the project and comparison group *silis* fairly comparable.

4.4.2. Setting base-line and end-line datasets

The base-line and the end-line were the situations of the five components of the SL framework for both the project and comparison groups before the project started and after the project finished respectively. While the end-line datasets for the project and comparison group *silis* were all collected through *sili* surveys carried out in 2007 as part of this study (see below), the base-line datasets were some collected through the 2001 ACIAR project socio-economic studies and some through the 2007 *sili* surveys. The original base-line datasets collected in 2001 included 14 project group *silis* (37% of the 38 project group *silis*) and 32 comparison group *silis* (17% of the 190 comparison group *silis*). The additional base-line datasets of the remaining project and comparison group *silis* were collected in 2007 using recall data techniques. The use of these techniques was confirmed by the participation of many *sili* members during the semi-structured group interviews (details below). These additional datasets were necessary because the original ones were not only small in the size of samples, but also covering only seven villages of the 20 villages.

4.5. Collecting data

Two types of datasets were intended to collect by this study. They were quantitative and qualitative datasets. While the quantitative datasets gave quantitative measures of the impact variables, the qualitative ones provided insight into understanding the quantitative measures. The following describes how the quantitative and qualitative datasets were collected through *sili* surveys and a series of FGDs respectively.

4.5.1. Sili surveys

Sili surveys visited all the 38 project group and 570 comparison group *silis*. They were all conducted by the five trained Dani interviewers in two stages (Appendix G). The first stage, from 18th June to 28th September 2007, collected the overall end-line datasets; while the second stage, from 8th October to 19th December 2007, collected only the additional base-line datasets. Each *sili* was visited four times in total for collecting the base-line datasets (two times) and the end-line datasets (two times). A PRA semi-structured group interview technique was employed here using the questionnaires as a guideline. When a *sili* was being interviewed, as many *sili* members as possible were encouraged to participate (Figure 4.1).

4.5.2. Focus group discussions

A series of FGDs were conducted in all the 20 villages from 18th June to 28th September 2007 (Appendix H). Each of these FGDs involved a mix of 10 Dani key informant women and men and aimed to obtain in-depth understanding of some quantitative measures collected through the *sili* surveys. A range of topics discussed in these FGDs are presented in Appendix I. Within these FGDs, a number of PRA techniques were employed including seasonal calendars, matrix scoring and weighting, and pair wise ranking. While the seasonal calendars clarified the cropping patterns of sweetpotatoes in the Baliem Valley, the matrix scoring and weighting as well as the pair wise ranking explored the livelihood strategies and outcomes of the

Dani community. Figure 4.2 shows a FGD held in Wamena. Appendix J presents an example of results taken from a FGD in Wamena.

NOTE:
This figure is included on page 57 of the print copy of the thesis held in the University of Adelaide Library.

Source: Author's fieldwork (2007)

Figure 4.1. A group interview in Napua

Source: Author's fieldwork (2007)

Figure 4.2. A focus group discussion in Wamena: matrix scoring and weighting (left) and pair wise ranking (right)

4.6. Analysing data

The survey data was tabulated in Excel spreadsheets, but the statistical analysis was processed using SPSS 17.0 for Windows. The core analysis includes independent samples t-tests which were used in Chapters 5 to 8 particularly to determine whether the measured impact variables are meaningful, and some Pearson correlation tests which were used in Chapters 6 and 8 to measure the ecological balance between human, sweetpotato and pig.

4.7. Closing remarks

The overall activities of the fieldwork for this study spent 10 months in total. They involved over 1,000 individuals who have all provided valuable inputs. The development of questionnaires, which initiated the fieldwork, involved 10 Dani key informant women, 10 Dani key informant men, and 12 officials from both local government and non-government organisations in the development of questionnaires. The *sili* surveys, which collected mostly quantitative measures of impact variables in the context of the SL framework, involved an ACIAR project field staff, five trained Dani interviewers, and importantly 608 project and comparison group *silis*. The FGDs in the 20 villages, which collected mostly qualitative information to gain in-depth understanding for the quantitative measures, were participated by 200 Dani key informant women and men. In terms of cost of operations, this fieldwork spent A$20,000 which was funded by the ACIAR project in the Baliem Valley. Finally and importantly, the methodology and methods have now been clarified to understand the results which will be presented in the next following Chapters 5 to 8.

5. Farming Systems of The Baliem Valley, Papua, Indonesia[3]

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6. The Vulnerability of Livelihoods Based on Sweetpotato-Pig Production in Papua, Indonesia[4]

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Abstract

Sweetpotato-pig production is central to the livelihood of Dani people of the Baliem Valley in Papua, Indonesia. Using the notion of 'vulnerability' within the context of the Sustainable Livelihoods framework, a number of important factors among Dani sweetpotato-pig producers are investigated as well as related livelihood coping strategies. Vulnerability factors impede the ability and stability of production, and one approach to alleviate poverty is to improve the ability to cope with vulnerability factors. Two groups of Dani people are surveyed, those who involved with an agricultural development project to improve sweetpotato-pig production systems (Project Group), and their neighbours who did not (Comparison Group). The factors affecting the vulnerability of their sweetpotato and pig production are weighted and ranked. The Project Group have significant advantages over the Comparison Group by association with the project and there are significant shifts in their perception of vulnerability in sweetpotato production. However, vulnerability factors affecting pig production remain basically the same. Locally-defined vulnerability factors need to be considered as a high priority among agricultural development interventions in the region and elsewhere.

Keywords: Vulnerability, Sweetpotato-pig production, Livelihoods, Dani people, Papua-Indonesia

Introduction

Papua is an important province to Indonesia with unique development challenges. It is the largest but the least populated province. It occupies 22% of the national land area, but the provincial population of 2.02 million constitutes less than 1% of the national population (BPS Papua 2008). Moreover, the province is endowed with incredible natural resources – from forests and marine products to oil, gas and minerals. This is reflected by the domestic and foreign projects investment in the region, which in the last decade (1998-2007) reached over 100 trillion Rupiah (US$10 billion). In 2007 alone Papua's Gross Regional Domestic Product (GRDP) was 55.4 trillion Rupiah, generating a per capita GRDP of 24.0 million Rupiah which was above the national average of 14.8 million Rupiah (BPS Papua 2008). However, these economic successes have not been shared by most Papuans. In Papua 40.4% of the population lives below the poverty line – defined as living with less than 182,000 Rp/month (US$18.2/month) – which is more than double the national average of 16.6% (BPS Papua 2008). Not all Papuans can directly benefit from the extractive industries operating in their province, but the wealth generated can be directed to raise the productivity and livelihood stability of the 74% of Papuans supported by agriculture. Before this can be done it is important to understand the agricultural-based livelihoods of the local people, and the factors affecting the vulnerability of these livelihoods. The Dani people of the Baliem Valley, in the Central Highlands of Papua, are one such community.

Traditional Sweetpotato-Pig Production Systems of the Dani People

The traditional farming systems that support all indigenous Papuans by securing food, generating income and carrying socio-cultural value is based on sweetpotato (*Ipomoea batatas*) and pig (*Sus scrofa papuensis*). Sweetpotato accounts for 90% of the daily diet in many areas, with some estimates calculating per capita annual consumption in Papua at nearly 100 kilos (Peters 2003). This crop also accounts for up to 100% of pig feed in Papua. The pig plays an increasing role for Papuan households in income generation as it demands high prices (a 50-60 kg pig can sell for 6-7 million Rupiah, or US$6-700). Sweetpotato and pig are always

involved in any Papuan traditional events such as marriages, conflict resolutions, and funerals (Schneider et al. 1993). The Dani tribe is one of the 312 indigenous tribes in Papua and they are the biggest with about 146,000 members (BPS Papua 2008).

The fundamental social unit of the Dani is the *sili*; it comprises several closely-related family groups living within the one enclosure. Lokobal et al. (2006) explain that in a *sili* several Dani families can live together, but they follow the ethic of *sabokhogon* which means they are "one for all and all for one", as they live and work together as the one unit with no separate ownership of means of production or wealth. The number of persons (5-32), the size in ha of sweetpotato gardens (0.3-2.7), and the number of pigs (0-46) are significantly correlated indicating a strong ecological balance between humans, sweetpotatoes, and pigs in the Dani farming systems (Mahalaya et al. 2009). According to Golson (1997), they have farmed the Baliem Valley for more than 9,000 years, and have grown sweetpotatoes and raised pigs for several hundred years. However, the efficiency of their sweetpotato-pig production under the traditional farming systems was found to be very low (Cargill 2009). For example, the yield of sweetpotatoes was 9.2 t/ha compared with 20-30 t/ha in a similar environment in other Indonesian highlands (Limbongan and Soplanit 2007). Similarly, the growth rate of pigs was only 18 g/day with a mortality of 40% over four months, and sows appeared to breed only once every two to three years (0.3-0.5 litters/year) with a small litter size (5 pigs/litter) and high piglet mortality (48% pre-weaning mortality). To improve the traditional farming systems, the Australian Centre for International Agricultural Research (ACIAR) funded a research project between 2001-6 titled 'Poverty alleviation and food security through improving the sweetpotato-pig systems in Papua, Indonesia' (ACIAR 2005). The improved system included: new sweetpotato cultivars; nutritious pig-feed formula based on local materials; better boar and sow management; and an improvement of the traditional pig enclosure (*laleken*) with fodder crops and trees.

This paper presents our understanding of the vulnerability of the livelihoods based on sweetpotato-pig production in the Baliem Valley of Papua. 'Vulnerability' is a concept derived from the Sustainable Livelihoods (SL) framework (DFID 1999) which is a model for understanding the many interrelated causes of poverty and how to alleviate poverty. This paper compares the relative changes in vulnerability factors observed by farmers directly involved with the ACIAR project as well as their

neighbours who did not. It also examines the strategies both groups of farmers follow to cope with those factors. We ask what factors are in priority to address, whether the two groups differ in their ability to cope with the exigencies of agricultural livelihoods, and what the implication is for extending the benefits of the project to the larger community.

The following background section briefly explains the SL framework and how we adapted it for measuring vulnerability. It also describes the ACIAR project.

Background

The Sustainable Livelihoods Framework

The SL framework developed by the Department for International Development of the United Kingdom, has five core livelihood components which relate each other, viz, Vulnerability Context, Livelihood Assets, Policy-Institutions-Processes, Livelihood Strategies, Livelihood Outcomes (Fig. 1). It is a tool to help understand livelihoods, the way in which livelihoods are constructed and how and why they change over time, which in turn can help identify the best way to support poor people (DFID 1999).

Vulnerability context is defined as the set of factors related to shocks, trends and seasonality issues that can have a great impact on people's livelihoods (DFID 1999). These factors are all outside people's control; they are constant realities – not just passing states – that many poor people have to deal with everyday. Examples of these factors are human health shocks, technological trends, and seasonality of prices. Vulnerability context can be influenced by society's policies, institutions and processes, exerting in turn influences on and be influenced by people's livelihood assets (see Fig. 1). To analyse it, DFID (1999) suggests that one can begin with understanding various groups within a target community and factors that make their life vulnerable. Once a factor has been identified as important, one can assess its relative importance compared to other factors, how widely applicable it is, what its effect on livelihoods is, and whether people have developed any way of coping with it. Analysing vulnerability context is important as it enables the identification of areas

or resources at risk, and the threats posed by the diminution or loss of such resources that can threaten future sustainable development (Berry et al. 2006).

The literature discussing vulnerability context focuses largely on conceptual issues as the attempts to make the SL framework more applicable in the field (e.g. Ashley and Hussein 2000; Carney 2003; Lautze and Raven-Roberts 2003; IFAD 2006). There is much less discussion of the actual methods for measuring vulnerability context. For example, Nabi et al. (2007) employed the Likert scale method (Likert 1932) to measure factors related to seasonality, shocks, and trends issues in the Estuarine Set Bag Net Fishermen Community of Bangladesh, and showed that the method can provide a means for quantifying the extent of those factors for vulnerability. Examples of the factors they measured were the number of months in a year fish price is lowest (a seasonality issue), conflict between neighbouring village (a shock issue), and fish production (a trend issue). Unfortunately there was no attempt to examine the coping strategies of their target community as a follow up to their findings.

Nevertheless, outside the SL framework there are other measures of vulnerability. For example, Phillipson et al. (2004) identified the 2001 Foot and Mouth Disease (FMD) outbreak in the UK countryside as an important vulnerability factor. Using telephone surveys, they interviewed rural small firms to collect data on economic and social impacts, coping strategies, and recourse to advisory sources and external aid. They concluded that the economic and social impacts of FMD varied between firms (e.g. livestock haulier and butcher) and sectors (e.g. transport and business services), but mostly in a negative way, and the recourse to advisory sources and external aid (e.g. family members and local authority) was important for many firms, showing how internal coping strategies, which all firms performed (e.g. employees take smaller wage and firm owners cancel or postpone to expand business), are often based upon interaction with the wider business environment. This work demonstrated how rural small firms and economies display resilience and serve to absorb the impacts of such a livestock health/economic shock issue.

There is very little known about the vulnerability of livelihoods of the Dani people. The only attempt has been that of Lassa (2004). However, this was only based on a one-week workshop without field observation and did not specifically focus on their sweetpotato-pig production system; as such it is incomplete for

understanding the vulnerability of their agricultural livelihoods. This study reported here employs a number of participatory techniques (Cramb and Purcell 2001) to quantitatively measure factors within the vulnerability context of Dani sweetpotato-pig production system and qualitatively assess coping strategies with those factors. Both quantitative and qualitative measurements were formulated by the Dani people themselves. The knowledge gained through this study can provide insight on how, and to what extent, the ACIAR project has benefited the Dani with regard to making them less vulnerable.

'Poverty Alleviation and Food Security through Improving the Sweetpotato-Pig Systems in Papua, Indonesia'

The ACIAR project of 'Poverty alleviation and food security through improving the sweetpotato-pig systems in Papua, Indonesia' was carried out in between 2001-6. This project targeted the Dani people of the Baliem Valley and aimed to alleviate poverty and increase food security through improving their sweetpotato-pig systems. Using participatory approaches, the project collaborated with 38 Dani farmers from 20 villages across the Baliem Valley (see Fig. 2) where the work was all done on-farm. This work included the development of new sweetpotato cultivars for both human food and pig feed, nutritious pig feed formula based on sweetpotato and other local materials, better boar and sow management, and an improved traditional pig enclosure (*laleken*) with fodder crops and trees.

Materials and Methods

Study Area and the 'Sili' as a Unit of Analysis

The Baliem Valley covers approximately 160 km^2 along the Baliem River of Jayawijaya Regency in Papua Province (Fig. 2). The total area of Jayawijaya Regency is 14,847 km^2, and the biggest part is occupied by forest (almost 87%) and followed by agricultural cultivable land (13%) and settlement (less than 1%) (BPS Jayawijaya 2006). Populated areas in the valley lie between 1,470-1,850 m above sea level (asl) while the surrounding Jayawijaya Mountains reach altitudes of 4,700 m asl

(Aditjondro 1982). The humid tropical climate is characterised by relatively consistent temperatures through the year (14ºC average monthly minimum; 27ºC average monthly maximum), and seasonal rainfall with the wetter months from December to April and the drier months from May to November. However, variability in annual rainfall is great, ranging from 1,266 mm in 1997 (an El Nińo period) to 2,617 mm in 2005 with variability in monthly rainfall (i.e. coefficients of variation) between years ranging from 28 to 87% (BMG Jayawijaya 2006).

The survey visited 20 villages across the Baliem Valley all within the Jayawijaya Regency (Fig. 2). These villages all had member *silis* that were involved with the ACIAR project during 2001-6. The fundamental unit for social data collection in Indonesia is the family unit. However, the use of *sili* as the unit of analysis was suggested by Dani key informants in a series of workshops held in 2007 for developing questionnaires for this survey (Mahalaya et al. 2009).

Sample Selection

Sili samples were selected to form two contrasting groups, namely the Project Group and the Comparison Group. The Project Group was simply formed by choosing all the 38 *silis* collaborating in the ACIAR project. Meanwhile, the Comparison Group was formed through two stages. A first stage involved the selection of 15 neighbour *silis* of each of the 38 Project Group *silis* using the stratified random sampling method (Babbie 1973). These 15 neighbour *silis* were *not* involved with the project and chosen from the list of *sili* population provided by each of the 20 village offices. The first stage resulted in a total of 570 Comparison Group *silis* (i.e. 15 non-collaborator *silis* X 38 collaborator *silis* = 570 *silis* in the first stage sample). Moreover, a second stage involved the selection of 5 'nearest neighbour *silis'* of each of the 38 Project Group *silis* using the propensity score matching method (Baker 2000). 'Nearest neighbour *silis*' here mean that they have similar observable characteristics (i.e. the size of sweetpotato gardens and the number of pigs) to the Project Group *silis*. These 5 nearest neighbour *silis* were chosen from the list of 15 neighbour *silis* selected through the first stage. The second stage resulted in a total of 190 Comparison Group *silis* (i.e. 5 non-collaborator *silis* X 38 collaborator *silis* = 190 *silis* in the second stage sample) which data is analysed here. The two sampling

stages for forming the final 190 Comparison Group *silis* were intended to make the sweetpotato-pig system characteristics of the Project and Comparison Group *silis* fairly comparable.

Data Collection

A number of approaches involving participatory techniques were employed to collect data in 2007. The first approach was multi-stakeholders Focus Group Discussion (FGD). There were three separate FGDs with three different groups of key informants which aimed to help develop questionnaires for *sili* surveys. The three FGDs comprised a group of 10 Dani women, a group of 10 Dani men, and a group of 10 local government and non-government officials. The separation of the FGDs was intended to avoid group domination and in particular get Dani women opinions. Within the FGDs, participatory brainstorming techniques were employed to list all possible factors within the vulnerability context of Dani sweetpotato-pig production-based livelihoods, while participatory pair-wise ranking techniques were employed to help determine 20 vulnerability factors (i.e. 10 factors related to sweetpotato production-based livelihoods and 10 factors related to pig production-based livelihoods), which the FGDs' participants believe that they are relatively important to question in *sili* surveys, selected from the list of all possible factors.

The second approach was Village Office Visit (VOV). Twenty VOVs were made, once to each of the 20 villages. Each VOV aimed to collect data on *sili* population, which is only available in the village offices (i.e. it is not available in the Jayawijaya Statistic Office), and discuss with the head of village, the head of village development unit, and the head of tribes. Within the discussion, participatory wealth and wellbeing ranking techniques were employed to help determine criteria for poor *silis* as perceived by Dani people in the visiting village, and list all potential *silis* which can be surveyed. From these potential *silis*, a group of *sili* samples were randomly chosen to be surveyed later. This group of *sili* samples taken from each of the 20 villages formed the 570 Comparison Group *silis*.

The third and final approach was *sili* survey. The 38 Project Group and 570 Comparison Group *silis* were all surveyed by five trained Dani interviewers. Within the *sili* survey, participatory matrix scoring and weighting techniques were

particularly employed to help score the 20 factors, while participatory semi-structured interview techniques were employed to collect qualitative information on coping strategies with the 20 factors. When a *sili* was being interviewed, as many members of the *sili* as possible were encouraged to participate.

Analysis of Results

The survey data was analysed using independent-samples t-tests statistical models with SPSS 17.0. The main focus of the analysis is on the factors which have relatively high weightings within the vulnerability context of Dani farming system, and on the coping strategies with those factors. However, in order to provide a foundation for this analysis, the results also present data on the ecological balance between human, sweetpotato and pig, and the relative importance of livelihoods based on sweetpotato-pig production.

Results

The Ecological Balance between Human, Sweetpotato and Pig

Table 1 shows the significant correlation between human, sweetpotato and pig within both the Project Group and the Comparison Group. The coefficient ranges between 0.67 and 0.91 and all the coefficients are positive. In summary, Dani *silis* strongly maintain their ecological balance whereby the number the people in the *silis*, the larger the sweetpotato garden they cultivate, and the more the pig they raise.

The Relative Importance of Livelihoods Based on Sweetpotato-Pig Production

Table 2 presents the average annual incomes earned by Dani *silis* from the various sources available along with the percentage that source contributes to total income. Pigs provide the greatest source of income for both Project and Comparison Groups, 67 and 86% respectively. In contrast, the contribution of sweetpotato production to income is low, only 1.9 and 2.4% respectively. This is explained by data in Table 3 which shows Dani *silis* use sweetpotatoes mainly for human food (32

and 34% respectively) and pig feed (49 and 48% respectively) and very little is actually sold (3.7 and 2.1% respectively). Pigs on the other hand are mainly for sale (73% and 75% respectively). In summary, sweetpotato is for food and feed security, while pigs are for income generation.

There are significant differences between the Project Group and the Comparison Group in terms of total income and income earned from selling pigs, forest products, and non-agricultural jobs (Table 2). The Project Group earns 50% more total income the Comparison Group, largely from non-agricultural jobs, but also from sale of pigs. The Comparison Group earns relatively little for non-agricultural jobs and relatively more of their income comes from pigs and forest products. Regardless of these differences, both groups allocate the stock of their sweetpotato and pig produce to domestic consumption, sale and customary ceremony in the same proportions (Table 3).

Vulnerability Factors of Livelihoods Based on Sweetpotato-Pig Production

The 20 vulnerability factors (10 each for sweetpotato and pig production respectively) identified from focus group discussions are listed in Table 4. The table also presents the relative weightings (out of 100) and the ranking (out of 10) given to these factors by both the Project and Comparison Groups. The t-test for significance applies to the weightings values.

For sweetpotato production both groups ranked damage from marauding pigs as the prime threat on their gardens and ranked the lesser threats on production to be soil fertility and sweetpotato prices. Between these extremes rankings there was divergence in rankings between the groups and a clearer picture can be gained from the weightings given to each vulnerability factor. It shows the two groups have a relative different focus of attention on which factors that make their sweetpotato production-based livelihoods vulnerable.

Soil hydrology refers to the nature of the garden soils, which are Histosols (Van Baal et al. 1984), to become easily waterlogged in the wet season but rapidly drying out in the dry season. Both groups ranked this highly as a problem but significantly more so for the Project Group. This is because the Comparison Group applied heavy weightings to the factors such as lack of technical assistance and

sweetpotato yields. Both groups applied relatively low weightings (<5%) for the other factors listed although the Project Group was significantly more concerned with conflict with other *silis* and soil fertility. The Comparison Group was significantly more concerned with sudden illness of a *sili* member as a factor affecting sweetpotato production.

For pig production the two groups applied very similar rankings of the vulnerability factors affecting their livelihood. Both groups were primarily concerned with pig diseases and the availability of medicines, although the Comparison Group applied a significantly greater weighting (40% cf. 25%). The rankings that followed in parallel were technical assistance (rank 2), quality of pig diets (rank 3), use of pigs in customary ceremonies (rank 4), theft (rank 5, boar and sow management (rank 6). The rankings diverged below this, but the factors had relatively low weightings (<5%). There were significant differences in the weightings applied by the two groups to all factors except for quality of pig diets, use of pigs in customary ceremonies and market access.

Coping Strategies

Table 5 presents the coping strategies used by both the Project and Comparison Groups for a selection of the vulnerability factors affecting Dani sweetpotato-pig production systems. In general, both groups have similar strategies to cope with the selected factors, but the Project Group has more options. For examples of these options: the Project Group has the wherewithal to make regulations controlling pig movements; they have direct access to sweetpotato cultivars that are better adapted to water logging and drought, and consequently higher yielding; they have direct and active access to assistance from the government agricultural service. These options are not available to the Comparison Group and the best they can do is to buy the new sweetpotato cultivars from their Project Group neighbours.

Similarly in pig production, the Project Group can cope with disease and productivity issues with the new management and diets adopted from the ACIAR project. For example, the spread of pig diseases and pig theft often occurs during the daytime when pigs are free to wander. The Project Group adopted improved *laleken*

(pig enclosures) which not only provided better nutrition but also better security. The Project Group also had better access to government veterinary service.

Discussion

The sampling method used in this survey ensured that the 38 Project Group *silis* were fairly matched with the 190 Comparison Group *silis* on the physical basis of their livelihoods, i.e. garden size and pig numbers. Nevertheless, the survey revealed significant differences in the incomes of the two groups and the way those incomes are earned. It showed that while the two groups differed in their ranking of factors affecting their sweetpotato production, they shared the same vulnerabilities in pig production. Both groups have strategies to cope with these vulnerability factors, but the Project Group had additional strategies by way of association with the project. This discussion will examine some of the key vulnerability factors and coping strategies asking how some of the benefits enjoyed by the Project Group can be extended to their neighbours.

Defining the Vulnerability Factors

During the process of defining vulnerability factors (see Data Collection above) the three groups of key informants uniformly refused to define their vulnerability in terms of the 'shocks, trends and seasonality issues' as presented in the SL literature (e.g. DFID 1999; Nabi et al. 2007). For example, they argued that while many factors related to trends (e.g. population trends, governance trends, technological trends) may be important, they seemed too distant from their daily experience of vulnerability to be able to comment on. Instead they identified the factors presented in Table 5 as being more real for them.

Vulnerability in Sweetpotato Production

For the Dani, whether they are the Project Group or the Comparison Group, maintaining the ecological balance between human, sweetpotato and pig was their priority (Table 1). They attempted to make sure that the sweetpotato can supply

enough food and feed while the pig can generate income (Table 3). Therefore they will naturally prioritise to deal with any factors that can directly break or have a great effect on the ecological balance and the function of the sweetpotato and the pig that follows it.

With respect to the sweetpotato, there was difference between the two groups in their prioritised factors. While the Project Group were concerned marauding pigs and soil hydrology, the Comparison Group dealt with marauding pigs, technical assistance, yields and soil hydrology (Table 4). The remaining factors were in low priority and so will not be discussed here, but it does not necessarily mean that they are not important. Despite the difference between the two groups, all the prioritised factors had the potential to greatly affect sweetpotato production. They either prevent optimal crop growth or threaten complete harvest failure. The following paragraphs elaborate some of these factors affecting the supply of food and feed.

The extensive management of pigs in the Baliem Valley involves allowing pigs to wander free during the day and only be penned at night (Peters 2001). Consequently marauding pigs can cause considerable damage on sweetpotato gardens resulting in great loss of produce. Traditionally the Dani coped with marauding pigs with wooden fences around their gardens in order to protect their crops. They regularly looked after the gardens and immediately repaired any damage fences. When there was a case, they brought it into the customary institutions who mediated the two parties to find an agreeable solution which often ended up with a severe fine involving the payment of pigs (Schneider et al. 1993). Such a fence can still be observed until now across the Baliem Valley. However the practice has declined, reportedly because of the general decline with inter-tribal warfare.

The nature of the local soil hydrology is such that during the rainy seasons they reach field capacity quickly, causing run-off and flooding, and during the dry seasons they hold little available water, and compact and crack. The potential for crop success or failure is strongly dependent upon the quality of bed and drain management and the quantity and distribution of seasonal rains. For example, in 1997 an El Nińo event resulted in most crops not being able to be harvested across the Baliem Valley (Ballard 2000). At other times many valley floor gardens suffer periodic flooding forcing Dani farmers to harvest early and experience a great loss of produce too.

While the Jayawijaya Agricultural Office exists, among other functions, to provide technical assistance for farmers, the resources and lines of communication are undeveloped. In 1987 this office also imposed a complete ban on the use of chemical fertilizers and pesticides in the region with the intention to prevent contamination of the river which is only water supply. Accordingly, farmers rely more on their own attempts to handle problems with soil fertility and pests and diseases.

Did the two groups differ in their ability to cope with the prioritised factors and move from the exigencies of sweetpotato livelihoods? It is clear that there was change within the Project Group, in that they became less concerned with access to technical assistance and sweetpotato yields (see Table 4). This is because the Project Group with help from the project established a link to the Jayawijaya Agricultural Office, so that they could call in when there was problems with their sweetpotato production (e.g. an attack of pests and diseases). Similarly, the Project Group with direct and active access to the project always had cuttings of the new cultivars, while the best the Comparison Group can do was to exchange and/or buy the cuttings, which were often unavailable due to limited in stock, from their Project Group neighbours.

The Project Group's ability to cope with the marauding pigs and the soil hydrology was also different in a way that they were empowered to deal with the local government offices. For example, the Project Group proposed through the Jayawijaya Livestock Office and the Dani customary institutions to make regulations which can control the marauding pigs. Similarly, they proposed through the Jayawijaya Agricultural Office to build a more permanent well-designed drainage system in the Baliem Valley floor which can overcome the soil hydrological problems. These proposals were being discussed in the Jayawijaya House of Representative at time of writing.

Vulnerability in Pig Production

In contrast to sweetpotato production, there was no difference between the Project Group and the Comparison Group in the vulnerabilities surrounding pig production. The two groups were equally concerned with diseases and medicines, technical assistance, quality of pig diets, and the tension between allocating pigs for

sale and for customary ceremonies (Table 4). These factors had the potential to greatly reduce the number of pigs that can be sold.

Disease and the lack of medicine are, after poor nutrition, the most significant impediment on pig production in the Baliem Valley. An early pig disease survey carried out in 2002 by Putra et al. (2004) showed that almost every species of pig parasite recorded in the literature was identified in the Baliem Valley. The impact on pig health of these parasites was clearly visible. Furthermore, an outbreak of swine fever, a viral disease spread by physical contact between pigs, killed over 65,000 pigs in the Baliem Valley in 2006. The lack of medicines and technical assistance were reported as two of the factors behind the outbreak (DISNAK Jayawijaya 2007).

The Jayawijaya Livestock Office constitutes only one veterinarian with one assistant, serving the entire regency. This is in contrast to the Jayawijaya Agricultural Office which has a staff of 40, many of whom are locals, and experimental demonstrations and outreach program. At the time there was a population 165,000 pigs raised by over 23,000 Dani *silis* in the regency (BPS Jayawijaya 2006); the veterinarian clearly did not have the resources to reach the farmers. From the farmers side, they may not even know to office exists or have funds to make a visit. The Dani commonly use traditional medicines such as *Kerokeka* (*Plectranthus scutellarioides*) leaves and *Hunirahoken* (*Medinilla speciosa*) seeds for controlling lung worms, *Pukalole* (*Uraria lagopoides*) leaves for diarrhoea, and *Munikaka* (*Pittosporum moluccanum*) leaves for scab (Source: A number of Dani farmers, pers. comm.). However, the extent and efficacy of this practice has not been recorded.

Pigs in the Baliem Valley grow slowly due to poor, protein-deficient diets (Peters 2003). Dani farmers usually feed their pigs only raw sweetpotato roots and vines. Average crude protein contents of 20 traditional cultivars are 0.5-4.0% and 11-15% of the dry matter basis in roots and vines respectively (Ketaren 2005). It is not surprising that the growth rate of pigs is only 18 g/day and the piglet can take three to five years to reach a body weight of 50-60 kg (Cargill 2009).

The ability to provide pigs for customary ceremonies is an indication of *sili* wealth and social status and an important redistributive mechanism to maintain the ecological balance between humans, pigs and sweetpotatoes. However, many of the interviewed *silis* reported a shift from a cultural to more economic orientation in pig production. In the past Heider (1970) noted that there were enough ceremonies (e.g.

marriages, conflict resolutions, funerals) for everyone to have some pork at least once a week; but there is no record of what proportion of pigs were sold. Our survey did not measure pork consumption, but over 70% of pigs are now going to sale (see Table 3) and the survey respondents claimed that there was a large reduction in the number of pigs going to the ceremonies. For example, funeral ceremonies which in the past may proceed for five days, now only last for two days. It would be worthwhile to determine if the diversion of pigs into the market has impacted on the protein intake of the poorer Dani.

While the two groups were similar in the rankings assigned to different vulnerability factors, their ability to cope with these factors of pig livelihoods were different. Disease and lack of medicine was the primary concern of both groups, but the Comparison Group gave a much higher weighting. The Project Group had learnt to separate infected pigs from the healthy ones in order to prevent the spread of the diseases. They also learnt to perform post-mortems on the dead pigs to find out the cause. They had more agencies in managing this problem. As the Project Group's weighting on the problem of disease and medicine was so markedly reduced, their weightings of the importance of lower ranked problems (theft, conflict, etc) increased relative to the Comparison Group.

The Project Group also applied a higher weighting to the lack of technical assistance, even though they actually had more direct and active access to the Jayawijaya Livestock Office services when they had problems with their pig production; they had learnt to value it greater than the Comparison Group.

In the meantime, the two groups shared the concerns over the quality of pig diets. The Project Group had a greater opportunity to adopt the new diets as they were directly involved in the project. This is confirmed by the level of adoption of almost 30% among the Project Group (see Table 5), even though the experiments to develop nutritious pig-feed formula based on local materials were carried out at only 3 villages. The annual inter-village visits to inspect the pig experiments were sufficient to influence the Project Group's perception of vulnerability in this matter, but it is clear that they needed more as they still shared the concerns with the Comparison Group. However, about 13% of the Comparison Group sought advice on this matter from their Project Group neighbours (see Table 5) providing evidence that the of technology diffusion. The shared concerns related to the extra time needed to

prepare the new. The diets were developed using locally-based and free materials and so were not costly.

Both groups applied similar rankings and weightings to the tension between the modern use of pigs as a source of cash and the traditional use of pigs as a source of cultural currency. Heider (1970) noted that the total impact of pigs on Dani life goes beyond their nutritional contribution. Pigs enjoy a protected status in Dani society because they are important in both cultural and economic terms (Gardner and Heider 1968). Although nowadays more pigs are being sold and the number of pigs available for ceremonies has declined, the pig is still tightly attached to the ecological triangle (see Table 1). This helps us understand the resistance of the pig, as well as the sweetpotato, to change (e.g. by trying to introduce new crops or livestock). So it appears that the Project Group's exposure to the benefits of scientific agriculture did not change their concern for balancing the economic and cultural functions of pig production. Further agricultural development in this society should recognise and account for this socio-cultural tension.

Diffusion and Extension of Improved Sweetpotato and Pig Technology

The Project Group clearly had more options from their association with the project to cope with the vulnerabilities of sweetpotato and pig livelihoods (Table 5). However, we also found that 34% of the Comparison Group sought advice from their Project Group neighbours to cope with problems associated with sweetpotato yield, while 17% and 13% sought advice from Project Group neighbours on pig diseases and diets respectively. The Comparison Group explained that they saw the benefit of the new technologies adopted by their neighbours. In particular, they observed all the Project Group's pigs confined in the pig enclosure (*lalaken*) surviving the 2006 swine fever outbreak.

Consequently, the Comparison Group interviewees unanimously requested to be part of further extension of the project benefits. In response to these requests, there was a series of Training-of-Trainers (ToT) sessions carried out in the middle of 2006, preparing selected Project Group members for a series of Farmers-to-Farmers (FtF) events only begun in late 2007, or after the data for this study was completely collected. This ToT and FtF training was adapted from the United Nations Food and

Agriculture Organization's Farmer Field School (UN-FAO's FFS) modality which is built on group-based learning processes (Pontius et al. 2002).

Conclusion

This study has investigated vulnerability factors of livelihoods based on sweetpotato-pig production in the Baliem Valley, Papua and examined coping strategies with those factors. Dani *silis* prioritised factors that had a great effect on the ecological balance between human, sweetpotato and pig; they attempted to make sure that the sweetpotato supplied enough food and feed while the pig generated income. With respect to the sweetpotato function, these factors included marauding pigs, soil hydrology, technical assistance from the Jayawijaya Agricultural Office, and yields; while with respect to the pig function, the prioritised factors were diseases and medicines, technical assistance from the Jayawijaya Livestock Office, the quality of diets, and custom ceremonies.

The Project Group and the Comparison Group differed in their ability to cope with the prioritised factors. The Project Group had more options to move from the exigencies of sweetpotato-pig livelihoods as an advantage from their association with the project. However, there was evidence that the Comparison Group sought advice from their Project Group neighbours. Therefore, farmers-to-farmers extension programmes were needed to extend the benefits of the project to the Comparison Group and beyond.

This study has shown that the factors affecting the vulnerability of the traditional farming system are diverse, and need to be defined by the farmers themselves. It shows that vulnerability can be reduced by participation in a development project based on participative agricultural research, and that some benefits are obvious to non-participant neighbours. Such information can inform the design and implementation of development projects in similar traditional societies.

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References

ACIAR. (2005). *Research that Works: Indonesia Country Profile*, Australian Centre for International Agricultural Research, Canberra.

Aditjondro, G.J. (1982). The Irianese ethnic minorities in Indonesia. An issue of national integration. *Impact* 17(2): 37-63.

Ashley, C., and Hussein, K. (2000). *Developing Methodologies for Livelihood Impact Assessment: Experience of the African Wildlife Foundation in East Africa*, Overseas Development Institute, London. Working Paper 129.

Babbie, E.R. (1973). *Survey Research Methods*, Wadsworth Publishing Company, Belmont.

Baker, J.L. (2000). *Evaluating the Impact of Development Projects on Poverty: A Handbook for Practitioners*, The World Bank, Washington DC.

Ballard, C. (2000). Condemned to Repeat History? Enso-Related Drought and Famine in Irian Jaya, Indonesia: 1997-8. In Grove, R.H., and Chappel, J. (eds.), *El-Niño History and Crisis: Studies from the Asia Pacific Region*, The White Horse Press, Kapwell, pp. 123-148.

Berry, P.M., Rounsevell, M.D.A., Harrison, P.A., and Audsley, E. (2006). Assessing the vulnerability of agricultural land use and species to climate change and the role of policy in facilitating adaptation. *Environmental Science & Policy* 9: 189-204.

BMG Jayawijaya. (2006). *Temperature and Rainfall Jayawijaya Regency 1987-2006*, Badan Meteorologi Geofisika Jayawijaya, Wamena. Unpublished report (In Indonesian).

BPS Jayawijaya. (2006). *Jayawijaya in Figures 2006*, Badan Pusat Statistik Jayawijaya, Wamena (in Indonesian).

BPS Papua. (2008). *Papua in Figures 2008*, Badan Pusat Statistik Papua, Jayapura (in Indonesian).

Cargill, C.F. (2009). *Poverty alleviation and food security through improving the sweetpotato-pig systems in Papua, Indonesia,* Australian Centre for International Agricultural Research, Canberra. Final report.

Carney, D. (2003). *Sustainable Livelihoods Approaches: Progress and Possibilities for Change*, Department for International Development, London.

Cramb, R., and Purcell, T. (2001). *Developing Forage Technologies with Smallholder Farmers: How to Monitor and Evaluate Impacts*, Australian Centre for International Agricultural Research, Canberra. Impact Assessment Program Working Paper Series No. 41.

DFID. (1999). *Sustainable Livelihood Guidance Sheets*, Department for International Development, London.

DISNAK Jayawijaya. (2007). *The Jayawijaya Livestock Office Annual Report 2006/2007*, Dinas Peternakan Jayawijaya, Wamena (in Indonesian).

Gardner, R., and Heider, K.G. (1968). *Gardens of War: Life and Death in the New Guinea Stone Age*. Random House, New York.

Golson, J. (1997). From horticulture to agriculture in the New Guinea Highlands: A case study of people and their environment. In Kirch, P.V., and Hunt, T.L. (eds.), *Historical Ecology in the Pacific Islands: Prehistoric Environmental and Landscape Change*, Yale University Press, New Haven, pp. 39-50.

Gomes, F., and Carr, M.K.V. (2003). Effects of Water Availability and Vine Harvesting Frequency on the Productivity of Sweetpotato in Southern Mozambique. II. Crop Water Use. *Experimental Agriculture* 39: 39-54.

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

IFAD. (2006). *An IFAD Sustainable Livelihoods Framework*, International Fund for Agricultural Development, Rome.

Jusuf, M., Setiawan, A., Peters, D., Cargill, C., Mahalaya, S., Limbongan, J., and Subandi. (2007). Improving the efficiency of sweetpotato-pig production in the Jayawijaya Regency, Papua,. In Limbongan, J. (ed.), *Proceedings of the National Seminar and Expose of the Acceleration of Local specific-based*

Agricultural Technology Innovation to Support the Development of Villages in Papua, Balai Pengkajian Teknologi Pertanian Papua, Jayapura, pp. 71-95 (In Indonesian).

Ketaren, P.P. (2005). *Proximate analysis of twenty cultivars from the Baliem Valley of Papua*, Balai Penelitian Ternak, Bogor. Unpublished report.

KIPPK Jayawijaya. (2004). *Map of the Jayawijaya Regency*, Kantor Informasi Penyuluhan Pertanian dan Kehutanan Jayawiya, Wamena (in Indonesian).

Lassa, J. (2004). *A Preliminary Study on Food and Livelihood Security in Highland Wamena, West Papua, Indonesia*, Penguatan Institusi dan Kapasitas Lokal, Kupang.

Lautze, S., and Raven-Roberts, A. (2003). *The Vulnerability Context: Is There Something Wrong with this Picture? Embedding vulnerability in livelihoods models: a work in progress*, Feinstein International Famine Center, Tufts University, Medford.

Likert, R. (1932). A Technique for the Measurement of Attitudes. *Archives of Psychology* 22 (140): 1-55.

Limbongan, J., and Soplanit, A. (2007). The Availability of Technology and the Potential to Develop Sweetpotato (Ipomoea batatas L.) in Papua Province. *Jurnal Litbang Pertanian* 26(4): 1-8 (In Indonesian).

Lokobal, N.A., Alua, A.A., and Mulait, T.N. (2006). *The life values of Hubula society in the Baliem Valley of Papua*, Biro Penelitian STFT Fajar Timur, Jayapura (in Indonesian).

Mahalaya, S., Nuberg, I., and Cargill, C. (2009). Farming systems of the Baliem Valley, Papua, Indonesia. *Development and Change*: Submitted in October 2009.

Nabi, Md.R.U., Hoque, Md.A., Rahman, R.A., Mustafa, S., and Kader, Md.A. (2007). Vulnerability Context of the Estuarine Set Bag Net Fishermen Community in Bangladesh. *International Journal of Rural Management* 3 (2): 213-227.

Papua. (2009). *The Geography of Papua Province*, http://www.papua.go.id, Accessed 21 May 2009 (in Indonesian).

Pardales Jr., J.R., Bańoc, D.M., Yamauchi, A., Iijima, M., and Kono, Y. (1999). Root System Development of Cassava and Sweetpotato during Early Growth Stage

as Affected by High Root Zone Temperature. *Plant Production Science* 2(4): 247-251.

Peters, D. (2003). Poverty alleviation and food security through improving human-sweetpotato-pig systems in Papua, Indonesia. In Fuglie, K.O. (ed.), *Progress in Potato and Sweetpotato Research in Indonesia*, International Potato Center, Bogor, pp. 215-224.

Peters, J. (2001). *Local Human-Sweetpotato-Pig Systems Characterization and Research in Irian Jaya, Indonesia with Limited Reference to Papua New Guinea: A Secondary Literature Review*, International Potato Center, Bogor.

Phillipson, J., Bennett, K., Lowe, P., and Raley, M. (2004). Adaptive response and asset strategies: the experience of rural micro-firms and Foot Mouth Disease. *Journal of Rural Studies* 20: 227-243.

Pontius, J., Dilts, R., and Bartlett, A. (2002). *Ten Years of IPM Training in Asia – From Farmer Field School to Community IPM*, Food and Agriculture Organization, Bangkok.

Putra, I. M., Cargill, C., Damriyasa, I. M., Putra, A.G., Kossay, L., Mahalaya, S., Tiffen, W., Ketaren, P., and Peters, D. (2004). Pig Disease Survey in Jayawijaya Regency, Papua, Indonesia. In Limbongan, J. (ed.), *Proceedings of the National Seminar on Agricultural Technology Assessment in Papua*, Balai Pengkajian Teknologi Pertanian, Jayapura, pp. 78-82.

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*, International Potato Center, Bogor.

Van Baal, J., Galis, K.W., and Koentjaraningrat, R.M. (1984). *West Irian: A Bibliography*, Koninklijk Instituut voor Taal, Land en Volkenkunde.

Table 1

Pearson correlation coefficients between human, sweetpotato and pig of Dani *silis* in 2006

Relationships	Pearson correlation coefficients	
	PG (n=38)	CG (n=190)
Human (number) – Sweetpotato (ha)	0.736**	0.705**
Human (number) – Pig (number)	0.670**	0.677**
Sweetpotato (ha) – Pig (number)	0.901**	0.912**

Notes: PG: Project Group. CG: Comparison Group. ** P<0.01

Table 2

Average annual incomes of Dani *silis* in 2006

Incomes earned from	PG (n=38)		CG (n=190)		Analysis
	(Rp/year)	(%)	(Rp/year)	(%)	
Selling pigs	16,500,000	67.2	14,110,263	86.2	**
Selling sweetpotatoes	460,934	1.9	386,671	2.4	NS
Selling forest products	159,737	0.7	728,921	4.5	**
Selling other livestocks	1,055,658	4.3	936,505	5.7	NS
Selling other crops	277,895	1.1	68,819	0.4	NS
Non-agricultural jobs	6,110,526	24.9	129,474	0.8	**
Total	24,564,750	100.0	16,360,653	100.0	**

Notes: PG: Project Group. CG: Comparison Group. Analysis refers to independent samples t-tests for two different groups of samples. ** P<0.01. *P<0.05. NS: Not Significant.

Table 3

Sweetpotato and pig uses of Dani *silis* in 2006

Uses	PG (n=38)	CG (n=190)	Analysis
	(%)		
Sweetpotato:			
Human food	32.3	33.9	NS
Pig feed	49.3	48.4	NS
Labour compensation	7.1	6.9	NS
Custom ceremonies	7.6	8.7	NS
Sale	3.7	2.1	NS
Pig:			
Own consumption	4.2	1.2	NS
Custom ceremonies	22.9	23.9	NS
Sale	72.9	74.9	NS

Notes: PG: Project Group. CG: Comparison Group. Analysis refers to independent samples t-tests for two different groups of samples. ** $P<0.01$. *$P<0.05$. NS: Not Significant.

Table 4

Twenty vulnerability factors of Dani *silis* livelihoods based on sweetpotato-pig production in 2006

Vulnerability factors	PG (n=38)	CG (n=190)	Analysis
	Mean (Standard Deviation) (Weighting Rank)		
Sweetpotato production-based livelihoods:			
Marauding pigs	45.2 (20.0) (1)	27.9 (9.9) (1)	**
Soil hydrology of gardens	23.7 (24.9) (2)	10.8 (11.6) (4)	**
Technical assistance from institutions	3.1 (3.6) (8)	19.9 (5.6) (2)	**
Yields	3.8 (2.6) (6)	18.4 (5.4) (3)	**
Thefts	5.7 (4.7) (3)	5.1 (3.4) (6)	NS
Conflict with other *silis*	5.5 (2.1) (4)	4.4 (3.3) (8)	*
Market access	4.6 (3.0) (5)	4.6 (2.1) (7)	NS
Sudden ill of *sili* members	3.6 (2.0) (7)	5.3 (1.9) (5)	**
Soil fertility of gardens	3.1 (5.1) (9)	1.5 (1.9) (10)	*
Prices	1.8 (2.6) (10)	2.1 (1.4) (9)	NS
Pig production-based livelihoods:			
Diseases and medicines	25.2 (7.5) (1)	40.5 (6.9) (1)	**
Technical assistance from institutions	17.9 (4.7) (2)	15.8 (4.4) (2)	**
The quality of diets	14.1 (4.0) (3)	14.1 (3.6) (3)	NS
Custom ceremonies	11.5 (4.8) (4)	11.2 (4.4) (4)	NS
Thefts	10.2 (3.8) (5)	7.5 (3.1) (5)	**
Boar and sow management	7.3 (5.4) (6)	4.6 (2.8) (6)	**
Pigsties and pig-enclosures (*lalekens*)	4.3 (2.9) (7)	1.7 (1.6) (8)	**
Conflict with other *silis*	4.2 (3.2) (8)	1.8 (2.0) (7)	**
Prices	3.2 (2.9) (9)	1.3 (1.4) (10)	**
Market access	2.0 (2.8) (10)	1.5 (1.5) (9)	NS

Notes: PG: Project Group. CG: Comparison Group. Analysis refers to independent samples t-tests for two different groups of samples. ** P<0.01. *P<0.05. NS: Not Significant.

Table 5

Coping strategies with the prioritised vulnerability factors of Dani *silis* livelihoods in 2006

Prioritised factors	Coping strategies	
	PG (n=38)	CG (n=190)
Sweetpotato production-based livelihoods:		
Marauding pigs	– Look after gardens – Repair damaged fences – Put severe fines for the lost crops – Propose to make a regulation to control this factor	– Look after gardens – Repair damaged fences – Put severe fines for the lost crops
Soil hydrology of gardens	– Make ditches to drain excessive water during the rainy seasons as well as to store water for use during the dry seasons – Harvest sweetpotato early – Grow more new sweetpotato varieties which are relatively more resistant to the condition of excessive and shortage of water	– Make ditches to drain excessive water during the rainy seasons as well as to store water for use during the dry seasons – Harvest sweetpotato early
Technical assistance from institutions	– Use their own experiences to handle sweetpotato production problems and combined with – Call in actively agricultural officials for help	– Rely more on their own experiences to handle sweetpotato production problems – Wait passively for agricultural officials to come and help
Yields	– Select best traditional sweetpotato cultivars with high yield – 100% of *silis* grow more new sweetpotato varieties which relatively have higher yields	– Select best traditional sweetpotato cultivars with high yield – 34% of *silis* exchange and/or buy the new sweetpotato varieties with/from the Project Group
Pig production-based livelihoods:		
Diseases and medicines	– Apply knowledge gained from the ACIAR project – Use traditional medicines	– Use traditional medicines – 17% of *silis* seek advice from the Project Group
Technical assistance from institutions	– Use their own experiences to handle pig production problems and combined with – Call in actively livestock officials for help	– Rely more on their own experiences to handle pig production problems – Wait passively for agricultural officials to come and help
The quality of diets	– 29% of *silis* adapt and adopt new nutrient-balanced diets introduced by the ACIAR project	– Most *silis* do not know what to do to improve this factor – 13% of *silis* seek advice from the Project Group
Custom ceremonies	– Most *silis* believe this factor is part of their life) – Few *silis* reduce the number of pigs provided for this factor	– All *silis* believe this factor is part of their life)

Source: DFID (1999)

Figure 1. The sustainable livelihoods framework

NOTE:
This figure is included on page 124 of the print copy of the thesis held in the University of Adelaide Library.

Source: Adapted from KIPPK Jayawijaya (2004)

Figure 2. The Baliem Valley of Jayawijaya Regency, Papua Province, Indonesia

7. Impact of Agricultural Intervention on Natural and Physical Livelihood Assets of Traditional Farming Systems in Papua, Indonesia[5]

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Abstract

This paper evaluates the impact of an agricultural development project, undertaken during 2001-6, on the natural and physical assets of traditional Dani farmers in the Baliem Valley of Papua, Indonesia. The project sought to improve the traditional sweetpotato-pig farming system with innovations in sweetpotato cultivars and pig management. The impact evaluation is based on a survey conducted in 2007 using the Double Difference method to test the before and after project status of project members and a comparison group. Association with the project significantly increased natural assets by way of crop yields, crop genetic diversity, production efficiency, resilience against environmental stress of crops, and reduced reliance on forest and river resources; and physical assets by way of access to agricultural tools, pig management technology, radios and mobile phones.

Keywords: impact evaluation; agricultural intervention; sustainable livelihood; double difference; agricultural development; Papua

1. Introduction

Papua, the eastern most province of Indonesia, is a source of great wealth to the country with a Gross Domestic Regional Product (GRDP) of 55.4 trillion Rupiah (US$5.5 billion) earned largely through the mining and forestry sectors (BPS Papua 2008). However, these industries support less than 2% of the total working population, while 75% of the population is engaged in agriculture. While the per capita GDRP of Papua of 24.0 million Rupiah is well above the national average of 14.8 million Rupiah, this has not been shared by most Papuans. In this province, 41% of the population live below the poverty line – which is defined as living with less than 202,379 Rupiah/month (US$20.2/month) – which is more than double the national average of 17% (BPS Indonesia 2009). It is clear that not all Papuans can directly benefit from the extractive industries operating in their province, but some of that wealth (1.6 trillion Rupiah or US$160 million) is being invested by the Indonesian Government into raising the productivity and livelihood stability of the agricultural population. Approximately another US$6.0 million is invested by international donors (BPS Papua 2008). To guide this investment is important to understand the agricultural-based livelihoods of the local people. To evaluate the impact of this investment it is important to measure, both quantitatively and qualitatively changes in assets underpinning these livelihoods.

The Dani tribe of the Baliem Valley, in the Central Highlands of Papua is one of the 312 indigenous tribes in Papua and they are the biggest with about 146,000 members (BPS Papua 2008). They follow a traditional system of sedentary agriculture based on sweetpotatoes and pigs. Their subsistence economy is becoming increasingly monetised in response to regional economic growth. The Indonesian Agency for Agricultural Research and Development (IAARD) recognised that scientific intervention is needed to develop this farming system so the Dani can participate in the sustainable and equitable development of the region (Darmajana 1996). To this effect they formed a partnership with the Australian Centre for International Agricultural Research (ACIAR) for a project called “Poverty alleviation and food security through improving the sweetpotato-pig systems in Papua, Indonesia” which ran in 2001-6 (ACIAR 2005).

This paper presents the evaluation of the impact of the ACIAR project on the natural and physical assets that constitute the foundation of Dani livelihoods. The concept of livelihood assets is derived from the Sustainable Livelihoods (SL) framework (DFID 1999) which is a model for understanding the many interrelated causes of poverty and how to alleviate poverty. In its entirety it comprises five types of assets; viz. natural, physical, human, social and financial. This paper focuses on natural assets – the biological resources in the sweetpotato production system and forest and rivers – and physical assets – the implements and technology the Dani use in their agriculture. It compares the impact, which is measured in terms of changes in natural and physical assets using the Double Difference (DD) method (Ravallion 2001), observed by farmers directly involved with the project as well as their neighbours who did not. Our hypothesis is that exposure to this agricultural development project will increase the natural and physical assets of the traditional farming system that underpin the livelihoods of the Dani people. We ask how and to what extent the project affected the target community, and what the implication of the project is for further agricultural development in the region. The following background section will briefly describe the Dani farming systems and the ACIAR agricultural intervention, and then explain the Sustainable Livelihoods framework and the Double Difference method, and how we adapted them for measuring impact.

2. Background

2.1. The sweetpotato-pig farming systems of the Dani people

The traditional farming systems that support all indigenous Papuans by securing food, generating income and carrying socio-cultural value are based on sweetpotato (*Ipomoea batatas*) and pig (*Sus scrofa papuensis*). Sweetpotato accounts for 90% of the daily diet in many areas, with some estimates calculating per capita annual consumption in Papua at nearly 100 kilos (Peters 2003). This crop also accounts for up to 100% of pig feed in Papua. The pig plays an increasing role for Papuan households in income generation as it demands high prices (a 50-60 kg pig can sell for 6-7 million Rupiah or US$6-700). Sweetpotato and pig are always

involved in any Papuan traditional events such as marriages, conflict resolutions, and funerals (Schneider et al. 1993).

The fundamental social unit of the Dani is the *sili*; it comprises several closely-related family groups living within the one enclosure. Lokobal et al. (2006) explain that in a *sili* several Dani families can live together, but they follow the ethic of *sabokhogon* which means they are "one for all and all for one", as they live and work together as the one unit with no separate ownership of means of production or wealth. The number of persons (5-32), the size in ha of sweetpotato gardens (0.3-2.7), and the number of pigs (0-46) are significantly correlated indicating a strong ecological balance between humans, sweetpotatoes, and pigs in the Dani farming systems (Mahalaya et al. 2009). According to Golson (1997), they have farmed the Baliem Valley for more than 9,000 years, and have grown sweetpotatoes and raised pigs for several hundred years. However, the efficiency of their sweetpotato-pig production under the traditional farming systems was found to be very low (Cargill 2009). For example, the yield of sweetpotatoes was 9.2 t/ha compared with 20-30 t/ha in a similar environment in other Indonesian highlands (Limbongan and Soplanit 2007). Similarly, the growth rate of pigs was only 18 g/day with a mortality of 40% over four months, and sows appeared to breed only once every two to three years (0.3-0.5 litters/year) with a small litter size (5 pigs/litter) and high piglet mortality (48% pre-weaning mortality). A more detailed description of the Dani farming systems may be found in Mahalaya, Nuberg and Cargill (2010).

2.2. 'Poverty alleviation and food security through improving the sweetpotato-pig systems in Papua, Indonesia'

The ACIAR project which ran in 2001-6 used participatory approaches collaborating with 38 Dani farmers from 20 villages across the Baliem Valley (see Figure 1). The project follows participative processes to develop new sweetpotato cultivars for both human food and pig feed, and nutritious pig feed formula based on sweetpotato and other local materials. The project also improved the traditional pig enclosure (*laleken*) by introducing of fodder crops and trees and dividing the enclosure to allow cell grazing. In addition, the traditional pigsties were improved by introducing ventilation, dunging area and access to *laleken*. The physical changes

were the basis on which better boar and sow management procedures were introduced. Further details of this project are given in Cargill (2009).

2.3. The Sustainable Livelihoods framework

The SL framework developed by the Department for International Development of the United Kingdom has five core livelihood components which relate with each other, and are illustrated in Figure 2. It is a tool to help understand livelihoods, the way in which livelihoods are constructed and how and why they change over time. This in turn can help identify the best way to support poor people (DFID 1999).

In practice, the SL framework has been used for evaluating the impact of agricultural intervention (e.g. Ashley and Hussein 2000, Orr 2001, Adato and Meizen-Dick 2002, Hallman et al. 2003, Reddy et al. 2004). It ensures a wide range of issues related to the five core livelihood components are considered and nothing is overlooked. It is an effective means of communicating across disciplines as well as a useful way of thinking about the many interacting factors that affect people's livelihoods. The SL framework acknowledges the complexity of people's livelihoods and the processes that dictate whether interventions will be effective (Meizen-Dick et al. 2004).

Livelihood assets refer to not only people's possession, but also their ability to access them (Carney, 1998, Helmore 1998). Several practical examples of measuring these assets have been published (see Winters et al. 2002, Reddy et al. 2004, Knutsson and Ostwald 2006, La Rovere et al. 2006, Babulo et al. 2008). While all these studies measure the key livelihoods assets of communities in their study area, and examine the importance of the assets to the livelihood, the specific measurements vary with the context.

Some examples of natural assets are those of land value and the availability of fodder as measured by Reddy et al. (2004) in India; and land ownership, access to grazing land, and walking distance to all-weather roads as measured by Babulo et al. (2008) in Ethiopia. Examples of physical assets are availability of local and major roads (measured in km), the possession of vehicles, expenditure for construction or improvement of houses and costs spent on vehicles as measured by Knutsson and

Ostwald (2006) in China.; and access to water in terms of the number of well owners and water buyers among various household types as measured by La Rovere et al. (2006) in Syria.

2.4. The Double Difference method

The DD method was developed by the World Bank to compare a treatment group with a comparison group both before and after an intervention (Baker 2000, Ravallion 2001). It is a tool to help measure estimates of the impact of intervention. The treatment group comprises participants of the intervention, while the comparison group consists of those who are not involved in the intervention (i.e. non-participants) which ideally be determined by the propensity score matching method. To use double difference, a baseline survey is needed before the intervention is in place, and the survey must cover both participants and non-participants. Then one or more follow-up surveys are needed after the intervention is put in place. The baseline and follow-up surveys should be comparable in terms of the questionnaire, the sampling, and the interviewing. Estimates of the impact of the intervention are obtained by calculating the mean difference between the 'after' and 'before' values of the outcome indicators for each of the treatment and comparison groups (first difference), and the difference between these two mean differences (second difference). The second difference is estimates of the impact of the intervention.

The literature discussing the use of the DD method for evaluating the impact of agricultural intervention is enormous (e.g. Feder et al. 2004, Hope 2005, White 2006, Bamberger 2006, Davis and Nkonya 2008), some of which combined the SL framework as the basis for the evaluation (e.g. Cramb and Purcell 2001, Reddy et al. 2004). Cramb and Purcell (2001) argued that if we measure changes over time and attribute these changes to the intervention, we need to be able to answer two questions: (1) what was the situation before the intervention began (i.e. the 'before-after' comparison)? (2) what would the situation be now if the intervention had not taken place (i.e. the 'with-without' comparison)? Without these comparisons we cannot be sure to what extent the changes we measure are actually the impact of the intervention. Moreover, Reddy et al. (2004) provided a good practical example of using the DD method with the SL framework as the basis for evaluating the impact of

the watershed development project on livelihood assets of the local people in India. They measured the impact of the project in terms of changes in all the livelihood assets (natural, physical, human, social and financial) – by comparing the beneficiaries and non-beneficiaries both before and after the project – and showed how and to what extent the changes were attributable to the project.

3. Materials and methods

3.1. Study area and the 'sili' as a unit of analysis

The Baliem Valley covers an approximately area of 160 km^2 (Aditjondro 1982). It administratively belongs to Jayawijaya Regency, Papua Province (Figure 1). The total area of the regency is 14,847 km^2 with the biggest part is occupied by forest (almost 87%) and followed by agricultural cultivable land (13%) and settlement (less than 1%) (BPS Jayawijaya 2006). The regency, which centres to Wamena (138°58'E, 4°45'S), has a population of 227,474 and is only accessible by air transport. Wamena lies at an altitude of 1,550 meters above sea level (m asl), but other populated areas in the regency lie between 1,470-1,850 m asl. Meanwhile, the surrounding Jayawijaya Mountains reach altitudes of 4,700 m asl (Aditjondro 1982). Soils in the valley in general are developed from limestone with poor native fertility (Schroo 1963, cited in Soenarto and Rumawas 1997), but most of the cultivated land is on Histosols and hydromorphic mineral soils like Aquepts and transitions of these main groups (Van Baal et al. 1984). Moreover, based on the 1987-2006 climatic data measured by the Jayawijaya Metrological Station (BMG Jayawijaya 2006), the regency has a humid tropical climate characterised by relatively consistent temperatures throughout the year (14ºC average monthly minimum; 27ºC average monthly maximum), and seasonal rainfall with the wetter months from December to April and the drier months from May to November. However, variability in annual rainfall is great, ranging from 1,266 mm in 1997 (an El Niño period) to 2,617 mm in 2005 with variability in monthly rainfall (i.e. coefficients of variation) between years ranging from 28 to 87%.

This study involved 20 villages across the Baliem Valley, all within the Jayawijaya Regency (Figure 1). These villages all had member *silis* that were involved with the ACIAR project during 2001-6. The fundamental unit for social data

collection in Indonesia is the family unit. However, the use of *sili* as the unit of analysis was suggested by Dani key informants in a series of workshops held in 2007 for developing survey questionnaires for this study (Mahalaya, Nuberg and Cargill 2010).

3.2 Sample selection

Sili samples were selected to form two contrasting groups, namely Project Group and Comparison Group. The Project Group was simply formed by choosing all the 38 ACIAR project collaborator *silis*. Meanwhile, the Comparison Group was formed through two stages. A first stage involved the selection of 15 neighbour *silis* of each of the 38 Project Group *silis* using the stratified random sampling method (Babbie 1973). These 15 neighbour *silis* were *not* collaborator *silis* and chosen from the list of *sili* population provided by each of the 20 village offices. The first stage resulted in a total of 570 Comparison Group *silis* (i.e. 15 non-collaborator *silis* X 38 collaborator *silis* = 570 *silis* in the first stage sample). Meanwhile, a second stage involved the selection of 5 'nearest neighbour *silis'* of each of the 38 Project Group *silis* using the propensity score matching method (Baker 2000). 'Nearest neighbour *silis*' here mean that they have similar observable characteristics (i.e. the size of sweetpotato gardens and the number of pigs) to the Project Group *silis*. These 5 nearest neighbour *silis* were chosen from the list of 15 neighbour *silis* selected through the first stage. The second stage resulted in a total of 190 Comparison Group *silis* (i.e. 5 non-collaborator *silis* X 38 collaborator *silis* = 190 *silis* in the second stage sample). The two sampling stages for forming the final 190 Comparison Group *silis* were intended to make the farming system based on sweetpotato-pig production characteristics of the Project and Comparison Group *silis* fairly comparable.

3.3 Data collection

The survey visited all the 38 Project Group and 570 Comparison Group *silis* and was conducted in 2007 by five trained Dani interviewers. Each *sili* was visited four times, once a week with each visit lasted a maximum of one hour. The four visits collected data on access to sweetpotato gardens and other local natural resources

(i.e. natural assets), and *sili* goods (i.e. physical assets) owned by the two groups before and after the project. All these data are analysed here. The visits also collected data on the other SL framework components (see Figure 2) which are discussed elsewhere (Mahalaya et al. 2009; Mahalaya, Nuberg and Cargill 2010; Mahalaya, Stringer and Nuberg 2010). When a *sili* was being interviewed, as many members of the *sili* as possible were encouraged to participate.

It is important to note here that some of the baseline (i.e. before the project) data on access to sweetpotato gardens for 14 Project Group *silis* and 32 Comparison Group *silis* from 6 villages were already available. These data were collected by Peters and Mahalaya in 2001 as part of the project initial socio-economic studies. The remaining data were collected by this study using participatory semi-structure group interview techniques (Cramb and Purcell 2001). In particular, recall data techniques (Baker 2000) were also employed to collect the unavailable baseline data for the remaining 24 (i.e. 38-14) Project Group and 538 (i.e. 570-32) Comparison Group *silis.* The use of recall data techniques was valid as the interviews gathered the collected memory of many *sili* members, not just individuals.

3.4 Analysis of results

Estimates of the impact of the project on natural and physical assets were measured in terms of changes in the key forms (i.e. indicators) of these assets. Figure 3 presents how these estimates were measured using the Double Difference method. Meanwhile, the impact was analysed using the statistical independent-samples t-test, which was carried out using SPSS 17.0 for Windows.

4. Results

Tables 1-3 show estimates of the impact of the project on various indicators of natural and physical assets. Under the double difference column, the first difference compares each indicator of the Project Group as well as the Comparison Group before and after the intervention, while the second difference compares the first difference of the two groups. The analysis refers to the t-test for significance which applies to the

first difference in order to determine whether the second difference is meaningful as impact.

4.1. Natural assets in sweetpotato gardens

With respect to the primary natural asset, the sweetpotato gardens, there was significant impact of the project on all the indicators of the status of this asset, except the number and size of gardens, and the period of crop growth (Table 1). The time taken for *silis* to travel to gardens declined by an average of 38 minutes, i.e. the Project Group spent 44 minutes less, while the Comparison Group took 6 minutes less. Similarly, the period of garden tillage declined 22 days (-16%). In the meantime, the period of garden fallow, crop harvest and overall cultivation tended to reduce, but the *silis* involved with the project clearly restrained the reduction by 89 (12%), 21 (17%), and 92 (8%) days respectively. Similarly, the influence of the project restrained the reduction in the number of traditional cultivars grown by *silis* by almost 4 cultivars. In contrast, the project *silis* grew up to 3 more new cultivars, characterized by high yields, and consequently gained higher yields both of roots and vines (2.0 [21%] and 0.8 [10%] t/ha respectively). These new cultivars were developed through and promoted by the project in the Baliem Valley. All these changes indicate that the project affected the natural assets embodied in sweetpotato gardens in three important ways: crop yields, crop genetic diversity, production efficiency (i.e. labour efficiency and the time taken to travel to the gardens), and resilience against environmental stress of crops as evident in relatively longer harvest and fallow periods.

4.2. Access to river, bush fallow, and forest resources

As regards to access to river, bush fallow, and forest resources, there was significant impact of the project on average annual incomes earned from selling river fish, bush fallow firewood, and customary forest wild animals, tree and other products (Table 2). These incomes were respectively reduced over the period of the project by 92,030 (-68%), 108,830 (-55%), 233,210 (-68%), 251,040 (-60%), and 32,740 (-38%) Rupiahs. This reduction indicates that the association with the project reduced the

dependence of *silis* on the natural river, bush fallow, and forest resource assets. In contrast, there were relatively no impacts on the time taken to travel to rivers, bush fallows, and customary forests.

4.3. Physical sili assets

Physical *sili* assets include agricultural tools (e.g. spades, hoes and sickles), technology (pigsties), hunting tools (eg spears, bows and arrows) and consumer goods (motorbikes, radios and mobile phones). The impact of the project on physical *sili* assets was enormous (Table 3). This significant impact was all positive, except the number of hunting tools, indicating their numbers tended to increase over the period of the project. Where the Project Group was buying new tools over this period, the number of tools owned by the Comparison Group declined, and this occurred similarly for the use of traditional pigsties and *laleken*. Both groups adopted improved pigsties technology, but clearly greater in the Project Group. In contrast, as the Project Group reduced their need for hunting tools, the Comparison Group maintained their stock of these tools.

5. Discussion

From the outset we make no claim that the Project and Comparison Groups were identical in every way at the beginning of the project. The sampling method used in the survey ensured that the 38 Project Group *silis* were fairly matched with the 190 Comparison Group *silis* on the physical basis of their livelihoods based on sweetpotato-pig production, i.e. garden size and pig numbers. While the Comparison Group was selected in this study using stratified random sampling, the Project Group mostly (74%) selected themselves by approaching the project and asking to be involved – the remaining 26% was randomly selected by the project before the project began. Perhaps the Project Group in general represented a sector of the Dani community that was more proactive and open to change. Indeed this group had longer education years and experienced some previous agricultural training (Mahalaya et al. 2010b). This might explain why the before-project values for many variables for the Project Group, other than garden size, were different to the

Comparison Group. Nevertheless, the results revealed significant impact of the project on various natural and physical assets. This discussion will examine some of the key impacts asking how and to what extent the project affected the natural and physical assets of Dani community, and what this implies for further agricultural development in the Baliem Valley.

5.1. The impact of intervention on natural assets in sweetpotato gardens

The natural assets of the Dani are constituted by their sweetpotato gardens and the natural resources customarily available to them in the surrounding rivers, bush fallows, and forests. The sweetpotato gardens are their primary source of food as well as fodder for their pigs. Pigs are the primary source of income as well as currency of cultural exchange. So while they are an integral part of the Dani farming systems, pigs are considered to be financial assets. Therefore, the sweetpotato gardens are the natural assets underpinning the production of the Dani's primary financial assets.

Traditional agricultural societies commonly maintain a wide variety of cultivars of their staple crop. Such diversity is a hedge against failure of any one cultivar, and different cultivars satisfy specific dietary and cultural functions. A common response to modernisation is a reduction in traditional cultivars as improved modern varieties become available, but also as the ability to maintain diversity is reduced (Schneider 1995, Yaku and Widyastuti 2001, Limbongan and Soplanit 2007). It is notable that both groups significantly reduced the number of traditional cultivars grown over the 5 year period of the project; the Project Group by 17% and the Comparison Group by 36%. Overall we found that about 69 cultivars are being grown in valley gardens, with a range of 10 to 27 grown in any one garden, and 38 cultivars are grown in upland gardens, with a range of 9 to 26 grown in any one garden (Mahalaya, Nuberg and Cargill 2010). Earlier surveys estimated 200 cultivars (10-40/garden) in valley gardens and 69 cultivars (7-20/garden) for upland gardens (Schneider et al. 1993).

The movement to reduce sweetpotato cultivars was established well before the project began. However, this process appears slower with the Project Group. This group explained that exposure to the project increased their knowledge about the potential of cultivars (i.e. strengths and weaknesses – see later for examples) which

resulted in more respect for the genetic diversity of the cultivars as well as improvement in their ability to maintain more cultivars. They were actually capable of adopting the improved cultivars offered by the project while maintaining more of the traditional cultivars.

Dani *silis* traditionally grow a number of different cultivars for different purposes in any single garden. There are four use categories: ritual ceremonies (cultivar e.g. *Helalekue, Arugulek, Hupuk*), adult food (e.g. *Kafiar, Wenabuge, Nabogum*), infant food (e.g. *Wortel, Wililum, Pikha*), and pig feed (e.g. *Musan, Mikmak, Tamue*) (Wydiastuti et al. 2002). From our survey it appears that Dani *silis* preferred to keep only the best cultivars in each category in terms of having high yields, good tastes, and big root shapes and sizes. They attempted to reduce their work loads by focusing on the best cultivars only. However, the Project Group had extra labour (see Mahalaya, Stringer and Nuberg 2010) and better knowledge gained from their participation in the project. For example, the project participants learnt that even though *Musan* has a higher yield than *Tamue*, the later cultivar has a higher dry matter content and so can be a better source of energy for pigs (Ketaren 2005). So the Project Group tended to keep more cultivars in each category compared to their Comparison Group neighbours. The reason for this, explained by the Project Group, was to maintain relatively higher crop diversification in order to minimize crop failure risks.

The project introduced four new cultivars, namely *Papua Salosa, Papua Patipi, Papua Sawentar* and *Cangkuang*. These are scientifically-improved cultivars developed through and promoted by the project in the Baliem Valley (Jusuf et al. 2007). The project employed a participatory breeding approach where the farmers were actively involved in the development of the new cultivars (Cargill 2009). All the Project Group members adopted these cultivars (range: 2-4), while only 34% of the Comparison Group did (range: 0-3). The Comparison Group was actually keen to grow more, but the best they can do was to buy and/or exchange the cuttings from their Project Group neighbours who often had limited cutting stocks. All the adopters explained that they liked these cultivars because of the higher yields; but some adopters noted that these cultivars were worthy of growing for their good taste too. The average fresh root yield of the new cultivars grown by Dani farmers was 25.3 t/ha, while for the best traditional cultivars, namely *Helalekue* for human food and

Musan for pig feed, were only 8.0 t/ha and 13.1 t/ha respectively (Limbongan and Soplanit 2007).

The increased yields reported by the Project Group were largely a reflection of the use of these new high yield cultivars. However, the benefit of the project went beyond the increased yield; it increased the labour efficiency of crop production practised by Dani *silis*. Labour efficiency is calculated by dividing the crop yield by the time in hours invested to produce the crop. Labour is an indicator of human capital presented in Mahalaya, Stringer and Nuberg (2010). The labour efficiency of the Project Group was 63% higher than the Comparison Group.

This can explain how the garden tillage periods of the Project Group was reduced by 13% or 2 weeks, compared to a slight increase (3%) of the time required for the Comparison Group. The Project Group explained that they had extra labour to help till their gardens. This extra labour came from the other Project Group members. The project's Dani coordinator reported that the Project Group members formed informal sweetpotato-pig farmers' groups where they helped each other in many activities including tillage (Kossay *pers. comm.*).

It was also observed that the physical quality of the tilled gardens improved markedly; this may also account for the increased crop yields. The improvement was by maintaining deeper water-filled ditches around the sweetpotato raised beds which are used for supplying water during the dry seasons as well as improving drainage during the rainy seasons. It seems that unintended collaborative labour arrangements followed by the Project Group farmers encouraged them to follow their own recognised best-practice tillage.

Both groups experienced a shortening of growing and harvest periods of their crops over the surveyed period. This was explained as being due to the floods that occurred almost every year over this period. The main reason for reducing harvest periods was usually to save the crop from flooding. There was no difference between the groups in the growing periods of their crops. However, since the Project Group built deeper ditches they could harvest their crops for more than 3 weeks longer than the Comparison Group without worrying much about the damaging flood. The relatively longer time to harvest also allowed the sweetpotato to develop roots in an optimal way, and may have been another contributor to the higher yields.

Both groups reduced their fallow times significantly over the period of the project. While they are aware of the importance of giving enough time for their gardens to recover, both groups explained that they have had increasingly more people and pigs to feed. Better tilled gardens with deeper ditches among the Project Group, plus some extra labour from their informal farmer groups, enabled them to begin a new crop production cycle relatively earlier than the Comparison Group (i.e. retaining the common reduction in garden fallow periods). The Project Group began the project with shorter fallow periods than the Comparison Group, perhaps because the earlier group had more people in their *silis* to feed which has given more pressure on their gardens. However, the contraction of their fallow periods was more restrained and at the end of project they had longer fallow periods than the Comparison Group. It seems the Project Group was more capable of dealing with food security as they had not only higher crop yields, but also better tilled gardens to cope with the reduced fallow. The deeper ditches in the improved gardens can preserve water containing rich soil nutrient loads (Soenarto and Rumawas 1997). This preserved water functions as a source of nutrients, which the Project Group can spread onto their sweetpotato raised beds, to help the recovery of their gardens during the shortened fallow periods. As the use of industrial fertilisers has been banned in the Baliem Valley to avoid river pollution, one can appreciate the value of such careful crop husbandry.

The net effect of these changes in tillage, growth, harvest and fallow on the overall cultivation periods was a 24% shortening of the Project Group's cultivation cycle and a 32% shortening of that of the Comparison Group over the five year period. Shortening of the cultivation cycle was due to land pressure and unusual flooding. The ability of the Project Group to cope with these stressors was due to the better genetics, social cohesion and resultant better tillage practices from association with the project.

The Dani *silis* characteristically own a few garden plots acquired through marriage, gifting or purchase, and separated by considerable distances. Travel time to gardens is considered as a negative indicator of natural capital as it is time subtracted from that available for working in gardens or other productive activity. Over the project period there could be changes in land tenure that significantly affect a *sili's*

productive capacity by way of the time required to travel to gardens. Farmers may gain access to gardens either further away or closer to the *sili* compound.

Changes in land tenure were observed over the period but there was no significant difference between the groups. However, the time taken to travel to gardens was a significant 38 minutes less for the Project Group at the end of the project. There is no direct data to explain this; however, the income-generating capacity of the Project Group was significantly improved from association with the project (see Mahalaya, Stringer and Nuberg 2010) as they had higher yielding gardens that could keep significantly more pigs which were then sold. In addition, public transport infrastructure improved markedly over the project period; from 27 to 38 local routes. Perhaps the Project Group could afford to pay the cost of the increasingly available public transport and consequently taking shorter times to reach their gardens.

5.2. The impact of intervention on access to river, bush fallow, and forest resources

While rivers in the Baliem Valley are regarded as common resources, the Dani have access to bush fallows and forests under customary arrangements. Lokobal et al. (2006) explain that the Dani follow their traditional community territorial patterns from alliances (*o-agum*), confederations (*inukul-oak* or *o-ukul*), to closely-related family enclosures (*sili*) (see Figure 4 for more details of how these patterns interact). The customary arrangements allow Dani *silis* to have access to bush fallows and forests within their own confederation and other confederations in peaceful relations with them. Accessing territory out of these confederations may trigger inter-confederation conflicts. Nowadays tribal wars are strictly controlled by the local government and every *sili* is granted equal access to common natural resources in the Baliem Valley (Kossay *pers. comm.*). However, *silis* we interviewed keep accessing only their safe confederation territory in order to avoid unnecessary conflicts. Association with the project supports such avoidance.

With respect to Dani *silis*' access to natural resources, the project affected it by *reducing* income earned from selling various natural resource products (Table 2). This income reduction included river fish, bush fallow firewood, and customary forest

wild animals, tree and other products by 92,000; 109,000; 233,000; 251,000; and 33,000 Rupiahs respectively (US$1=10,000 Rupiah in the year of 2006).

There was no significant difference in before and after incomes from these products in the Comparison Group, while the difference in the Project Group was marked. Both groups explained that they now relied more on sale of pigs as their major source of incomes, but the data shows that this shift was more meaningful for the Project Group. The sale of pigs contributed 67 and 86% to the total income of the Project and Comparison Groups respectively (data presented in Mahalaya et al. 2009). Even though the contribution of pigs to the Project Group was smaller, the actual amount of money received by this group was 17% greater than it did by the Comparison Group. The income earned from non-agricultural jobs by the Project Group, which was the second greatest source of income for this group, contributed 25% to their total income which was much higher than the contribution of income earned from the same source by the Comparison Group of only less than 1%. The greater access to non-agricultural jobs for Project Group members was mostly associated with their improved skills in pig production learnt from their participation in the project. As the Project Group earned 50% more than the Comparison Group, largely from sale of pigs and non-agricultural jobs, they could rely less on wild animal and forest products for income.

5.3. The significance of intervention on physical sili assets

Table 3 revealed that the project affected Dani *silis*' physical assets in two different ways. Firstly, it mostly *increased* primary farm assets such as agricultural tools, traditional pigsties, traditional pig-enclosures (*lalekens*), and improved pigsties with access to *lalekens* by 2.18, 4.33, 0.35, and 2.06 $units_{2dif}$/*sili* respectively; as well as secondary *sili* goods such as radios and mobile phones by 0.12 and 0.21$units_{2dif}$/*sili* respectively. Secondly, it *reduced* hunting tools by 0.47 $units_{2dif}$/*sili*.

Since the Project Group relied more on and got greater income from agriculture, they consequently invested more into the farm tools and technology. In contrast, the Comparison Group did not have the same capacity to invest in tools and technology.

One of the functions of traditional pigsties and *lalekens* is to contain and protect pigs from theft. With the decline of tribal wars in the Baliem Valley under modern government, many respondents allow their pigs to wander freely and allow the pigsties and *laleken* to decline. However, respondents complain about the conflict generated by wandering pigs which destroying sweetpotato gardens as well as the increased susceptibility to diseases (Mahalaya et al. 2009). The 2006 swine fever outbreak, a viral disease spread by physical contact between pigs, was a good example. This outbreak killed over 65,000 pigs in the Baliem Valley (DISNAK Jayawijaya 2007). However, the Project Group's confined pigs were safe and this consequently encouraged the Project Group to continue confining their pigs. Since their pig numbers increased, they have built more pigsties and *lalekens*.

The benefit of confining pigs experienced by the Project Group was also reflected by the increasing number of improved pigsties with access to *lalekens* owned by both the Project and Comparison Groups. This improved pigsty with access to *laleken* technology was developed through and promoted by the project (Cargill 2009). Our survey data indicates 29% of the Project Group and 2% of the Comparison Group have adopted the technology (Mahalaya et al. 2009). This provides evidence that the technology began to diffuse beyond the Project Group.

In the meantime, the project also increased secondary *sili* goods (radios and mobile phones) owned by Dani *silis*. There is no electricity in the rural areas of the Baliem Valley, so battery-operated radios have been the only source of information and entertainment available. Mobile phone services began in the Baliem Valley only in 2002. Only a very few *silis* could afford to buy such an expensive luxury. The Project Group's greater income presumably afforded their members to better access to this modern technology. Hunting tools were reduced in both groups, but more with the Project Group. This was in line with the reduction in income earned by the two groups from selling customary forest wild animals (see Table 2). As previously discussed above, both groups nowadays relied more on sale of pigs as their major source of incomes. Moreover, as they both explained, hunting has recently become harder (e.g. it needs to walk further into the customary forest to be able to find and catch wild animals) and when they did it, they often returned with empty hands. Therefore, both groups did not invest much into hunt tools anymore and the Project Group did less investment than the Comparison Group.

5.5. The implication of the intervention for further agricultural development in the region

The new technologies introduced in this project were relatively simple modifications of the existing farming system. They included improved sweetpotato cultivars; improved pig diets based on sweetpotato and other naturally occurring ingredients; an improvement of the traditional pig enclosure (*laleken*) by introducing local fodder species and dividing it up for cell-grazing; an improvement of the traditional pig pigsty with ventilation and providing access to a dunging area and the *laleken*; and improved boar and sow management following changes in the physical structures of the sty and *laleken*. The beneficial impact of the project on the natural and physical assets of the participating farmers was significant; but what is the likelihood of adoption of these innovations into the rest of the region?

There are five factors known to affect the adoption of agricultural technology (Rogers and Shoemaker 1971, Rogers 1983) and they all apply for the innovations developed in the project. A successful innovation will have: 1) relative advantage compared to the existing system; 2) be compatibility with the existing farming system and culture; 3) not requiring complex knowledge or skills; 4) have benefits that are readily observable; and 5) can be trialled without too much risk. The survey team's confidence in the appeal of these innovations was supported by the unanimous request of Comparison Group members to be part of further extension of the project benefits. In response to these requests, a series of Training-of-Trainers (ToT) sessions were carried out in 2006, preparing selected Project Group members for a series of Farmers-to-Farmers (FtF) events over 2007-8 Cargill (2009). This ToT and FtF training was adapted from the United Nations Food and Agriculture Organization's Farmer Field School modality which is built on group-based learning processes (Pontius et al. 2002).

Previous agricultural intervention in this region has focussed on the introduction of rice cultivation and has had very poor adoption (Peters 2001). Policy makers may consider that further investment in agricultural development in this region could follow the principle of modifying traditional agriculture, as exemplified in this ACIAR project, rather than replacement with a radically different farming system.

6. Conclusion

This study measured the impact of an agricultural project on various indicators of natural and physical capital in the Baliem Valley, Papua. It examined the extent to which the project affected the Dani community, and discussed the implication for further agricultural development in the region.

Dani *silis* associated with the project benefited by accessing new higher yielding sweetpotato cultivars and improved crop production efficiency. They could afford to spend less time to travel to gardens and reduced their garden tillage periods. Compared with *silis* not associated with the project they retained more traditional cultivar numbers, and did not need to reduce their crop harvest, garden fallow and overall cultivation periods as much as their neighbours in response to environmental stressors. The project reduced the Dani's need to earn income from river and forest products and increased their capacity to buy or build primary physical assets (e.g. agricultural tools, traditional pigsties and *lalekens,* and improved pigsties with access to *lalekens*) as well as secondary *sili* assets (e.g. radios and mobile phones). After increased *sili* wealth, other related benefits observed were increased resilience in the sweetpotato production system, increased social cohesion and reduced reliance on forest and river resources for income. The innovations introduced by the project were relatively simple modifications of the traditional farming system and should be readily adoptable by other Dani farmers.

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References

ACIAR, 2005. *Research that Works: Indonesia Country Profile*. Canberra: The Australian Centre for International Agricultural Research.

Adato, M. and Meinzen-Dick, R., 2002. *Assessing the Impact of Agricultural Research on Poverty Using the Sustainable Livelihoods Framework*. FCND Discussion Paper No. 128. Washington, DC: International Food Policy Research Institute.

Aditjondro, G.J., 1982. The Irianese ethnic minorities in Indonesia. An issue of national integration. *Impact* 17(2), 63-37.

Ashley, C. and Hussein, K., 2000. *Developing Methodologies for Livelihood Impact Assessment: Experience of the African Wildlife Foundation in East Africa*. Working Paper 129. London: Overseas Development Institute.

Babbie, E.R., 1973. *Survey Research Methods*. Belmont: Wadsworth Publishing Company, Inc.

Babulo, B., Muys, B., Nega, F., Tollens, E., Nyssen, J., Deckers, J. and Mathijs, E., 2008. Household livelihood strategies and forest dependence in the highlands of Tigray, Northern Ethiopia. *Agricultural Systems* 98: 147-155.

Baker, J.L., 2000. *Evaluating the Impact of Development Projects on Poverty: A Handbook for Practitioners*. Washington, DC: The World Bank.

Bamberger, M., 2006. *Conducting quality impact evaluations under budget, time and data constraints*. Washington, DC: Independent Evaluation Group, The World Bank.

BMG Jayawijaya, 2006. *Rainfall and Temperature in Jayawijaya Regency 1987-2006*. Wamena: Badan Meteorologi dan Geofisika Jayawijaya (in Indonesian).

BPS Indonesia, 2009. *Trends of the Selected Socio-Economic Indocators of Indonesia March 2009*. Jakarta: Badan Pusat Statistik Indonesia.

BPS Jayawijaya, 2006. *Jayawijaya in Figures 2006*. Wamena: Badan Pusat Statistik Jayawijaya.

BPS Papua, 2008. *Papua in Figures 2008*. Jayapura: Badan Pusat Statistik Papua.

Cargill, C.F., 2009. *Poverty alleviation and food security through improving the sweetpotato-pig systems in Papua, Indonesia. A final report.* Canberra: The Australian Centre for International Agricultural Research.

Carney, D., 1998. *Sustainable Rural Livelihoods: What Contribution Can We Make?* London: The Department for International Development.

Cramb, R. and Purcell, T., 2001. *Developing Forage Technologies with Smallholder Farmers: How to Monitor and Evaluate Impacts*. Impact Assessment Program Working Paper Series No. 41. Canberra: The Australian Centre for International Agricultural Research.

Darmajana, R.D.A., 1996. Introducing Agricultural Technologies in Rural Development Programs in Wamena. *In*: A. S. Susanto-Sunario, ed. *Rural Society Development: An Analitical Review of Wamena Society, Irian Jaya*. Jakarta: Pustaka Sinar Harapan (in Indonesian).

Davis, K. and Nkonya, E., 2008. *Developing a Methodology for Assessing the Impact of Farmer Field Scholls in East Africa*. Costa Rica: E.A.R.T.H. University.

DFID, 1999. *Sustainable Livelihood Guidance Sheets*. London: The Department for International Development.

DISNAK Jayawijaya, 2007. *The Jayawijaya Livestock Office Annual Report 2006/2007*. Wamena: Dinas Peternakan Jayawijaya (in Indonesian).

Feder, G., Murgai, R. and Quizon, J.B., 2004. Sending Farmers Back to School: The Impact of Farmer Field Schools in Indonesia. *Review of Agricultural Economics* 26(1): 45-62.

Golson, J., 1997. From horticulture to agriculture in the New Guinea Highlands: A case study of people and their environment. *In*: P.V. Kirch and T.L. Hunt, eds. *Historical Ecology in the Pacific Islands: Prehistoric Environmental and Landscape Change*. New Haven: Yale University Press, 39-50.

Hallman, K., Lewis, D. and Begum, S., 2003. *An Integrated Economic and Social Analysis to Assess the Impact of Vegetable and Fishpond Technologies on Poverty in Rural Bangladesh*. FCND Discussion Paper No. 163. Washington, DC: International Food Policy Research Institute.

Helmore, K., 1998. Local know-how the right stuff. *Choices* 7(3): 6-14.

Hope, R.A., 2005. *Evaluating Social Impacts of Watershed Development in Rural India*. Newcastle: Centre for Land Use and Water Resources Research, University of Newcastle-upon-Tyne.

Jusuf, M., Setiawan, A., Peters, D., Cargill, C., Mahalaya, S., Limbongan, J. and Subandi, 2007. Improving the efficiency of sweetpotato-pig production in the Jayawijaya Regency, Papua. *In*: J. Limbongan, ed. *Proceedings of the National Seminar and Expose of the Acceleration of Local specific-based Agricultural Technology Innovation to Support the Development of Villages in Papua*. Jayapura: Balai Pengkajian Teknologi Pertanian Papua, 71-95 (in Indonesian).

Ketaren, P.P., 2005. *Proximate analysis of twenty cultivars from the Baliem Valley of Papua*. Unpublished report. Bogor: Balai Penelitian Ternak.

KIPPK Jayawijaya, 2004. *Map of Jayawijaya Regency*. Wamena: Kantor Informasi Penyuluhan Pertanian dan Kehutanan Jayawiya (in Indonesian).

Knutsson, P. and Ostwald, M., 2006. A process-oriented sustainable livelihoods approach – A toll for increased understanding of vulnerability, adaptation and resilience. *Mitigation and Adaptation Strategies for Global Change* (2006).

La Rovere, R., Aw-Hassan, A., Turkelboom, F. and Thomas, R., 2006. Targeting Research for Poverty Reduction in Marginal Areas of Rural Syria. *Development and Change* 37(3): 627-648.

Limbongan, J. and Soplanit, A., 2007. The Availability of Technology and the Potential to Develop Sweetpotato (*Ipomoea batatas L*.) in Papua Province. *Jurnal Litbang Pertanian* 26(4): 1-8 (in Indonesian).

Lokobal, N.A., Alua, A.A. and Mulait, T.N., 2006. *The life values of Hubula society in the Baliem Valley of Papua*. Jayapura: Biro Penelitian STFT Fajar Timur (in Indonesian).

Mahalaya, S., Nuberg, I. and Cargill, C., 2010. Farming systems of the Baliem Valley, Papua, Indonesia. *Asia-Pacific Development Journal*: (submitted for publication).

Mahalaya, S., Nuberg, I. and Taylor, J., 2009. The vulnerability of livelihoods based on sweetpotato-pig production in Papua, Indonesia. *Human Ecology*: (submitted for publication).

Mahalaya, S., Stringer, R. and Nuberg, I., 2010. Impact of agricultural intervention on livelihood human, social and financial assets of traditional farming systems in Papua, Indonesia. *Agriculture and Human Values*: (submitted for publication).

Meinzen-Dick, R., Adato, M., Haddad, L. and Hazell, P., 2004. *Science and Poverty: An Interdisciplinary Assessment of the Impact of Agricultural Research*. Washington, DC: International Food Policy Research Institute.

Orr, A., 2001. Adapting to Adjustment: Smallholder Livelihood Strategies in Southern Malawi. *World Development* 29(8): 1325-1343.

Peters, J., 2001. *Local Human-Sweetpotato-Pig Systems Characterization and Research in Irian Jaya, Indonesia with Limited Reference to Papua New Guinea: A Secondary Literature Review.* Unpublished report of ACIAR AH/1998/054 Project. Bogor: International Potato Center.

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*. Bogor: International Potato Center, 215-224.

Pontius, J., Dilts, R. and Bartlett, A., 2002. *Ten Years of IPM Training in Asia – From Farmer Field School to Community IPM*. Bangkok: Food and Agriculture Organization.

Ravallion, M., 2001. The Mystery of the Vanishing Benefits: An Introduction to Impact Evaluation. *World Bank Economic Review* 15 (1): 115-140.

Reddy, V.R., Reddy, M.G., Galab, S., Soussan, J. and Springate-Baginski, O., 2004. Participatory Watershed Development in India: Can it Sustain Rural Livelihoods? *Development and Change* 35(2): 297-326.

Rogers, E.M., 1983. *Diffusion of Innovations*. London: Coller Macmillan Publishers.

Rogers, E.M. and Shoemaker, F.F., 1971. *Communication of Innovations: A Cross-Cultural Approach*. New York: The Free Press.

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: International Potato Center.

Schneider, J., 1995. Farmer Practices and Sweetpotato Diversity in Highland New Guinea. *In*: J. Schneider, ed. *Indigenous Knowledge in Conservation of Crop Genetic Resources. Proceedings of an International Workshop Held in Cisarua, Bogor, Indonesia January 30-February 3, 1995*. Bogor: International Potato Center and Central Research Institute for Food Crops, 63-70.

Soenarto and Rumawas, F., 1997. An agro-ecological analysis of *wen-tinak*, a sustainable sweetpotato wetland production system in the Baliem Valley, Irian Jaya, Indonesia. *Science in New Guinea* 23(2), 55-66.

Van Baal, J., Galis, K.W. and Koentjaraningrat, R.M., 1984. *West Irian: A Bibliography*. Land en Volkenkunde: Koninklijk Instituut voor Taal.

White, H., 2006. *Impact Evaluation: The Experience of the Independent Evaluation Group of the World Bank*. Washington, DC: Independent Evaluation Group, The World Bank.

Widyastuti, C.A., Prain, G. and Yaku, A., 2002. Dani Women's Knowledge on and Its Contribution to Maintenance of Sweetpotato Diversity in Baliem Valley. In: R. Rao and D. Campilan, eds. *Exploring the complementarities of in situ and ex situ conservation strategirs for Asian sweetpotato genetic resources. Proceedings of the 3rd International Workshop of the Asian Network for Sweetpotato Genetic Resources (ANSWER), Denpasar, Bali, Indonesia on 2-4 October 2001*. Serdang: International Plant Genetic Resource Institute, 150-158.

Winters, P., Davis, B. and Corral, L., 2002. Assets, activities and income generation in rural Mexico: factoring in social and public capital. *Agricultural Economics* 27: 139-156.

Yaku, A. and Widyastuti, C.A., 2001. In situ Conservation of Sweetpotato: An Irian Jaya Experience. In: R. Rao and D. Campilan, eds. *Exploring the complementarities of in situ and ex situ conservation strategirs for Asian sweetpotato genetic resources. Proceedings of the 3rd International Workshop of the Asian Network for Sweetpotato Genetic Resources (ANSWER), Denpasar, Bali, Indonesia on 2-4 October 2001*. Serdang: International Plant Genetic Resource Institute, 142-149.

Table 1. Estimates of the impact of the project on natural assets in sweetpotato gardens

Indicators	PG (n=38)		CG (n=190)		Double Difference			Analysis
	BP	AP	BP	AP	First difference:		Second difference: $(PG_{AP} - PG_{BP}) - (CG_{AP} - CG_{BP})$ (% change)	
	Means (Standard Error)				$PG_{AP} - PG_{BP}$ (% change)	$CG_{AP} - CG_{BP}$ (% change)		
Gardens (number)	2.95 (0.136)	3.45 (0.176)	3.24 (0.119)	3.69 (0.105)	0.50 (17)	0.45 (14)	0.05 (3)	NS
Size (ha)	0.74 (0.053)	0.80 (0.057)	0.82 (0.036)	0.93 (0.032)	0.06 (8)	0.11 (13)	-0.05 (-5)	NS
Distance (travel hours)	1.93 (0.151)	1.20 (0.062)	1.77 (0.045)	1.68 (0.031)	-0.73 (-38)	-0.09 (-5)	-0.64 (-33)	**
Traditional cultivars (number)	18.92 (0.330)	15.79 (0.381)	18.47 (0.201)	11.80 (0.204)	-3.13 (-17)	-6.67 (-36)	3.54 (19)	**
New cultivars (number)	0.00 (0.000)	2.97 (0.133)	0.00 (0.000)	0.30 (0.054)	2.97 (n.a.)	0.30 (n.a.)	2.67 (n.a.)	**
Tillage (months)	4.66 (0.204)	4.05 (0.164)	4.19 (0.125)	4.32 (0.057)	-0.61 (-13)	0.13 (3)	-0.74 (-16)	**
Grow (months)	6.61 (0.080)	6.34 (0.102)	6.98 (0.038)	6.57 (0.034)	-0.27 (-4)	-0.41 (-6)	0.14 (2)	NS
Harvest (months)	4.50 (0.163)	4.08 (0.157)	4.36 (0.071)	3.23 (0.037)	-0.42 (-9)	-1.13 (-26)	0.71 (17)	**
Fallow (months)	12.00 (0.392)	6.61 (0.321)	14.68 (0.304)	6.34 (0.198)	-5.39 (-45)	-8.34 (-57)	2.95 (12)	**
Overall cultivation (months)	27.76 (0.526)	21.08 (0.450)	30.22 (0.210)	20.46 (0.328)	-6.68 (-24)	-9.76 (-32)	3.08 (8)	**
Yield of roots (t/ha)	9.58 (0.118)	11.02 (0.116)	8.89 (0.111)	8.32 (0.079)	1.44 (15)	-0.57 (-6)	2.01 (21)	**
Yield of vines (t/ha)	7.99 (0.110)	9.15 (0.092)	7.27 (0.150)	7.62 (0.126)	1.16 (15)	0.35 (5)	0.81 (10)	**

Notes: PG: Project Group. CG: Comparison Group. BP: Before Project. AP: After Project. Analysis refers to statistical independent-samples t-tests for differences in means of two different groups of samples. ** P<0.01. NS: Not Significant.

Table 2. Estimates of the impact of the project on access to river, bush fallow, and forest resources

Indicators	PG (n=38)		CG (n=190)		Double difference			Analysis
	BP	AP	BP	AP	First difference:		Second difference: $(PG_{AP} - PG_{BP}) - (CG_{AP} - CG_{BP})$ (% change)	
	Means (Standard Error)				$PG_{AP} - PG_{BP}$ (% change)	$CG_{AP} - CG_{BP}$ (% change)		
Distance to rivers (travel hours)	0.85 (0.082)	0.90 (0.085)	0.87 (0.034)	0.88 (0.035)	0.05 (6)	0.01 (1)	0.04 (400)	NS
Distance to bush fallows (travel hours)	0.39 (0.031)	0.76 (0.044)	0.79 (0.025)	1.17 (0.031)	0.37 (95)	0.38 (48)	-0.01 (-3)	NS
Distance to customary forests (travel hours)	0.96 (0.074)	1.19 (0.069)	1.24 (0.028)	1.53 (0.031)	0.23 (24)	0.29 (23)	-0.06 (-21)	NS
River fish (Rp $.10^3$/year)	131.39 (30.497)	8.07 (3.270)	131.38 (11.837)	100.09 (11.446)	-123.32 (-92)	-31.29 (-24)	-92.03 (-294)	*
Bush fallow firewood (Rp $.10^3$/year)	194.01 (32.674)	48.95 (21.000)	185.53 (16.519)	149.30 (16.607)	-145.06 (-75)	-36.23 (-20)	-108.83 (-300)	*
Customary forest wild animals (Rp $.10^3$/year)	327.34 (77.821)	40.23 (16.187)	269.41 (32.432)	215.51 (26.329)	-287.11 (-88)	-53.90 (-20)	-233.21(-433)	*
Customary forest tree products (Rp $.10^3$/year)	391.21 (83.767)	61.66 (24.020)	321.81 (34.228)	243.66 (28.386)	-329.55 (-84)	-78.15 (-24)	-251.04 (-321)	*
Customary forest other products (Rp $.10^3$/year)	65.25 (27.443)	1.09 (0.724)	52.80 (22.160)	21.38 (10.476)	-64.16 (-98)	-31.42 (-60)	-32.74 (-104)	***

Notes: PG: Project Group. CG: Comparison Group. BP: Before Project. AP: After Project. Analysis refers to statistical independent-samples t-tests for differences in means of two different groups of samples. * $P < 0.05$. ***$P<0.06$. NS: Not Significant. US$1=Rp 10,000.00 in the year of 2006.

Table 3. Estimates of the impact of the project on physical *sili* goods assets

Indicators	PG (n=38)		CG (n=190)		Double difference			Analysis
	BP	AP	BP	AP	First difference:		Second difference: $(PG_{AP} - PG_{BP}) - (CG_{AP} - CG_{BP})$ (% change)	
	Means (Standard Error)				$PG_{AP} - PG_{BP}$ (% change)	$CG_{AP} - CG_{BP}$ (% change)		
Agricultural tools (number)	13.45 (0.696)	14.26 (0.974)	14.49 (0.455)	13.12 (0.442)	0.81 (6)	-1.37 (-9)	2.18 (159)	**
Hunt tools (number)	1.50 (0.154)	0.87 (0.077)	1.55 (0.065)	1.39 (0.062)	-0.63 (-42)	-0.16 (-10)	-0.47 (-294)	*
Traditional pigsties (number)	9.74 (1.066)	13.76 (1.292)	21.47 (0.583)	21.16 (0.587)	4.02 (41)	-0.31 (-1)	4.33 (1397)	**
Traditional *lalekens* (number)	0.76 (0.070)	0.89 (0.050)	0.59 (0.041)	0.37 (0.039)	0.13 (17)	-0.22 (-37)	0.35 (159)	**
Improved pigsties with access to *lalekens* (number)	0.00 (0.000)	2.21 (0.352)	0.00 (0.000)	0.15 (0.046)	2.21 (n.a.)	0.15 (n.a.)	2.06 (n.a.)	**
Motorbikes (number)	0.05 (0.037)	0.16 (0.060)	0.02 (0.010)	0.07 (0.019)	0.11 (220)	0.05 (250)	0.06 (120)	NS
Radios (number)	0.24 (0.070)	0.37 (0.079)	0.05 (0.016)	0.06 (0.017)	0.13 (54)	0.01 (20)	0.12 (1200)	*
Mobile phones (number)	0.00 (0.000)	0.26 (0.072)	0.00 (0.000)	0.05 (0.015)	0.26 (n.a.)	0.05 (n.a.)	0.21 (420)	**

Notes: PG: Project Group. CG: Comparison Group. BP: Before Project. AP: After Project. Analysis refers to statistical independent-samples t-tests for differences in means of two different groups of samples. ** $P < 0.01$. * $P < 0.05$. NS: Not Significant.

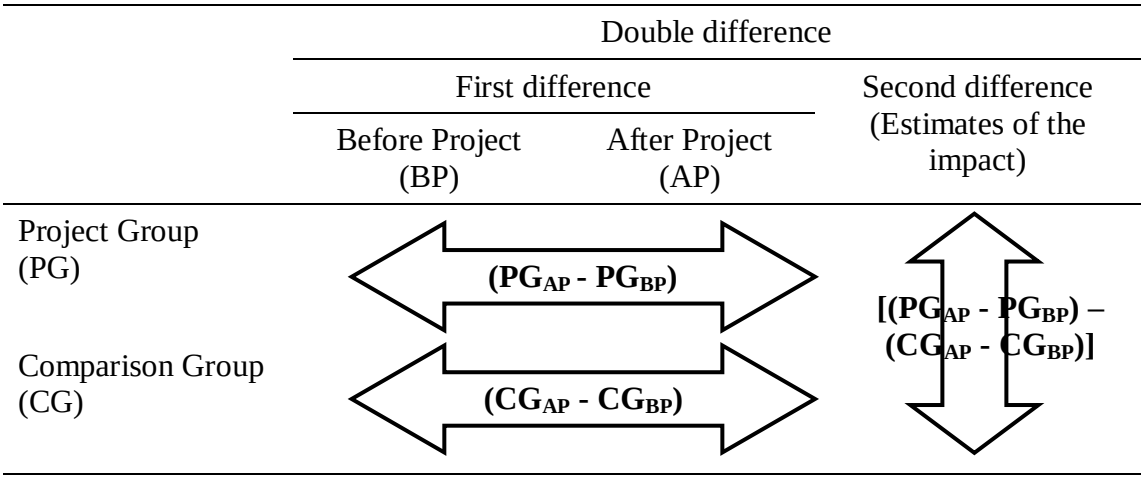
Source: Adapted from KIPPK Jayawijaya (2004)

Figure 1. The Baliem Valley of Jayawijaya Regency, Papua Province, Indonesia

NOTE:
This figure is included on page 156 of the print copy of the thesis held in the University of Adelaide Library.

Source: DFID (1999)

Figure 2. The Sustainable Livelihoods framework



Source: Adapted from Ravallion (2001)

Figure 3. The Double Difference method for measuring estimates of the impact of the project

Source: Lokobal et al. (2006)

Figure 4. The Dani community territorial patterns

8. Improving Livelihood Assets through Innovative Smallholder Sweetpotato-Pig Production Systems in Papua, Indonesia[6]

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Abstract

This study examines how innovations in traditional sweetpotato-pig farming systems impact the livelihood assets of the Dani people in the Baliem Valley of Papua, Indonesia. It uses a double-difference impact approach to examine the extent to which the innovations make changes in three livelihood assets of *silis*: human, social and financial. The social unit of the Dani tribe is the *sili*, a collective of 2 to 8 families living within the one enclosure. Project evaluation literature suggests various approaches to evaluating new crop-livestock systems on people, emphasizing the importance of using multiple methods to achieve a comprehensive understanding. This paper contributes to this literature, evaluating an innovative sweetpotato-pig using the Sustainable Livelihood (SL) framework. The project innovations include three new sweetpotato cultivars for human consumption, four new sweetpotato cultivars for pig feed, five sustainable nutrient-balanced diets for pigs, a novel management scheme for boars and sows, and a modified *laleken*-based rotational foraging system for confining pigs. These innovations affected the quality of labour available in *silis* through improving their education, sweetpotato-pig husbandry skills, and capacity to work (human assets); social cohesion through the formation of an informal group in association with the project wherein more work collaborations and access to financial assistance are encouraged (social assets); and sweetpotato-pig production and cash incomes (financial assets).

Keywords: Livelihood assets, sweetpotato-pig systems, double difference impact, Dani people, Papua-Indonesia

Introduction

The province of Papua is a source of great wealth to Indonesia. Its abundant natural resources contribute around US$1.7 billion per year (BPS Indonesia 2008). Papua, however, continues to present the Indonesian government with an intractable development challenge. One-third of the province's children are not in school; nine out of ten villages lack health centres, doctors or midwives; and 41% of Papuans live below the poverty line – defined as living with less than Rp202,379 (US$ 21) per month – more than double the national average of 17% (BPS Indonesia 2009).

In its attempts to address poverty, the Papuan provincial government, with help from the United Nations Development Programme (UNDP), has focused on enhancing community development through promoting two broad strategies: (i) 'making markets work for the poor' and (ii) 'sustainable livelihoods' (UNDP 2005). The common theme in these strategies is the role of agriculture in poverty reduction with the unifying aspiration to achieve the Millenium Development Goals (MDGs).

The Baliem Valley, located in the Central Highlands of Papua, is home to the Dani people. The vast majority of the Dani depend on a traditional sweetpotato-pig farming system for their livelihoods. In the Baliem Valley, improving livelihood outcomes means focusing on the sweetpotato-pig production systems. These traditional production systems provide a year round source of food for families, generate cash income, supply manure for soil fertility, convert low value sweetpotatoes into high value pigs, and are at the centre of the Dani's culture – all cultural traditions (e.g. marriages, conflict resolutions and funerals) always involve sweetpotatoes and pigs (Schneider et al. 1993; Peters 2003; Peters et al. 2005). The difficult challenge facing the region's development programs and the policy community is how to achieve coherence between the pro-poor market liberalisation agenda and sustainable livelihoods goals in these relatively isolated communities.

This article contributes to the rich literature on project impact assessment by illustrating how the Sustainable Livelihoods (SL) framework can be used to assess the development impacts of a sweetpotato-pig project funded by the Australia Centre for International Agricultural Research (ACIAR). The ACIAR project's main goals include improving incomes and food security of the Dani. A major project activity was to introduce new sweetpotato varieties and a new pig management system.

This paper is part of series of studies to evaluate the impact of the introduced sweetpotato-pig system. The SL framework, developed by the Department for International Development of the United Kingdom, is a useful model for understanding the many interrelated causes of poverty and how to address those causes to help alleviate poverty (see Figure 1 for details, DFID 1999). This impact assessment presented here focuses on three livelihood assets: human, social and financial. The study explores how and to what extent the project innovations affect these three assets and, importantly, considers the implications for further agricultural development projects in the region.

In the next section, the paper attempts to place the Dani sweetpotato-pig project impact assessment in context of the ongoing debate about the role of project impact assessments in agriculture. This brief overview is followed by a description of the study area. The next section outlines the research methods, survey instrument and sampling design. The final section presents the results and discussion.

Agriculture and sustainable livelihoods and project impact assessments

The recent, renewed focus on sustainable livelihoods and agriculture's contribution to economic growth and poverty reduction draws on several past market-oriented lessons from the development literature: (1) agricultural growth, with low asset concentration and labour-intensive technologies, is conducive to poverty reduction, (2) poverty cannot be reduced without economic growth or raising mean incomes, (3) large income inequalities restrict both poverty reduction and growth, and (4) better nutrition, health and education benefit the poor through increased consumption and higher future incomes (Lipton and Ravallion 1995; Ravallion and Datt 1999; Atkinson and Bourguignon 2000; Khan 2001).

However, these market-oriented and sustainable development lessons tend to measure only private economic benefits based on productivity gains, ignoring and understating the other livelihood assets: the human, social and environmental values and how these values benefit households and the wider community. This literature also ignores the ability of poor households even to participate and adopt more innovative sustainable land management practices. Poor households may not adopt because they can neither afford the investments nor the short term trade off between the initial production loss and the longer term productivity gain.

Another literature includes a recurring conceptual debate focusing on the relative poverty reduction benefits of promoting household diversification strategies compared with improving and expanding existing activities (Barret et al. 2001; Ellis and Freeman 2005; Hyman et al. 2008). Hyman et al. (2008) highlight several valuable conclusions from the literature on this debate. First, improving economic returns from a household's existing activities can often be more realistic than introducing new income generating activities. Second, natural, physical and social capital are key assets determining livelihood options; however, "*even households with similar resource endowments demand different technologies because of differences in preferences, objectives, constraints and incentives attached to certain livelihood activities*" (Hyman et al. 2008).

Third, the poverty and environmental outcomes and the policy implications of these heterogeneities among households living in the same community are rarely investigated. This paper contributes to our understanding of how different households from the same community who share the same biophysical resources respond to a range of innovations. These innovations include three new sweetpotato cultivars for human consumption, four new sweetpotato cultivars for pig feed, five sustainable nutrient-balanced diets for pigs, a novel management scheme for boars and sows, and a modified *laleken*-based rotational foraging system for confining pigs (Cargill 2009). *Laleken* is a Dani term for a traditional fenced area to confine pigs.

Evaluating the impacts of these project interventions on crop-livestock systems and target beneficiaries is complex and evolves over time. Changes in the production systems need to be translated into impacts on people's assets (often grouped into human, social, financial, natural and physical capital), incomes, food security, or other measures of wellbeing (Kristjanson and Thornton, 2004). Not surprisingly, depending on the context, translating interventions into outcomes often requires a number of different approaches or even integrating multiple methods.

For example, Thornton and Herrero (2001) propose an integrated crop-livestock simulation model approach for impact assessment. Their approach can be combined with related evaluation tools and techniques to generate useful information on changes to production and productivity, income, food security, social welfare and the environment. Paris (2002) suggests four types of information are key to project evaluation: (i) biological/technical feasibility, (ii) economic viability, (iii) socio-cultural acceptability and (iv) environmental soundness.

Thornton *et al*. (2003) summarise the strengths and weaknesses of a number of impact assessment approaches for crop-livestock systems. All the approaches they examined involved participatory elements, specified the type of information to be generated (eg, quantitative and qualitative) and indicated the type of expertise required to employ the approach (eg, social science, economics and technical biophysical). They conclude that it is necessary to take a broad, integrated look at the systems themselves and the processes going on within them, encouraging combining multiple approaches and methods.

Assessing the project impacts of Forages for Smallholders Project (FSP) in Vietnam, Cramb *et al*. (2004) demonstrate the use of integrated multiple approaches and methods. To assess the impact of the FSP, they employ participatory rural appraisal methods within a rural livelihoods framework, which is adapted from the SL framework, and find that such an integrated approaches and methods technique provides considerable insights into understanding the impact on the diversity of resources and strategies of households in the FSP area.

A number of important recent studies identify the economic benefits from improving sweetpotato-pig systems, including useful mechanisms for increasing adoption rates (Peters et al. 2005; Lemke et al. 2005; Lemke and Zarate 2008). In an impact study on sweetpotato-based pig production systems in Vietnam, Peters *et al.* (2005) use a survey approach and among other results, find that the ensilaged sweetpotato technology for pig feed introduced by the project increases the number of pigs (financial capital), while at the same time reduces labour input, particularly of women.

In their study of assessing the development potential of sweetpotato-pig systems in Vietnam (yields and profitability), Lemke et al. (2005) compare production systems by input intensity, location and market access. Among other contributions, Peters et al. (2005) provide insights into scaling up adoption to wider project impacts.

These examples indicate that there are various approaches to evaluating the impact of crop-livestock systems on people – meaning in the SL framework terms, their assets (human, social, financial, natural and physical capital), activities (strategies), incomes and food security (outcomes) – and the importance of integrating multiple methods to achieve a comprehensive understanding of the impact. However, there is generally little known about the impact of crop-livestock interventions on human, social and financial capital assets in detail. This study attempts to add to

these studies by evaluating the sweetpotato-pig project in Papua, Indonesia using the Sustainable Livelihood (SL) framework.

The Study Site

The Baliem Valley covers an approximately area of 160 km^2 (Aditjondro 1982). It administratively belongs to the Jayawijaya Regency (Figure 2). This regency, which centres to Wamena and is accessible only by air transport, has a total area of 14,847 $km^{2.}$ Forests occupy around 87% of the landscape, with agriculture on 13%. (BPS Jayawijaya 2006). The population is 227,474, comprising indigenous Dani and non-Papuan migrants of approximately 90% and 10% respectively. The non-Papuan migrants all live in Wamena. Wamena lies at an altitude of 1,550 meters above sea level (m asl), but other populated areas in the regency lie between 1,470-1,850 m asl.

The surrounding Jayawijaya Mountains reach altitudes of 4,700 m asl (Aditjondro 1982). Soils in the valley in general are developed from limestone with poor native fertility (Schroo 1963, cited in Soenarto and Rumawas 1997), but most of the cultivated land is on Histosols and hydromorphic mineral soils like Aquepts and transitions of these main groups (Van Baal et al. 1984). Based on the 1987-2006 climatic data measured by the Jayawijaya Metrological Station (BMG Jayawijaya 2006), the regency is a humid tropical climate characterised by relatively consistent temperatures throughout the year (14ºC average monthly minimum; 27ºC average monthly maximum), and seasonal rainfall with the wetter months from December to April and the drier months from May to November. However, variability in annual rainfall is great, ranging from 1,266 mm in 1997 (an El Niño period) to 2,617 mm in 2005 with variability in monthly rainfall (i.e. coefficients of variation) between years ranging from 28 to 87%.

This study involves 20 villages across the Baliem Valley, all within the Jayawijaya Regency (Figure 2), where the sweetpotato-pig innovations have been introduced. These villages all have member *silis* (a Dani language term) that have been involved participatorily in the development of the innovations. The fundamental unit for social data collection in Indonesia is the household unit. However, the use of *sili* as the unit of analysis is suggested by Dani key informants in a series of workshops for developing survey questionnaires for this study. *Sili* is an important

part of the Dani traditional 'household' systems. A *sili* is several Dani households who live together and follow an ethic of *sabokhogon,* meaning they are *one for all and all for one,* living and working together as a *sili* unit. There is no separate ownership. Farm infrastructure, gardens, sweetpotatoes and pigs are owned and shared collectively under the management of a chief who controls access and rights for the benefit of all *sili* members (Lokobal et al. 2006).

The Dani people of the Baliem Valley are the largest tribe in the Central Highlands of Papua with approximately 150 thousand members (BPS Jayawijaya 2006). Golson (1997) claims that they have likely farmed the valley for more than 9,000 years, growing sweetpotatoes (*Ipomoea batatas*) and raising pigs (*Sus scrofa papuensis*) for several hundred years. Sweetpotatoes remain a staple food for the Dani; about half their production is consumed, while the other half is pig feed.

In most cases, sweetpotato roots and vines account for 100% of the pigs' diet (Mahalaya et al. 2005). Surveys demonstrate sweetpotato yields average 9 t/ha; pig growth rates average 18 g/day with a mortality rate of 40% over four months; and sows breed only once every two to three years (0.3-0.5 litters/year) with a small litter size (5 pigs/litter) and high piglet mortality (48% pre-weaning mortality) (Cargill 2009). The project introduced three new sweetpotato cultivars for human consumption, four new sweetpotato cultivars for pig feed, five sustainable nutrient-balanced diets for pigs, a novel management scheme for boars and sows, and a modified *laleken*-based rotational foraging system for confining pigs

Table 1 presents the general socio demographic characteristics from the survey of the Dani *silis* and their sweetpotato-pig sytems in the six districts in the Baliem valley. In the study area, the average number of people in a *silis* is 13 persons. Most persons in *silis* have little education and almost none have been to university. However, some now study in either elementary, junior or senior high schools. With respect to their sweetpotato-pig systems, *silis* have about three gardens with a total size of almost one ha. To reach these gardens, *silis*' members need to walk almost two hours. In a single garden, there are about 16 different sweetpotato cultivars. Almost every *sili* raises pigs (i.e. growing-pigs and piglets) and keeps sows for breeding purposes.

Research Methods

This study employs a Double Difference Impact (DDI) approach to measure quantitatively the impacts of the sweetpotato-pig innovations introduced by the project. The project DDI is given by the difference between the differences in mean outcomes for the project group and the comparison group reported at the base-line and the end-line (Baker 2000; Ravallion 2001; White 2006).

For this study, the outcomes include impacts of the sweetpotato-pig innovations in terms of changes in human, social and financial asset variables. The human asset variables are measured for both women and men (16-60 years old), consisting of the number of women and men in *silis*, the number of years of education, sweetpotato-pig husbandry training, and sweetpotato and pig work. The social asset variables comprise the number of memberships in formal groups and informal networks, the number of formal group-based and informal network-based labour exchanges, and the number of trusted *silis* for financial helps. The financial asset variables are the number of boars, sows, growing-pigs, piglets and other livestock, the production of sweetpotato roots and vines and other crops, and the income earned from selling pigs, other livestock, sweetpotatoes, other crops and natural resource products, and non-agricultural salaries and remittances.

The project group is represented by all collaborator *silis* involved in the development of the sweetpotato-pig innovations. There are 38 *silis* in the project group. The comparison group is used to identify what would have happened without the project intervention. This non-project group includes two sub groups. First, a total of 570 *sili* samples are chosen from the population of 2,058 *silis* available in the 20 villages by using stratified random sampling methods. Stratification uses the number of collaborator *silis* at each of the 20 villages. Second, a total of 190 *sili* samples are rechosen from the total of 570 *sili* samples using propensity score matching methods. Propensity scores are calculated basing on the same observable characteristics attached to the project group *silis*, i.e. the size of sweetpotato gardens and the number of pigs owned by *silis*. The five propensity scores of the 570 *sili* samples closest to propensity scores of the 38 collaborator *silis* at each of the 20 villages are then chosen, resulting in the total of 190 *sili* samples. These 190 *sili* samples form the comparison group.

The base-line and the end-line are the situations of the outcomes for both the project and comparison groups before the project started and after the project finished respectively. The end-line datasets for the project and comparison group *silis* are all collected through *sili* surveys carried out in 2007 as part of this study. The base-line datasets include surveys completed through the 2001 ACIAR project socio-economic studies and others through the 2007 *sili* surveys. The original base-line datasets collected in 2001 include 14 project group *silis* (37% of the 38 project group *silis*) and 32 comparison group *silis* (17% of the 190 comparison group *silis*). Recall data techniques were used to collect the additional base-line datasets in 2007. These additional datasets are necessary because the original ones are not only small in the size of samples, but also covering only seven villages of the 20 villages.

The survey instrument

To inform the analysis and to develop the survey instrument, a series of three focus group discussions are carried out. The first series involve three different three separate focus groups, each consisting of 10 Dani key informant women, 10 Dani key informant men and 10 local government and non-government organization officials. The second focus group series involve the head of tribes and village officials at each of the 20 villages. The main aim here is to help determine the 570 *sili* samples. Finally, the third series involve 10 Dani key informant men and women at each of the 20 villages to collect qualitative information to support quantitative data collected through *sili* surveys. Participatory rural appraisal techniques such as mapping and diagramming, and ranking and scoring are employed variously during the focus group discussions.

Sili surveys are carried out in 2007 using semi-structured group interview techniques to collect necessary quantitative data in the context of the SL framework. They involve the 38 project group and 570 comparison group *silis* and are conducted by five trained Dani interviewers. Each *sili* is visited four times. When a *sili* is being interviewed, as many members of the *sili* as possible are encouraged to participate. The separation of time and the participation of the many *sili* members are part of the efforts to increase the reliability of data, particularly for the base-line datasets for which the recall data techniques are employed.

The *sili* surveys collected quantitative data on impacts of the sweetpotato-pig innovations in terms of changes in the five types of livelihood assets, i.e. natural, physical, human, social and financial, as presented in the SL framework. However, this paper only focuses on human, social and financial assets. The remaining natural and physical assets are presented elsewhere (see Mahalaya and Nuberg 2010).

Results and Discussion

The measurable impacts of the innovations on Dani livelihoods are presented in terms of changes in human (Table 2), social (Table 3) and financial (Table 4) asset variables. Within these tables, under the double difference column, the first difference compares each variable of the project group as well as the comparison group before and after the intervention, while the second difference compares the first difference of the two groups. The analysis refers to the t-test for significance applied to the first difference to determine whether the second difference is meaningful as impact.

The impacts of the project innovations vary among the tested variables. In the human asset variables, significant changes occur in the number of women in *silis*, the number of years of education of women and men, women and men sweetpotato-pig husbandry training and pig work, and women sweetpotato work (Table 2). In the social asset variables, significant changes can be seen in all the tested variables, except for the number of memberships in informal networks (Table 3). Finally, in the financial asset variables, significant changes are obvious in the number of sows, growing-pigs, and piglets, the production of sweetpotato roots and vines, and the earned incomes from selling pigs and natural resource products, and non-agricultural salaries and remittances (Table 4). Measured impacts of the other tested variables are negligible.

The significance of changes in human assets

Improvements in human assets through crop-livestock interventions are well documented. For example, Randolph et al. (2007) review improved human nutrition and health through crop-livestock interventions in several developing countries in Asia and Africa. In Indonesia, integration of animals in rubber and food crop-based

upland farming has been directly linked to enhanced household welfare, better clothing for the family, and improved health care and education for the children (Paris 2002). In Vietnam, a crop-based pig production intervention improved the capacity of rural smallholders in producing silage for pig feed (Peters et al. 2005). Similarly, in China, a sweetpotato-pig production intervention improved the same capacity of producing sweetpotato silage for pig feed as well as enabled the rural smallholders to pursue higher education for their children (Fredenburg et al. 2007).

For the Dani of the Baliem Valley, human assets are constituted as their human resources in terms of the number of women and men labour power available in *silis* and their sweetpotato-pig husbandry skills, knowledge and capacity to work and their general education. These assets are viewed here as a characteristic of the *sili* rather than the individual because of the *sabokhogon* ethic described earlier.

The innovations introduced in this project affect Dani human assets in two distinct ways. First, they improve the quality of labour and the resulting productivity gains. An important indicator is the increased education (measured in years) of both women and men of the *sili*, influencing their capacity to work. In particular, the positive changes in women and men sweetpotato-pig husbandry training and pig work and women sweetpotato work highlight new stocks of knowledge. Education, training, and work experiences which increase skills, knowledge and capacity to work represent human assets (DFID 1999). Second, in contrast, the reduced the availability of women labour power in *silis* as indicated is the negative sign. At a household level, the availability of labour is also a factor of human assets (DFID 1999). For the *silis*, what is important is the net effect of the higher productivity of the reduced availability of labour.

The increase in education of members of the participating *silis* is attributed directly to increased income, especially from selling pigs. About 13% of a *silis* annual income is invested into education. Pigs are sold to raise the cash to pay semester school fees, which can be as much as Rp100,000. For smaller incidental expenditures, incuding books and pens, the *silis* tend to harvest and sell sweetpotatoes for raise the money. The children of project *silis* attended on average two more years of education because of the extra wealth and benefits generated from their participation. This benefit is shared equally between girls and boys. Many of the *silis* interviewed, acknowledged the importance of sending their girls to school. While there was a slight increase in men's education among the comparison group (but still

significantly less than the project group) there was no change in women's education in this group.

Significant positive changes also occur in both women and men sweetpotato-pig husbandry training. These changes result from *silis*' participation in the development of the sweetpotato-pig innovations. Mahalaya *et al.* (2005) report that the innovations are developed in a participatory manner whereby the project always involves both women and men in all on-farm sweetpotato and pig trials from designing, reviewing, monitoring to evaluating these trials. Such participation not only increases sweetpotato-pig husbandry skills of the Dani, but also allows them to decide whether the innovations are suitable for their own environments. In addition, even though the time spent on the training of women is slightly lower than men, the project has provided an equal training opportunity for both women and men. This introduces a new model for agricultural development in the region.

The amount of time both women and men spend on pig activities also increased significantly. These changes are influenced by two factors relating to the innovations themselves. The first factor is the adoption of the innovations by Dani *silis*. Compared to the traditional system, which is an extensive pig management system (Peters 2001; Hide 2003), the introduced innovations are relatively more intensive. For example, in the traditional systems raw sweetpotato roots and vines harvested from gardens are used for feeding pigs. The five new sustainable nutrient-balanced diets for pigs take time to process before they can be used to feed pigs. The second factor influencing times is straightforward: the new project boosts pig production (see Table 4) and more pigs mean more work.

Pearson correlation tests between the time that women and men spent on pig work and the number of pigs used to test this argument show significant positive relationships ($p<0.01$, 2-tailed). In addition, the time spent on pig work by men is almost double the women's time. This is because in the Baliem valley men tend to engage more with pig work as pigs represent power and money. Women spend more time on sweetpotato tasks. Men tend to do most of the cleaning of pigsties, collecting and changing dried grasses in pigsties, washing, mating and looking after pigs in *lalekens*. Women's main pig related task is the preparation of feed and feeding pigs.

Sweetpotato work changes significantly with a positive sign for women, and remains unchanged for men. Women do most of the sweetpotato work and the project introduced new sweetpotato cultivars aimed at increasing the production of

sweetpotato roots and vines (see Table 4). Similar to the adoption of pig-related innovations, as sweetpotato production increases, so too does the time required to manage and harvest. Pearson correlation tests between the time that women spent on sweetpotato work and the production of sweetpotato roots and vines used to test this argument result in significant positive relationships ($p<0.01$, 2-tailed). Similarly the reason why the time that men spent on sweetpotato work remains unchanged is that because in the Baliem valley women usually do most of the sweetpotato work from planting to harvesting, while men only deal with the preparation of gardens. The *sili* surveys demonstrate that the size of gardens is relatively unchanged during the project period (see Mahalaya and Nuberg 2010) and so is the number of men in *silis* (see Table 2), hence men sweetpotato work remains unchanged too.

In contrast, the number of women in *silis* reduces. This reduction is likely due to both cultural and religious reasons which prevent bringing new women into *silis*. In the Baliem valley marriages always involve a payment of a number of pigs (Schneider et al., 1993). The *sili* surveys demonstrate that the percentage of using pigs for custom ceremonies, which among others include for marriages, has fallen over time (from 41% in 2001 to 24% in 2006 of the total pig production) which may indicate that the number of marriages has fallen too and this prevents bringing new women into *silis*. Putra (*pers. comm.*), after working years with the Dani in the Baliem valley, argues that there has been a shift in the orientation of pig uses from previously social to more economic purposes. Meanwhile, for the religious reason churches may also influence the traditional marriage systems by eliminating polygamy practices. The sili surveys also demonstrate that 78% of interviewed *silis* are Christian and many of them say that at present, they leave such practices as they are not suitable with Christian doctrine.

The significance of changes in social assets

The most important social assets, as defined by the Dani people themselves through the focus group discussions, include their memberships in both formal groups and informal networks, their interactions through work that increase their ability to work together, and their relationships of trust that facilitate reciprocal financial assistance. The *sili* surveys show that the Dani memberships in formal groups are limited to religious-based organisations, mostly churches and a few mosques – the

later is only found in one village out of the 20 villages. The other formal group is a co-operative organisation operating in Wamena, but there are only two *silis*, both within the project group, out of the 608 *sili* samples who have memberships in this organisation. The informal networks consist of a network of kinship (different *silis* but still have family relationships), a network of neighbourhoods, and a network of friends outside the village. These memberships in both formal groups and informal networks facilitate interactions through work wherein *silis* help each other through providing labour exchanges. Meanwhile, the relationships of trust focus mainly on reciprocal financial assistance between *silis*. The following discusses some key changes in these social assets.

There is a significant positive change in the number of memberships in formal groups. Even though this change is mostly with the religious-based organisations, there is *ad hoc* evidence to suggest that these affiliation help *silis* to build more work collaborations. For example, gathering at the churches and mosques provide opportunities for discussions about their work and often leads to agreements to help each other (e.g. in opening a new sweetpotato gardens where more labourers are needed). In these cases, social organisations facilitate exchanges of ideas and collaborations.

This work transaction is reflected by the positive impact on the number of formal group-based labour exchanges. This change is more than double the number of informal network-based labour exchanges. It is a clear indication that Dani *silis* begin to rely more on their affiliation with formal groups, in this case the religious-based organisations, for labour exchanges. This should be respected by further agricultural development in the Baliem Valley.

However, it is also noticeable that the informal networks remain important as both the actual number of memberships in informal networks and the actual number of informal network-based labour exchanges before and after the project are much higher than those associated with the formal groups (see Table 3). There is relatively no change in the number of memberships in informal networks, but labour exchanges based on these informal networks increase significantly. This has two explanations. First, there is more work available encouraging more work collaborations. This is confirmed by the increasing production of sweetpotatoes and pigs (see Table 4). Second, the network of friends within the informal networks actually expands slightly in association with the project. The project group *silis* explain that they have formed

a kind of an informal group since becoming involved with the project. This informal group provides opportunities for more work collaborations.

The informal group formed in association with the project is likely to be responsible too for the significant positive change in the number of trusted *silis* to whom one can rely on getting financial help. This change is obvious within the project group *silis* (see Table 3). So the project group *silis* can provide reciprocal financial assistance when they need it. While a few moneylenders operate in the Baliem Valley with relatively high interest rates, and there is only one co-operative operating in Wamena which is difficult to access, and there are no *silis* with access to the banks operating in Wamena, the growing number of trusted *silis* become important. However, with noticeable changes in financial assets (see below) further agricultural development in the region needs to look even closely at this lack of access to locally available financial institutions.

The significance of changes in financial assets

One can easily notice that the financial assets of the Dani are mainly built by their traditional farming systems based on sweetpotato-pig production (Table 4). Their liquid assets are dominated by sweetpotatoes and pigs, as are their earned incomes, derived from selling pigs. These pigs are fed mainly by sweetpotatoes (see Mahalaya, Nuberg and Taylor 2010). Overall these two commodities contribute almost 90% to the total annual incomes of Dani *silis*. The remaining contributions (10%) come collectively from incomes earned by selling other livestock and crops, natural resource products, and those earned from non-agricultural salaries and remittances.

There are significant positive changes in the number of sows, growing-pigs, and piglets, while there is a slightly positive change but insignificant in the number of boars. The project final report shows that the novel management scheme for boars and sows has enabled sows to farrow 1.5 times/year with an average litter size of 5.1 piglets compared with less than once/year for control sows with an average litter size of 2.8 piglets – this scheme yields 87% more piglets/year (Cargill 2009). This achievement is strengthened further by the five sustainable nutrient-balanced diets for pigs and the modified *laleken*-based rotational foraging system with access to high-protein pastures for confining pigs. The same report indicates that the introduced

diets resulted in increased pig growth rates ranging from 120 to 300 g/day compared with from 18 to 48 g/day for pigs fed using the traditional diets, while the later has made pigs growing 80% faster than pigs confined using the traditional *lalekens* without access to high-protein pastures.

The change in the number of growing-pigs is subsequently followed by the significant positive change in the earned income from selling pigs. As their pig production increases, *silis* can sell more pigs as well. The *sili* surveys also reveal a big shift in the use of pigs particularly for sale over time; expanding from 58% in 2001 to 73% in 2006 of the total production. This shift indicates that *silis* are gradually becoming more financially oriented with the use of pigs for custom ceremonies falling over time from 41% in 2001 to 26% in 2006. It also indicates the role pigs play in income generation.

Another significant impact is in the increased productivity and production of sweetpotato roots and vines. A project document reported by Jusuf *et. al.* (2007) shows that the new cultivars grown under the traditional cultivation systems yield in average 25.3 t roots/ha and 22.5 t vines/ha which are more than double the best traditional cultivars namely *Helalekue* and *Musan* do. The *sili* surveys find that these new cultivars have been adopted by 100% and 34% of the project and comparison group *silis* respectively. This high adoption rate likely contributes to the change in the production of sweetpotato roots and vines. In addition, in contrast to pigs, sweetpotatoes are mainly for food and feed security. The *sili* surveys indicate that *silis* use 56% and 42% of the total sweetpotato produce for pig feed and human food respectively both for the year of 2001 and 2006.

The earned income from non-agricultural salaries is also changed significantly in a positive manner. This change is influenced by two factors. First, there are, of course, salary increments for those who have already had the non-agricultural jobs since the beginning of the project. Second, and more importantly, some of the project group *silis* engage in new non-agricultural jobs. These new jobs come from their improved skills resulting from their participation in the project. For example, a member of a *sili* collaborator from Napua is appointed to be a secretary to the head of the village since the *sili* has been the only one whose pigs survived from the 2006 swine fever outbreak, which is a viral disease spread by physical contact between pigs (DISNAK Jayawijaya 2007). This sili adopts the modified *laleken*-based rotational foraging system for confining pigs.

Also significantly impacted is in the earned income from remittances. This change is mostly influenced by the increasing number of pigs raised by *silis*. The *sili* surveys reveal that the increasing number of pigs attracts members of the *silis* who work outside the Baliem Valley to help meet the everyday cost of raising more pigs. There are of course a few members who send remittances not for this purpose.

In contrast, income earned from selling natural resource products reduces and is statistically significant. Both the project and comparison groups explain that they now rely more on pigs sales as their major source of income, but the data illustrates that this shift is more meaningful for the project group. The sale of pigs contributes 67% and 86% to the total income of the project and comparison groups respectively. Even though the contribution of pigs to the project group is smaller, the actual amount of money received by this group is 17% greater than the comparison group. The earned income from non-agricultural jobs by the project group, which is the second greatest source of income for this group, contributes 25% to their total income which is much higher than the contribution of earned income from the same source by the comparison group of only less than 1%. The greater access to non-agricultural jobs for the project group *silis* is mostly associated with their improved skills resulted from their participation in the project as previously discussed above. As the project group earns 50% more than the comparison group, largely from sale of pigs and non-agricultural jobs, they can rely less on natural resource products for income.

Implications of the innovations for future agricultural development in the Baliem Valley

The sweetpotato-pig innovations introduced by the project are relatively simple modifications of the existing traditional farming systems. These innovations include three new sweetpotato cultivars for human consumption, four new sweetpotato cultivars for pig feed, five sustainable nutrient-balanced diets for pigs, a novel management scheme for boars and sows, and a modified *laleken*-based rotational foraging system for confining pigs. Previous agricultural intervention in this region has focussed on the introduction of rice cultivation and has had very poor adoption (Peters 2001). Therefore, policy makers may consider that further agricultural development in this region could follow the principle of modifying

traditional agriculture, as exemplified in this project, rather than replacement with a radically different farming system.

The documented benefits of the project innovations are already evident, suggesting additional economic and social benefits from extending the project more *silis*. Rogers (1983) suggests that the adoption of agricultural innovation is influenced by five factors; that is a successful innovation will have: (1) relative advantage compared to the existing system, (2) be compatibility with the existing farming system and culture, (3) not requiring complex knowledge or skills, (4) have benefits that are readily observable, and (5) can be trialled without too much risk – these factors are clearly all applied to the innovations introduced by the project. There are unanimous requests made by the comparison group *silis* to be part of further extension of these benefits which supports this need. In response to these requests, the project provides a good model by conducting a series of Training-of-Trainers (ToT) sessions, which were carried out in 2006, preparing selected project group members for a series of Farmers-to-Farmers (FtF) events over 2007-8 Cargill (2009). This ToT and FtF training is adapted from the United Nations Food and Agriculture Organization's Farmer Field School modality which is built on group-based learning processes (Pontius et al. 2002). Therefore, policy makers may continue this training model in their attempts to extend the benefits of the innovations as part of future agricultural development in the Baliem Valley.

Conclusion

This study quantitatively measures the impact of the sweetpotato-pig innovations in terms of changes in various human, social and financial livelihood asset variables in the Baliem Valley of Papua, Indonesia. It examines the extent to which the innovations affect heterogeneous *silis* who share the same resources in the Dani community, and discuss the implication for further agricultural development in the region.

The innovations affect the quality of labour available in *silis* through improving their education, sweetpotato-pig husbandry skills, and capacity to work (human assets); social cohesion through the formation of an informal group in association with the project wherein more work collaborations and access to financial

assistance are encouraged (social assets); and sweetpotato-pig production and cash incomes (financial assets).

The innovations are relatively simple modifications of the existing traditional farming systems. They should be readily adoptable by other Dani farmers. The extension of these innovations through farmer-to-farmer extension programmes are suggested to continue as part of further agricultural development in the region.

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References

Aditjondro, G.J. 1982. The Irianese ethnic minorities in Indonesia. An issue of national integration. *Impact* 17(2): 37-63.

Atkinson, A.B. and F. Bourguignon. 2000. *Handbook of Income Distribution.* Volume I. Amsterdam: Elsevier.

Baker, J. L. 2000. *Evaluating the Impact of Development Projects on Poverty: A Handbook for Practitioners*. Washington, DC: The World Bank.

Barrett, C.B., T. Reardon and P. Webb. 2001. Nonfarm Income Diversification and Household Livelihood Strategies in Rural Africa: Concepts, Dynamics, and Policy Implications. *Food Policy* 26(5): 315-331.

BMG Jayawijaya. 2006. *Rainfall and Temperature in Jayawijaya Regency 1987-2006*. Wamena: Badan Meteorologi dan Geofisika Jayawijaya (in Indonesian).

BPS Indonesia. 2008. *Indonesia in Figures*. Jakarta: Badan Pusat Statistik Indonesia.

_____. 2009. *Trends of the Selected Socio-Economic Indocators of Indonesia March 2009*. Jakarta: Badan Pusat Statistik Indonesia.

BPS Jayawijaya. 2006. *Jayawijaya in Figures 2006*. Wamena: Badan Pusat Statistik Jayawijaya.

Cargill, C.F. 2009. *Poverty alleviation and food security through improving the sweetpotato-pig systems in Papua, Indonesia*. Final Report. Canberra: Australian Centre for International Agricultural Research.

Cramb, R.A., T. Purcell and T.C.S. Ho. 2004. Participatory assessment of rural livelihoods in the Central Highlands of Vietnam. *Agricultural Systems* 81: 255-272.

DFID. 1999. *Sustainable Livelihood Guidance Sheets*. London: Department for International Development.

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

Ellis, F. and H.A. Freeman (eds.). 2005. *Rural Livelihoods and Poverty Reduction Policies*. London: Routledge.

Fredenburg, P., P. Mooney and A. Barclay. 2007. *China: Voices for Sustainable Agriculture*. Beijing: CGIAR Secretariat, Department of International Cooperation, Chinese Academy of Agricultural Science.

Golson, J. 1997. From horticulture to agriculture in the New Guinea Highlands: A case study of people and their environment. In: P.V. Kirch and T.L. Hunt (eds.). *Historical Ecology in the Pacific Islands: Prehistoric Environmental and Landscape Change*. New Haven: Yale University Press, pp. 39-50.

Hide, R. 2003. *Pig Husbandry in New Guinea: A Literature review and Bibliography*. Canberra: Australian Centre for International Agricultural Research.

Hyman, G., S. Fujisaka, P. Jones, S. Wood , M. Carmen de Vicente and J. Dixon. 2008. Strategic approaches to targeting technology generation: Assessing the coincidence of poverty and drought-prone production. *Agricultural Systems* 98: 50-61.

Jusuf, M., A. Setiawan, D. Peters, C. Cargill, S. Mahalaya, J. Limbongan and Subandi. 2007. Improving the efficiency of sweetpotato-pig production in the Jayawijaya Regency, Papua. In: J. Limbongan (ed.). *Proceedings of the National Seminar and Expose of the Acceleration of Local specific-based Agricultural Technology Innovation to Support the Development of Villages in Papua.* Jayapura: Balai Pengkajian Teknologi Pertanian Papua, pp. 71-95.

Kahn, K.B. 2001. Market orientation, interdepartmental integration, and product development performance. *The Journal of Production Innovation Management* 18(5): 314–323.

KIPPK Jayawijaya. 2004. *Map of the Jayawijaya Regency*. Wamena: Kantor Informasi Penyuluhan Pertanian dan Kehutanan Jayawiya (in Indonesian).

Kristjanson, P.M., and P.K. Thornton. 2004. *Methodological challenges in evaluating impact of crop-livestock interventions.* Nairobi: International Livestock Research Institute (ILRI).

Lemke, U. and Zarate, V.A. 2008. Dynamics and development trends of smallholder pig production systems in North Vietnam. *Agricultural Systems* 96: 207–223.

_____, B.A. Kaufmann, L.T. Thuy and V.A. Zárate. 2005. *Evaluation of smallholder pig production systems in North Vietnam*. Paper presented in the 56th Annual Meeting of the European Association for Animal Production, Uppsala, Sweden, 5-8 June.

Lipton, M. and M. Ravallion. 1995. Poverty and Policy. In: J. Behrman and T.N. Srinivasan (eds.). *Handbook of Development Economics.* Volume III. Amsterdam: Elsevier.

Lokobal, N.A., A.A. Alua and T.N. Mulait. 2006. *The Life Values of Hubula Society in the Baliem Valley of Papua*. Jayapura: Biro Penelitian STFT Fajar Timur (in Indonesian).

Mahalaya, S., C. Cargill and L. Kossay. 2005. *Poverty Alleviation and Food Security through Improving the Sweetpotato-Pig Systems in Papua, Indonesia: Plans to Measure Outcomes and Impacts*. Paper presented at the UPWARD Network Meeting, Hanoi, 18-23 January.

_____ and I. Nuberg. 2010. Impact of agricultural intervention on natural and physical livelihood assets of traditional farming systems in Papua, Indonesia. *Journal of Development Effectiveness*: Submitted in February 2010.

_____ and J. Taylor. 2010. The vulnerability of livelihoods based on sweetpotato-pig production in Papua, Indonesia. *Human Ecology*: Submitted in November 2009.

Paris, T.R. 2002. Crop-animal systems in Asia: socio-economic benefits and impacts on rural livelihoods. *Agricultural Systems* 71: 147-168.

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.* Bogor: International Potato Center, pp. 215-224.

_____, N.T. Tinh, M.T. Hoan, N.T. Yen, P.N. Thach and K. Fuglie. 2005. Rural income generation through improving crop-based pig production systems in Vietnam: Diagnostics, interventions, and dissemination. *Agriculture and Human Value* 22: 73-85.

Peters, J. 2001. *Local Human-Sweetpotato-Pig Systems Characterization and Research in Irian Jaya, Indonesia with Limited Reference to Papua New Guinea: A Secondary Literature Review.* Unpublished report of ACIAR AH/1998/054 Project. Bogor: International Potato Center.

Pontius, J., D. Dilts and A. Bartlett. 2002. *Ten Years of IPM Training in Asia – From Farmer Field School to Community IPM*. Bangkok: Food and Agriculture Organization.

Randolph, T.F., E. Schelling, D. Grace, C. F. Nicholson, J. L. Leroy, D. C. Cole, M. W. Demment, A. Omore, J. Zinsstag and M. Ruel. 2007. Invited Review: Role of livestock in human nutrition and health for poverty reduction in developing countries. *Journal of Animal Science* 85: 2788-2800.

Ravallion, M. 2001. The Mystery of the Vanishing Benefits: An Introduction to Impact Evaluation. *The World Bank Economic Review* 15(1): 115-140.

_____ and G. Datt. 1999. *When Is Growth Pro-Poor?* World Bank Policy Research Working Paper No. 2263. Washington, DC: The World Bank.

Rogers, E.M. 1983. *Diffusion of Innovations*. London: Coller Macmillan Publishers.

Schneider, J., C.A. Widyastuti and M. Djazuli. 1993. *Sweetpotato in the Baliem Valley Area, Irian Jaya: A report on collection and study of sweetpotato germplasm*. Bogor: International Potato Center.

Soenarto and F. Rumawas. 1997. An agro-ecological analysis of *wen-tinak*, a sustainable sweetpotato wetland production system in the Baliem Valley, Irian Jaya, Indonesia. *Science in New Guinea* 23(2): 55-66.

Thornton, P.K., and M. Herrero. 2001. Integrated crop-livestock simulation models for scenario analysis and impact assessment. *Agricultural Systems* 70: 581-602.

_____, P.M. Kristjanson, and P.J. Thorne. 2003. Measuring the potential impacts of improved food-feed crops: methods for ex ante assessment. *Field Crops Research* 84: 199-212.

UNDP. 2005. *Papua Needs Assessment: An Overview of Findings and Implications for the Programming of Development Assistance*. Jayapura: United Nations Development Programme.

Van Baal, J., K.W. Galis and R.M. Koentjaraningrat. 1984. *West Irian: A Bibliography*. Amsterdam: Land en Volkenkunde, Koninklijk Instituut voor Taal.

White, H. 2006. *Impact evaluation – The experience of the Independent Evaluation Group of the World Bank*. Washington, DC: The World Bank.

Table 1. General characteristics of the Dani *silis* and their sweetpotato-pig systems in six districts in the Baliem valley of Papua in 2006

Characteristics	Asologaima (n=30)	Hubikosi (n=120)	Kelila (n=15)	Kurulu (n=270)	Makki (n=15)	Wamena (n=120)
	Means (Standard Deviation)					
People in *silis*:						
Men (number)	4.5 (2.0)	5.3 (2.8)	4.9 (1.9)	5.5 (2.6)	6.1 (2.3)	5.3 (2.6)
Women (number)	7.4 (2.4)	8.0 (3.5)	8.2 (2.1)	8.3 (3.4)	8.5 (2.7)	8.3 (3.1)
Age:						
< 16 years old (number)	4.2 (2.3)	4.5 (2.9)	4.9 (3.4)	5.0 (2.7)	5.3 (3.0)	5.1 (2.7)
16 - 60 years old (number)	6.8 (2.1)	7.5 (3.1)	6.9 (1.5)	7.5 (3.0)	7.6 (2.1)	7.3 (2.8)
> 60 years old	0.8 (1.1)	1.2 (1.4)	1.3 (1.3)	1.3 (1.3)	1.7 (1.2)	1.2 (1.2)
Education:						
Never school (number)	6.8 (2.0)	7.4 (2.8)	6.9 (1.5)	7.3 (2.7)	7.6 (2.1)	7.1 (2.5)
Elementary school (number)	2.7 (1.7)	2.6 (2.0)	3.0 (2.5)	2.9 (1.8)	2.8 (2.0)	2.8 (1.9)
Junior high school (number)	0.6 (0.9)	0.8 (1.0)	0.7 (0.6)	1.0 (1.2)	1.1 (1.2)	1.2 (1.3)
Senior high school (number)	0.9 (1.3)	1.3 (1.7)	1.3 (1.3)	1.4 (1.6)	1.7 (1.2)	1.4 (1.5)
University (number)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.1)	0.0 (0.0)	0.0 (0.1)
Sweetpotato-pig systems:						
Gardens (number)	2.9 (1.0)	3.7 (1.2)	3.3 (1.0)	3.6 (1.3)	3.4 (0.8)	3.3 (1.2)
Size of gardens (ha)	0.7 (0.3)	1.0 (0.4)	0.8 (0.3)	0.9 (0.4)	0.9 (0.3)	0.9 (0.4)
Distance from *silis* to gardens (travel hours)	1.7 (0.4)	1.7 (0.4)	1.6 (0.3)	1.7 (0.4)	1.8 (0.5)	1.6 (0.4)
Cultivars (number)	16.2 (3.6)	16.3 (3.5)	15.3 (2.4)	17.2 (3.9)	15.0 (2.6)	16.1 (3.8)
Boars (number)	0.5 (0.7)	1.0 (0.9)	0.6 (0.7)	0.8 (0.9)	0.8 (0.7)	0.8 (0.9)
Sows (number)	2.1 (1.4)	3.2 (2.3)	2.4 (1.5)	3.0 (2.1)	3.2 (1.7)	2.9 (1.9)
Growing-pigs (number)	8.4 (7.4)	8.5 (7.0)	9.0 (7.2)	8.1 (7.3)	8.6 (5.3)	8.9 (7.3)
Piglets (number)	5.0 (4.1)	5.1 (4.2)	5.4 (2.5)	5.1 (5.0)	5.5 (3.0)	5.2 (4.7)

Table 2. Impacts of the sweetpotato-pig innovations on human asset variables

Variables	PG (n=38)		CG (n=190)		Double difference			Analysis
	BP	AP	BP	AP	First difference:		Second difference: $\{(PG_{AP}) - (PG_{BP})\} - \{(CG_{AP}) - (CG_{BP})\}$	
	Means (Standard Error)				$(PG_{AP}) - (PG_{BP})$	$(CG_{AP}) - (CG_{BP})$		
Women (16-60 years old) (number)	4.24 (0.218)	4.26 (0.269)	3.52 (0.123)	4.23 (0.134)	0.02	0.71	-0.69	**
Education (years)	5.11 (0.355)	7.45 (0.413)	5.19 (0.222)	5.73 (0.213)	2.34	0.54	1.80	**
Sweetpotato-pig husbandry training (days/year)	0.00 (0.000)	18.95 (2.005)	0.00 (0.000)	0.00 (0.000)	18.95	0.00	18.95	**
Sweetpotato work (hours/week)	32.92 (1.679)	41.14 (2.564)	48.47 (0.796)	53.79 (1.250)	8.22	5.32	2.90	**
Pig work (hours/week)	5.21 (0.458)	9.02 (0.779)	4.66 (0.233)	5.75 (0.288)	3.81	1.09	2.72	**
Men (16-60 years old) (number)	3.03 (0.263)	3.42 (0.306)	2.71 (0.104)	3.05 (0.119)	0.39	0.34	0.05	NS
Education (years)	7.18 (0.413)	9.37 (0.469)	6.75 (0.239)	7.83 (0.208)	2.19	1.08	1.11	**
Sweetpotato-pig husbandry training (days/year)	0.53 (0.315)	22.34 (1.922)	0.00 (0.000)	0.11 (0.052)	21.81	0.11	21.70	**
Sweetpotato work (hours/week)	19.23 (1.593)	22.24 (1.933)	27.00 (0.810)	29.86 (0.990)	3.01	2.86	0.15	NS
Pig work (hours/week)	7.20 (0.540)	13.67 (0.985)	6.51 (0.192)	8.23 (0.238)	6.47	1.72	4.75	**

Notes: Analysis refers to statistical independent-samples t-tests for differences in means of variables of two different groups of samples. ** P<0.01. NS: Not Significant.

Table 3. Impacts of the sweetpotato-pig innovations on social asset variables

Variables	PG (n=38)		CG (n=190)		Double difference			Analysis
	BP	AP	BP	AP	First difference:		Second difference: $\{(PG_{AP}) - (PG_{BP})\} - \{(CG_{AP}) - (CG_{BP})\}$	
	Means (Standard Error)				$(PG_{AP}) - (PG_{BP})$	$(CG_{AP}) - (CG_{BP})$		
Memberships in formal groups (number)	0.53 (0.082)	0.74 (0.082)	0.17 (0.028)	0.25 (0.036)	0.21	0.08	0.13	*
Memberships in informal networks (number)	1.32 (0.101)	1.37 (0.088)	1.18 (0.029)	1.18 (0.029)	0.05	0.00	0.05	NS
Formal group-based labourer exchanges (number)	0.29 (0.106)	1.11 (0.219)	0.08 (0.021)	0.13 (0.028)	0.82	0.05	0.77	**
Informal network-based labourer exchanges (number)	5.32 (0.711)	6.45 (0.631)	5.62 (0.094)	6.42 (0.068)	1.13	0.80	0.33	*
Trusted *silis* for financial helps (number)	0.68 (0.114)	1.34 (0.109)	1.06 (0.052)	1.01 (0.046)	0.66	-0.05	0.71	**

Notes: Analysis refers to statistical independent-samples t-tests for differences in means of variables of two different groups of samples. **P<0.01. *P<0.10. NS: Not Significant.

Table 4. Impacts of the sweetpotato-pig innovations on financial asset variables

Variables	PG (n=38)		CG (n=190)		Double difference			Analysis
	BP	AP	BP	AP	First difference:		Second difference: $\{(PG_{AP}) - (PG_{BP})\} - \{(CG_{AP}) - (CG_{BP})\}$	
	Means (Standard Error)				$(PG_{AP}) - (PG_{BP})$	$(CG_{AP}) - (CG_{BP})$		
Liquid assets:								
Boars (number)	0.79 (0.108)	1.03 (0.133)	0.66 (0.056)	0.83 (0.062)	0.24	0.17	0.07	NS
Sows (number)	2.45 (0.291)	3.21 (0.251)	2.33 (0.131)	2.82 (0.126)	0.76	0.49	0.27	*
Growing-pigs (number)	3.61 (0.604)	9.08 (1.326)	7.85 (0.571)	8.47 (0.412)	5.47	0.62	4.85	**
Piglets (number)	2.95 (0.621)	5.16 (0.525)	3.34 (0.225)	5.08 (0.339)	2.21	1.74	0.47	*
Other livestock (number)	6.71 (0.993)	7.58 (1.652)	6.73 (0.688)	7.01 (0.690)	0.87	0.28	0.59	*
Sweetpotato root production (t)	8.21 (0.572)	10.35 (0.602)	8.00 (0.380)	8.72 (0.371)	2.14	0.72	1.42	**
Sweetpotato vine production (t)	6.86 (0.493)	8.55 (0.507)	6.56 (0.275)	7.25 (0.268)	1.69	0.69	1.00	**
Other crops (t)	0.34 (0.067)	0.36 (0.073)	0.33 (0.029)	0.35 (0.031)	0.02	0.02	0.00	NS
Earned incomes (Rp $.10^6$):								
Selling pigs	8.84 (1.180)	16.50 (1.298)	10.77 (0.720)	14.11 (0.854)	7.66	3.34	4.32	**
Selling other livestock	0.73 (0.188)	1.06 (0.540)	0.52 (0.071)	0.94 (0.133)	0.33	0.42	-0.09	NS
Selling sweetpotatoes	0.39 (0.047)	0.46 (0.077)	0.35 (0.027)	0.39 (0.028)	0.07	0.04	0.03	NS
Selling other crops	0.20 (0.033)	0.28 (0.111)	0.06 (0.008)	0.07 (0.010)	0.08	0.01	0.07	NS
Selling natural resource products	1.11 (0.239)	0.16 (0.064)	0.96 (0.090)	0.73 (0.076)	-0.95	-0.23	-0.72	**
Non-agricultural salaries	1.15 (0.700)	4.85 (2.143)	0.02 (0.009)	0.04 (0.020)	3.70	0.02	3.68	**
Remittances	0.09 (0.070)	1.26 (0.356)	0.04 (0.021)	0.09 (0.036)	1.17	0.05	1.12	**

Notes: Analysis refers to statistical independent-samples t-tests for differences in means of variables of two different groups of samples. ** P<0.01. *P<0.10. NS: Not Significant.

Source: DFID (1999)

Figure 1. The Sustainable Livelihoods framework

Source: Adapted from KIPPK Jayawijaya (2004)

Figure 2. The Baliem Valley of Jayawijaya Regency, Papua Province, Indonesia

9. Discussion

The preceding four chapters, presented as submitted journal publications, cover in detail the evaluation of the impact of the ACIAR project in terms of the five livelihood assets and the vulnerability context as described in the SL framework. Chapter 5 described the Dani traditional farming system as observed during the period of the project and how that has been changed from earlier descriptions in the literature. Chapter 6 provided details on the vulnerability of sweetpotato and pig production as defined by the Dani within participatory processes and how that has been changed from participation in the project. Chapter 7 and 8 presented the impact of the project on livelihood assets – natural and physical (Chapter 7) and human, social and financial (Chapter 8) which relates to livelihood strategies and outcomes. The current chapter takes the knowledge generated in these earlier chapters and examines their collected value in evaluating the project in the context of the SL framework. Thereby it answers the central research question of this study that is "*what were the measurable impacts of agricultural research on Dani livelihoods and how can these impacts be evaluated using the SL framework?"*

The SL framework was not conceived as only an evaluation tool but also a framework for policy development and planning for sustainable and equitable community development. In this thesis the framework has been used to indicate the type of variables that can be influenced by a development project, that could be measured and analysed in a statistically robust manner, and that logically contributed to sustainable livelihood outcomes. So the previous four chapters have used the framework as a guide for selecting appropriate variables for impact evaluation. In this chapter the framework is further used to determine how the benefits of the project can be best promoted to the rest of the Dani community.

At the time of writing this thesis (2010) the ACIAR project has continuing funding until 2014 during which time activity will be divided into farmer-to-farmer extension of the improved sweetpotato-pig systems and value-adding of the new sweetpotato cultivars (e.g. sweetpotato flour production). At some stage beyond 2014 external funding will cease and the real test of the impact of the project will be the extent to which these improved systems have become part of the Dani traditional farming

practice. The component of the SL framework that has so far not been examined has been 'Policies, Institutions and Processes'. While the improved systems are demonstrably beneficial to participating farmers, and while non-participating farmers may even show interest in acquiring these improved systems, the capacity for the diffusion of the improved systems beyond the influence of external funding will depend on the nature of the government policies, institutions and processes that either facilitate or hinder farmers to adopt them. This knowledge will be essential for the effective implementation of extension in the short term and perhaps the development of more appropriate policies, institutions and processes for the deeper future.

The following discussion answers three questions: (1) what were the measurable impacts that emerged from the ACIAR project?; (2) how can that knowledge be used to provide policy advice using the SL framework?; and (3) how do the knowledge and recommendations developed here compare with similar uses of the SL framework in other contexts?

9.1. Measurable impacts

Table 9.1 summarises the impact of the ACIAR project on the Dani's livelihood assets. The key impacts included improvements in crop genetic diversity which involve the adoption of new sweetpotato cultivars developed through and promoted by the project in the Baliem Valley, production efficiency, production cycles and resilience against environmental stress, and yields (natural assets embodied in sweetpotato gardens), less dependence on natural resource products for income (access to natural resources), improvements in most physical *sili* goods and the adoption of the pigsty-*laleken* technology (physical assets), improvements in education and sweetpotato-pig husbandry skills of *sili* members (human assets), improvements in social cohesion particularly through the formation of a group of farmers in association with the project (social assets), and improvements in the capacity of producing more sweetpotatoes and pigs as well as earned incomes from selling these commodities (financial assets). In contrast, the variables with no impacts were the number and size of gardens (natural assets embodied in sweetpotato gardens), the time taken to travel to rivers, bush fallows and forests to

collect natural resource products (access to natural resources), the number of motorbikes (physical assets), the number of men labour power and their work on sweetpotato (human assets), the number of memberships in informal networks (social assets), and the production of other livestock and crops as well as earned incomes from selling these non-pig and non-sweetpotato commodities (financial assets).

Table 9.1. The impact of the ACIAR project on the Dani's livelihood assets (A simplification of Table 1, 2 and 3 in Chapter 7, and Table 1, 2 and 3 in Chapter 8)

Livelihood assets	Variables	Impacts	
		Yes	No
Natural assets embodied in sweetpotato gardens	Gardens (number)		x
	Size (ha)		x
	Distance (travel hours)	x	
	Traditional cultivars (number)	x	
	New cultivars (number)	x	
	Tillage (months)	x	
	Grow (months)		x
	Harvest (months)	x	
	Fallow (months)	x	
	Overall cultivation (months)	x	
	Yield of roots (t/ha)	x	
	Yield of vines (t/ha)	x	
Access to natural assets	Distance to rivers (travel hours)		x
	Distance to bush fallows (travel hours)		x
	Distance to customary forests (travel hours)		x
	River fish (Rp $.10^3$/year)	x	
	Bush fallow firewood (Rp $.10^3$/year)	x	
	Customary forest wild animals (Rp $.10^3$/year)	x	
	Customary forest tree products (Rp $.10^3$/year)	x	
	Customary forest other products (Rp $.10^3$/year)	x	
Physical assets	Agricultural tools (number)	x	
	Hunt tools (number)	x	
	Traditional pigsties (number)	x	
	Traditional *lalekens* (number)	x	
	Improved pigsties with access to *lalekens* (number)	x	
	Motorbikes (number)		x
	Radios (number)	x	
	Mobile phones (number)	x	

Table 9.1. (*cont.*)

Livelihood assets	Variables	Impacts	
		Yes	No
Human	Women (16-60 years old) (number)	x	
	Education (years)	x	
	Sweetpotato-pig husbandry training (days/year)	x	
	Sweetpotato work (hours/week)	x	
	Pig work (hours/week)	x	
	Men (16-60 years old) (number)		x
	Education (years)	x	
	Sweetpotato-pig husbandry training (days/year)	x	
	Sweetpotato work (hours/week)		x
	Pig work (hours/week)	x	
Social assets	Memberships in formal groups (number)	x	
	Memberships in informal networks (number)		x
	Formal group-based labourer exchanges (number)	x	
	Informal network-based labourer exchanges (number)	x	
	Trusted *silis* for financial helps (number)	x	
Financial assets (Liquid)	Boars (number)		x
	Sows (number)	x	
	Growing-pigs (number)	x	
	Piglets (number)	x	
	Other livestock (number)	x	
	Sweetpotato root production (t)	x	
	Sweetpotato vine production (t)	x	
	Other crops (t)		x
Financial assets (Earned incomes)	Selling pigs (Rp $.10^6$)	x	
	Selling other livestock (Rp $.10^6$)		x
	Selling sweetpotatoes (Rp $.10^6$)		x
	Selling other crops (Rp $.10^6$)		x
	Selling natural resource products (Rp $.10^6$)	x	
	Non-agricultural salaries (Rp $.10^6$)	x	
	Remittances (Rp $.10^6$)	x	

Moreover, the ACIAR project reduced the vulnerability of the Dani sweetpotato and pig production from their participation in the project and affected the way in which the Dani look at the vulnerability factors of their sweetpotato and pig production (Table 9.2). In the sweetpotato production the Dani were concerned more about marauding pigs,

soil hydrology of gardens, technical assistance from institutions, and yields; while in the pig production they were concerned more about diseases and medicines, technical assistance from institutions, the quality of diets, and customary ceremonies. These vulnerability factors, which ranked 1 to 4 in each category, were in priority to cope with. The remaining factors (e.g. thefts, conflict among *silis*, prices, market access) did not mean that they were not important, but they were just not in priority to cope with in the time the Dani was being interviewed.

Overall, it was clear that the ACIAR project had a substantial impact on the Dani livelihood assets and their vulnerability context and thus influenced their livelihood strategies and outcomes. The following section will discuss how this knowledge can be used to provide policy advice within the context of policies, institutions and processes of the SL framework in order to make the project benefit sustainable in the Baliem Valley and maybe Papua and beyond.

Table 9.2. The impact of the ACIAR project on the Dani's vulnerability context of their sweeetpotato and pig production (A simplification of Table 4 in Chapter 6)

Vulnerability factors	Rank
In sweetpotato production:	
Marauding pigs	1
Soil hydrology of gardens	2
Technical assistance from institutions	3
Yields	4
Thefts	5
Conflict with other *silis*	6
Market access	7
Sudden ill of *sili* members	8
Soil fertility of gardens	9
Prices	10
Vulnerability factors	Rank
In pig production:	
Diseases and medicines	1
Technical assistance from institutions	2
The quality of diets	3
Custom ceremonies	4
Thefts	5
Boar and sow management	6
Pigsties and pig-enclosures (*lalekens*)	7
Conflict with other *silis*	8
Prices	9
Market access	10

9.2. Policies, Institutions and Processes

The ACIAR project's key impacts lead to the need to formulate a number of policies for sustainable and more equitable agricultural development in the Baliem Valley for the benefit of all Dani *silis* (Table 9.3). This formulation certainly involves a number of appropriate institutions and some processes accordingly.

Table 9.3. Policies, institutions and processes for equitable agricultural development in the Baliem Valley

Policies	Institutions	Processes
1. Extension of the improved sweetpotato-pig systems		– *Silis* participation – Capacity building of Dani technical staff
2. Efficient sweetpotato-pig husbandry and other agricultural technical assistance from associated institutions		
3. Formation of farmer organisations		
4. Equitable sweetpotato-pig husbandry and other agricultural training opportunities for both Dani men and women		
5. Wider access to loans from local financial institutions (e.g. banks, co-operatives)	JCO in collaboration with JEO, JAO, JLO, WVI, JICD and tribe heads	
6. On-farm multiplication of new sweetpotato cultivar cuttings	JAO in collaboration with JEO	
7. Regulations to control marauding pigs	JLO in collaboration with JEO, JAO and tribe heads	

Note: JEO: Jayawijaya Extension Office, JAO: Jayawijaya Agricultural Office, JLO: Jayawijaya Livestock Office, JCO: Jayawijaya Co-operative Office; WVI: World Vision Indonesia; JICD: Jayawijaya Institute for Customary Discussion

9.2.1. Policy proposals

A first and most obvious necessary policy is to ***extend the improved sweetpotato-pig systems into more Dani silis.*** These improved systems include new sweetpotato cultivars for human food and pig feed, more nutrient-balanced pig diets, pigsty technologies with access to *lalekens*, and more efficient boar and sow management. The project was carried out not for only the 38 participating *silis*, but it was for all Dani *silis* in the Baliem Valley. Special attention should be given to *silis* who rely more on upland

gardens (i.e. upland *silis*) as they were found to remain relatively poorer at the end of the project (see Chapter 5). The training-of-trainers and the farmers-to-farmers extension programmes employed by the project (see Chapter 4) can be a model as rapid diffusion of the improved systems through these programmes was already evident. These programmes have been adapted from the United Nations Food and Agriculture Organisation's Farmer Field School modality which is built on group-based learning processes (Pontius et al. 2002). They have been adopted widely in many developing countries for scaling up technology developed through projects (e.g. Feder et al. 2004, Peters et al. 2005, Davis 2006, Millar and Connell 2009).

A second policy deals with the need of ***efficient sweetpotato-pig husbandry and other agricultural technical assistance from associated institutions***. Together with the attempt to extend the improved sweetpotato-pig systems, such assistance has to work quickly and effectively in an organised manner. This requires sufficient qualified technical staff as well as a close collaboration between associated institutions involved in providing the assistance. Over the project period, it was reported by the head of a number of both government and non-government institutions that they had lack of qualified technical staff, particularly local ones (BKD Jayawijaya 2007). For example, in the JLO there was only one non-local veterinarian serving 15 sub-districts, 366 villages and 23,201 *silis* (Disnak Jayawijaya 2007a). Local technical staff are important as they are relatively more acceptable by the Dani community. They are familiar with the security issues associated with travelling long distances over poor roads. Moreover, it was also found through the focus group discussion with a number of government and non-government policy-making officials, which even though they had quite similar poverty alleviation programmes, there was rare discussion and opportunities for collaboration action between these officials. Nevertheless, the project has built the capacity of a number of local technical staff through various training programmes and it has also initiated work collaborations between both government and non-government institutions working in the Baliem Valley through regular meeting programmes. These training and meeting programmes should be a good model to continue in order to meet the need of efficient sweetpotato-pig husbandry and other agricultural technical assistance from associated institutions.

A third policy concerns the ***formation of farmer organisations***. Farmer organisations have widely been acknowledged to have many advantages. In Uganda, Tanzania, Kenya and Ethiopia it was reported that farmer organisations have enhanced capacity building among farmers, promoted more market-oriented production, increased savings and credit, improved social assets, changed mindset of extension service providers, contributed to the national extension policy, influenced rural development, increased governing transparency, and balanced gender participation (Abaru et al. 2006). The Indonesian government itself has released a National Regulation No. 16 Year 2006 as part of agriculture, fishery, and forestry revitalization policies for 2005-2025 which values the importance of farmer organisations in rural development (Syahyuti 2007). Over the project period, the *sili* group formed in association with the project provided evident that it has helped encourage more work collaborations. For example, this group had extra labour obtained from labour exchanges between its *sili* members which have enabled them to have a better physical quality of gardens which then influenced crop production cycles and more importantly improved crop yields. Ideally, there should be a *sili* group or organisation in every village which can facilitate work collaborations in a more effective way as the project *silis* group indicated that with its members spread across the valley (i.e. 20 villages) only those who live relatively close one to another in terms of distance can actually make work collaborations effectively. The extension of the improved systems (i.e. the first policy) and the provision of the sweetpotato-pig husbandry and other agricultural technical assistance from associated institutions (i.e. the second policy) can make use of this *sili* organisation.

A fourth policy relates to an ***equitable sweetpotato-pig husbandry and other agricultural training opportunity for both Dani men and women***. To a broader extent, this policy meets the third United Nations' Millennium Development Goals (MDG) which calls to promote gender equality and empower women (UN 2001). The Indonesian government, who was among the 147 governments from around the world gathered at the United Nations Millennium Summit and signed the Millennium Declaration, has committed to achieve this goal by 2015. In the Indonesia MDG report 2004 it was reported that the focus has been on education and that Indonesia has achieved much progress in reducing gender disparity in education and literacy, and has also increased the participation of women in the political and legislative sectors (Bappenas Indonesia 2004).

To a lesser extent, the project involved both Dani men and women in sweetpotato-pig husbandry training equitably over the project period. This worked effectively as it is Dani women who actually perform most, not only sweetpotato, but also pig work in the Baliem Valley, while Dani men seem to only take care of making decisions on the use of sweetpotato and pig produce, and performing the heavy work (e.g. land preparation – see Chapter 5 and Chapter 8 for more details) which they usually do. There was also evident that the equitable training opportunity offered by the project has further encouraged Dani men to engage more in both sweetpotato and pig work. The implementation of this policy can also make use of the *sili* organisation.

A fifth policy concerns ***wider access to loans***. The World Bank emphasises that rural financial services are continued being critical to developing the rural economy and helping the rural poor build assets that can reduce their agricultural vulnerability factors and this is reflected in its investments into the development of rural financial services which remained around US$350 million a year over the fiscal year of 2005 to 2006 period (World Bank 2008). The literature provides several models for financing smallholders engaged in agricultural production in rural areas. In India, a partnership between ICICI Bank, the country's second largest commercial bank, and a leading microfinance institution has been successful in linking the formal financial sector with poor microfinance clients. The approach is based on having microfinance institutions bear the responsibility of monitoring and recovering loans from individuals and self-help groups, while the commercial bank supplies credit and shares the risk (Ananth 2005). In Rwanda, CARE helps mobilize the rural poor into village savings and credit associations and link them to the existing network of credit unions in the country (Aeschliman et al. 2007). In Ethiopia, the local government of Kebele with help from Catholic Relief Services (CRS) brings the Metemamen Microfinance Institution (MMI) which has been serving the rural Ethiopian credit market for over five years to introduce an innovative loan product called "Eshet" which has much low interest compared to operating moneylenders. The Eshet loans encourage farmers to organise themselves into groups as these loans are only available to members of the groups. These loans are also tied to compulsory savings, properly deposited by farmers as a group in the MMI. These savings partially guarantee the loans, but more importantly they help promote a savings culture among farmers (CRS 2008). Similarly, in Sudan, the national government brings

the Agricultural Bank of Sudan (ABS) to provide low interest loans through farmer cooperatives previously set up by the ABS (IWDS 1994). All these models indicate the importance of the role of the government either at national or local level and group approaches for successful access to loans. Similarly, as the number of pigs grown by Dani *silis* increased significantly, there was a growing need to have wider access to loans particularly from local banks and/or co-operatives to fund their pig husbandry over the project period. It was found that only two out of 608 interviewed *silis* in this PhD study had access to loans and both did from a local co-operative operating in Wamena. There were no co-operatives working in the villages. No *silis* had access to loans from any local banks operating in Wamena either. They explained that it was difficult to get loans from both banks and co-operatives as these financial institutions require a kind of formal guarantee (e.g. government land certificates, valuable goods such as gold) which they were unable to provide. The local government of Jayawijaya can play an important role here in linking *silis* to financial institutions. The attempt to get loans from these financial institutions will work better using a *silis* organisation approach rather than an individual *sili* approach – this is another reason to account to the importance of *sili* organisations.

A sixth policy needed is to ***provide more new sweetpotato cultivar cuttings***. Multiplication of seeds of new varieties in other projects was usually done by farmers themselves (Hallman et al. 2003, Hossain et al. 2003), with help from government extension services (Bellon et al. 2003, Bourdillon et al. 2003, Hallman et al. 2003, Hossain et al. 2003, Place et al. 2003), non-government organisations (Hallman et al. 2003, Place et al. 2003), and private sectors (Bellon et al. 2003, Bourdillon et al. 2003). Through this PhD study it was found that many *silis* were keen to grow more of these cultivars, but they were constrained by the availability of its cuttings over the project period. So far the best they can do was to buy and/or exchange the cuttings from *silis* who participated in the project. These project *silis* often had limited stocks. The best way for carrying out the multiplication of these cuttings is through involving the participation of as many *silis* as possible on-farm. This way gives *silis* an opportunity to learn while they adapt the cultivars in their gardens and select only the best cuttings to grow. However, the JAO can also help produce more cuttings through multiplication in their experimental stations to be distributed to non-participating *silis* particularly in the non-project areas.

Finally, a seventh policy relates to ***regulations to control marauding pigs***. Over the project period, it was found that the pig management system in the Baliem Valley was extensive where pigs are allowed to wander during the days and only penned during the nights. This system makes pigs not only often enter and damage sweetpotato gardens which result in conflicts among *silis*, but also susceptible to diseases. The thousands of pigs killed during the 2006 swine fever outbreak were evidence of such disease transmission (Disnak Jayawijaya 2007b). The confined pigs managed by the project *silis* using the improved pigsty-*laleken* technology mostly survived the outbreak and since then the non-project *silis* have widely begun to adopt this technology. Nevertheless, there is a need to make a clear regulation which can control marauding pigs. When the fieldwork for this study was carried out in 2007, this regulation was proposed by the JLO and being discussed in the Jayawijaya House of Representatives.

For these seven policies to take place effectively in the Baliem Valley there are several institutions which need to be involved. These institutions cover both government and non-government organisations including informal customary ones. The following will discuss about these institutions and how they can interact one to another for the effective implementation of these policies.

9.2.2. Institutions

The seven policies proposed above relate to the work of institutions dealing with agricultural extension, services, and funds (see Table 9.3). The main institutions dealing with such work in the Baliem Valley include Jayawijaya Extension Office (JEO, or *Kantor Informasi Penyuluhan Pertanian dan Kehutanan, KIPPK* in local name and abbreviation), Jayawijaya Agriculture Office (JAO, or *Dinas Tanaman Pangan, DISTAN*), Jayawijaya Livestock Office (JLO, or *Dinas Peternakan, DISNAK*), Jayawijaya Co-operative Office, (JCO, or *Dinas Koperasi, DISKOP*), World Vision Indonesia (WVI, or *Wahana Visi Indonesia, WVI*), and Jayawijaya Institute for Customary Discussion (JICD, or *Lembaga Musyawarah Adat Masyarakat Jayawijaya, M-Mula*) (see Chapter 3 for elaboration). While JEO, JAO, JLO and JCO are government organisations, WVI and JICD are non-government organisations. In practice, the government organisations are still more dominant particularly in the

formulation of policies, while the non-government organisations can be a big help in the implementation of policies. Therefore, the following will focus more on the role of the government organisations, but will also show where the non-government organisations can give their contributions.

While the JEO can take a lead in the formulation of the first to the fourth proposed policies (i.e. extension of the improved sweetpotato-pig systems, efficient sweetpotato-pig husbandry and other technical assistance from associated institutions, *sili* group formations, and equitable sweetpotato-pig husbandry and other agricultural training opportunities for both Dani men and women), the JCO, the JAO and the JLO can look after the formulation of the fifth to the seventh proposed policies respectively (i.e. wider access to loans from local financial institutions, on-farm multiplication of new sweetpotato cultivar cuttings, and regulations to control marauding pigs). However, for an appropriate formulation, and further in the implementation of these policies, the government organisations have to collaborate with each other. Similarly, it is also important to involve the two existing non-government organisations (i.e. the WVI and the JICD) as they can also provide valuable feedback based on their experiences working in the Baliem Valley. Last but not least the involvement of religious (e.g. churches in particular and mosques) and informal customary institutions (i.e. tribe heads) is also crucial. The survey's Dani interviewers reported anecdotally that awareness of the project's improved sweetpotato-pig systems spread readily through members attending the churches or the mosques. Meanwhile, the tribe heads can help explain cultural aspects which may facilitate or hinder the implementation of the policies in the near future. These heads usually get more respect in the Dani society as well.

In particular the JCO also needs to approach the financial institutions operating in the Baliem Valley (e.g. banks and co-operatives). This institution can help make a link between *silis* as a group and banks/co-operatives. On one side they can help the *silis* prepare acceptable guarantees (e.g. sweetpotato garden and/or pig ownership letters); while on the other side they can convince banks/co-operatives to accept such guarantees. This institution can also negotiate the financial institutions to provide lower interest.

Finally, all the institutions involved in the implementation of the policies are strongly suggested to use the *sili* groups formed in every village (policy-3) as an entry point of their attempts. The importance of the *sili* as the fundamental social unit in Dani

society was established in Chapter 5. This way will make the attempts relatively more efficient as the effectiveness of the project *sili* group was evident over the project period.

From the discussion about policies and institutions above it was clear that participation is at the core of any attempts to formulate appropriate policies and implement these policies in an efficient manner. The following will discuss several processes in terms of necessary changes in the way in which this participation should be carried out for the appropriateness of policies and the effectiveness of institutions.

9.2.3. Processes

There are at least two necessary changes in this context (see Table 9.3). A first is the widely participation of *silis* in the formulation of policies. The importance of farmer participation in making agricultural policies to happen at the farm level has been well acknowledged (e.g. Collins and Mack 1995, Van Huis and Meerman 1997, Braun et al. 2000, Bystrom 2004, Kariuki 2006, Man and Sadiya 2009). Similarly, over the project period the project employed a participatory approach in the development of the improved sweetpotato-pig systems whereby the project group *silis* were fully involved from needs assessment, research planning, on-farm experimentation and monitoring to results review and evaluation. The project also involved closely a number of associated institutions (e.g. JEO, JAO, JLO and WVI). This approach allowed the *silis* to directly adapt the improved systems in their own circumstances which then helped them make decisions whether to adopt the systems all or some or even not at all. So *silis* participation was crucial here as it was *silis* who know what they need and that the improved systems were intended for the benefit of them. Moreover, the training-of-trainers and farmer-to-farmer extension programmes offered by the project also strongly involved the participation of *silis* as these programmes are designed from *silis*, by *silis*, and for *silis*. Therefore, the participatory approach introduced by the project can be a model for the formulation of policies whereby the participation of *silis* and the involvement of associated institutions are in the heart of policies formulation exercises.

Another necessary change relates to building the capacity of the Dani technical staff. Participatory approaches to development require not only the involvement of local staff, but also maintaining their continued participation (Eicher 1990, Clark et al. 2003,

Scott 2004, Hannah and Lester 2009). Similarly, in the context of Jayawijaya government organisations this change includes providing more training opportunities for their local staff and more importantly maintaining the continuation of the training. These training opportunities do not always mean a formal one as an informal one is usually more readily available. For example, when the veterinarian of the JLO visits *silis*, say for a pig diseases investigation, this veterinarian can always bring some Dani technical staff, not only to assist in the investigation, but more importantly to train this staff for similar work in the future. This way should of course be performed regularly until this staff is ready to work independently. The trained staff can repeat the same process of training by bringing another Dani technical staff so that there will be more Dani technical staff available. A similar informal training process was employed during the ACIAR project. It prioritised Dani technical staff in any training opportunities and then encouraged them to share what they have learned from the training with the other local technical staff and Dani farmers as well. Overall, the "policies, institutions and processes" component of the SL framework have helped identify policy advice in terms of the necessary policies, institutions involved, and necessary processes drawn on the ACIAR project's key impacts for sustainable and more equitable agricultural development in the Baliem Valley for the benefit of all Dani *silis*. The next section will compare the knowledge and recommendations developed here with similar uses of the SL framework in other contexts.

9.3. Comparison with other uses of the SL framework

9.3.1 Comparison with financial methods

The aim of this thesis has not been to compare the SL framework and the specific methods of survey and analysis used here with conventional financial methods of impact evaluation. However, a simple Net Present Value (NPV) evaluation is a way of exploring the financial boundaries of the project. The following evaluation is not intended to illustrate the limitations and problems of evaluation presents; these have already been established in Chapter 2.

Applying a simple NPV analysis of the ACIAR project produces Table 9.4. The analysis is for a period of 20 years using discount rates from 0-10% and assuming 5 levels of adoption. The assumptions and key inputs behind this analysis are:

- The period of analysis is from 2001 to 2021.
- The initial investment of A$1,253,608 (ACIAR 2005) was invested in equal shares of A$208,904 for the years 2001-2006[7].
- The average income of the 38 *silis* involved in the project was A$1,200 per *sili* more than comparison group *silis*. This value is calculated from the difference in incomes between these groups shown in Table 6.2 in Chapter 6.
- Adoption assumptions begin in 2006, the year when the above incomes were estimated. The improved income from adopting the project innovations is held constant throughout the period 2006-2021.
- The exchange rate for the full period was set at Rp 6,800 per A$1.
- Seven discount rates are applied: 0%, 1%, 2%, 3%, 4%, 5%, 10%
- Five adoption rates are assumed. Adoption of the innovations is assumed to begin from 2006 when the project concludes.

The analysis only considers the money invested, the financial wealth generated in the community that can be directly attributed to the project, the timing of investment and wealth return and the time-value of money, measured as discount rate. The conventional use of NPV in commerce will assume discount rates above 5%. In projects with considerable 'public good' lower discount rates are appropriate.

Table 9.4. Net Present Value (NPV) of the ACIAR project in various adoption and discount rates

Discount rate (%)	Adoption rate (%)				
	1	5	10	15	20
0	-$462,397	-$168,997	$394,559	$1,300,839	$2,755,301
1	-$650,153	-$448,452	-$62,999	$553,945	$1,540,170
2	-$770,777	-$631,431	-$366,513	$55,470	$727,329
3	-$845,603	-$748,868	-$565,921	-$275,934	$183,874
4	-$889,139	-$821,663	-$694,729	-$494,528	-$178,416
5	-$911,297	-$864,010	-$775,531	-$636,688	-$418,393
10	-$878,130	-$869,578	-$854,012	-$830,222	-$793,653

[7] The ACIAR investment was actually made not in equal shares, but it was invested twice a year during 2001-2006 with a different share each time. However, the actual share data was not available and therefore, this assumption was made.

From this analysis, if no discount rate is applied to the value of money, then the project will be considered to have returned its investment if there is a 10% adoption rate over the 20 year period. A 10% adoption rate equates to the number of *silis* using the project innovations increasing from 38 in 2006 to 158 in 2021. From the table, the NPV is positive at a 2% discount rate at 15% adoption, and at 3% discount rate for 20% adoption. All this analysis does is to indicate the adoption rates at which the project can be considered to have returned its investment at these relatively low discount rates. However, it should be noted here that these NPVs would be changed if the actual share data was applied.

The project innovations were being adopted by non-project *silis* even before the project had completed in 2006. These adoption rates were captured by the survey and presented in Table 9.5. Importantly the table shows that the four distinct innovations promoted by the project had very different adoption rates. The effective adoption rate of new sweetpotato cultivars was 34% among the Comparison Group. Members of the Comparison Group were not necessarily near neighbours of the Project Group; some were at great distance, e.g. a day's walk from Project *silis.* It is reasonable to expect high adoption rates to continue as this has happened all by word-of-mouth; i.e. not as a result of formal extension activity. The other innovations had lower adoption rates, and because they require various levels of instruction, it is necessary to continue the farmer-to farmer extension programmes.

The adoption survey indicates that pig innovations were not as readily adopted as improved sweetpotato cultivars. However, with appropriate farmer-to-farmer extension it is possible that adoption rates in the larger community may approach the 24-29% achieved within the Project Group. Even if a conservative 15% is assumed then it is clear that considerable impact on the monetised economy of the Baliem Valley within the 20 year scope of the NPV analysis.

Table 9.5. Adoption rates of the improved sweetpotato-pig systems in 2007

The improved sweetpotato-pig systems	Sili adopters		
	PG (n=38)	CG (n=570)	PG+CG (n=608)
	Number (%)		
New sweetpotato cultivars	38 (100)	194 (34)	232 (38)
Pig diets	11 (29)	74 (13)	85 (14)
Pigsty with access to *laleken* technology	11 (29)	11 (2)	22 (4)
Boar and sow management	9 (24)	6 (1)	15 (2)

Note: PG: Project Group, CG: Comparison Group including *silis* who were not chosen by the PSM method

The A$1,200 improvement in income assumed in the NPV analysis came mainly from sale of pigs, not sale of sweetpotatos. So the NPV analysis does not capture the immense and well-received benefit of the new cultivars. The improvements in reduced vulnerability and social cohesion are also not measured in NPV analysis. However, the evaluation in this study is not purely financial. The previous sections have shown through the quantitative and qualitative assessments made within the SL Framework, that there has been considerable positive impact of the project on the Baliem Valley community. The next section will show the comparison of the knowledge and recommendations developed here with similar uses of the SL framework in other contexts.

9.3.2. Uses of the SL framework in other contexts

Since its establishment in 1999 by DFID, the SL framework has been used in many different projects funded by many funding bodies in many developing countries particularly in Asia and Africa (Table 9.6). As a founder, DFID funded a significant number of projects in the early use of this framework (2000-2003). These projects by sectors include agriculture, livestock, forestry, fishery, natural resource management, and

Table 9.6. Comparison of the extent to which and the way in which the five components of the SL framework are used in the 21 projects and this project

No.	Project	Country	Year	The SL framework components					Use of the SL framework
				VC	LA	PIP	LS	LO	
1.	Country agricultural-based poverty reduction strategy[1] (DFID funded)	Cambodia	2000	✓	✓	✓	✓	✓	– As an analytical tool to design the strategy – Helped structure information, draw out key linkages, and ensure major issues covered and key information gaps identified
2.	Watershed development[2] (DFID funded)	India	2000	✓	✓	✓	✓	✓	– As an analytical tool to design and review the project – Added value to the project design and review process
3.	Wildlife conservation[3] (DFID funded)	East Africa	2000	✓	✓	✓	✓	✓	– As an analytical tool to develop methodologies for monitoring and evaluating the project – Demonstrated the relevance of the framework to impact monitoring and evaluation, identified appropriate methods which can be employed within the framework, and drew on lessons as to how to best develop the practical application of the framework
4.	Forestry policy[4] (DFID funded)	India	2000	×	✓	✓	×	×	– As an overview to analyse necessary institutions and policies – Helped analyse the nature and functions of different agencies in the forest environment of the Western Ghats of India and examine the relationship between these agencies and the development of livelihood assets
5.	Drinking water supply[5] (DFID funded)	Developing countries	2000	✓	✓	✓	✓	✓	– As analytical tool to help develop new approaches in order to better achieve the sustainability of drinking water supply
6.	Watershed development[6] (DFID funded)	India	2000	✓	✓	✓	✓	✓	– Project impact assessment: As a point of departure and an analytical tool – Identified the *qualitative* impact of the project
7.	Tourism[7] (DFID funded)	Namibia	2000	✓	✓	✓	✓	✓	– Project impact assessment: As a point of departure and an analytical tool – Primary data, both quantitative and qualitative, are collected in the context of the framework
8.	Modern Rice Varieties[8] (DFID funded)	Bangladesh	2003	✓	✓	✓	✓	✓	– Project impact assessment: As a point of departure and an analytical tool – In particular: Structured *qualitative* data collection and analysis
9.	Polyculture Fish-ponds and Improved Vegetables[9] (DFID funded)	Bangladesh	2003	✓	✓	✓	✓	✓	– Project impact assessment: As a point of departure and an analytical tool – In particular: Helped frame specific research questions, devise a *qualitative* data collection strategy, and orient the collection of supplementary data on a range of new issues
10.	Soil Fertility Replenishment (SFR) practices[10] (DFID funded)	Kenya	2003	✓	✓	✓	✓	✓	– Project impact assessment: As a point of departure and an analytical tool – Primary data, both quantitative and qualitative, are collected in the context of the framework
11.	Modern Maize Varieties[11] (DFID funded)	Zimbabwe	2003	✓	✓	✓	✓	✓	– Project impact assessment: As a point of departure and an analytical tool – In particular: Helped frame specific research questions and structure *qualitative* data collection and analysis

Table 9.6. (*cont.*)

12.	Improved Maize Varieties[12] (DFID funded)	Mexico	2003	✓	×	×	✓	✓	– Project impact assessment: As a point of departure and an overview. In particular: Structured *qualitative* data collection and analysis – Focused mainly on livelihood strategies and livelihood outcomes and the link between these two components to vulnerability context
13.	Watershed Development (WD)[13] (DFID funded)	India	2004	×	✓	×	×	×	– Project impact assessment: As a point of departure and an overview – Focused mainly on livelihood assets whereby the impact of WD is measured in terms of changes in the five types of livelihood assets using the double differences method (i.e. beneficiary vs. non-beneficiary households at before vs. after the interventions)
14.	Forages for Smallholders[14] (ACIAR funded)	Vietnam	2004	×	✓	×	✓	×	– As an overview to analyse rural livelihoods
15.	Agricultural land management practices in salt affected areas[15] (Pakistani government funded)	Pakistan	2005	×	✓	×	✓	×	– As an overview to analyse rural livelihoods
16.	Poverty reduction in marginal dry areas[16] (BMZ funded)	Syria	2006	×	✓	×	✓	×	– As an overview to analyse rural livelihoods
17.	Livelihood strategies in rural highlands[17] (USAID funded)	Kenya	2006	×	✓	×	✓	×	– As an overview to quantify asset-based livelihood strategies in the rural Kenyan highlands
18.	Fishermen community[18] (DFID funded)	Bangladesh	2007	✓	×	×	×	×	– As an approach to quantitatively measure vulnerability factors: problem identification.
19.	Household livelihood strategies and forest dependence[19] (VLIR funded)	Ethiopia	2008	×	✓	×	✓	×	– As an overview to examine livelihood strategies of those who rely on forest resources
20.	Environmental variability and vulnerable livelihoods[20]	Ghana	2009	✓	×	×	✓	×	– As an overview to examine changes in livelihood strategies and options in vulnerable environments of communities
21.	Livelihood assets and strategies among tobacco and non-tobacco growing households[21] (IDRC funded)	Kenya	2009	×	✓	×	✓	×	– As an overview to assess livelihood assets and strategies
22.	**Improved sweetpotato-pig systems** (ACIAR funded)	**Papua, Indonesia**	**2010**	✓	✓	✓	✓	✓	– **As a point of departure, an overview, and an analytical tool to quantify the impact of the project and use the measurable impact as a guide to provide policy advice**

Source: [1]Turton 2000a; [2]Turton 2000b; [3]Ashley and Hussein 2000; [4]Hobley and Shields 2000; [5]Nicol 2000; [6]Turton 2000c; [7]Ashley 2000; [8]Hossain et al. 2003; [9]Hallman et al. 2003; [10]Place et al. 2003; [11]Bourdillon et al. 2003; [12]Bellon et al. 2003; [13]Reddy et al. 2004; [14]Cramb et al. 2004; [15]Shah et al. 2005; [16]La Rovere et al. 2006; [17]Brown et al. 2006; [18]Nabi et al. 2007; [19]Babulo et al. 2008; [20]Assan et al. 2009; [21]Kibwage et al. 2009

even tourism. It is clear that this framework has been widely adapted and adopted for the purpose of development projects in developing countries. In general, this framework has been used in project design and review, monitoring and evaluation, and impact assessment.

However, the manner in which the SL framework has been used has varied over time. During 2000-2003, the early use of the framework, the majority of projects took all the five components of the framework into account. In contrast, from 2004 onwards the projects tended to focus on the livelihood assets and strategies component only. One can detect from Table 9.6 three distinct ways in which the SL framework has been used since its inception in 2000:

1. ***Analytical tool.*** The majority of the 2000-2003 projects used the whole framework as a comprehensive analytical tool incorporating the five components (projects 1-3, 5-11). They explored in detail the livelihood priorities of target communities by identifying the factors that make their livelihood vulnerable, and assets and access to assets that can be used to reduce the vulnerability factors. They formulated policy advice concerning the institutions and processes that can enhance livelihood priorities, strategies and outcomes. As an analytical tool the SL framework directed the process of analysis orderly from the identification of livelihood problems (i.e. vulnerability context) to the provision of livelihood options (i.e. livelihood strategies and outcomes).

2. ***Impact assessment.*** Another set of projects used the framework for project impact assessment. Most of these used the framework as an analytic tool (projects 6-11). However, two of the projects (projects 12-13) just used the framework as an overview; i.e. to provide the big picture from which one can see an appropriate entry point to initiate assessment of the project. These overlap somewhat with the next category.

3. ***Overview.*** The projects from 2004 onwards (projects 13-21) did not use all components of the SL Framework, and apart from project 13, nor did they use it for impact assessment. Instead the framework was used as an overview from which they just used those components that directly related to their project objectives. These projects focused only on the 'livelihood assets and strategies'

components as they only attempted to examine what their target communities have (i.e. available assets) and how these assets are used (i.e. strategies) in order to provide appropriate policy advice which can enhance livelihood impacts.

Moreover, when the framework was employed as an ***analytical tool***, it was found to be useful in generating *qualitative* information, but difficult in *quantifying* change. These projects successfully provided policy advice based on qualitative information they generated through the framework, but they failed to measure the extent to which the change was affected by the projects. Each project claimed that this was too difficult to do. This failure likely led to the employment of the framework as an ***overview.*** Employing the framework as an overview allowed users to focus on certain components and thus avoided generating excessive qualitative information. Evidence from the 2004 onwards projects indicated that these projects have successfully quantified the extent to which the change was affected by the projects. However, since the framework used as an overview only focused on certain components, the analysis was of course not as comprehensive as the framework as an analytical tool.

The approach taken in this PhD study is unique in that it combines the three categories of using the SL framework, and attempts to overcome the limitations of previous approaches. It has used the ***overview*** provided by the SL framework to understand what components of the farming systems of the Baliem Valley should be studied. Chapter 5 quantitatively established the key importance of the traditional sweetpotato-pig production systems in Dani livelihoods. Later on, the framework prompted the study to focusing on the vulnerability context and livelihood assets components as presented in Chapter 6, 7, and 8. Chapter 6 quantitatively measured the ecological balance between humans, sweetpotatoes and pigs; the change in use of sweetpotatoes and pigs from participation in the ACIAR project; and ranks the significance of the various vulnerability factors of Dani traditional sweetpotato and pig production. Chapter 7 and 8 quantitatively measured the impact of the ACIAR project in terms of changes in natural and physical assets (Chapter 7) and human, social and financial assets (Chapter 8). So these chapters were using the SL framework for quantitative ***impact assessment***. Finally, it has employed the framework as an ***analytical tool*** re-visiting the knowledge gained from Chapter 5-8 to

provide appropriate policy advice including necessary institutions and processes involved as structured in the policies, institutions, and processes component.

Overall, there are similarities and differences between this project and the 2000-2003 and 2004 onwards projects in the development of knowledge and recommendations (i.e. policy advice) through the use of the SL framework (Table 9.7). This project and the 2000-2003 projects are similar as both made use of the five components of the SL framework, but they are different as this project set up recommendations mainly based on *quantitative* impact measures while the 2000-2003 projects built their recommendations based on mainly *qualitative* impact measures. In contrast, this project and the 2004 onwards projects are similar as both set up recommendations mainly based on quantitative impact measures, but they are different as this project made use of the five components of the SL framework while the 2004 onwards projects only focused on certain components. This project offers a relatively more comprehensive impact evaluation while it provides a relatively more quantification of impacts to set up recommendations.

Table 9.7. Similarity and difference between this project and the 2000-2003 and 2004 onwards projects in the development of knowledge and recommendations through the use of the SL framework

Comparison	Similarity	Difference
This project vs the 2000-2003 projects	Made use of the five components of the SL framework	This project set up recommendations mainly based on *quantitative* impact measures, while the the 2000-2003 projects built their recommendations mainly based on *qualitative* impact measures
This project vs the 2004 onwards projects	Set up recommendations mainly based on quantitative impact measures	This project made use of the five components of the SL framework, while the 2004 onwards projects focused only certain components

9.4. Some closing words

This PhD study attempts to answer what the impacts of the ACIAR project were and how these impacts be evaluated using the SL framework. Therefore, the aim of this study is to evaluate the impact of the ACIAR projects on the Dani people

in Papua, Indonesia and to examine the value of the SL framework for the purpose of impact evaluation.

This study has provided clear quantified improvements in the Dani society gained through agricultural research as part of development efforts in the Baliem Valley. It has also shown good adoption of the innovations for future extension efforts as well as produced a number of recommendations which need to take into account for equitable and sustainable agricultural development for the benefit of local people in the region and maybe beyond Papua.

This study has further examined the value of the SL framework for the purpose of impact evaluation. It has shown that the SL framework can be used to capture the impact of agricultural research in a relatively comprehensive manner. In terms of cost and time, using this framework has relatively been inexpensive. It cost A$20,000 for the entire 11 months of fieldwork to collect necessary data, and key researchers time of two years worth about $60,000 roughly (in terms of scholarship stipend provided by ACIAR) to analyse the data and write the thesis.

Overall, the real value of this type of study has been clear. For the Dani people, they had a great opportunity to involve in the process of evaluation (e.g. determine what, to what extent, and how to evaluate) as part of their learning processes. For the organisations, both government and non-government, working in the Baliem Valley, they had clear direction as to what to do next as part of their continuing efforts to enhance the development of the region. For the Baliem Valley, this region could be proud of all the improvements they made over the project period and the other potential improvements they possibly could achieve in the deeper future. For ACIAR, if they were only relying on economic impact evaluation such as NPV analysis, they might be satisfied, but this study showed all the values not easily translated into the value of money.

10. Conclusion

Three sets of conclusions emerged from this study: (1) conclusions on the impact of the ACIAR project on Dani livelihoods, (2) conclusions resulting in recommendations for sustainable and more equitable agricultural development in the Baliem Valley, and (3) conclusions on the value of the SL framework for the purpose of impact evaluation.

10.1. The impact of the ACIAR project on Dani livelihoods

1. Key impacts emerged in natural, physical, human, social and financial livelihood assets. Embodied in their sweetpotato garden (***natural assets)***, the Dani improved their crop genetic diversity by the adoption of new sweetpotato cultivars, enhanced production efficiency, production cycles and resilience against environmental stress, and increased yields. In access to natural resources, they became less dependent on natural resource products for income. In ***physical assets***, they improved most of their physical *sili* goods, in particular the adoption of pigsty-*laleken* technology. In ***human assets***, they now enjoy better education and improvement in their sweetpotato-pig husbandry skills. In ***social assets***, social cohesion improved through the formation of a group of farmers in association with the project. Finally, in ***financial assets***, the capacity to produce more sweetpotatoes and pigs resulted in higher incomes from selling their pigs and non-agricultural salaries.
2. Participation in the project reduced the vulnerability factors of sweetpotato and pig production sub-systems. These factors were marauding pigs, soil hydrology of gardens, technical assistance from institutions, and yields in sweetpotato production; and diseases, technical assistance from institutions, diets quality, and custom ceremonies in pig production.

10.2. Policy proposals, institutions involved, and necessary processes

3. Drawing on the impact of the ACIAR project, seven policies were proposed: (1) extension of the improved sweetpotato-pig systems through training-of-trainers

and farmer-to-farmer extension programmes; (2) efficient sweetpotato-pig husbandry and other agricultural technical assistance from locally available institutions; (3) the formation of *sili* organisations in every village; (4) equitable sweetpotato-pig husbandry and other agricultural training opportunity for both Dani men and women; (5) wider access to loans from locally available financial institutions; (6) on-farm multiplication of new sweetpotato cultivar cuttings; and (7) regulations to control marauding pigs.

4. For these proposed policies to take place effectively, a number of institutions were suggested to be involved. These institutions included both government and non-government organisations. They were the Jayawijaya Extension Office, the Jayawijaya Agricultural Office, the Jayawijya Livestock Office and the Jayawijaya Co-operative Office (government organisations); and the World Vision Indonesia and the Jayawijaya Institute for Customary Discussion (non-government organisations). Close collaboration between these organisations were also suggested.
5. Participation is at the core of any attempts to formulate and implement policies in an efficient manner. Accordingly two processes were recommended: (1) the widely participation of *silis* in the formulation of policies, and (2) the provision and continuation of training opportunities for local staff within organisations working in the Baliem Valley.

10.3. The value of the SL framework for the purpose of impact evaluation

6. The use of the SL framework by other workers was examined and revealed that there are three categories of use: (1) as an ***analytical tool***, (2) for ***impact assessment***, and (3) as an ***overview***. When the SL framework has been used for impact assessment in the past it has been as either as an analytical tool or just an overview to guide the assessment. When used as an analytical tool it mainly generated *qualitative* information, but the evaluation failed to quantify changes. In contrast, as when used as an overview it allowed the *quantification* of changes, but the evaluation was not comprehensive.
7. This PhD study has combined the three categories of using the SL framework, and eliminated the limitations of each of the categories when it was applied solely. It

has used the ***overview*** provided by the SL framework to understand what components of the farming systems of the Baliem Valley should be studied. At this point, it *quantitatively* established the key importance of the traditional sweetpotato-pig production systems in Dani livelihoods. Later on, the framework prompted the study to focusing on the vulnerability context and livelihood assets components. At this point, it quantitatively measured the significance of the various vulnerability factors of Dani traditional sweetpotato and pig production, and the impact of the ACIAR project in terms of changes in natural, physical, human, social and financial livelihood assets and how these changes influenced livelihood strategies and outcomes. So the SL framework has been used for quantitative ***impact assessment***. Finally, it has used the framework as an ***analytical tool*** re-visiting the knowledge gained previously to provide recommendations according to the policies, institutions, and processes component.

8. Overall, this PhD study offers a relatively more comprehensive impact evaluation while it provides a relatively more quantification of impacts.

References

Abaru, M.B., A. Nyakuni and G. Shone. 2006. *Strengthening farmer's organizations: RELMA's experience in Eastern and Southern Africa*. ICRAF Working Paper no 23. World Agroforestry Centre, Nairobi.

Achmady, L. and J. Schneider. 1995. Tuber crops in Irian Jaya: Diversity and the need for conservation. In: J. Schneider (ed.). *Indigenous Knowledge in Conservation of Crop Genetic Resources*. International Potato Center (CIP) and Central Research Institute for Food Crops (CRIFC), Bogor, pp. 71-79.

ACIAR. 2005. *Research that Works: Indonesia Country Profile*. Australian Centre for International Agricultural Research (ACIAR), Canberra.

_____. 2009. *Annual Operational Plan 2009-10*. Australian Centre for International Agricultural Research (ACIAR), Canberra.

Adato, M. and R. Meinzen-Dick. 2002. *Assessing the Impact of Agricultural Research on Poverty Using the Sustainable Livelihoods Framework.* FCND Discussion Paper No. 128. International Food Policy Research Institute (IFPRI), Washington, D.C.

ADB. 2006. *Impact Evaluation. Methodological and Operational Issue*. Asian Development Bank (ADB), Manila.

Aditjondro, G.J. 1982. The Irianese ethnic minorities in Indonesia. An issue of national integration. *Impact* 17(2): 37-63.

Alene, A.D. and O. Coulibaly. 2009. The impact of agricultural research on productivity and poverty in Sub-Saharan Africa. *Food Policy* 34: 198-209.

Alston, J.M., G.W. Norton and P.G. Pardey. 1998. *Science under Scarcity. Principles and Practice for Agricultural Research Evaluation and Priority Setting*. CAB International, Wallingford.

Alua, A.A. 2006. *Permulaan Pekabaran Injil di Lembah Baliem: Peringatan 50 Tahun Jubelium Pekabaran Injil di Lembah Baliem 20 April 1954-2004* (*Early Evangelism in the Baliem Valley: Fifty Years Celebration of Evangelism in the Baliem Valley 20 April 1954-2004*. Biro Penelitian STFT Fajar Timur, Jayapura.

Ananth, B. 2005. Financing microfinance – the ICICI Bank partnership model. *Small Enterprise Development* 16(1): 57-65.

Angrist, J. and A. Krueger. 2001. Instrumental variables and the search for identification: From supply and demand to natural experiments. *Journal of Economic Perspectives* 15(4): 69–85.

Ashley, C. and D. Carney. 1999. *Sustainable Livelihoods: Lessons from Early Experience*. Department for International Development (DIFD), London.

_____. and K. Hussein. 2000. *Developing Methodologies for Livelihood Impact Assessment: Experience of the African Wildlife Foundation in East Africa.* Working Paper 129. Overseas Development Institute (ODI), London.

Atkinson, A.B. and F. Bourguignon. 2000. *Handbook of Income Distribution.* Volume I. Elsevier, Amsterdam.

Babbie, E.R. 1973. *Survey Research Methods*. Wadsworth Publishing Company, Inc., Belmont.

Babulo, B., Muys, B., Nega, F., Tollens, E., Nyssen, J., Deckers, J. and Mathijs, E. 2008. Household livelihood strategies and forest dependence in the highlands of Tigray, Northern Ethiopia. *Agricultural Systems* 98: 147-155.

Baker, J. L. 2000. *Evaluating the Impact of Development Projects on Poverty: A Handbook for Practitioners.* World Bank, Washington, D.C.

Ballard, C. 2000. Condemned to Repeat History? Enso-Related Drought and Famine in Irian Jaya, Indonesia: 1997-8. In: R.H. Grove and J. Chappel (eds.). *El-Niño History and Crisis: Studies from the Asia Pacific Region.* The White Horse Press, Kapwell, pp. 123-148.

Bamberger, M. 2000. *Integrating Quantitative and Qualitative Methods in Development Research.* World Bank, Washington, D.C.

_____. 2006. *Conducting Quality Impact Evaluations under Budget, Time and Data Constraints.* World Bank, Washington, D.C.

_____. 2009. *Institutionalizing impact evaluation within the framework of a monitoring and evaluation system*. World Bank, Washington, D.C.

Bappenas Indonesia. 2004. *Indonesia Progress Report on the Millennium Development Goals*. Badan Perencanaan dan Pembangunan Nasional Indonesia, Jakarta.

Barnow, B. The Impact of CETA Programs on Earnings: A Review of the Literature. *Journal of Human Resources* 22 (2): 157–193.

Barrett, C.B., T. Reardon and P. Webb. 2001. Nonfarm Income Diversification and Household Livelihood Strategies in Rural Africa: Concepts, Dynamics, and Policy Implications. *Food Policy* 26(5): 315-331.

Bellon, M.R., M. Adato, J. Becerril and D. Mindek. 2005. *Impact of Improved Germplasm on Poverty Alleviation: The Case of Tuxpeño-Derived Materials in Mexico*. International Maize and Wheat Improvement Center (CIMMYT), Mexico, D.F.

Bensley, J. 1994. *The Dani church of Irian Jaya and the challenges it is facing today*. MA thesis. Monash Asia Institute, Monash University, Melbourne.

Berry, P.M., M.D.A. Rounsevell, P.A. Harrison and E. Audsley. 2006. Assessing the vulnerability of agricultural land use and species to climate change and the role of policy in facilitating adaptation. *Environmental Science & Policy* 9: 189-204.

BKD Jayawijaya. 2007. *Local institutional staff data 2006/2007*. Badan Kepegawaian Daerah Jayawijaya, Wamena (in Indonesian).

BMG Jayawijaya. 2006. *Temperature and Rainfall Jayawijaya Regency 1987-2006*. Badan Meteorologi Geofisika Jayawijaya, Wamena (In Indonesian).

Boelaars, J. 1986. *Irian people: Past, Now, and Future (Manusia Irian: Dahulu, Sekarang, dan Masa Depan)*. PT. Gramedia, Jakarta.

Bourdillion, M., P. Hebinck, J. Hoddinott, B. Kinsey, J. Marondo, N. Mudege and T. Owens. 2003. *Assessing the Impact of High-Yielding Varieties of Maize in Resettlement Areas of Zimbabwe*. FCND Discussion Paper No. 161. International Food Policy Research Institute (IFPRI), Washington, D.C.

BMG Jayawijaya. 2006. *Rainfall and Temperature in Jayawijaya Regency 1987-2006*. Wamena: Badan Meteorologi dan Geofisika Jayawijaya (in Indonesian).

BPS Indonesia. 2008. *Indonesia in Figures 2008*. Badan Pusat Statistik Indonesia, Jakarta.

_____. 2009. *Trends of the Selected Socio-Economic Indocators of Indonesia March 2009*. Badan Pusat Statistik Indonesia, Jakarta.

BPS Jayawijaya. 2006. *Jayawijaya in Figures 2006*. Badan Pusat Statistik Jayawijaya, Wamena.

BPS Papua. 2008. *Papua in Figures 2008*. Badan Pusat Statistik Papua, Jayapura.

Braun, A.R., G. Thiele and M. Fernandez. 2000. *Farmer Field Schools and Local Agricultural Research Committees: Complementary Platforms for Integrated Decision-Making in Sustainable Agriculture*. AgREN Network Paper No. 105. Overseas Development Institute (ODI), London.

Bredahl, M.E. and W.L. Peterson. 1976. The productivity and allocation of research at U.S. agricultural experiment stations. *American Journal of Agricultural Economic*, 58(4): 684-692.

Bromley, H.M. 1972. *The Grammar of Lower Grand Valley Dani in Discourse Perspective*. PhD dissertation. Yale University, New Haven.

Brown, D.R., E.C. Stephens, J.O. Ouma, F.M. Murithi and C.B. Barrett. 2006. Livelihood strategies in the rural Kenyan highlands. *Afjare* 1(1): 21-36.

Bryson, A., R. Dorsett and S. Purdon. 2002. *The Use of Propensity Score Matching in the Evaluation of Active Labour Market*. Working Paper No. 4. Department of Work and Pensions (DWP), London.

Buddelmeyer, H. and E. Skoufias. 2004. *An Evaluation of the Performance of Regression Discontinuity on PROGRESA*. Policy Research Working Paper 3386. World Bank, Washington, D.C.

Butt, L. 1998. *The social and political life of infants among the Baliem Valley Dani, Irian Jaya*. PhD dissertation. Department of Anthropology, McGill University, Montreal.

Bystrom, M. 2004. *Formal and Informal Systems in Support of Farmer Management of Agro-Biodiversity: Some Policy Challenges to Consolidate Lessons Learned.* CAPRi Working Paper No. 31. International Food Policy Research Institute (IFPRI), Washington, D.C.

Caliendo, M. and S. Kopeinig. 2005. *Some Practical Guidance for the Implementation of Propensity Score Macthing.* IZA DP No. 1588. Institute for the Study of Labor (IZA), Bonn.

Cargill, C.F. 2009. *Poverty alleviation and food security through improving the sweetpotato-pig systems in Papua, Indonesia*. Final Report. Australian Centre for International Agricultural Research (ACIAR), Canberra.

Carvalho, S. and H. White. 2004. Theory-based evaluation: the case of social funds. *American Journal of Evaluation* 25(2): 141-160.

Carney, D. 1998. *Sustainable Rural Livelihoods: What Contribution Can We Make?* Department for International Development (DFID), London.

_____. 1999. *Livelihood approaches compared*. Department for International Development (DFID), London.

_____. 2003. *Sustainable Livelihoods Approaches: Progress and Possibilities for Change.* Department for International Development (DIFD), London.

CGIAR. 2006. Impact Assessment Methods. http://impact.cgiar.org/methods/basics.asp. Accessed on 29/6/2006.

Chambers, R. and G.R. Conway. 1992. *Sustainable rural livelihoods: practical concepts for the 21st century.* IDS Discussion Paper No. 296. IDS, Brighton.

Clark, N., A. Hall, R. Sulaiman and G. Naik. 2003. Research as Capacity Building: The Case of an NGO Facilitated Post-Harvest Innovation System for the Himalayan Hills. *World Development* 31(11): 1845–1863.

Collins, N. and N. Mack. 1995. Farm household participation in agricultural policy decision making. *Irish Political Studies* 10(1): 1-25.

Cramb, R.A. and T. Purcell. 2001. *Developing Forage Technologies with Smallholder Farmers: How to Monitor and Evaluate Impacts*. ACIAR Impact Assessment Program Working Paper Series No. 41. Australian Centre for International Agricultural Research (ACIAR), Canberra.

_____. and T.C.S. Ho. 2004. Participatory assessment of rural livelihoods in the Central Highlands of Vietnam. *Agricultural Systems* 81: 255-272.

CRS. 2008. *Developing Agriculture Loan Products for Poor Rural Communities: Metemamen Microfinance Institution in Ethiopia*. Microfinance Learning Paper Series No.2. Catholic Relief Services (CRS), Addis Ababa.

Cromwell, E., P. Kambewa, R. Mwanza, R. Chirwa and KWERA Development Centre. 2001. *Impact Assessment Using Participatory Approaches: 'Starter Pack' and Sustainable Agriculture in Malawi*. Agren Network Paper No. 112. Agricultural Research and Extension Network (AGREN), London.

Czajka, J., S.M. Hirabayashi, R.J. A. Little and D.B. Rubin. 1992. Projecting from Advance Data Using Propensity Modeling: An Application to Income and Tax Statistics. *Journal of Business and Economic Statistics* 10 (2): 117–131.

Darmajana, R.D.A. 1996. Introducing Agricultural Technologies in Rural Development Programs in Wamena. *In*: A. S. Susanto-Sunario (ed.). *Rural Society Development: An Analitical Review of Wamena Society, Irian Jaya*. Pustaka Sinar Harapan, Jakarta (in Indonesian), pp. 16-35.

Davis, J., J. Gordon, D. Pearce and D. Templeton. 2008. *Guidelines for assessing the impacts of ACIAR's research activities.* Australian Centre for International Agricultural Research (ACIAR), Canberra.

Davis, K. 2006. Farmer Field Schools: A Boon or Bust for Extension in Africa? *Journal of International Agricultural and Extension Education* 13(1): 91-97.

_____. and E. Nkonya. 2008. *Developing a Methodology for Assessing the Impact of Farmer Field Scholls in East Africa*. E.A.R.T.H. University, Costa Rica.

Dehejia, R.H. and S. Wahba. 1999. Causal Effects in Non-Experimental Studies: Re-Evaluating the Evaluation of Training Programs. *Journal of the American Statistical Association* 94(448): 1053–1062.

_____. 2002. Propensity Score Matching Methods for Non-experimental Causal Studies. *The Review of Economics and Statistics* 84(1): 151-161.

Deng, X., Y. Luo, S. Dong and X. Yang. 2005. Impact of resources and technology on farm production in northwestern China. *Agricultural Systems* 84: 155-169.

DFID. 1998. *Sustainable Livelihoods: Building on Strengths*. Department for International Development (DFID), London.

____. 1999. *Sustainable Livelihood Guidance Sheets*. Department for International Development (DFID), London.

Disnak Jayawijaya. 2007a. *Staff data 2006/2007*. Dinas Peternakan Jayawijaya, Wamena (in Indonesian).

_____. 2007b. *The Jayawijaya Livestock Office Annual Report 2006/2007*. Dinas Peternakan Jayawijaya, Wamena (in Indonesian).

Douthwaite, B., T. Kuby, E. van de Fliert and S. Schulz. 2003. Impact pathway evaluation: an Approach for achieving and attributing impact in complex systems. *Agricultural Systems* 78: 243-265.

_____, S. Schulz, A.S. Olanrewaju and J. Ellis-Jones. 2007. Impact pathway evaluation of integrated *Striga hermonthica* control project in Northern Nigeria. *Agricultural Systems* 92: 201-222.

Drinkwater, M. and T. Rusinow. 1999. Application of CARE's livelihoods approach. Presentation on CARE's livelihoods approach for NRAC 1999. http://www.**care**international.org.uk/download.php?id=160. Accessed on 24/10/2009.

Eicher, C.K. 1990. Building African Scientific Capacity for Agricultural Development. *Agricultural Economics* 4: 117-143.

Ellis, F. and H.A. Freeman (eds.). 2005. *Rural Livelihoods and Poverty Reduction Policies*. Routledge, London.

Evenson, R.E. and C. Pray (eds). 1991. *Research and Productivity in Asian Agriculture.* Cornell University Press, Ithaca.

Ezemeneri, K., A. Rudqvist and K. Subbarao. 1999. *Impact Evaluation: A Note on Concepts and Methods*. Poverty Reduction and Economic Management Network (PREMN), Washington D.C.

Feder, G., R. Murgai and J.B. Quizon. 2004. Sending farmers back to school: The impact of farmer field schools in Indonesia. *Review of Agricultural Economics* **26**: 45–62.

Flores-Moya, P., R. E. Evenson and Y. Hayami. 1978. Social returns to rice research in the Philippines: Domestic benefits and foreign spillovers. *Economic Development and Cultural Change* 26(3): 591-607.

Friedlander, D., D. Greenberg and P. Robins. 1997. Evaluating Government Training Programs for the Economically Disadvantaged. *Journal of Economic Literature* 35 (4): 1809–1855.

Gacitua-Mario, E. and Q. Woden. 2001. *Measurement and meaning: Combining quantitative and qualitative methods for the analysis of poverty and social exclusion in Latin America.* World Bank, Washington, D.C.

Galasso, E. and M. Ravallion. 2004. Social Protection in a Crisis: Argentina's Plan *Jefes y Jefas*. *World Bank Economic Review* 18(3): 367-400.

Garbarino, S. and J. Holland. 2009. *Quantitative and Qualitative Methods in Impact Evaluation and Measuring Results. Issues Paper.* Governance and Social Development Resource Centre (GSDRC), Birmingham.

Gardner, R. and K.G. Heider. 1968. *Gardens of War: Life and Death in the New Guinea Stone Age*. Random House, New York.

Golson, J. 1997. From horticulture to agriculture in the New Guinea Highlands: A case study of people and their environment. In: P.V. Kirch and T.L. Hunt (eds.). *Historical*

Ecology in the Pacific Islands: Prehistoric Environmental and Landscape Change. Yale University Press, New Haven, pp. 39-50.

Gomes, F. and M.K.V. Carr. 2003. Effects of Water Availability and Vine Harvesting Frequency on the Productivity of Sweetpotato in Southern Mozambique. II. Crop Water Use. *Experimental Agriculture* 39: 39-54.

Griliches, Z. 1958. Research costs and social returns: Hybrid corn and related innovations. *Journal of Political Economy* 66: 419-431.

Hallman, K., D. Lewis and S. Begum. 2003. *An Integrated Economic and Social Analysis to Assess the Impact of Vegetable and Fishpond Technologies on Poverty in Rural Bangladesh*. FCND Discussion Paper No. 163. International Food Policy Research Institute (IFPRI), Washington, D.C.

Hannah, S.T. and P.B. Lester. 2009. A multilevel approach to building and leading learning organizations. *The Leadership Quarterly* 20: 34–48.

Harding, M., T. Jiang and D. Pearce. 2009. *Analysis of ACIAR's returns on investment: appropriateness, efficiency and effectiveness*. Australian Centre for International Agricultural Research (ACIAR), Canberra.

Haynes, P. 1989. Agriculture, Soil, and Climate in Irian Jaya. *Irian* 12: 89-105.

Heckman, J. 1997. Instrumental variables: A study of implicit behavioral assumptions used in making program evaluations. *Journal of Human Resources* 32(3): 441-462.

_____, H. Ichimura, J. Smith and P. Todd. 1996. Sources of Selection Bias in Evaluating Social Programs: An Interpretation of Conventional Measures and Evidence on the Effectiveness of Matching as a Program Evaluation Method. *Proceedings of the National Academy of Sciences* 93 (23): 13416–13420.

_____. 1998. Characterizing Selection Bias Using Experimental Data. *Econometrica* 66 (5): 1017–1098.

_____ and P. Todd. 1997. Matching as an Econometric Evaluation Estimator: Evidence from Evaluating a Job Training Programme. *Review of Economic Studies* 64 (4): 605–654.

_____. 1998. Matching as an Econometric Evaluation Estimator. *Review of Economic Studies* 65 (2): 261–294.

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

Helmore, K. 1998. Local know-how the right stuff. *Choices* 7(3): 6-14.

Hide, R. 2003. *Pig Husbandry in New Guinea: A Literature review and Bibliography*. Australian Centre for International Agricultural Research (ACIAR), Canberra.

Holland, J. and J. Campbell (eds). 2005. *Methods in development research: Combining qualitative and quantitative approaches*. ITDG Publications, London.

Hope, R.A. 2006. *Evaluating social impacts of watershed development in rural India*. Centre for Land Use and Water Resources Research (CLUWR), Newcastle.

Hossain, M., D. Lewis, M.L. Bose and A. Chowdhury. 2003. *Rice Research, Technological Progress, and Impacts on the Poor: The Bangladesh Case*. EPTD Discussion Paper No. 110. International Food Policy Research Institute (IFPRI), Washington, D.C.

Hyman, G., S. Fujisaka, P. Jones, S. Wood , M. Carmen de Vicente and J. Dixon. 2008. Strategic approaches to targeting technology generation: Assessing the coincidence of poverty and drought-prone production. *Agricultural Systems* 98: 50-61.

IFAD. 2002. *A Guide for Project M&E*. International Fund for Agricultural Development (IFAD), Rome.

____. 2006. *An IFAD Sustainable Livelihoods Framework*. International Fund for Agricultural Development (IFAD), Rome.

Indonesia. 2001. *Law No. 21/2001 on Special Autonomy for the Province of Papua*. The State Secretariat of the Republic of Indonesia, Jakarta.

_____. 2004. *Peta Kabupaten Jayawijaya* (*Map of Jayawijaya Regency*). Jayawijaya Agricultural and Forestry Information and Extension Office, Wamena.

_____. 2006a. *Jayawijaya dalam Angka 2006* (*Jayawijaya in Figures 2006*). Jayawijaya Statistical Office, Wamena.

_____. 2006b. Suhu dan Curah Hujan Kabupaten Jayawijaya 1987-2006 (Temperature and Rainfall Jayawijaya Regency 1987-2006). Jayawijaya Geo-Meteorological Office, Wamena.

_____. 2006c. Papua dalam Angka 2006 (Papua in Figures 2006). Papua Statistical Office, Jayapura.

_____. 2007. *Laporan Tahunan Dinas Peternakan Kabupaten Jayawijaya 2006/7* (*Jayawijaya Livestock Office Annual Report 2006/7*). Jayawijaya Livestock Office, Wamena.

IWDS. 1994. *National Sectoral Report on Women, Agriculture and Rural Development*. Integration of Women in Development Service (IWDS), Food and Agriculture Organization (FAO) of the United Nations, Rome.

Jayasuriya, R.T. 2003. Economic assessment of technological change and land degradation in agriculture: application to Sri Lanka tea sector. *Agricultural Systems* 78: 405-423.

Jayawijaya Government Office. 2010. *Situs Resmi Pemerintah Daerah Kabupaten Jayawijaya (The Official Website of the Jayawijaya Government Office)*. http://www.jayawijayakab.go.id. Accessed on 3/7/2010.

Jusuf, M., A. Setiawan, D. Peters, C. Cargill, S. Mahalaya, J. Limbongan and Subandi. 2007. Improving the efficiency of sweetpotato-pig production in the Jayawijaya Regency, Papua. In: J. Limbongan (ed.). *Proceedings of the National Seminar and Expose of*

the Acceleration of Local specific-based Agricultural Technology Innovation to Support the Development of Villages in Papua. Balai Pengkajian Teknologi Pertanian Papua), Jayapura, pp. 71-95.

Kahn, K.B. 2001. Market orientation, interdepartmental integration, and product development performance. *The Journal of Production Innovation Management* 18(5): 314–323.

Kapoor, A.G. 2002. *Review of Impact Evaluation Methodologies Used by the Operations Evaluation Department Over Past 25 Years*. The Operations Evaluation Department (OED), World Bank, Washington D.C.

Karafir, Y.P. 1988. *Pola-pola Ekonomi Daerah Pedesaan di Kabupaten Yapen Waropen* (*The Economic Patterns of Rural Areas in the Yapen Waropen District*). A Paper presented at the Seminar on Irian Jaya Development and Research in Eastern Indonesia II, Jayapura, 18-23 July.

Kariuki, L.N. 2006. Participation of smallholders in international trade. In: R. Ruben, M. Slingerland and H. Nijhoff (eds.). *Agro-food chains and networks for development*. Springer, New York, pp. 41-48.

Kepas. 1990. *Agro-ecosystems Analysis for Rural Development in Irian Jaya: The case of six villages (Analisis Agro-ekosistem untuk Pembangunan Masyarakat Pedesaan Irian Jaya: Kasus enam desa)*. Kelompok Penelitian Agro-ekosistem, Badan Penelitian dan Pengembangan Pertanian, Universitas Cendrawasih, Jayapura.

Kerr, J. and K. Chung. 2002. Evaluating watershed management projects. *Water Policy* 3(6): 537-554.

Ketaren, P.P. 2005. *Proximate analysis of twenty cultivars from the Baliem Valley of Papua*. Unpublished report. Balai Penelitian Ternak, Bogor.

Kibwage, J.K., A.J. Odondo and G.M. Momanyi. 2009. Assessment of livelihood assets and strategies among tobacco and non-tobacco growing households in South Nyanza region, Kenya. *African Journal of Agricultural Research* 4(4): 294-304.

KIPPK Jayawijaya. 2004. *Map of the Jayawijaya Regency*. Kantor Informasi Penyuluhan Pertanian dan Kehutanan Jayawiya (KIPPK Jayawijaya), Wamena (in Indonesian).

Knutsson, P. and M. Ostwald. 2006. A process-oriented sustainable livelihoods approach – A toll for increased understanding of vulnerability, adaptation and resilience. *Mitigation and Adaptation Strategies for Global Change* (2006).

Kristjanson, P.M., and P.K. Thornton. 2004. *Methodological challenges in evaluating impact of crop-livestock interventions.* International Livestock Research Institute (ILRI), Nairobi.

La Rovere, R., A. Aw-Hassan, F. Turkelboom and R. Thomas. 2006. Targeting Research for Poverty Reduction in Marginal Areas of Rural Syria. *Development and Change* 37(3): 627-648.

Lassa, J. 2004. *A Preliminary Study on Food and Livelihood Security in Highland Wamena, West Papua, Indonesia*. Penguatan Institusi dan Kapasitas Lokal (PIKL), Kupang.

Lautze, S., and A. Raven-Roberts. 2003. *The Vulnerability Context: Is There Something Wrong with this Picture? Embedding vulnerability in livelihoods models: a work in progress*. Feinstein International Famine Center, Tufts University, Medford.

Leeuw, F. and Vaessen, J. 2009. *Impact Evaluations and Development. NONIE Guidance on Impact Evaluation*. NONIE, Washington D.C.

Leigh, J.P. and M. Schembri. 2004. Instrumental variables technique: cigarette price provided better estimate of effects of smoking on SF-12. *Journal of Clinical Epidemiology* 57(3): 284–293.

Lemke, U. and Zarate, V.A. 2008. Dynamics and development trends of smallholder pig production systems in North Vietnam. *Agricultural Systems* 96: 207–223.

_____ B.A. Kaufmann, L.T. Thuy and V.A. Zárate. 2005. *Evaluation of smallholder pig production systems in North Vietnam*. Paper presented in the 56th Annual Meeting of the European Association for Animal Production, Uppsala, Sweden, 5-8 June.

Likert, R. 1932. A Technique for the Measurement of Attitudes. *Archives of Psychology* 22 (140): 1-55.

Limbongan, J. and A. Soplanit. 2007. Ketersedian Teknologi dan Potensi Pengembangan Ubi Jalar (*Ipomoea batatas L*.) di Provinsi Papua (The Availability of Technology and Potency of Sweetpotato (*Ipomoea batatas L*) Development in Papua Province). *Jurnal Litbang Pertanian (Agricultural Research and Development Journal)* 26(4): 1-8.

Lipton, M. and M. Ravallion. 1995. Poverty and Policy. In: J. Behrman and T.N. Srinivasan (eds.). *Handbook of Development Economics.* Volume III. Elsevier, Amsterdam.

Lokobal, N.A., A.A. Alua and T.N. Mulait. 2006. *Nilai-nilai Hidup Masyarakat Hubula di Lembah Baliem Papua* (*The Life Values of Hubula Society in the Baliem Valley of Papua*. Biro Penelitian STFT Fajar Timur, Jayapura.

Mackay, R. and D. Horton. 2003. Expanding the use of impact assessment and evaluation in agricultural research and development. *Agricultural Systems* 78: 143-165.

Mahalaya, S., C. Cargill and L. Kossay. 2005. *Poverty Alleviation and Food Security through Improving the Sweetpotato-Pig Systems in Papua, Indonesia: Plans to Measure Outcomes and Impacts*. Paper presented at the UPWARD Network Meeting, Hanoi, 18-23 January.

_____ and I. Nuberg. 2010. Impact of agricultural intervention on natural and physical livelihood assets of traditional farming systems in Papua, Indonesia. *Journal of Development Effectiveness*: Submitted in February 2010.

_____ and C. Cargill. 2010a. Farming systems of the Baliem Valley, Papua, Indonesia. *Asia-Pacific Development Journal*: Submitted in January 2010.

_____ and J. Taylor. 2010b. The vulnerability of livelihoods based on sweetpotato-pig production in Papua, Indonesia. *Human Ecology*: Submitted in November 2009.

_____, R. Stringer and I. Nuberg. 2010c. Impacts of the improved sweetpotato-pig system on human, social and financial livelihood assets in the Baliem Valley of Papua, Indonesia. *Agriculture and Human Values*: Submitted in July 2010.

Man, N. and S.I. Sadiya. 2009. Off-farm employment participation among paddy farmers in the Muda Agricultural Development Authority and Kemasin Semerak granary areas of Malaysia. *Asia-Pacific Development Journal* 16(2): 141-154.

Mancini, F., A.H.C. van Bruggen and J.L.S. Jiggins. 2007. Evaluating Cotton Integrated Pest Management Farmer Field School Outcomes Using The Sustainable Livelihoods Approach In India. *Expl. Agric.* 43: 97–112.

Marasas, C.N., M. Smale and R.P. Singh. 2003. The economic impact of productivity maintenance research: breeding for leaf rust resistance in modern wheat. *Agricultural Economics* 29: 253-263.

Maredia, M., D. Byerlee and J. Anderson. 2002. *Ex-Post Evaluation of Economic Impacts of Agricultural Research Programs: A Tour of Good Practice*. Paper presented at the SPIA-CGIAR Workshop. Rome, Italy, 3-5 May.

Matanubun, H., A. Rochani and A. Sumule. 1995. Some aspects of the indigenous knowledge of selected sweetpotato farming systems in Irian Jaya. In: J. Schneider (ed.). *Indigenous Knowledge in Conservation of Crop Genetic Resources*. International Potato Center (CIP) and Central Research Institute for Food Crops (CRIFC), pp. 57-63.

Meinzen-Dick, R., M. Adato, L. Haddad, and P. Hazell. 2004. *Science and Poverty: An Interdisciplinary Assessment of the Impact of Agricultural Research*. International Food Policy Research Institute (FPRI), Washington, D.C.

Miguel, E., S. Satyanath and E. Sergenti. 2004. Economic shocks and civil conflict: An instrumental variable approach. *Journal of Political Economy* 112: 725–753.

Millar, J. and J. Connell. 2009. Strategies for scaling out impacts from agricultural systems change: the case of forages and livestock production in Laos. *Agriculture and Human Value* 27(2): 213-225.

Morris, M.L., H.J. Dubin and T. Pokhrel. 1994. Returns to wheat research in Nepal. *Agricultural Economics* 10: 269-282.

Nabi, Md.R.U., Md.A. Hoque, R.A. Rahman, S. Mustafa and Md.A. Kader. 2007. Vulnerability Context of the Estuarine Set Bag Net Fishermen Community in Bangladesh. *International Journal of Rural Management* 3 (2): 213-227.

Naudet, J. and J. Delarue. 2007. *Fostering impact evaluations at the Agence Française de Développement: A process of building in-house ownership and capacities*. Agence Française de Développement, Paris.

Naylor, L.L. 1974. *Culture Change and Development in the Balim Valley, Irian Jaya, Indonesia*. PhD dissertation. Department of Anthropology, Southern Illinois University, Carbondale.

Nkonya, E., D. Phillip, T. Mogues, J. Pender, M.K. Yahaya, G. Adebowale, T. Arokoyo and E. Kato. 2008. *From the Ground Up: Impacts of a Pro-Poor Community-Driven Development Project in Nigeria.* IFPRI Discussion Paper 00756. International Food Policy Research Institute (IFPRI), Washington, D.C.

Norton, G.W. and J.S. Davis. 1981. Evaluating returns to agricultural research: A review. *American Journal of Agricultural Economics* **63:** 685–699.

Okali, C., J. Sumberg and J. Farrington. 1994. *Farmer Participatory Research. Rhetoric and realty.* Overseas Development Institute (ODI), London.

Orr, A. 2001. Adapting to Adjustment: Smallholder Livelihood Strategies in Southern Malawi. *World Development* 29(8): 1325-1343.

Palanisami, K., D.S. Kumar, S.P. Wani and M. Giordano. 2009. Evaluation of Watershed Development Programmes in India Using Economic Surplus Method. *Agricultural Economics Research Review* 22: 197-207.

Papua. 2009. *The Geography of Papua Province*. http://www.papua.go.id, Accessed 21/5/2009 (in Indonesian).

Pardales Jr., J.R., D.M. Bańoc, A. Yamauchi, M. Iijima and Y. Kono. 1999. Root System Development of Cassava and Sweetpotato during Early Growth Stage as Affected by High Root Zone Temperature. *Plant Production Science* 2(4): 247-251.

Paris, T.R. 2002. Crop-animal systems in Asia: socio-economic benefits and impacts on rural livelihoods. *Agricultural Systems* 71: 147-168.

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.* International Potato Center (CIP), Bogor, pp. 215-224.

_____, N.T. Tinh, M.T. Hoan, N.T. Yen, P.N. Thach and K. Fuglie. 2005. Rural income generation through improving crop-based pig production systems in Vietnam:

Diagnostics, interventions, and dissemination. *Agriculture and Human Value* 22: 73-85.

Peters, J. 2001. *Local Human-Sweetpotato-Pig Systems Characterization and Research in Irian Jaya, Indonesia with Limited Reference to Papua New Guinea: A Secondary Literature Review.* Unpublished report of ACIAR AH/1998/054 Project. International Potato Center (CIP), Bogor.

Pearce, D. 2002. *Measuring the Poverty Impact of ACIAR Projects—A Broad Framework.* Impact Assessment Series Report No. 19. Australian Centre for International Agricultural Research (ACIAR), Canberra.

Phillipson, J., K. Bennett, P. Lowe and M. Raley. 2004. Adaptive response and asset strategies: the experience of rural micro-firms and Foot Mouth Disease. *Journal of Rural Studies* 20: 227-243.

Place, F., M. Adato, P. Hebinck and M. Omosa. 2005. *The Impact of Agroforestry-Based Soil Fertility Replenishment Practices on the Poor in Western Kenya*. Research Report No. 142. International Food Policy Research Institute (IFPRI), Washington, D.C.

Ploeg, A. 1966. Some comparative remarks about the Dani of the Baliem Valley and the Dani at Bokondini. *Bijdragen tot de Taal-, Land- en Volkenkunde* 122: 255-273.

Pontius, J., D. Dilts and A. Bartlett. 2002. *Ten Years of IPM Training in Asia – From Farmer Field School to Community IPM*. Food and Agriculture Organization (FAO), Bangkok.

Putra, I. M., C. Cargill, I.M. Damriyasa, A.G. Putra, L. Kossay, S. Mahalaya, W. Tiffen, P. Ketaren and D. Peters. 2004. Pig Disease Survey in Jayawijaya Regency, Papua, Indonesia. In: J. Limbongan (ed.). *Proceedings of the National Seminar on Agricultural Technology Assessment in Papua*, Balai Pengkajian Teknologi Pertanian Papua (BPTP Papua), Jayapura, pp. 78-82.

_____, L. Kossay, S. Mahalaya and D. Peters. 2004. The Importance of Boar Contact in Improving Sow Fertility. In: J. Limbongan, Y. Sujitno, N.E. Lewaherilla, A. Malik and M. Nggobe (eds.). *Proceedings of National Seminar on Agricultural Technology Assessment*. Central Research and Development Institute for Socio-Economic Agriculture (PSE), Bogor pp. 371-375.

Raitzer, D. A. and R. Lindner. 2005. *Review of the Returns to Aciar's Bilateral R&D Investments*. Impact Assessment Series Report No. 35. Australian Centre for International Agricultural Research (ACIAR), Canberra.

_____. and T.G. Kelley. 2008. Benefit-cost meta-analysis of investment in the International Agricultural Research Centers of the CGIAR. *Agricultural Systems* 96: 108-123.

Randolph, T.F., E. Schelling, D. Grace, C. F. Nicholson, J. L. Leroy, D. C. Cole, M. W. Demment, A. Omore, J. Zinsstag and M. Ruel. 2007. Invited Review: Role of livestock in human nutrition and health for poverty reduction in developing countries. *Journal of Animal Science* 85: 2788-2800.

Ravallion, M. 2001. The Mystery of the Vanishing Benefits: An Introduction to Impact Evaluation. *The World Bank Economic Review* 15(1): 115-140.

_____. 2008a. Evaluating Anti-poverty Programs. In: T.P. Schultz and J. Strauss (eds). *Handbook of Development Economics*. North-Holland, Amsterdam, pp. 3787-3846.

_____. 2008b. *Evaluation in the Service of Development*. Policy Research Working Paper No. 4547. World Bank, Washington D.C.

_____ and G. Datt. 1999. *When Is Growth Pro-Poor?* World Bank Policy Research Working Paper No. 2263. World Bank, Washington D.C..

Reddy, V.R., M.G. Reddy, S. Galab, J. Soussan and O. Springate-Baginski. 2004. Participatory Watershed Development in India: Can it Sustain Rural Livelihoods? *Development and Change* 35(2): 297-326.

_____. and . Soussan. 2003. Assessing the impact of participatory watershed development: A sustainable rural livelihoods approach. *In*: B. Shiferaw and H.A. Freeman (eds.). *Methods for assessing the impacts of natural resource management research. A summary of the proceedings of an International Workshop held by ICRISAT, 6-7 Dec 2002*. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, pp. 84-93.

Rogers, E.M. 1983. *Diffusion of Innovations*. Coller Macmillan Publishers, London.

Rosenbaum, P. and D. Rubin. 1983. The Central Role of the Propensity Score in Observational Studies for Causal Effects. *Biometrika* 70 (1): 41–55.

_____. 1985. Constructing a Control Group Using Multivariate Matched Sampling Methods that Incorporate the Propensity. *American Statistician* 39 (1): 33–38.

Ruthenberg, H. 1980. *Farming Systems in the Tropics*. Oxford University Press, Oxford.

Sayce, K. and P. Norrish. 2006. *Perceptions and Practice: An Anthology of Impact Assessment Experiences*. The Technical Centre for Agricultural and Rural Cooperation (CTA), Wageningen.

Schneider, J. 1995. Farmer practices and sweetpotato diversity in highland New Guinea. In: J. Schneider (ed.). *Indigenous Knowledge in Conservation of Crop Genetic Resources*. International Potato Center (CIP) and Central Research Institute for Food Crops (CRIFC), Bogor, pp. 63-71.

_____, C.A. Widyastuti and M. Djazuli. 1993. *Sweetpotato in the Baliem Valley Area, Irian Jaya: A report on collection and study of sweetpotato germplasm*. International Potato Center (CIP), Bogor.

Scoones, I. 1998. *Sustainable rural livelihoods. A framework for análisis*. IDS Working Paper No. 72. IDS, Brighton.

Scott, M. 2004. Building institutional capacity in rural Northern Ireland: the role of partnership governance in the LEADER II programme. *Journal of Rural Studies* 20: 49–59.

Segers, K. J. Dessein, J. Nyssen, M. Behailu and J. Deckers. 2005. The Sustainable Livelihoods Approach as an Impact Assessment Tool for Development Interventions in Rural Tigray, Ethiopia: Opportunities and Challenges. In: G. Alemu, B. Simane and M. Feseha (eds). *Proceedings of the conference on poverty and development in Ethiopia: Challenges and options held by IDR, 6-7 May 2005*. Institute of Development Research (IDR), Addis Ababa, pp. 1-8.

Shah, H., M.A. Khan, N. Akmal and M. Sharif. 2005. Livelihood assets and livelihood strategies of small farmers in salt range: A case study of Pind Dadan Khan District Jhelum, Pakistan. *Pakistan Journal of Agricultural Science* 42(1-2): 82-88.

Silaban, T. 2007. 11-12 Ribu Orang di Papua Terinveksi HIV (11-12 thousand people in Papua are infected by HIV). Papua Health Office, Jayapura. www.silaban.net/2007/05/10/11-12-ribu-orang-di-papua-terinveksi-hiv/. Accessed on 19/8/2009.

Singh, N. and J. Gilman. 1999. Making livelihoods more sustainable. *International Social Science Journal* 162: 539-545.

Smale, M., M.R. Bellon, J.A. Aguirre, I. Manuel Rosas, J. Mendoza, A.M. Solano, R. Martınez, A. Ramırez and J. Berthaud. 2003. The Economic Costs and Benefits of a Participatory Project to Conserve Maize Landraces on Farms in Oaxaca, Mexico. *Agricultural Economics* 29: 265–275.

Soenarto. 1987. *Wen Hipere: A Sweetpotato (Ipomoea batatas (L) Lam) Cultivation System in the Baliem Valley, Irian Jaya*. MS thesis. Bogor Agricultural University (IPB), Bogor.

_____ and F. Rumawas. 1997. An agro-ecological analysis of *wen-tinak*, a sustainable sweetpotato wetland production system in the Baliem Valley, Irian Jaya, Indonesia. *Science in New Guinea* 23(2): 55-66.

Springer-Heinzea, A., F. Hartwichb, J. S. Hendersonc, D. Hortond and I. Mindee. 2003. Impact pathway analysis: an approach to strengthening the impact orientation of agricultural research. *Agricultural Systems* 78: 267-285.

Suprapto, A. 2002. Land and water resources development in Indonesia. In FAO (ed.). *Investment in land and water*. Food and Agriculture Organisation of the United Nations (FAO), Bangkok, pp. 233-242.

Syahyuti. 2007. Policies for the development of farmer organisations as institutional economics in rural area. *Analisis Kebijakan Pertanian* 5(1): 15-35.

Taylor, C.R., R.D. Lacewell and H. Talpaz. 1979. Use of Extraneous Information with an Econometric Model to Evaluate Impacts of Pesticide Withdrawals. *Western Journal of Agricultural Economics* (1979): 1-7.

Terza, J.V., W.D. Bradford and C.E. Dismuke. 2007. The Use of Linear Instrumental Variables Methods in Health Services Research and Health Economics: A Cautionary Note. *Health Services Research* 43(3): 1102-1120.

Thornton, P.K., and M. Herrero. 2001. Integrated crop-livestock simulation models for scenario analysis and impact assessment. *Agricultural Systems* 70: 581-602.

_____, P.M. Kristjanson, and P.J. Thorne. 2003. Measuring the potential impacts of improved food-feed crops: methods for ex ante assessment. *Field Crops Research* 84: 199-212.

Tucker, A.F. 1987. *Ekosistem-ekosistem Tani di Irian Jaya dan Arah Pembangunannya* (*The Agricultural Ecosystems of Irian Jaya and their Future Development)*. Volume 1 and 2. YAPIN, Jayapura.

UNDP. 1999. Sustainable Livelihoods: Concepts, Principles and Approaches to Indicator Development. Available on-line at http://www.sustainable-livelihoods.com/pdf/sustainablelivelihoodsc-1.pdf. Accessed on 16/10/2009.

____. 2005. *Papua Needs Assessment: An Overview of Findings and Implications for the Programming of Development Assistance*. United Nations Development Programme (UNDP), Jayapura.

UN. 2001. *Road map towards the implementation of the United Nations Millennium Declaration. Report of the Secretary-General*. United Nations (UN), New York.

Van Baal, J., K.W. Galis and R.M. Koentjaraningrat. 1984. *West Irian: A Bibliography*. Land en Volkenkunde, Koninklijk Instituut voor Taal, Amsterdam.

Van Huis, A. and F. Meerman. 1997. Can we make IPM work for resource-poor farmers in sub-Saharan Africa? *International Journal of Pest Management* 43(4): 313-320.

Walker, T., M. Maredia, T. Kelley, R. La Rovere, D. Templeton, G. Thiele and B. Douthwaite. 2008. *Strategic Guidance for Ex Post Impact Assessment of Agricultural Research*. Consultative Group on International Agricultural Research (CGIAR), Rome.

WCED. 1987. *Food 2000: Global policies for sustainable agriculture. A report of the advisory panel on food security, agriculture, forestry and environment to the World Commission on Environment and Development*. Zed Books, London and New Jersey.

White, H. 2006. *Impact evaluation – The experience of the Independent Evaluation Group of the World Bank*. World Bank, Washington D.C.

_____. 2008. *Of Probits and Participation: The Use of Mixed Methods in Quantitative Impact Evaluation*. NONIE Working Paper No. 7. NONIE, Washington, D.C.

_____. 2009. *Some reflections on current debates in impact evaluation*. The International Initiative for Impact Evaluation (3ie), New Delhi.

_____. 2009. Theory-based impact evaluation: principles and practice. *Journal of Development Effectiveness* 1(3): 271-284.

_____. and E. Masset. 2007. Assessing intervention to improve child nutrition: A theory-based impact evaluation of the Bangladesh integrated nutrition project. *Journal of International Development* 19: 627-652.

Widyastuti, C.A. 2000. *Knowledge of Women on and its Contribution to the Sustainability of Sweetpotato Bio-Diversity in the Baliem Valley: A Case Study in Waga-waga Village, Kurulu District, Jayawijaya Regency, Irian Jaya*. MS thesis. Bogor Agricultural University (IPB), Bogor.

_____, G. Prain and A. Yaku. 2002. Dani Women's Knowledge on and Its Contribution to Maintenance of Sweetpotato Diversity in Baliem Valley. In: R. Rao and D. Campilan (eds.). *Exploring the complementarities of in situ and ex situ conservation strategirs for Asian sweetpotato genetic resources. Proceedings of the 3rd International Workshop of the Asian Network for Sweetpotato Genetic Resources (ANSWER), Denpasar, Bali, Indonesia on 2-4 October 2001*. International Plant Genetic Resource Institute (IPGRI), Serdang, pp. 150-158.

Winters, P., B. Davis and L. Corral. 2002. Assets, activities and income generation in rural Mexico: factoring in social and public capital. *Agricultural Economics* 27: 139-156.

Woolfe, J.A. 1992. *Sweetpotato an untapped food resource*. Cambridge University Press, Cambridge.

World Bank. 1998. *Measuring the Poverty Impact of Projects in LAC*. Poverty Reduction and Economic Management Network (PREMN), World Bank, Washington, D.C.

_____. 2008. *World Development Report*. World Bank, Washington, D.C.

_____. 2010. *What is Impact Evaluation*? http://go.worldbank.org/2DHMCRFFT. Accessed on 14/4/2010.

Yaku, A. and C.A. Widyastuti. 2001. In situ Conservation of Sweetpotato: An Irian Jaya Experience. In: R. Rao and D. Campilan (eds.). *Exploring the complementarities of in situ and ex situ conservation strategirs for Asian sweetpotato genetic resources.*

Proceedings of the 3rd International Workshop of the Asian Network for Sweetpotato Genetic Resources (ANSWER), Denpasar, Bali, Indonesia on 2-4 October 2001. International Plant Genetic Resource Institute (IPGRI), Serdang, pp. 142-149.

APPENDIX

Appendix A. Key informants involved in the three focus group discussions for developing questionnaires

Dani women group		Dani men group		Institutional officials group	
Name	Village	Name	Village	Name	Organisation
Penina	Napua	Wamisik	Napua	Ir. Albert Soplanit	Papua Assessment Institute for Agricultural Technology[1]
Herlina	Sinakma	Elly	Sinakma	drh. I Made Putra	Jayawijaya Livestock Office[1]
Lince	Siepkosi	Edison	Siepkosi	Ir. Winarto	Jayawijaya Statistical Office[1]
Iheldek	Kumima	Dabi	Kumima	Yusuf Toding, S.Pi	Jayawijaya Annual Crops[1]
Terposa	Pisugi	Yohanes	Pisugi	Andi Hendarka, S.Hut.	Jayawijaya Forestry Office[1]
Elizabeth	Wanima	Step	Wanima	Fredrik Y. Rumboyrusi, S.Pi	Jayawijaya Fishery Office[1]
Paniai	Timia	Kosmas	Timia	Calvin, B.Sc.	Jayawijaya Cooperation Office[1]
Lina	Assolokobal	Yosia	Tulem	Franz B. Navo, B.Sc.	Jayawijaya Agricultural Office[1]
Helena	Wouma	Hendrikus	Sunili	Riza Marinus, Amd. P.	Jayawijaya Information and Extension Office for Agriculture and Forestry[1]
Maria	Wamena	Edy	Molima	Mr. Hendrik Marian	Jayawijaya Information and Extension Office for Agriculture and Forestry[1]
				Ir. Josep F. Sanjoto	World vision Indonesia[2]
				Mr. Kayo Hubi	M Mula Foundation[2]

Note: [1]Government organisations; [2]Non-government organisations

Appendix B. Questionnaires for *sili* surveys (Translated from the original version written in Indonesian)

Evaluation of the ACIAR-CIP-SARDI project:

"POVERTY ALLEVIATION AND FOOD SECURITY THROUGH IMPROVING THE SWEETPOTATO-PIG SYSTEMS IN PAPUA, INDONESIA"

Data and information: 2001 (Before project started) / 2006 (After project finished)[1]

Name of interviewer : .....

Date of interview : .....

Name of interviewee (head of *Sili*[2]) : .....

Location of the *Sili* : Valley / Mountain[1]

Social status of the *Sili* : Rich / Poor[1]

Village : .....

Sub-District : .....

[1] Please delete the unnecessary

[2] *Sili* is a place of living in the Baliem valley of Papua, where several Dani families may live together. It has several components: a *pilamo* (house for men), several *ebeai* (houses for women) and a *dawula* (kitchen with several pig pens inside). These components are surrounded by a wood fence which has only a gate to access in.

1. Livelihood assets

1.1. Human capital

1.1.1. Labour power

Name of people in your *Sili*	Sex	Age (years)	Educa-tion (years)	Work experience		Trainning		Work average		Sick (days/year)
				SP[1]	Pig	SP	Pig	SP	Pig	
				(years)		(days/year)		(hours/week)		

[1] SP = Sweetpotato

1.2. Natural capital

1.2.1. Cultivated land

Plot	Size (m^2)	Distance from home (walk hours)	Status of land[1]	Type of land[2]
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

[1] a = own, b = cultural land, c = borrow from relative, d = borrow from friend, e = others (please specify)

[2] a = dry land; b = wet land (paddy field); c = pond; d = others (please specify)

1.2.2. Biodiversity of SPs and pigs

SPs and pigs	Type	The most important (Five)
SPs for human	Helalekue	
SPs for pig		
Pigs		

1.3. Physical capital

1.3.1. Personal production equipments

1.3.1.1. Agriculture and livestock, hunting and other business equipments

Type of agriculture and livestock equipments:	Number	Source[1]	Age of using (years)	Type of hunting and other business equipments:	Number	Source[1]	Age of using (years)
- Spade				Hunt equipments:			
- Sword				- Spear			
- Axe				- Bow and arrows			
- Sickle				-			
- Saw				-			
- Hammer				-			
- Roll meter				-			
- *Noken* (traditional bag)				-			
- Sack				-			
- Cart				-			
- Bycicle				Other business equipments:			
-				(What?)			
-				-			
-				-			
-				-			
-				-			
-				-			
-				-			

1 a = buy; b = got for free; c = others (please specify)

1.3.1.2. Pig housing and *laleken* (a traditional wood fenced area where pigs may be released to roam in)

Questions	Answers
Number of pig pens?	
Model of pig pens?	Traditional[1] / Semi-modern[2]
Size of a pig pen (m^2)?	
Did your *Sili* have *laleken*?	Yes / No; If Yes, how many?
Size of a *laleken* - average (m^2)?	
Did your *laleken* have a dunging area?	Yes / No; If Yes, since when?
Did your *Sili* divide your *laleken* into several smaller paddocks?	Yes / No; If Yes, why (for what purposes)?
What plants were in your *laleken*?	
Which plants were specially planted by your *Sili*?	
Why did your *Sili* plant those plants?	
From whom did your *Sili* know about dividing *laleken* into smaller paddocks?	
From whom did your *Sili* know about planting special plants inside laleken?	
Since when did your *Sili* know and practice that knowledge?	We know since: We practice since:

[1] The roof is made from dry grasses, the pens are relatively closed and dark, [2] The roof is made from zinc, the pens are relatively opened.

1.3.1.3. Other livestocks housing and secondary goods

Type of livestock	Pen			Type of secondary goods	Number	Total (Rp)
	Number	Size of a pen (m^2)	Model[1]			
-				-		
-				-		
-				-		
-				-		
-				-		
-				-		
-				-		

[1] a = traditional, b = semi-modern

1.3.2. Public Infrastructures

Road	Type[1]	Distance (walk hours)	Type of other public infrastructures	Number
From home to the village road			- Village/Cultural meeting office	
From home to the public meeting point			- Church	
From village road to the closest market			- School	
From village road to the city			- Helth centre	
			- Market	
			-	
			-	
			-	

[1] a = soil, b = stone, c = paved/asphalt

1.4. Financial capital

1.4.1. SP

Information	Unit	Plot									
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
When did you start to harvest?	(month/year)										
When did you finish to harvest?	(month/year)										
When did you start to plant?	(month/year)										
Number of *bedeng* (bed)	*bedeng*										
Size of a *bedeng*	m2										
Plant spacing (*kuming*)	m2										
Harvest/*kuming*:											
1st	kg										
2nd	kg										
3rd	kg										
4th	kg										
5th	kg										
Production per		(Calculate and fill in later)									
Kuming	kg										
Bedeng	kg										
Plot	kg										

1.4.1. SP (*continue*)

Information	Plot									
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Type of cultivars for human (…….. %) Type of cultivars for pig (…….. %)										

1.4.2. SP leaves and other staple food crops

Type	Production/harvest					
	1st	2nd	3rd	4th	5th	Total
	(kg/kuming)					
- SP leaves for human						
- SP leaves for pig						
Other staple food crops:						
- Taro						
-						
-						

1.4.3. Other crops; Pigs and other livestoks

Type of crops	Frequency of harvest (times/year)	Production (kg/harvest)	Type of livestocks	Classification	Number (animals)
Vegetables:			Pigs	Boar	
- Cabbage				Sow	
-				Growing pig	
-				Piglet	
-			Other livestocks:		
-			-		
-			-		
-			-		
Fruits:			-		
- Orange			-		
-			-		
-			-		
-			-		
-			-		
Annual crops:			-		
- Coffee			-		
-			-		
-			-		
-			-		

1.4.4. Catched wild animal and tree products and other forest products collected from the forest

Type	Unit	Frequency (times/month)	Total per month	Total per year
Catched wild animals:				
- Wild pig	(animals)			
- Big squirrel	(animals)			
- Bird	(animals)			
- Snake	(animals)			
- Fish	(bunches)			
- Prawn	(*noken*)			
-				
-				
-				
Tree products and other forest products:				
- Wood planks	(m^3)			
- Root rope	(bounches)			
- Pandanus nuts	(pcs)			
- Fossil	(pcs)			
-				
-				
-				
-				
-				
-				

1.4.5. Other financial resources

Type	Total (Rp)
- Cash saving	
- Wage	
- Remittance	
- Aid	
- Loan	
-	
-	
-	
-	

1.5. Social capital

1.5.1. Organisations that your *Sili* became a member

Name of organisation	Long of membership (years)	Position in orga-nisation[1]	Being active[2]	Usefulness for your *Sili*

[1] a = leader; b = board; c = ordinary member

[2] In the decision making process: a = very active, b = active, c = not active

1.5.2. Networks

Questions	Helpers	Type of helps	Repayment
In SP farming, when your *Sili* needed any helps, who did you ask for?			
In Pig farming, when your *Sili* needed any helps, who did you ask for?			
In other businesses (according to what businesses the *Sili* had), when your *Sili* needed any helps, who did you ask for?			
For cultural ceremonies (e.g. funeral), when your *Sili* needed any helps, who did you ask for?			

1.5.3. Trust and solidarity

Questions	Answers
In SP farming, from those who helped (see the answers of 1.5.2), which one did your *Sili* trust the most?	
In Pig farming, from those who helped (see the answers of 1.5.2), which one did your *Sili* trust the most?	
In other businesses (according to what businesses the *Sili* had), from those who helped (see the answers of 1.5.2), which one did your *Sili* trust the most?	
For cultural ceremonies (e.g. funeral), from those who helped (see the answers of 1.5.2), which one did your *Sili* trust the most?	
If there is a community project that does not directly benefit your *Sili*, but has benefits for many others in your village, would your *Sili* still contribute to the project?	Yes / No. If Yes, what would your *Sili* contribute and why?

1.5.4. Collective action and cooperation

Questions	Number of *Sili*	Location of *Sili*[1]
In SP farming, how many other *Silis* helped your *Sili*?		
In SP farming, how many other *Sili* did your *Sili* help?		
In Pig farming, how many other *Sili* helped your *Sili*?		
In Pig farming, how many other *Sili* did your *Sili* help?		

[1] a = the same village, b = other villages

1.5.4. Collective action and cooperation (continue)

Questions	Number of *Sili*	Location of *Sili*[1]
In other businesses (according to what businesses the *Sili* had), how many other *Sili* helped your *Sili*?		
In other businesses (according to what businesses the *Sili* had), how many other *Sili* did your *Sili* help?		
For cultural ceremonies (e.g. funeral), how many other *Sili* helped your *Sili*?		
For cultural ceremonies (e.g. funeral), how many other *Sili* did your *Sili* help?		

[1] a = the same village, b = other villages

1.5.5. Information and communication

Questions	Answers
When your *Sili* looked for help from other *Sili* (e.g. to help in planting), how did your *Sili* call them?	
How did your *Sili* get information about the acitivities of government institutions, NGOs and other institutions, particularly related to your *Sili*'s businesses (SP, Pig and others)?	
How did your *Sili* get information about the market prices of SPs, pigs, and other products produced by your *Sili*?	
Did your *Sili* have any radio?	Yes / No. If Yes, what did your *Sili* listen to?
How often did you go to: - the city of Wamena: times/week - the outside of Wamena (other cities): times/year	The purpose of visiting the city of Wamena:
	The purpose of visiting the outside of Wamena (other cities):

1.5.6. Social cohesion and inclusion

Questions	Answers
In running SP and pig farming and other businesses, did your *Sili* get along well with other *Sili*?	Yes / No. If No, why?
In running SP and pig farming and other businesses, did your *Sili* feel being considered for inclusion by other *Sili*?	Yes / No. If Yes, why?
Did these problems encourage a wider conflict?	Yes / Not. If Yes, what conflict?

1.5.7. Empowerment and political action

Questions	Answers
How strong was your *Sili*'s influence on the other *Sili*'s SP and pig farming and other businesses in the village?	Very strong / Strong / Not strong
Using the influence level of your *Sili*, could your *Sili* freely take any necessary actions in order to take as many advantages as your *Sili* wants for your *Sili*'s SP and pig farming and other businesses in the village?	Yes / No. If No, why?
Did your *Sili* try to submit any proposals for the benefit of your *Sili*'s SP and pig farming and other businesses to the government institutions and/or other institutions (e.g. NGOs)?	Yes / No. If Yes, what did your *Sili* propose and to what institutions?
Were your proposals accepted?	Yes / No. If No, why they were not accepted?
When your proposals were not accepted, did your *Sili* try to negotiate in order to change their decisions?	Yes / No. If Yes, how did your *Sili* negotiate?

2. Vulnerability context

2.1. Shocks (Type and impact)

Category	Type	How many times (per year)?	How long (please list per event)?	Impact on *Sili* (negative)
Natural disaster				
Epidemic diseases on human				
Epidemic diseases on livestock				
Epidemic pests and diseases on crops				
Economic				
Conflict/War				

2.2. Trends (Type and impact)

Category	Type	Impact on *Sili* (positive and negative)
Governance / political		Positive:
		Negative:

2.3. Seasonality shifts (Type and impact)

Category	Type	Impact on *Sili* (positive and negative)
Production		Positive:
		Negative:
Price		Positive:
		Negative:
Health		Positive:
		Negative:

3. Institution, policy and process

3.1. Institution

3.1.1. Programme and activity

Programmes and activities in the village	Institutions	
	Leading agency	Supporting agencies
1.		
2.		
3.		

3.1.2. Function and task

No. Programmes and activities (see table 3.1.1.)	Functions and tasks	
	Leading agency	Supporting agencies (list according to the name of institutions)

3.1.3. Participation of *Sili*, involvement of *Sili* in the decision-making process and its impact

No. Programmes and activities (see table 3.1.1.)	Participation of *Sili* (Yes / No. If Yes, as what?)	Involvements of *Sili* in the decision-making processes	Impacts of the participation and involvements of *Sili* on the implementation of programmes and activities

3.2. Policy

3.2.1. Available policy, involvement of *Sili* in the policy-making process and its impact

No. Programmes and activities (see table 3.1.1.)	Available policies (including local norms/law/culture attached)	Involvements of *Sili* in the policies-making processes	Impacts of the available policies and involments of *Sili* on the implementation of programmes and activities

3.3. Processes

3.3.1. Changed policy, involvements of *Sili* in the policy-changing process and its impact

Changed policies (see table 3.2.1.)	Reasons for changing	Involvements of *Sili* in the policy-changing processes	Impacts of the involvements of *Sili* on the implementation of the changed policies

3.3.2. Changed institution, involvements of *Sili* in the institution-changing process and its impact

Changed institutions (see table 3.1.1.) and type of change[1]	Reasons for change	Involvements of *Sili* in the institution-changing processes	Impacts of the involvements of *Sili* on the operation of the changed institutions

1 a = leadership, b = staf, c = structure of organisation, d = form of institution, e = responsibility line, f = others (please specify)

4. Livelihood strategies

4.1. The sources of income and its use

4.1.1. SP and other staple food crops

Type	Use			Price of selling	Total
	Consumed	Given for free[1]	Sold		
	(%)			(Rp/kg)	(Rp)
- SP for human					
- SP for pig					
Other staple food crops:					
- Taro					
-					
-					
-					
-					
-					
-					
-					
-					
-					
-					

[1] Cultural ceremony

4.1.2. Other crops

Type	Use			Price of selling	Total
	Consumed	Given for free	Sold		
	(%)			(Rp/kg)	(Rp)
Vegetables:					
- Cabbage					
-					
-					
-					
-					
-					
Fruits:					
- Orange					
-					
-					
-					
-					
-					
Annual crops:					
- Coffee					
-					
-					
-					
-					

4.1.3. Pig and other livestocks

Type	Category	Use			Price of selling	Total
		Consumed	Given for free[1]	Sold		
		(%)			(Rp/animal)	(Rp)
- Pig:						
	Boar					
	Sow					
	Growing pig					
	Piglet					
Other livestocks:						
- Chicken						
-						
-						
-						
-						
-						
-						
-						
-						
-						
-						
-						
-						

[1] Cultural ceremony

4.1.4. Catched wild animals and tree products and other forest products collected from the forest

Type	Use			Price of selling (Rp/unit)	Total (Rp)
	Consumed	Given for free	Sold		
	(%)				
Catched wild animals:					
- Wild pig					
- Big squirrel					
- Bird					
- Snake					
- Fish					
- Prawn					
-					
-					
Tree products and other forest products:					
- Wood planks					
- Root rope					
- Pandanus nuts					
- Fossil					
-					
-					

4.1.5. Other financial resources

Type	Use		Total of saving (Rp)
	Saved	Used	
	(%)		
- Cash saving			
- Wage			
- Remittance			
- Aid			
- Loan			
-			
-			

4.1.6. Sources of expense

Type of expenses	Total of expense		Type of expenses	Total of expense	
	(Rp/month)	(Rp/year)		(Rp/month)	(Rp/year)
Cloth			Agriculture/Livestock equipments		
Food			Hunting/other equipments		
House (including laleken)			Education		
Cost of crops production:			Health		
- SP			Donation		
- Other staple food crops			Investment:		
- Vegetables			- Saving		
- Fruits			- Buy land		
- Annual crops			- Buy pig		
Cost of livestocks production:			- Others (specify):		
- Pig			-		
-			-		
-			Other expenses (specify):		
-			-		
-			-		
-			-		

4.2. The pig husbandry

Questions		Answers	Source of information	Since when?
Pig	Type of pigs?			
	Pigs freely roam during the day?			
	How to select boar?			
	How to select sow?			
	How to increase the frequency of mating?			
	How to increase the number of litters?			
Feed	Type of feed?			
	How to feed?			
Diseases management	When your pigs were sick, what did you do?			
	Did you shoot your pigs regularly? Who did?			

4.3. Controlling the vulnerability context

4.3.1. Shocks

Type of shocks (see table 2.1.)	Efforts that your *Sili* did to minimise the negative impacts of these shocks on your *Sili*

4.3.2. Trends

Type of trends (see table 2.2.)	Efforts that your *Sili* did to minimise the negative impacts of these trends on your *Sili*	Efforts that your *Sili* did to maximise the positive impacts of these trends on your *Sili*

4.3.3. Seasonality shifts

Type of seasonality shifts (see table 2.3.)	Efforts that your *Sili* did to minimise the negative impacts of these seasonality shifts on your *Sili*	Efforts that your *Sili* did to maximise the positive impacts of these seasonality shifts on your *Sili*

4.4. Controlling the institution, policy and processes

4.4.1. Institution

Questions	Answers
Efforts that your *Sili* did to make the institutions work in your village and/or with your *Sili*?	
Efforts that your *Sili* did to increase the participation of your *Sili* in the decision-making processes related to the programmes and activities of the institutions which work in your village and/or with your *Sili*?	
Efforts that your *Sili* did to maximise the positive impacts of the programmes and activities of the institutions which work in your village and/or with your *Sili*?	
Efforts that your *Sili* did to minimise the negative impacts of the programmes and activities of the institutions which work in your village and/or with your *Sili*?	
Efforts that your *Sili* did to prevent the unsuitability of the programmes and activities of the institutions which work in your village and/or with your *Sili* with the local norms/laws/cultures?	

4.4.2. Policy

Questions	Answers
Efforts that your *Sili* did to increase the participation of your *Sili* in the policy-making processes related to the programmes and activities of the institutions which work in your village and/or with your *Sili*??	
Efforts that your *Sili* did to maximise the positive impacts of the available policies and involvements of your *Sili* in the policy-making process on the implementation of programmes and activities?	
Efforts that your *Sili* did to minimise the negative impacts of the available policies and involvements of your *Sili* in the policy-making process on the implementation of programmes and activities?	
Efforts that your *Sili* did to prevent and/or to control the unsuitability of the available policies with the local norms/laws/cultures?	

4.4.3. Processes: Changed policy

Questions	Answers
Efforts that your *Sili* did to increase the participation of your *Sili* in the policy-changing processes?	
Efforts that your *Sili* did to maximise the positive impacts of the involvements of your *Sili* in the policy-changing processes on the implementation of the changed policies?	
Efforts that your *Sili* did to minimise the negative impacts of the involvements of your *Sili* in the policy-changing processes on the implementation of the changed policies?	
Efforts that your *Sili* did to prevent and/or to control the unsuitability of the changed policies with the local norms/laws/cultures?	

4.4.4. Processes: Changed institution

Questions	Answers
Efforts that your *Sili* did to increase the participation of your *Sili* in the institution-changing processes?	
Efforts that your *Sili* did to maximise the positive impacts of the involvements of your *Sili* in the institution-changing processes on the operation of the changed institutions?	
Efforts that your *Sili* did to minimise the negative impacts of the involvements of your *Sili* in the institution-changing processes on the operation of the changed institutions?	
Efforts that your *Sili* did to prevent and/or to control the unsuitability of the changed institutions with the local norms/laws/cultures?	

5. Livelihood outcomes

5.1. From all of the livelihood assets that your *Sili* had, the vulnerability context problems that your *Sili* faced, the institutions, policies and processes that your *Sili* dealt with, and all the efforts that your *Sili* did to use the livelihood assets and to control the vulnerability context and the institutions, policies and processes, what have actually the outcomes that your *Sili* achived?

5. Livelihood outcomes (*continue*)

5.2. From all the outcomes that your *Sili* tried to achieve, which two of them were the most important for your *Sili*? First: Second :
5.3. Why these two outcomes were the most important? Reasons for the first : Reasons for the second:
5.4. After these two outcomes were achieved by your *Sili* , what did your *Sili* then do with these two outcomes?

The end – Thank you for the participation of your *Sili*!

Appendix C. Dani interviewers

Interviewers	Age	Education	Village
Triono[1]	24	BS	ACIAR project field staff
Otnil	20	High school	Napua
Amon	19	High school	Tulem
Lazarus	18	High school	Wamena
Ami	18	High school	Holima
Asai	18	High school	Muliama

Note: [1]Coordinator

Appendix D. The 38 project group *silis*

No.	*Sili*	Village	Involvement in on-farm trials of the ACIAR project	
			Sweetpotato	Pig
1.	Wamisik Elopere	Napua	√	√
2.	Elly Haluk	Sinakma	√	√
3.	Tinus Wenda	Sinakma	X	√
4.	Mulia Matuan	Wouma	X	√
5.	Gandi	Megapura	X	√
6.	Ruben	Assolokobal	X	√
7.	Yosia Mosip	Tulem	√	√
8.	Tadius Marian	Tulem	X	√
9.	Martinus	Tulem	√	√
10.	Yan	Tulem	√	√
11.	Paulus Kossay	Tulem	√	√
12.	Agus Lengka	Tulem	√	√
13.	Thomas Abraham	Tulem	√	X
14.	John	Tulem	√	X
15.	Edi Surabut	Molima	X	√
16.	Dabi Leloba	Kumima	√	√
17.	Yohanes Kossay	Pisugi	√	√
18.	Frans Matuan	Pisugi	√	√
19.	Albert	Pisugi	X	√
20.	Henok Kossay	Pisugi	X	√
21.	Edison Kossay	Siepkosi	√	√
22.	Airon	Siepkosi	√	X
23.	Frans	Siepkosi	√	X
24.	Penor Walilo	Siepkosi	X	√
25.	Andi	Hubikiak	√	√
26.	Weragoba	Holima	√	X
27.	Erik	Holima	√	X
28.	Usman	Holima	√	X
29.	Step Hilapok	Wanima	X	√
30.	Yakobus	Wanima	X	√
31.	Hendrikus Meage	Sunili	X	√
32.	Kosmas Kossay	Timia	X	√
33.	Paulus	Muliama	√	X
34.	Luther Kossay	Wamena	√	√
35.	Matias	Wamena	X	√
36.	Hunidekma Yoman	Ibele	X	√
37.	Daniel Tabuni	Makki	√	X
38.	Waro Tabuni	Kelila	√	X

Appendix E. The 570 non-collaborator *silis* chosen randomly in the 20 villages

Assolokobal (n=15)	Hubikiak (n=15)	Ibele (n=15)	Kelila (n=15)	Kumima (n=15)
Nico A	Obet K	Buamimo E	Warna K	Daud
Emaus A	Holeak M	O-Biluk M	Markus K	Zakius
Yudas W	Kefas H	Ape E	Wayus W	Yafet
Matius W	Yulianus Y	B-min E	Amos W	Mathias
Yafet W	Kain K	P-nas E	Melkias W	Yakobus
Yan A	Andrias H	Abura E	Yorda W	Wamoko
Hans A	Yunus K	Musa W	Benyamin K	Lukas
Yirugi A	Anelek H	Albert H	Teriamus K	Bernard
Efesus L	Niko H	Dokop W	Barius W	Wimabok
Yunus A	Wimato H	L-lego H	Herman K	Wenako
Henok M	Waloken A	Arian H	Soleman K	Titus
Muligi W	Yanius K	Huatmi W	Wardi K	David
Tilogo W	Yorim H	Maruk H	Thomas W	Wenarek
Anton W	Marten H	Motok H	Paulus W	Benyamin
Benyamin L	Yaniarus H	Handi W	Horim K	Onius

Maki (n=15)	Megapura (n=15)	Molima (n=15)	Muliama (n=15)	Napua (n=15)
Apeme W	Sasalok W	Elokama F	Bulaihe E	Sakius
Wenemuk W	Herman A	Waya F	Kenitius W	Benyamin
Soleman Y	Luis W	Weakpo M	Anton L	Luka
Yordan W	Thomas L	Victor S	Peter L	Korinus
Benny W	Tonny W	Yance W	Enti L	Martinus
Thomas W	Yinawan W	Izak P	Yoel W	Ruben
Meky K	Roni L	Wilino W	Narius W	Petrus
Yahya K	Desmon L	Kostan H	Osarus E	Yosa
Matius K	Ismael W	Yulius W	Yoabiluk W	Elkius
Yokal T	Yopi A	Karlos S	Jor L	Alex
Titus K	Matuan A	Waru S	Woliur K	Holagoba
Saul W	Musa W	Ananias A	Giarue K	Sep
Ilukma Y	Deski A	Ben M	Aminus K	Yeskiel
Titus W	Frans W	Ruben W	Parima W	Sanagimo
Handi W	Wahyu W	Tinus H	Liber W	Obasok

Sunili (n=15)	Timia (n=15)	Wouma (n=15)	Sinakma (n=30)	
Linus M	Laos A	Yeinat W	Sem W	Baret T
Husupi M	Lipinus W	Yudas W	Agustinus M	Dekis W
Wenewelek K	Yeremias K	Temul H	Hesa J	Ecoko J
Pelima K	Obayak W	Andi L	Piter E	Eperama W
Yakob M	Marten W	Thomas H	Yupinus K	Etron K
Sole M	Wardis W	Matius M	Ismail T	Inapik M
Wasik E	Yosep W	Wempi W	Tenas M	Karlus J
Daud M	Daniel H	Here M	Yesaya T	Lani G
Huiyarek K	Wempi Y	Mathius M	Jeri E	Luter G
Kalius K	Welem W	Yudas M	Sakius W	Mas G
Abas H	Otis K	Wetik L	Yohanes D	Migak T
Hondius M	Paulus W	Wao A	Jon P	Obet E
Thomas H	Pilep W	Yosia A	Opis K	Panus T
Philipus M	Anton L	Yemi W	Arman Y	Silas J
Paulus K	Ukum W	Frans I	Anis M	Elimus W

Appendix E. (*cont.*)

Wamena (n=30)	Wanima (n=30)		Holima (n=45)	
Alex K	Agus H	Agus H	Obet H	Manfret H
Anton H	Ananias W	Alius K	Pion H	Lukas H
Domi H	Barnabas M	Ambros W	Serlus K	Nicho K
Eka W	Ebekena H	Asir W	Thomas H	Pilatus K
Ester S	Herman W	Eko K	Vincent K	Teo H
Herman Y	Ikilabuk M	Frans K	Wapo K	Yance K
Hiruk A	Kerekama E	Horas H	Wempi H	Yuidek H
Ilias A	Leome H	Kancius S	Yeki H	Itoko K
Jelesimo W	Okake E	Kemakla K	Yhon H	Aser H
Kisaran A	Soisalok H	Komalaikhe K	Yoran H	Yonathan W
Kuruka W	Telima E	Linus K	Yoseph H	Rudi W
Leader W	Wamberan H	Luki K	Elias H	Domi H
Leme W	Wilem H	Markus H	Helek W	Micha H
Luis H	Yulianus E	Natalis K	Kaneke H	Yeri H
Makzi K	Alerarek M	Oanek H	Lapius H	Oim H
Marianus K	Ares H			
Marlius K	Isnawan W			
Marten M	Kosai H			
Mikeal W	Lukas H			
Nerug I	Paulus P			
Obet H	Welius H			
Ois M	Yairus W			
Pilatus K	Abusiak W			
Saus S	Ereroba H			
Silike H	Welly W			
Teo H	Tadius H			
Tinus D	Zakrias W			
Urbanus M	Hunik W			
Wenehisa K	Bona H			
Yopi H	Tuing H			

Pisugi (n=60)	Siepkosi (n=60)		Tulem (n=120)	
Depius H	Obet L	Abas O	Ibrahim M	Yunus O
Alfarius M	Hardi M	Abraham H	Ilai	Simon M
Musa H	Platus	Adekma O	Imanuel O	Simson A
Wempi K	Petrus H	Aebaga M	Ismael Y	Sole M
Elias Y	Step L	Aga	Kalaihe H	Soleman O
Yusak K	Sakeka H	Agus A	Kamsaluk O	Stanis O
Ponthius H	Olly	Agus L	Karel Tabuni	Supuk O
Tadius K	Mathias H	Aken K	Karlos K	Thomas S
Simon M	Abas O	Alex I	Karlos O	Thomas Y
Amond H	Aga M	Alex K	Yulius D	Yusup A
Stepanus W	Deki J	Alkos K	Kepuke K	Timotius O
Thomas O	Enim H	Alpius O	Kiluake M	Titus O

Appendix E. (*cont.*)

Pisugi (n=60)	Siepkosi (n=60)	Tulem (n=120)		
Yakobus K	Habekka K	Anerekhabuk Y	Kobor O	Trianus O
Alfius H	Heri K	Anton O	Marcel M	Tuitamuk M
Nikson O	Ismael L	April Y	Mari M	Unus K
Pikareyek M	Itelekma A	Arigat A	Marius A	Unus M
Elias M	Agus W	Aser A	Markus A	Usamo K
Sipe K	Alkos K	Auwe K	Marten D	Uwelesi K
Toni Y	April L	Awolok O	Marten Y	Uwemae A
Imanuel K	Auwe K	Awukha D	Martinus Y	Waetuik H
Step H	Dakebus J	Benny O	Mathius H	Wakober H
Hendrik M	Hendrikus H	Zakarias O	Mathius Y	Wakoloba A
Hengki Y	Hosea D	Dariem A	Musa K	Wamasue I
Delpianus H	John H	Daud A	Musak A	Waow K
Elly H	Jalim H	Yohanes W	Nagamoh Y	Weak Y
Ibrahim M	Leome A	Deki K	Yoel Y	Weakodek K
Matias O	Lukas L	Doalekma O	Natalis K	Wempi Y
Elias Y	Alex K	Dokob M	Natalis O	Wesak K
Alvaret H	Huiyarek L	Elikius A	Nicholas M	Wesarue K
Agus O	Lai K	Yulianus P	Nikhalok O	Yop O
Akius K	Adekma O	Habeka K	Nuarik O	Wilem K
Andreas K	Anerekhabuk L	Haledek O	Obet H	Wim O
Deptha O	Daud W	Yodak M	Paulus K	Yahya K
Edison K	Elias H	Hapuk O	Pilamus K	Yairus Y
Frans I	Erauk M	Heri K	Pilatus H	Yali Y
Holagoba O	Hali A	Herman A	Yusak H	Yance K
Kolaghedek O	Husupi M	Hermanus O	Pilipus M	Yapet O
Libertus M	Isnawan K	Hosea D	Ruben O	Yarep O
Luka H	Kerekama E	Humy M	Salihe H	Zakius O
Manu K	Kosai A	Ibrahim K	Samuel O	Yasarek K
Musa K	Martin H			
Okake I	Nomologo H			
Sereken M	Petrus L			
Step K	Sademaga H			
Thomas H	Step H			
Wayes M	Awukha M			
Yeskiel H	Deki W			
Yulius H	Haugu M			
Agustinus H	Hermanus O			
Alek H	Leri K			
Andreas K	Dokob M			
Daniel O	Elius K			
Enog K	Haledek O			
Hendrik H	Hendrikus M			
Holago H	Huiyarek S			
Karlius K	Inomonim H			
Korinus Y	Kalius M			
Martinus M	Martin H			
Linus W	Onius H			
Ngaikmotok M	Sim L			

Appendix F. The 190 comparison group silis chosen by using the Propensity Score Matching method

Village	Sili	X1	X2	Y	Ŷ	P-Score	Village	Sili	P-Score	No.	P-Score
Napua	1	0.70	15	1	6.753	1.909987	Napua	1	1.909987	**190**	**1.716138**
Sinakma	2	0.40	11	1	5.173	1.643453				**191**	**1.656894**
	3	0.55	18	1	8.313	2.117821				**182**	**1.562975**
Wamena	4	1.00	21	1	9.273	2.227107				**181**	**1.459312**
	5	1.10	24	1	10.583	2.359249				**183**	**1.112844**
Wouma	6	1.00	19	1	8.333	2.120224				186	1.079429
Megapura	7	0.60	3	1	1.213	0.193097				194	1.062294
Assolokobal	8	1.80	40	1	17.403	2.856643				192	0.905432
Hubikiak	9	1.10	25	1	11.053	2.402702				189	0.812263
Holima	10	0.50	14	1	6.483	1.869183				193	0.766862
	11	0.90	17	1	7.493	2.013969				195	0.766862
	12	0.55	14	1	6.433	1.861441				184	0.272315
Wanima	13	1.20	23	1	10.013	2.303884				185	-0.231932
	14	1.10	23	1	10.113	2.313822				188	-0.231932
Ibele	15	0.50	16	1	7.423	2.004583				187	-0.473209
Sunili	16	0.90	22	1	9.843	2.286761	Sinakma	2	1.643453	324	2.520354
Pisugi	17	1.30	23	1	9.913	2.293847		3	2.117821	317	2.330492
	18	0.30	11	1	5.273	1.662599				**344**	**2.303884**
	19	0.30	9	1	4.333	1.466260				**335**	**2.134521**
	20	0.60	17	1	7.793	2.053226				**322**	**2.009957**
Siepkosi	21	0.70	19	1	8.633	2.155592				**343**	**2.009957**
	22	0.65	19	1	8.683	2.161367				**333**	**1.980035**
	23	0.60	14	1	6.383	1.853638				**319**	**1.742744**
	24	0.70	17	1	7.693	2.040311				**345**	**1.583710**
Tulem	25	0.70	17	1	7.693	2.040311				**325**	**1.562975**
	26	0.60	16	1	7.323	1.991020				**334**	**1.562975**
	27	0.30	12	1	5.743	1.747982				**328**	**1.459312**
	28	0.55	18	1	8.313	2.117821				340	1.382035
	29	1.22	25	1	10.937	2.392152				342	1.363026
	30	1.10	24	1	10.583	2.359249				326	1.270603
	31	0.75	17	1	7.643	2.033790				330	1.112844
	32	0.75	16	1	7.173	1.970324				327	1.079429
Molima	33	0.55	15	1	6.903	1.931956				331	1.079429
Kumima	34	1.70	36	1	15.623	2.748744				341	1.079429
Timia	35	0.45	15	1	7.003	1.946339				336	1.001734
Muliama	36	1.05	22	1	9.693	2.271404				329	0.983201
Makki	37	0.85	16	1	7.073	1.956285				320	0.789820
Kelila	38	0.80	17	1	7.593	2.027227				321	0.743365
Assolokobal	1	0.95	12	0	5.093	1.627867				318	0.719302
(n=15)	2	1.15	17	0	7.243	1.980035				323	0.694646
	3	1.05	12	0	4.993	1.608037				339	0.578297
	4	0.50	3	0	1.313	0.272315				337	0.233490
	5	0.50	2	0	0.843	-0.170788				316	-0.113169
	6	0.55	4	0	1.733	0.549854				332	-0.473209
	7	0.70	7	0	2.993	1.096276				338	-5.809143
	8	1.35	19	0	7.983	2.077314	Wamena	4	2.227107	500	2.613227
	9	1.00	14	0	5.983	1.788922		5	2.359249	504	2.447810

Appendix F. (*cont.*)

Village	Sili	X1	X2	Y	Ŷ	P-Score	Village	Sili	P-Score	**No.**	**P-Score**
	10	0.40	0	0	0.003	-5.809143				**521**	**2.393613**
	11	0.65	11	0	4.923	1.593918				**514**	**2.330492**
	12	0.45	3	0	1.363	0.309688				**517**	**2.330492**
	13	0.75	7	0	2.943	1.079429				**497**	**2.140419**
	14	0.50	4	0	1.783	0.578297				**498**	**1.986915**
	15	0.95	12	0	5.093	1.627867				**511**	**1.942046**
Holima	16	1.40	21	0	8.873	2.183013				**510**	**1.920299**
(n=45)	17	0.60	6	0	2.623	0.964319				**513**	**1.864545**
	18	0.40	0	0	0.003	-5.809143				523	1.864545
	19	0.50	2	0	0.843	-0.170788				507	1.725085
	20	1.80	36	0	15.523	2.742323				496	1.707109
	21	0.95	13	0	5.563	1.716138				525	1.647312
	22	0.70	5	0	2.053	0.719302				501	1.618001
	23	0.75	9	0	3.883	1.356608				503	1.618001
	24	0.85	6	0	2.373	0.864155				515	1.597972
	25	1.20	18	0	7.663	2.036404				505	1.459312
	26	1.15	12	0	4.893	1.587806				506	1.459312
	27	1.15	17	0	7.243	1.980035				522	1.363026
	28	0.60	5	0	2.153	0.766862				520	1.112844
	29	1.15	17	0	7.243	1.980035				502	1.079429
	30	1.15	13	0	5.363	1.679524				519	0.885006
	31	1.00	12	0	5.043	1.618001				509	0.834213
	32	0.60	5	0	2.153	0.766862				499	0.605954
	33	0.80	11	0	4.773	1.562975				512	0.578297
	34	0.75	7	0	2.943	1.079429				524	0.578297
	35	1.05	16	0	6.873	1.927601				508	0.345715
	36	0.55	2	0	0.793	-0.231932				518	0.151003
	37	0.80	6	0	2.423	0.885006				516	-0.231932
	38	0.70	8	0	3.463	1.242135	Wouma	6	2.120224	560	2.824529
	39	0.75	9	0	3.883	1.356608				561	2.613227
	40	1.00	12	0	5.043	1.618001				565	2.520354
	41	1.05	12	0	4.993	1.608037				564	2.498399
	42	1.05	16	0	6.873	1.927601				**559**	**2.330492**
	43	0.75	7	0	2.943	1.079429				**563**	**2.330492**
	44	1.05	16	0	6.873	1.927601				**558**	**2.183013**
	45	0.45	4	0	1.833	0.605954				**566**	**2.134521**
	46	0.65	6	0	2.573	0.945073				**567**	**1.980035**
	47	0.60	6	0	2.623	0.964319				557	1.890548
	48	0.85	7	0	2.843	1.044860				569	1.879923
	49	1.00	12	0	5.043	1.618001				556	1.864545
	50	0.75	7	0	2.943	1.079429				568	1.805498
	51	1.00	17	0	7.393	2.000534				562	1.597972
	52	1.05	13	0	5.463	1.697998				570	1.387044
	53	1.40	21	0	8.873	2.183013	Megapura	7	0.193097	136	2.000534
	54	2.35	42	0	17.793	2.878805				144	1.788922
	55	1.80	36	0	15.523	2.742323				137	1.707109
	56	1.10	15	0	6.353	1.848927				138	1.697998

Appendix F. (*cont.*)

Village	Sili	X1	X2	Y	Ŷ	P-Score	Village	Sili	P-Score	**No.**	**P-Score**
	57	0.75	7	0	2.943	1.079429				150	1.688803
	58	0.80	10	0	4.303	1.459312				148	1.637637
	59	0.75	7	0	2.943	1.079429				149	1.435799
	60	1.20	19	0	8.133	2.095930				139	1.363026
Hubikiak	61	0.90	14	0	6.083	1.805498				146	1.363026
(n=15)	62	1.05	11	0	4.523	1.509175				141	1.242135
	63	1.30	20	0	8.503	2.140419				**143**	**1.242135**
	64	0.85	6	0	2.373	0.864155				**145**	**0.964319**
	65	1.05	16	0	6.873	1.927601				**140**	**0.694646**
	66	0.45	3	0	1.363	0.309688				**142**	**0.520578**
	67	0.45	1	0	0.423	-0.860383				**147**	**0.520578**
	68	0.85	11	0	4.723	1.552444	Assolokobal	8	2.856643	**8**	**2.077314**
	69	1.95	33	0	13.963	2.636411				**2**	**1.980035**
	70	1.05	12	0	4.993	1.608037				**9**	**1.788922**
	71	0.75	7	0	2.943	1.079429				**1**	**1.627867**
	72	0.95	13	0	5.563	1.716138				**15**	**1.627867**
	73	1.40	24	0	10.283	2.330492				3	1.608037
	74	1.80	36	0	15.523	2.742323				11	1.593918
	75	1.15	17	0	7.243	1.980035				7	1.096276
Ibele	76	0.50	3	0	1.313	0.272315				13	1.079429
(n=15)	77	0.65	7	0	3.043	1.112844				14	0.578297
	78	0.60	5	0	2.153	0.766862				6	0.549854
	79	0.75	9	0	3.883	1.356608				12	0.309688
	80	0.70	5	0	2.053	0.719302				4	0.272315
	81	1.20	18	0	7.663	2.036404				5	-0.17078
	82	0.75	9	0	3.883	1.356608				10	-5.80914
	83	0.50	3	0	1.313	0.272315	Hubikiak	9	2.402702	**74**	**2.742323**
	84	0.65	7	0	3.043	1.112844				**69**	**2.636411**
	85	0.60	5	0	2.153	0.766862				**73**	**2.330492**
	86	0.75	9	0	3.883	1.356608				**63**	**2.140419**
	87	0.70	5	0	2.053	0.719302				**75**	**1.980035**
	88	1.20	19	0	8.133	2.095930				65	1.927601
	89	0.75	11	0	4.823	1.573396				61	1.805498
	90	0.70	10	0	4.403	1.482286				72	1.716138
Kelila	91	0.95	13	0	5.563	1.716138				70	1.608037
(n=15)	92	0.50	4	0	1.783	0.578297				68	1.552444
	93	0.60	5	0	2.153	0.766862				62	1.509175
	94	1.05	14	0	5.933	1.780530				71	1.079429
	95	0.95	12	0	5.093	1.627867				64	0.864155
	96	0.55	4	0	1.733	0.549854				66	0.309688
	97	1.40	18	0	7.463	2.009957				67	-0.86038
	98	0.80	7	0	2.893	1.062294	Holima	10	1.869183	54	2.878805
	99	0.45	3	0	1.363	0.309688		11	2.013969	20	2.742323
	100	0.85	8	0	3.313	1.197854		12	1.861441	55	2.742323
	101	0.75	9	0	3.883	1.356608				16	2.183013
	102	0.65	5	0	2.103	0.743365				53	2.183013

Appendix F. (*cont.*)

Village	Sili	X1	X2	Y	Ŷ	P-Score	Village	Sili	P-Score	**No.**	**P-Score**
	103	1.20	18	0	7.663	2.036404				**60**	**2.095930**
	104	1.05	14	0	5.933	1.780530				**25**	**2.036404**
	105	0.85	7	0	2.843	1.044860				**51**	**2.000534**
Kumima	106	1.80	37	0	15.993	2.772151				**27**	**1.980035**
(n=15)	107	0.75	5	0	2.003	0.694646				**29**	**1.980035**
	108	0.50	3	0	1.313	0.272315				**35**	**1.927601**
	109	1.15	17	0	7.243	1.980035				**42**	**1.927601**
	110	1.15	12	0	4.893	1.587806				**44**	**1.927601**
	111	1.40	24	0	10.283	2.330492				**56**	**1.848927**
	112	2.32	42	0	17.82	2.880321				**21**	**1.716138**
	113	1.80	36	0	15.523	2.742323				**52**	**1.697998**
	114	1.00	12	0	5.043	1.618001				**30**	**1.679524**
	115	1.40	24	0	10.283	2.330492				**31**	**1.618001**
	116	1.40	18	0	7.463	2.009957				**40**	**1.618001**
	117	1.60	29	0	12.433	2.520354				49	1.618001
	118	1.35	20	0	8.453	2.134521				41	1.608037
	119	1.15	17	0	7.243	1.980035				26	1.587806
	120	0.60	5	0	2.153	0.766862				33	1.562975
Maki	121	0.60	5	0	2.153	0.766862				58	1.459312
(n=15)	122	1.05	13	0	5.463	1.697998				23	1.356608
	123	0.60	6	0	2.623	0.964319				39	1.356608
	124	0.80	11	0	4.773	1.562975				38	1.242135
	125	1.40	19	0	7.933	2.071031				34	1.079429
	126	1.00	14	0	5.983	1.788922				43	1.079429
	127	1.00	12	0	5.043	1.618001				50	1.079429
	128	0.85	13	0	5.663	1.733954				57	1.079429
	129	0.90	16	0	7.023	1.949190				59	1.079429
	130	0.40	3	0	1.413	0.345715				48	1.044860
	131	0.65	13	0	5.863	1.768661				17	0.964319
	132	0.90	17	0	7.493	2.013969				47	0.964319
	133	0.75	5	0	2.003	0.694646				46	0.945073
	134	0.95	15	0	6.503	1.872264				37	0.885006
	135	1.20	20	0	8.603	2.152111				24	0.864155
Megapura	136	1.00	17	0	7.393	2.000534				28	0.766862
(n=15)	137	1.00	13	0	5.513	1.707109				32	0.766862
	138	1.05	13	0	5.463	1.697998				22	0.719302
	139	0.73	9	0	3.908	1.363026				45	0.605954
	140	0.75	5	0	2.003	0.694646				19	-0.170788
	141	0.70	8	0	3.463	1.242135				36	-0.231932
	142	0.60	4	0	1.683	0.520578				18	-5.809143
	143	0.70	8	0	3.463	1.242135	Wanima	13	2.303884	552	2.963880
	144	1.00	14	0	5.983	1.788922		14	2.313822	536	2.709582
	145	0.60	6	0	2.623	0.964319				550	2.585732
	146	0.73	9	0	3.908	1.363026				549	2.349755
	147	0.60	4	0	1.683	0.520578				547	2.330492
	148	0.90	12	0	5.143	1.637637				551	2.330492

Appendix F. (*cont.*)

Village	Sili	X1	X2	Y	Ŷ	P-Score	Village	Sili	P-Score	**No.**	**P-Score**
	149	0.90	10	0	4.203	1.435799				**535**	**2.255808**
	150	1.10	13	0	5.413	1.688803				**555**	**2.134521**
Molima	151	0.75	7	0	2.943	1.079429				**534**	**1.993747**
(n=15)	152	0.50	5	0	2.253	0.812263				**539**	**1.944910**
	153	1.25	21	0	9.023	2.199777				**541**	**1.905534**
	154	1.10	17	0	7.293	1.986915				545	1.898070
	155	1.15	12	0	4.893	1.587806				526	1.879923
	156	1.40	24	0	10.283	2.330492				544	1.763531
	157	2.35	42	0	17.793	2.878805				533	1.716138
	158	1.80	34	0	14.583	2.679856				529	1.707109
	159	1.00	13	0	5.513	1.707109				542	1.562975
	160	1.40	23	0	9.813	2.283708				554	1.531044
	161	1.40	18	0	7.463	2.009957				530	1.431029
	162	1.60	29	0	12.433	2.520354				546	1.356608
	163	1.35	20	0	8.453	2.134521				537	1.270603
	164	1.15	17	0	7.243	1.980035				548	1.242135
	165	0.60	5	0	2.153	0.766862				528	1.096276
Muliama	166	0.95	11	0	4.623	1.531044				553	0.964319
(n=15)	167	0.80	12	0	5.243	1.656894				531	0.766862
	168	0.75	6	0	2.473	0.905432				540	0.669367
	169	1.15	18	0	7.713	2.042907				543	0.309688
	170	1.00	12	0	5.043	1.618001				532	0.151003
	171	0.55	5	0	2.203	0.789820				538	-0.058689
	172	0.80	5	0	1.953	0.669367				527	-0.860383
	173	0.75	7	0	2.943	1.079429	Ibele	15	2.004583	**88**	**2.095930**
	174	0.95	15	0	6.503	1.872264				**81**	**2.036404**
	175	0.80	5	0	1.953	0.669367				**89**	**1.573396**
	176	0.75	7	0	2.943	1.079429				**90**	**1.482286**
	177	0.80	12	0	5.243	1.656894				**79**	**1.356608**
	178	0.75	7	0	2.943	1.079429				82	1.356608
	179	0.75	6	0	2.473	0.905432				86	1.356608
	180	1.20	15	0	6.253	1.833061				77	1.112844
Napua	181	0.80	10	0	4.303	1.459312				84	1.112844
(n=15)	182	0.80	11	0	4.773	1.562975				78	0.766862
	183	0.65	7	0	3.043	1.112844				85	0.766862
	184	0.50	3	0	1.313	0.272315				80	0.719302
	185	0.55	2	0	0.793	-0.231932				87	0.719302
	186	0.75	7	0	2.943	1.079429				76	0.272315
	187	0.25	1	0	0.623	-0.473209				83	0.272315
	188	0.55	2	0	0.793	-0.231932	Sunili	16	2.286761	358	2.504137
	189	0.50	5	0	2.253	0.812263				346	2.365842
	190	0.95	13	0	5.563	1.716138				347	1.942046
	191	0.80	12	0	5.243	1.656894				348	1.608037
	192	0.75	6	0	2.473	0.905432				359	1.541801
	193	0.60	5	0	2.153	0.766862				355	1.509175
	194	0.80	7	0	2.893	1.062294				350	1.423831
	195	0.60	5	0	2.153	0.766862				349	1.096276

Appendix F. (*cont.*)

Village	Sili	X1	X2	Y	Ŷ	P-Score	Village	Sili	P-Score	**No.**	**P-Score**
Pisugi	196	0.60	5	0	2.153	0.766862				357	1.079429
(n=60)	197	0.90	13	0	5.613	1.725085				353	0.964319
	198	0.60	4	0	1.683	0.520578				352	0.945073
	199	0.80	5	0	1.953	0.669367				360	0.925449
	200	0.55	7	0	3.143	1.145178				354	0.359770
	201	0.90	16	0	7.023	1.949190				356	0.233490
	202	0.40	2	0	0.943	-0.058689				351	0.061095
	203	1.20	19	0	8.133	2.095930	Pisugi	17	2.293847	225	3.023493
	204	0.60	10	0	4.503	1.504744		18	1.662599	**228**	**2.561327**
	205	0.75	9	0	3.883	1.356608		19	1.466260	**203**	**2.095930**
	206	0.40	3	0	1.413	0.345715		20	2.053226	**239**	**2.036404**
	207	0.50	5	0	2.253	0.812263				**243**	**1.980035**
	208	0.65	4	0	1.633	0.490419				**201**	**1.949190**
	209	0.75	5	0	2.003	0.694646				**229**	**1.942046**
	210	0.60	5	0	2.153	0.766862				**254**	**1.912944**
	211	0.70	5	0	2.053	0.719302				**244**	**1.805498**
	212	0.65	4	0	1.633	0.490419				**197**	**1.725085**
	213	0.80	6	0	2.423	0.885006				**246**	**1.725085**
	214	0.55	2	0	0.793	-0.231932				**253**	**1.637637**
	215	0.75	5	0	2.003	0.694646				**245**	**1.627867**
	216	0.60	4	0	1.683	0.520578				**255**	**1.627867**
	217	0.60	4	0	1.683	0.520578				**237**	**1.597972**
	218	0.35	2	0	0.993	-0.007025				**227**	**1.593918**
	219	0.55	4	0	1.733	0.549854				**248**	**1.541801**
	220	0.55	4	0	1.733	0.549854				**250**	**1.509175**
	221	0.85	10	0	4.253	1.447625				**204**	**1.504744**
	222	0.65	5	0	2.103	0.743365				**242**	**1.482286**
	223	0.65	5	0	2.103	0.743365				**221**	**1.447625**
	224	0.60	4	0	1.683	0.520578				205	1.356608
	225	2.40	48	0	20.563	3.023493				200	1.145178
	226	0.50	4	0	1.783	0.578297				252	1.079429
	227	0.65	11	0	4.923	1.593918				230	1.062294
	228	1.55	30	0	12.953	2.561327				247	1.062294
	229	0.95	16	0	6.973	1.942046				241	1.044860
	230	0.80	7	0	2.893	1.062294				232	0.925449
	231	0.65	5	0	2.103	0.743365				236	0.905432
	232	0.70	6	0	2.523	0.925449				213	0.885006
	233	0.70	5	0	2.053	0.719302				207	0.812263
	234	0.90	5	0	1.853	0.616806				196	0.766862
	235	0.90	4	0	1.383	0.324255				210	0.766862
	236	0.75	6	0	2.473	0.905432				238	0.766862
	237	1.10	12	0	4.943	1.597972				240	0.766862
	238	0.60	5	0	2.153	0.766862				222	0.743365
	239	1.20	18	0	7.663	2.036404				223	0.743365
	240	0.60	5	0	2.153	0.766862				231	0.743365
	241	0.85	7	0	2.843	1.044860				211	0.719302

Appendix F. (*cont.*)

Village	Sili	X1	X2	Y	Ŷ	P-Score	Village	Sili	P-Score	**No.**	**P-Score**
	242	0.70	10	0	4.403	1.482286				233	0.719302
	243	1.15	17	0	7.243	1.980035				209	0.694646
	244	0.90	14	0	6.083	1.805498				215	0.694646
	245	0.95	12	0	5.093	1.627867				199	0.669367
	246	0.90	13	0	5.613	1.725085				249	0.669367
	247	0.80	7	0	2.893	1.062294				234	0.616806
	248	0.90	11	0	4.673	1.541801				226	0.578297
	249	0.80	5	0	1.953	0.669367				219	0.549854
	250	1.05	11	0	4.523	1.509175				220	0.549854
	251	0.40	3	0	1.413	0.345715				198	0.520578
	252	0.75	7	0	2.943	1.079429				216	0.520578
	253	0.90	12	0	5.143	1.637637				217	0.520578
	254	1.15	16	0	6.773	1.912944				224	0.520578
	255	0.95	12	0	5.093	1.627867				208	0.490419
Siepkosi	256	0.40	6	0	2.823	1.037800				212	0.490419
(n=60)	257	0.75	13	0	5.763	1.751458				206	0.345715
	258	0.65	7	0	3.043	1.112844				251	0.345715
	259	1.05	16	0	6.873	1.927601				235	0.324255
	260	0.45	4	0	1.833	0.605954				218	-0.007025
	261	0.95	13	0	5.563	1.716138				202	-0.058689
	262	0.75	9	0	3.883	1.356608				214	-0.231932
	263	1.10	16	0	6.823	1.920299	Siepkosi	21	2.155592	288	2.880321
	264	0.75	10	0	4.353	1.470865		22	2.161367	297	2.647096
	265	0.95	13	0	5.563	1.716138		23	1.853638	**304**	**2.413500**
	266	0.45	3	0	1.363	0.309688		24	2.040311	**277**	**2.303884**
	267	0.50	5	0	2.253	0.812263				**276**	**2.152111**
	268	0.85	7	0	2.843	1.044860				**303**	**2.140419**
	269	1.05	15	0	6.403	1.856767				**281**	**2.128589**
	270	0.65	3	0	1.163	0.151003				**289**	**1.980035**
	271	0.95	13	0	5.563	1.716138				**259**	**1.927601**
	272	1.00	14	0	5.983	1.788922				**263**	**1.920299**
	273	0.75	6	0	2.473	0.905432				**282**	**1.879923**
	274	0.80	7	0	2.893	1.062294				**269**	**1.856767**
	275	0.65	5	0	2.103	0.743365				**305**	**1.805498**
	276	1.20	20	0	8.603	2.152111				**272**	**1.788922**
	277	1.20	23	0	10.013	2.303884				**294**	**1.788922**
	278	0.70	7	0	2.993	1.096276				**306**	**1.788922**
	279	0.85	12	0	5.193	1.647312				**257**	**1.751458**
	280	0.50	4	0	1.783	0.578297				**261**	**1.716138**
	281	1.40	20	0	8.403	2.128589				**265**	**1.716138**
	282	0.90	15	0	6.553	1.879923				**271**	**1.716138**
	283	0.80	7	0	2.893	1.062294				**309**	**1.707109**
	284	0.80	7	0	2.893	1.062294				**314**	**1.707109**
	285	0.80	12	0	5.243	1.656894				**293**	**1.666385**
	286	0.50	3	0	1.313	0.272315				**285**	**1.656894**
	287	0.95	12	0	5.093	1.627867				**279**	**1.647312**
	288	2.32	42	0	17.82	2.880321				**287**	**1.627867**

Appendix F. (*cont.*)

Village	Sili	X1	X2	Y	Ŷ	P-Score	Village	Sili	P-Score	**No.**	**P-Score**
	289	1.15	17	0	7.243	1.980035				313	1.608037
	290	0.75	9	0	3.883	1.356608				295	1.552444
	291	0.50	3	0	1.313	0.272315				264	1.470865
	292	0.75	9	0	3.883	1.356608				311	1.399457
	293	0.75	12	0	5.293	1.666385				262	1.356608
	294	1.00	14	0	5.983	1.788922				290	1.356608
	295	0.85	11	0	4.723	1.552444				292	1.356608
	296	0.60	4	0	1.683	0.520578				298	1.356608
	297	1.80	33	0	14.113	2.647096				307	1.227592
	298	0.75	9	0	3.883	1.356608				258	1.112844
	299	0.50	3	0	1.313	0.272315				312	1.112844
	300	0.65	3	0	1.163	0.151003				278	1.096276
	301	0.70	4	0	1.583	0.459322				308	1.079429
	302	0.50	3	0	1.313	0.272315				274	1.062294
	303	1.30	20	0	8.503	2.140419				283	1.062294
	304	1.45	26	0	11.173	2.413500				284	1.062294
	305	0.90	14	0	6.083	1.805498				268	1.044860
	306	1.00	14	0	5.983	1.788922				256	1.037800
	307	0.75	8	0	3.413	1.227592				310	1.009052
	308	0.75	7	0	2.943	1.079429				273	0.905432
	309	1.00	13	0	5.513	1.707109				267	0.812263
	310	0.95	7	0	2.743	1.009052				275	0.743365
	311	1.05	10	0	4.053	1.399457				315	0.743365
	312	0.65	7	0	3.043	1.112844				260	0.605954
	313	1.05	12	0	4.993	1.608037				280	0.578297
	314	1.00	13	0	5.513	1.707109				296	0.520578
	315	0.65	5	0	2.103	0.743365				301	0.459322
Sinakma	316	0.45	2	0	0.893	-0.113169				266	0.309688
(n=30)	317	1.40	24	0	10.283	2.330492				286	0.272315
	318	0.70	5	0	2.053	0.719302				291	0.272315
	319	0.80	13	0	5.713	1.742744				299	0.272315
	320	0.55	5	0	2.203	0.789820				302	0.272315
	321	0.65	5	0	2.103	0.743365				270	0.151003
	322	1.40	18	0	7.463	2.009957				300	0.151003
	323	0.75	5	0	2.003	0.694646	Tulem	25	2.040311	389	2.824529
	324	1.60	29	0	12.433	2.520354		26	1.991020	441	2.772151
	325	0.80	11	0	4.773	1.562975		27	1.747982	417	2.742323
	326	0.60	8	0	3.563	1.270603		28	2.117821	473	2.647096
	327	0.75	7	0	2.943	1.079429		29	2.392152	377	2.578169
	328	0.80	10	0	4.303	1.459312		30	2.359249	460	2.520354
	329	0.55	6	0	2.673	0.983201		31	2.033790	481	2.520354
	330	0.65	7	0	3.043	1.112844		32	1.970324	387	2.424183
	331	0.75	7	0	2.943	1.079429				448	2.393613
	332	0.25	1	0	0.623	-0.473209				436	2.365842
	333	1.15	17	0	7.243	1.980035				459	2.349755
	334	0.80	11	0	4.773	1.562975				403	2.330492

Appendix F. (*cont.*)

Village	Sili	X1	X2	Y	Ŷ	P-Score	Village	Sili	P-Score	**No.**	**P-Score**
	335	1.35	20	0	8.453	2.134521				**453**	**2.330492**
	336	0.50	6	0	2.723	1.001734				**404**	**2.183013**
	337	0.55	3	0	1.263	0.233490				**445**	**2.183013**
	338	0.40	0	0	0.003	-5.809143				**415**	**2.140419**
	339	0.50	4	0	1.783	0.578297				**430**	**2.140419**
	340	0.65	9	0	3.983	1.382035				**474**	**2.134521**
	341	0.75	7	0	2.943	1.079429				**495**	**2.134521**
	342	0.73	9	0	3.908	1.363026				**466**	**2.009957**
	343	1.40	18	0	7.463	2.009957				**406**	**1.986915**
	344	1.20	23	0	10.013	2.303884				**395**	**1.980035**
	345	0.70	11	0	4.873	1.583710				**480**	**1.980035**
Sunili	346	1.50	25	0	10.653	2.365842				**488**	**1.980035**
(n=15)	347	0.95	16	0	6.973	1.942046				**428**	**1.944910**
	348	1.05	12	0	4.993	1.608037				**492**	**1.944910**
	349	0.70	7	0	2.993	1.096276				**429**	**1.942046**
	350	0.95	10	0	4.153	1.423831				**378**	**1.927601**
	351	0.75	3	0	1.063	0.061095				**398**	**1.927601**
	352	0.65	6	0	2.573	0.945073				**411**	**1.898070**
	353	0.60	6	0	2.623	0.964319				**432**	**1.890548**
	354	0.85	4	0	1.433	0.359770				**434**	**1.879923**
	355	1.05	11	0	4.523	1.509175				**493**	**1.833061**
	356	0.55	3	0	1.263	0.233490				**444**	**1.805498**
	357	0.75	7	0	2.943	1.079429				**394**	**1.780530**
	358	1.80	29	0	12.233	2.504137				**476**	**1.763531**
	359	0.90	11	0	4.673	1.541801				**427**	**1.751458**
	360	0.70	6	0	2.523	0.925449				**426**	**1.725085**
Timia	361	0.50	4	0	1.783	0.578297				**486**	**1.725085**
(n=15)	362	0.55	2	0	0.793	-0.231932				**442**	**1.716138**
	363	0.50	6	0	2.723	1.001734				**456**	**1.716138**
	364	0.45	1	0	0.423	-0.860383				**477**	**1.716138**
	365	0.90	14	0	6.083	1.805498				**381**	**1.707109**
	366	0.25	1	0	0.623	-0.473209				**414**	**1.707109**
	367	0.80	4	0	1.483	0.394067				**419**	**1.679524**
	368	0.65	6	0	2.573	0.945073				**446**	**1.627867**
	369	0.55	2	0	0.793	-0.231932				**396**	**1.618001**
	370	0.50	2	0	0.843	-0.170788				**433**	**1.618001**
	371	1.40	18	0	7.463	2.009957				**487**	**1.618001**
	372	0.25	1	0	0.623	-0.473209				**407**	**1.608037**
	373	0.60	5	0	2.153	0.766862				**449**	**1.608037**
	374	0.80	4	0	1.483	0.394067				**461**	**1.593918**
	375	0.70	5	0	2.053	0.719302				**382**	**1.587806**
Tulem	376	0.50	2	0	0.843	-0.170788				**462**	**1.587806**
(n=120)	377	1.80	31	0	13.173	2.578169				**455**	**1.562975**
	378	1.05	16	0	6.873	1.927601				**482**	**1.552444**
	379	0.70	5	0	2.053	0.719302				**380**	**1.531044**
	380	0.95	11	0	4.623	1.531044				**435**	**1.520169**
	381	1.00	13	0	5.513	1.707109				**418**	**1.509175**

Appendix F. (*cont.*)

Village	Sili	X1	X2	Y	Ŷ	P-Score	Village	Sili	P-Score	**No.**	**P-Score**
	382	1.15	12	0	4.893	1.587806				421	1.509175
	383	0.55	5	0	2.203	0.789820				457	1.509175
	384	0.45	5	0	2.303	0.834213				458	1.459312
	385	0.55	5	0	2.203	0.789820				472	1.459312
	386	0.95	10	0	4.153	1.423831				386	1.423831
	387	1.80	27	0	11.293	2.424183				452	1.387044
	388	0.45	5	0	2.303	0.834213				494	1.387044
	389	2.35	40	0	16.853	2.824529				393	1.356608
	390	0.50	3	0	1.313	0.272315				454	1.356608
	391	0.50	2	0	0.843	-0.170788				465	1.356608
	392	0.85	6	0	2.373	0.864155				451	1.197854
	393	0.75	9	0	3.883	1.356608				423	1.160961
	394	1.05	14	0	5.933	1.780530				422	1.112844
	395	1.15	17	0	7.243	1.980035				400	1.096276
	396	1.00	12	0	5.043	1.618001				405	1.096276
	397	0.80	3	0	1.013	0.012916				440	1.079429
	398	1.05	16	0	6.873	1.927601				484	1.079429
	399	0.80	7	0	2.893	1.062294				485	1.079429
	400	0.70	7	0	2.993	1.096276				489	1.079429
	401	0.45	6	0	2.773	1.019930				399	1.062294
	402	0.80	5	0	1.953	0.669367				401	1.019930
	403	1.40	24	0	10.283	2.330492				420	0.964319
	404	1.40	21	0	8.873	2.183013				463	0.905432
	405	0.70	7	0	2.993	1.096276				464	0.905432
	406	1.10	17	0	7.293	1.986915				392	0.864155
	407	1.05	12	0	4.993	1.608037				384	0.834213
	408	0.70	5	0	2.053	0.719302				388	0.834213
	409	0.65	3	0	1.163	0.151003				437	0.834213
	410	0.60	4	0	1.683	0.520578				475	0.834213
	411	1.25	16	0	6.673	1.898070				491	0.834213
	412	0.50	3	0	1.313	0.272315				425	0.812263
	413	0.60	5	0	2.153	0.766862				483	0.812263
	414	1.00	13	0	5.513	1.707109				383	0.789820
	415	1.30	20	0	8.503	2.140419				385	0.789820
	416	0.40	0	0	0.003	-5.809143				413	0.766862
	417	1.80	36	0	15.523	2.742323				439	0.766862
	418	1.05	11	0	4.523	1.509175				450	0.766862
	419	1.15	13	0	5.363	1.679524				479	0.743365
	420	0.60	6	0	2.623	0.964319				379	0.719302
	421	1.05	11	0	4.523	1.509175				408	0.719302
	422	0.65	7	0	3.043	1.112844				424	0.694646
	423	0.50	7	0	3.193	1.160961				467	0.694646
	424	0.75	5	0	2.003	0.694646				402	0.669367
	425	0.50	5	0	2.253	0.812263				410	0.520578
	426	0.90	13	0	5.613	1.725085				438	0.345715
	427	0.75	13	0	5.763	1.751458				468	0.345715

Appendix F. (*cont.*)

Village	Sili	X1	X2	Y	Ŷ	P-Score	Village	Sili	P-Score	**No.**	**P-Score**
	428	1.40	17	0	6.993	1.944910				469	0.309688
	429	0.95	16	0	6.973	1.942046				390	0.272315
	430	1.30	20	0	8.503	2.140419				412	0.272315
	431	0.45	1	0	0.423	-0.860383				443	0.272315
	432	1.30	16	0	6.623	1.890548				471	0.233490
	433	1.00	12	0	5.043	1.618001				470	0.193097
	434	0.90	15	0	6.553	1.879923				409	0.151003
	435	1.00	11	0	4.573	1.520169				397	0.012916
	436	1.50	25	0	10.653	2.365842				376	-0.170788
	437	0.45	5	0	2.303	0.834213				391	-0.170788
	438	0.40	3	0	1.413	0.345715				490	-0.297059
	439	0.60	5	0	2.153	0.766862				431	-0.860383
	440	0.75	7	0	2.943	1.079429				416	-5.809143
	441	1.80	37	0	15.993	2.772151				447	-5.809143
	442	0.95	13	0	5.563	1.716138				478	-5.809143
	443	0.50	3	0	1.313	0.272315	Molima	33	1.931956	157	2.878805
	444	0.90	14	0	6.083	1.805498				158	2.679856
	445	1.40	21	0	8.873	2.183013				162	2.520354
	446	0.95	12	0	5.093	1.627867				156	2.330492
	447	0.40	0	0	0.003	-5.809143				160	2.283708
	448	1.20	25	0	10.953	2.393613				153	2.199777
	449	1.05	12	0	4.993	1.608037				**163**	**2.134521**
	450	0.60	5	0	2.153	0.766862				**161**	**2.009957**
	451	0.85	8	0	3.313	1.197854				**154**	**1.986915**
	452	1.10	10	0	4.003	1.387044				**164**	**1.980035**
	453	1.40	24	0	10.283	2.330492				**159**	**1.707109**
	454	0.75	9	0	3.883	1.356608				155	1.587806
	455	0.80	11	0	4.773	1.562975				151	1.079429
	456	0.95	13	0	5.563	1.716138				152	0.812263
	457	1.05	11	0	4.523	1.509175				165	0.766862
	458	0.80	10	0	4.303	1.459312	Kumima	34	2.748744	**112**	**2.880321**
	459	1.20	24	0	10.483	2.349755				**106**	**2.772151**
	460	1.60	29	0	12.433	2.520354				**113**	**2.742323**
	461	0.65	11	0	4.923	1.593918				**117**	**2.520354**
	462	1.15	12	0	4.893	1.587806				**111**	**2.330492**
	463	0.75	6	0	2.473	0.905432				115	2.330492
	464	0.75	6	0	2.473	0.905432				118	2.134521
	465	0.75	9	0	3.883	1.356608				116	2.009957
	466	1.40	18	0	7.463	2.009957				109	1.980035
	467	0.75	5	0	2.003	0.694646				119	1.980035
	468	0.40	3	0	1.413	0.345715				114	1.618001
	469	0.45	3	0	1.363	0.309688				110	1.587806
	470	0.60	3	0	1.213	0.193097				120	0.766862
	471	0.55	3	0	1.263	0.233490				107	0.694646
	472	0.80	10	0	4.303	1.459312				108	0.272315
	473	1.80	33	0	14.113	2.647096	Timia	35	1.946339	**371**	**2.009957**
	474	1.35	20	0	8.453	2.134521				**365**	**1.805498**
	475	0.45	5	0	2.303	0.834213				**363**	**1.001734**

Appendix F. (*cont.*)

Village	Sili	X1	X2	Y	Ŷ	P-Score	Village	Sili	P-Score	**No.**	**P-Score**
	476	1.15	14	0	5.833	1.763531				**368**	**0.945073**
	477	0.95	13	0	5.563	1.716138				**373**	**0.766862**
	478	0.40	0	0	0.003	-5.809143				375	0.719302
	479	0.65	5	0	2.103	0.743365				361	0.578297
	480	1.15	17	0	7.243	1.980035				367	0.394067
	481	1.60	29	0	12.433	2.520354				374	0.394067
	482	0.85	11	0	4.723	1.552444				370	-0.170788
	483	0.50	5	0	2.253	0.812263				362	-0.231932
	484	0.75	7	0	2.943	1.079429				369	-0.231932
	485	0.75	7	0	2.943	1.079429				366	-0.473209
	486	0.90	13	0	5.613	1.725085				372	-0.473209
	487	1.00	12	0	5.043	1.618001				364	-0.860383
	488	1.15	17	0	7.243	1.980035	Muliama	36	2.271404	**169**	**2.042907**
	489	0.75	7	0	2.943	1.079429				**174**	**1.872264**
	490	0.60	2	0	0.743	-0.297059				**180**	**1.833061**
	491	0.45	5	0	2.303	0.834213				**167**	**1.656894**
	492	1.40	17	0	6.993	1.944910				**177**	**1.656894**
	493	1.20	15	0	6.253	1.833061				170	1.618001
	494	1.10	10	0	4.003	1.387044				166	1.531044
	495	1.35	20	0	8.453	2.134521				173	1.079429
Wamena	496	1.00	13	0	5.513	1.707109				176	1.079429
(n=30)	497	1.30	20	0	8.503	2.140419				178	1.079429
	498	1.10	17	0	7.293	1.986915				168	0.905432
	499	0.45	4	0	1.833	0.605954				179	0.905432
	500	1.80	32	0	13.643	2.613227				171	0.789820
	501	1.00	12	0	5.043	1.618001				172	0.669367
	502	0.75	7	0	2.943	1.079429				175	0.669367
	503	1.00	12	0	5.043	1.618001	Makki	37	1.956285	135	2.152111
	504	2.00	28	0	11.563	2.447810				**125**	**2.071031**
	505	0.80	10	0	4.303	1.459312				**132**	**2.013969**
	506	0.80	10	0	4.303	1.459312				**129**	**1.949190**
	507	0.90	13	0	5.613	1.725085				**134**	**1.872264**
	508	0.40	3	0	1.413	0.345715				**126**	**1.788922**
	509	0.45	5	0	2.303	0.834213				131	1.768661
	510	1.10	16	0	6.823	1.920299				128	1.733954
	511	0.95	16	0	6.973	1.942046				122	1.697998
	512	0.50	4	0	1.783	0.578297				127	1.618001
	513	1.00	15	0	6.453	1.864545				124	1.562975
	514	1.40	24	0	10.283	2.330492				123	0.964319
	515	1.10	12	0	4.943	1.597972				121	0.766862
	516	0.55	2	0	0.793	-0.231932				133	0.694646
	517	1.40	24	0	10.283	2.330492				130	0.345715
	518	0.65	3	0	1.163	0.151003	Kelila	38	2.027227	**103**	**2.036404**
	519	0.80	6	0	2.423	0.885006				**97**	**2.009957**
	520	0.65	7	0	3.043	1.112844				**94**	**1.780530**
	521	1.20	25	0	10.953	2.393613				**104**	**1.780530**
	522	0.73	9	0	3.908	1.363026				**91**	**1.716138**
	523	1.00	15	0	6.453	1.864545				95	1.627867

Appendix F. (*cont.*)

Village	Sili	X1	X2	Y	Ŷ	P-Score	Village	Sili	P-Score	**No.**	**P-Score**
	524	0.50	4	0	1.783	0.578297				101	1.356608
	525	0.85	12	0	5.193	1.647312				100	1.197854
Wanima	526	0.90	15	0	6.553	1.879923				98	1.062294
(n=30)	527	0.45	1	0	0.423	-0.860383				105	1.044860
	528	0.70	7	0	2.993	1.096276				93	0.766862
	529	1.00	13	0	5.513	1.707109				102	0.743365
	530	0.45	9	0	4.183	1.431029				92	0.578297
	531	0.60	5	0	2.153	0.766862				96	0.549854
	532	0.65	3	0	1.163	0.151003				99	0.309688
	533	0.95	13	0	5.563	1.716138					
	534	1.05	17	0	7.343	1.993747					
	535	1.20	22	0	9.543	2.255808					
	536	2.30	36	0	15.023	2.709582					
	537	0.60	8	0	3.563	1.270603					
	538	0.40	2	0	0.943	-0.058689					
	539	1.40	17	0	6.993	1.944910					
	540	0.80	5	0	1.953	0.669367					
	541	1.20	16	0	6.723	1.905534					
	542	0.80	11	0	4.773	1.562975					
	543	0.45	3	0	1.363	0.309688					
	544	1.15	14	0	5.833	1.763531					
	545	1.25	16	0	6.673	1.898070					
	546	0.75	9	0	3.883	1.356608					
	547	1.40	24	0	10.283	2.330492					
	548	0.70	8	0	3.463	1.242135					
	549	1.20	24	0	10.483	2.349755					
	550	1.70	31	0	13.273	2.585732					
	551	1.40	24	0	10.283	2.330492					
	552	2.65	46	0	19.373	2.963880					
	553	0.60	6	0	2.623	0.964319					
	554	0.95	11	0	4.623	1.531044					
	555	1.35	20	0	8.453	2.134521					
Wouma	556	1.00	15	0	6.453	1.864545					
(n=15)	557	1.30	16	0	6.623	1.890548					
	558	1.40	21	0	8.873	2.183013					
	559	1.40	24	0	10.283	2.330492					
	560	2.35	40	0	16.853	2.824529					
	561	1.80	32	0	13.643	2.613227					
	562	1.10	12	0	4.943	1.597972					
	563	1.40	24	0	10.283	2.330492					
	564	1.40	28	0	12.163	2.498399					
	565	1.60	29	0	12.433	2.520354					
	566	1.35	20	0	8.453	2.134521					
	567	1.15	17	0	7.243	1.980035					
	568	0.90	14	0	6.083	1.805498					
	569	0.90	15	0	6.553	1.879923					
	570	1.10	10	0	4.003	1.387044					

Note: X1: The size of sweetpotato gardens (ha); X2: The number of pigs; $\hat{Y}$=0.403-X1+0.47X2; P-Score= (Log[P/(1-P)]); Numbers in bold are selected to be members of the Comparison Group (non-project *silis*)

Appendix G. Timeline of *sili* surveys in 2007

Date	Village	Interviewed *sili*	Questionnaire page
End-line datasets:			
Monday, 18 Jun	Hubikiak	15	1-15
Tuesday, 19 Jun	Sinakma	15	1-15
Wednesday, 20 Jun	Sinakma	15	1-15
Thursday, 21 Jun	Wouma	15	1-15
Friday, 22 Jun	Megapura	15	1-15
Saturday, 23 Jun	-	-	-
Sunday, 24 Jun	-	-	-
Monday, 25 Jun	Hubikiak	15	16-31
Tuesday, 26 Jun	Sinakma	15	16-31
Wednesday, 27 Jun	Sinakma	15	16-31
Thursday, 28 Jun	Wouma	15	16-31
Friday, 29 Jun	Megapura	15	16-31
Saturday, 30 Jun	-	-	-
Sunday, 1 Jul	-	-	-
Monday, 2 Jul	Wamena	15	1-15
Tuesday, 3 Jul	Wamena	15	1-15
Wednesday, 4 Jul	Holima	15	1-15
Thursday, 5 Jul	Holima	15	1-15
Friday, 6 Jul	Holima	15	1-15
Saturday, 7 Jul	-	-	-
Sunday, 8 Jul	-	-	-
Monday, 9 Jul	Wamena	15	16-31
Tuesday, 10 Jul	Wamena	15	16-31
Wednesday, 11 Jul	Holima	15	16-31
Thursday, 12 Jul	Holima	15	16-31
Friday, 13 Jul	Holima	15	16-31
Saturday, 14 Jul	-	-	-
Sunday, 15 Jul	-	-	-
Monday, 16 Jul	Assolokobal	15	1-15
Tuesday, 17 Jul	Pisugi	15	1-15
Wednesday, 18 Jul	Pisugi	15	1-15
Thursday, 19 Jul	Pisugi	15	1-15
Friday, 20 Jul	Pisugi	15	1-15
Saturday, 21 Jul	-	-	-
Sunday, 22 Jul	-	-	-
Monday, 23 Jul	Assolokobal	15	16-31
Tuesday, 24 Jul	Pisugi	15	16-31
Wednesday, 25 Jul	Pisugi	15	16-31
Thursday, 26 Jul	Pisugi	15	16-31
Friday, 27 Jul	Pisugi	15	16-31

Appendix G. (*cont.*)

Date	Village	Interviewed *sili*	Questionnaire page
Saturday, 28 Jul	-	-	-
Sunday, 29 Jul	-	-	-
Monday, 30 Jul	Wanima	10	1-15
Tuesday, 31 Jul	Wanima	10	1-15
Wednesday, 1 Aug	Wanima	10	1-15
Thursday, 2 Aug	Ibele	15	1-15
Friday, 3 Aug	Sunili	15	1-15
Saturday, 4 Aug	-	-	-
Sunday, 5 Aug	-	-	-
Monday, 6 Aug	Wanima	10	16-31
Tuesday, 7 Aug	Wanima	10	16-31
Wednesday, 8 Aug	Wanima	10	16-31
Thursday, 9 Aug	Ibele	15	16-31
Friday, 10 Aug	Sunili	15	16-31
Saturday, 11 Aug	-	-	-
Sunday, 12 Aug	-	-	-
Monday, 13 Aug	Molima	15	1-15
Tuesday, 14 Aug	Kumima	15	1-15
Wednesday, 15 Aug	Timia	15	1-15
Thursday, 16 Aug	Muliama	15	1-15
Friday, 17 Aug	-	-	-
Saturday, 18 Aug	-	-	-
Sunday, 19 Aug	-	-	-
Monday, 20 Aug	Molima	15	16-31
Tuesday, 21 Aug	Kumima	15	16-31
Wednesday, 22 Aug	Timia	15	16-31
Thursday, 23 Aug	Muliama	15	16-31
Friday, 24 Aug	-	-	-
Saturday, 25 Aug	-	-	-
Sunday, 26 Aug	-	-	-
Monday, 27 Aug	Siepkosi	20	1-15
Tuesday, 28 Aug	Siepkosi	20	1-15
Wednesday, 29 Aug	Siepkosi	20	1-15
Thursday, 30 Aug	Kelila	15	1-15
Friday, 31 Aug	Makki	15	1-15
Saturday, 1 Sep	-	-	-
Sunday, 2 Sep	-	-	-
Monday, 3 Sep	Tulem	10	1-15
Tuesday, 4 Sep	Napua	15	1-15
Wednesday, 5 Sep	Siepkosi	20	16-31

Appendix G. (*cont.*)

Date	Village	Interviewed *sili*	Questionnaire page
Thursday, 6 Sep	Siepkosi	20	16-31
Friday, 7 Sep	Siepkosi	20	16-31
Saturday, 8 Sep	-	-	-
Sunday, 9 Sep	Tulem	10	1-15
Monday, 10 Sep	Tulem	10	16-31
Tuesday, 11 Sep	Napua	15	16-31
Wednesday, 12 Sep	Tulem	10	16-31
Thursday, 13 Sep	Kelila	15	16-31
Friday, 14 Sep	Makki	15	16-31
Saturday, 15 Sep	-	-	-
Sunday, 16 Sep	-	-	-
Monday, 17 Sep	Tulem	20	1-15
Tuesday, 18 Sep	Tulem	20	1-15
Wednesday, 19 Sep	Tulem	20	1-15
Thursday, 20 Sep	Tulem	20	1-15
Friday, 21 Sep	Tulem	20	1-15
Saturday, 22 Sep	-	-	-
Sunday, 23 Sep	-	-	-
Monday, 24 Sep	Tulem	20	16-31
Tuesday, 25 Sep	Tulem	20	16-31
Wednesday, 26 Sep	Tulem	20	16-31
Thursday, 27 Sep	Tulem	20	16-31
Friday, 28 Sep	Tulem	20	16-31
Total	20	570	1-31
Additional base-line datasets:			
Monday, 8 Oct	Sinakma	15	1-15
Tuesday, 9 Oct	Sinakma	15	1-15
Wednesday, 10 Oct	Wouma	15	1-15
Thursday, 11 Oct	Megapura	15	1-15
Friday, 12 Oct	Assolokobal	15	1-15
Saturday, 13 Oct	-	-	-
Sunday, 14 Oct	-	-	-
Monday, 15 Oct	Sinakma	15	16-31
Tuesday, 16 Oct	Sinakma	15	16-31
Wednesday, 17 Oct	Wouma	15	16-31
Thursday, 18 Oct	Megapura	15	16-31
Friday, 19 Oct	Assolokobal	15	16-31
Saturday, 20 Oct	-	-	-
Sunday, 21 Oct	-	-	-
Monday, 22 Oct	Wamena	15	1-15
Tuesday, 23 Oct	Wamena	15	1-15

Appendix G. (*cont.*)

Date	Village	Interviewed *sili*	Questionnaire page
Wednesday, 24 Oct	Holima	15	1-15
Thursday, 25 Oct	Holima	15	1-15
Friday, 26 Oct	Holima	15	1-15
Saturday, 27 Oct	-	-	-
Sunday, 28 Oct	-	-	-
Monday,29 Oct	Wamena	15	16-31
Tuesday, 30 Oct	Wamena	15	16-31
Wednesday, 31 Oct	Holima	15	16-31
Thursday, 1 Nov	Holima	15	16-31
Friday, 2 Nov	Holima	15	16-31
Saturday, 3 Nov	-	-	-
Sunday, 4 Nov	-	-	-
Monday, 5 Nov	Molima	15	1-15
Tuesday, 6 Nov	Ibele	15	1-15
Wednesday, 7 Nov	Sunili	15	1-15
Thursday, 8 Nov	Timia	15	1-15
Friday, 9 Nov	Muliama	15	1-15
Saturday, 10 Nov	-	-	-
Sunday, 11 Nov	-	-	-
Monday, 12 Nov	Molima	15	16-31
Tuesday, 13 Nov	Ibele	15	16-31
Wednesday, 14 Nov	Sunili	15	16-31
Thursday, 15 Nov	Timia	15	16-31
Friday, 16 Nov	Muliama	15	16-31
Saturday, 17 Nov	-	-	-
Sunday, 18 Nov	-	-	-
Monday, 10 Dec	Kumima	15	1-15
Tuesday, 11 Dec	Kelila	15	1-15
Wednesday, 12 Dec	Makki	15	1-15
Saturday, 15 Dec	-	-	-
Sunday, 16 Dec	-	-	-
Monday, 17 Dec	Kumima	15	16-31
Tuesday, 18 Dec	Kelila	15	16-31
Wednesday, 19 Dec	Makki	15	16-31
Total	14	270	1-31

Appendix H. Timeline of focus group discussions in 2007

Date	Village	Participant
Monday, 18 Jun	Napua	10
Wednesday, 19 Jun	Sinakma	10
Thursday, 22 Jun	Wouma	10
Friday, 23 Jun	Wamena	10
Monday, 10 Sep	Tulem	10
Tuesday, 11 Sep	Megapura	10
Wednesday, 12 Sep	Pisugi	10
Thursday, 13 Sep	Kelila	10
Friday, 14 Sep	Makki	10
Monday, 17 Sep	Siepkosi	10
Tuesday, 18 Sep	Assolokobal	10
Wednesday, 19 Sep	Holima	10
Thursday, 20 Sep	Hubikiak	10
Friday, 21 Sep	Wanima	10
Saturday, 22 Sep	Ibele	10
Monday, 24 Sep	Sunili	10
Tuesday, 25 Sep	Molima	10
Wednesday, 26 Sep	Kumima	10
Thursday, 27 Sep	Timia	10
Friday, 28 Sep	Muliama	10
Total	20	200

Appendix I. Topics discussed in focus group discussions

Focus Group Discussions

Name of Village: ……

1. Seasonal calendars and daily routines.
2. Sources of sili incomes, which one is the most important? Why?
3. Sources of sili incomes, which one makes you busiest? Why?
4. The use of sweetpotatoes, for what do you use the most? Why?
5. The use of pigs, for what do you use the most? Why?
6. In sweetpotato cultivation, which activity do you invite other *silis* to help?
7. Do you think the ACIAR project has helped you meet what you wish? How?

Appendix J. An example of results taken from the focus group discussion in Wanima

Village : Wanima
Date : 21st September 2007
Participants : Albert Pase, Azer Hilapok, Daniel Walilo, Inait Hilapok, Longginus Walilo, Manius Hilapok, Paulus Pase, Petrus Walilo, Yabu Elopere, and Yusuf Walilo

1. Seasonal calendars and daily routines

Years/ Month	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
2007	H	H	H	H	H	H	H	F	F			
2006	H	H	H	H	F	F	F	F	F	P	P	P
2005		F	F	F	F	F	P	P	P	H	H	H

Note: F: Fallow; H: Harvest; P: Planting

Participants agreed that everyone's seasonal calendars and daily routines will vary depending on the location of gardens, the availability of labour, and rain.

2. The source of *sili* incomes: The most important one

The source of incomes	Weighing	Scoring
Pig	24	1
Sweetpotato	22	2
Orange	13	4
Fish	16	3
Banana	5	7
Firewood	5	7
Non-agricultural job	6	6
Handcraft	9	5

Participants agreed that sweetpotato is an important source of incomes, although in practice it is mainly for own consumption, either for human food or pig feed. It saves a lot of money as *silis* do not need to buy it.

Pair wise ranking

	SP	P	O	F
Sweetpotato (SP)	X	X	X	X
Pig (P)	Wam	X	X	X
Orange (O)	Hipere	Wam	X	X
Fish (F)	Hipere	Wam	Fish	X

Ranking: (1) Pig: 3; (2) Sweetpotato: 2; (3) Fish: 1; and (4) Orange: 0.

3. The source of incomes: The one that makes you busiest

The source of income	Weighing	Scoring
Sweetpotato	26	1
Pig	21	2
Orange	8	5
Fish	20	3
Banana	0	7
Firewood	9	4
Non-agricultural job	9	4
Handcraft	7	6

Pair wise ranking

	SP	P	Ca	Fw	Ch	Na	Ha	Ba
Sweetpotato (SP)	X	X	X	X	X	X	X	X
Pig (P)	P	X	X	X	X	X	X	X
Cassava (Ca)	SP	P	X	X	X	X	X	X
Firewood (Fw)	SP	P	Fw	X	X	X	X	X
Chicken (Ch)	SP	P	Ca	Fw	X	X	X	X
Non-agri job (Naj)	SP	P	Na	Na	Na	X	X	X
Handcraft (Ha)	SP	P	Ha	Fw	Ch	Na	X	X
Banana (Ba)	SP	P	Ca	Fw	Ch	Na	Ha	X

Ranking: (1) Sweetpotato: 7; (2) Pig: 6; (3) Non-agricultural job: 5; (4) Firewood: 4; (6) Cassava: 2 and Chicken: 2; and (7) Handcraft: 1.

4. The use of sweetpotatoes

The use of sweetpotatoes	∑	%
Pig	41	41
Human	33	33
Labour compensation	10	10
Custom ceremony	10	10
Sell	6	6

5. The use of pigs

The source for using wam	∑	%
Sell	73	73
Custom ceremony	21	21
Own consumption	6	6

6. Invitation in sweetpotato cultivation

Activity	Invite other silis	Do not invite other silis
Making fence	√	
Cutting grasses	√	
Burning		√
Preparing land	√	
Planting	√	
Weeding 1	√	
Weeding 2	√	
Harvesting 1	√	
Harvesting 2 and next		√

7. All the participants knew that Step (the project group *sili* collaborator) has been involving in the ACIAR project (i.e. the sow and boar management experimentation). Two participants lent their sows to be used in the experiment. Overall, they understood the benefit of the technology, which is simple and easy to follow, and have been adopting it for some time.