Strategies for Improving Small-scale Native Forest Management In Papua New Guinea

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Strategies for Improving Small-scale Native Forest Management In Papua New Guinea

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Abstract

This thesis assessed past small-scale native forest management strategies used in Papua New Guinea and explored options for improving future operations. In the early 1990s, multiple organizations began facilitating small-scale native forest management by Indigenous landowners as an alternative approach to the industrial-scale timber harvest approach to forest management. This approach to small-scale management was referred to as 'eco-forestry' and involved the selective harvesting of timber to produce rough-sawn lumber with portable sawmills for export. This thesis assessed the effectiveness of the eco-forestry management model by conducting a thematic analysis on the outcomes of the eco-forestry organizations and by executing a discounted cash flow analysis of portable sawmill operations that incorporated Monte Carlo risk assessment simulation. This thesis also analysed log export revenue cash flow distributions, to assess the forest resource rents received by the forest resource owners relative to the portions captured by the PNG government and the logging industry. Finally, this thesis conducted a case study on the small-scale forest products informal market in PNG to identify causal linkages between the informal market operators so that opportunities for future improvement could be identified. Four themes emerged from this research; 1) the eco-forestry management model failed because the eco-forestry organizations struggled to maintain financial viability and meet the quality and quantity lumber production targets; 2) using portable sawmills in tropical forests to produce rough-sawn lumber has a high probability of non-financial viability due to the high variable costs of operating portable sawmills relative to the sales prices received for the rough-sawn milled lumber; 3) the existing forest policies regarding forest resource rents has caused the forest resource owners to receive little compensation for the timber harvested on their lands with almost all the value has been captured by the PNG government and the logging industry; 4) the existing forest policies are a hindrance to the economic development of the small-scale forest industry participants. Implications and recommendations of this research are; 1) future small-scale forest management should re-focus to serve domestic markets; 2) competency-based training for future timber harvests and portable mill processing should be developed prior to implementing commercial activities; 3) additional processing of the rough-sawn lumber into value-add products is necessary to improve profitability; and 4) forest policies should be revised to increase the resource rents received by landowners and to improve the legality and productivity of the small-scale forest products market.

Declaration of Originality

I, Micah G. Scudder, declare that the work does not contain material which has been previously published or written by any person other than myself with contributions of the co-authors of the publications included in this thesis, except where due and proper reference has been given in the text.

I have clearly stated the contribution of other authors to my thesis, including collaboration in the design of the studies, data collection, data analysis, interpretation of results, and drafting and editing the manuscripts. All authors read and approved the final manuscripts.

Micah G. Scudder

List of Publications and Contributions of Co-Authors

SCUDDER, M. G., HERBOHN, J., & BAYNES, J. (2018). The Failure of eco-forestry as a small-scale native forest management model in Papua New Guinea. Land Use Policy 77: 696-704. (Incorporated as Chapter Four)

> M. G. Scudder (Candidate) designed the study, carried out the data collection, conducted the data analysis and interpretation of results, and drafted the manuscript. J. Herbohn participated in the interpretation of results and drafting and editing the manuscript. J. Baynes participated in interpreting the results and drafting and editing the manuscript.

SCUDDER, M. G., HERBOHN, J., & BAYNES, J. (2019). Are portable sawmills a financially viable option for economic development in tropical forests? Forest Policy and Economics 100: 188-197. (Incorporated as Chapter Five).

> M. G. Scudder designed the study, carried out the data collection, conducted the data analysis and interpretation of results, and drafted the manuscript. J. Herbohn participated in the design of the study, the interpretation of results, and drafting and editing the manuscript. J. Baynes participated in drafting and editing of the manuscript.

SCUDDER, M. G., BAYNES, J., & HERBOHN, J. (2019). Timber royalty reform to improve the livelihoods of forest resource owners in Papua New Guinea. Forest Policy and Economics 100: 113-119. (Incorporated as Chapter Six).

> M. G. Scudder designed the study, carried out the data collection, conducted the analysis and interpretation of results, and drafted the manuscript. J. Baynes participated in drafting and editing the manuscript. J. Herbohn participated in drafting and editing the manuscript.

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> M. G. Scudder designed the study, carried out the data collection, conducted the analysis and interpretation of results, and drafted the manuscript. J. Baynes participated in drafting and editing the manuscript. G. Applegate participated in data collection and editing the manuscript. J. Herbohn participated in drafting and editing the manuscript.

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Dedication

I would like to dedicate this thesis to the memory of my younger brother, Karl Miles Scudder, (31 January 1985 – 2 January 2017). I greatly miss our conversations, your laughter, and the love you shared with family and friends. God bless.

Table of Contents

Figures

Tables

Acronyms

ACIAR	Australian Centre for International Agricultural Research
ATM	Automatic teller machine
BPNG	Bank of Papua New Guinea
C&I	Criteria and Indicators
CBD	Convention on Biological Diversity
CBF	Community-based forestry
CFE	Community forest enterprise
CIA	Central Intelligence Agency
CMU	Central Marketing Unit
CSD	Commission on Sustainable Development
DCF	Discounted cash flow
DFAT	Department of Foreign Affairs and Trade
DOE	Department of Education
DSIP	District Services Improvement Programme
EA	Ecosystem Approach
EFP	Eco-forestry Programme
EU	European Union
FAO	Food and Agriculture Organization
FFB	Fiji Forest Bill
FIP	Forest Industry Participant
FMA	Forest Management Agreement
FOB	Free on board
FORTECH	Forestry Technical Services Ltd.
FPCD	Foundation for People and Community Development
FRO	Forest resource owner
FSC	Forest Stewardship Council
FSP	Foundation for People of the South Pacific
ILG	Incorporated Land Group
IRC	Internal Revenue Commission
IRECDP	Islands Region Environmental & Community Development Programme
ITSGC	ITS Global Consultants
ITTO	International Tropical Timber Organization
JANT	Japan and New Guinea Timbers Ltd.
LLG	Local Level Government
NGO	Non-governmental organization
NPV	Net present value
NSO	National Statistical Office
NTFP	Non-timber forest products
OEC	Observatory of Economic Complexity
PGK	Papua New Guinea Kina

PHF	Pacific Heritage Foundation
PILII	Pacific Islands Legal Information Institute
PMV	Public motor vehicle
PNG	Papua New Guinea
PNGC	Papua New Guinea Customs
PNGDL	Papua New Guinea Directories Limited
PNGDT	Papua New Guinea Department of Treasury
PNGENW	PNG Education News Website
PNGFA	Papua New Guinea Forest Authority
PNGFIA	Papua New Guinea Forest Industry Association
PNGNFS	Papua New Guinea National Forest Service
PNGP	Papua New Guinea Parliament
PSIP	Provincial Services Improvement Programme
PwC	PricewaterhouseCoopers
RBA	Reserve Bank of Australia
RH	Rimbunan Hijau
RHG	Rimbunan Hijau Group
RIL	Reduced impact logging
SABLE	Special Agriculture and Business Lease
SFM	Sustainable Forest Management
SGS	Sociele Generale de Surveillance
SIFB	Solomon Islands Forest Bill
SMFE	Small to medium forest enterprise
T&G	Tongue and groove
TA	Timber Authority
TFF	Tuition Fee Free
TFTC	Timber and Forestry Training College
TRP	Timber Rights Purchase
UNCED	United Nations Conference on Environment and Development
USD	U.S. Dollar
USDOS	United States Department of State
VDT	Village Development Trust
VFP	Vanuatu Forest Policy

Chapter 1
Introduction to Research Objectives and Methods

1.1 Introduction

This thesis is concerned with improving small-scale native forest management in Papua New Guinea (PNG). PNG has approximately 29 million hectares of forest, with 97% of the forest held under customary land ownership by clan groupings (PNGFA 2009). The principal focus of past forest management in PNG has been large-scale timber harvests of the primary forests to achieve economic growth, with about 90% of the harvested logs being exported (PNGFA 2009). While it is recognized there is a limited amount of accessible primary forests remaining, there is an interest in identifying models for sustainable management of both the remaining primary and logged-over forests in PNG to achieve better economic, social, and environmental outcomes for the forest resource owners (FROs) (PNGFA 2004). Furthermore, the large-scale timber harvests have resulted in social inequalities due to the royalty payments received by FROs being disproportionally small relative to the value of the logs being harvested.

The current small-scale native forest management model that has primarily been practiced as an alternative to large-scale logging is 'eco-forestry.' Eco-forestry is a forest management method focused on deriving economic benefits from the forest utilizing small-scale selective timber harvests, while maintaining and/or improving the ecological functions of the forest (Hammond 1997, Bun and Bazakie 2006). Maintenance and restoration of these ecological functions is done through sustaining the composition, structure, biodiversity, and connectivity of the forest, while pursuing timber removals (Drescher 1997, Hammond 1997). The eco-forestry approach to forest management was introduced in PNG by multiple non-governmental organizations (NGOs) in the early 1990s. The NGOs presented eco-forestry through the introduction of portable sawmills to be operated by the customary land owners (Holzknecht et al. 2012). Investments or donations from NGOs largely influenced this practice, seeking a means for FROs to manage their own forests and retain larger profits from timber harvests on their land than they received from industrial logging companies (Fox et al. 2011, Grigoriou 2011, Holzknecht et al. 2012).

Multiple studies have suggested that the best opportunity for eco-forestry in PNG to succeed is to pursue the high value export market (Hunt 2000, Fox et al. 2011, Grigoriou 2011). The studies determined that there is an interest in 'Select grade' tropical hardwoods by architects and builders in industrial economies like the U.S. and Australia and high profit margins could be made if international buyers believed that they were buying a unique product whose value extended beyond functional utility (Fox et al. 2011). However, eco-forestry has experienced limited success despite substantial support

provided by NGOs over two decades. There have been few rigorous attempts to critically assess the effectiveness of the eco-forestry management model and the peer-reviewed literature is limited in scope. Further research is required to critically evaluate previous small-scale native forest management practices in order to improve future small-scale forest management. In addition, the forest policies that impact the FROs ability to benefit from the timber on their land needs to be reviewed to ascertain if revisions to the policies could assist in improving FRO livelihoods.

The aim of this thesis is to evaluate the effectiveness of the eco-forestry approach to small-scale native forest management, to analyze the forest policies impacting small-scale native forest operations, and to identify any alternatives to the existing eco-forestry model that could improve small-scale native forest management. This has been achieved through a mixed methods approach to the research involving a literature review and thematic analysis of past eco-forestry operations, a discounted cash flow analysis with Monte Carlo risk simulation of portable sawmill operations, a financial analysis of the forest resource rents paid to FROs, and a descriptive case study of the small-scale forest products industry in PNG.

The remainder of this chapter is structured as follows. The research questions are discussed in section 1.2. The justification for the research is discussed in section 1.3. The research methods are discussed in section 1.4. The research limitations are discussed in section 1.5. The research ethics is discussed in section 1.6. The thesis structure is outlined in section 1.7 and the conclusion is in section 1.8.

1.2 The Research Questions

Research Problem:

What is the best approach to small-scale native forest management in Papua New Guinea to improve forest landowner livelihoods?

The overall approach to this research was to identify the barriers that have negatively impacted previous small-scale forest management projects, recognize the aspects of previous projects that were successful, and develop new approaches to management that can improve the livelihoods of FROs. Previous eco-forestry operations experienced struggles in production that the NGOs were unable to mitigate. The focus of this research was to recognize the cause of the NGO shortcomings and identify strategies that can improve small-scare forest management to provide FROs with an increased value for their timber, while adhering to environmentally sustainable management principles. The region initially selected for this research was the Madang Province. Madang was chosen because this research was being conducted in association with the Australian Centre for International Agricultural Research (ACIAR) project

FST/2011/057, "Enhancing the implementation of community forestry approaches in Papua New Guinea," which had a regional focus in Madang. This project ended in early 2017 and transitioned to a second phase of research with a regional focus in Lae as part of ACIAR Project FST/2016/153, "Enabling Community Forestry in Papua New Guinea".

From the Research Problem, four subsidiary research questions were derived. It was determined that addressing these questions would identify the causes of past small-scale forest management shortcomings. Furthermore, it was expected to reveal critical success factors for future small-scale native forest management in PNG. effective

Research Question One: Is the eco-forestry management model a viable option for small-scale native forest management in PNG?

The answer to Research Question One described the positive and negative factors of the eco-forestry management model. This question will identified what had occurred in the past so that previous mistakes could be avoided and the components of eco-forestry that were deemed to be positive could be repeated. Answering this question laid the groundwork for determining the best approach to small-scale native forest management in PNG.

Research Question Two: Are portable sawmills a financially viable option for economic development in tropical forests?

Research Question Two was designed to determine if portable sawmills are a viable component for small-scale native forest management in tropical forests. During the course of addressing Research Question One, it was found that all the eco-forestry NGOs and their affiliated Indigenous portable mill producers struggled to achieve financial viability. Ultimately, all the eco-forestry operations ceased when NGOs were no longer able to obtain the funding that was required to subsidize eco-forestry. There have been few studies conducted on the financial viability of portable sawmills being utilized for community forestry in tropical forests. Answering Research Question Two identified the financially viable harvest and milling parameters for using portable sawmills, as well as the circumstances that portable sawmills are an appropriate and/or inappropriate tool for future of small-scale forest management in PNG.

Research Question Three: Do timber royalties provide an equitable distribution of forest resource rents to FROs?

Research Question Three was designed to explore government policies that impact the livelihoods of FROs when timber harvests occur. In PNG, the majority of the rural population is heavily dependent on subsistence agriculture for their livelihoods. Indigenous people that own timberland are able to receive resource rents through royalty payments when timber harvests occur on their lands. The rents received are an important source of additional income to FROs to support their access to economic goods and services that they cannot produce themselves. The answer to Research Question Three determined if the current royalty rates represent an equitable resource rent for the timber harvested, or if revisions to the existing forest policies were warranted.

Research Question Four: How does the forest products informal market in PNG function and why do participants choose to operate in this market?

During the course of addressing Research Questions One, Two, and Three, the author became aware of a forest products informal market that operates outside the jurisdiction of the government forest authorities. Little is known about this market, as the government does not have the resources to track or regulate it. Visual evidence suggests that this market is comprised of numerous participants throughout the country that are illegally harvesting and milling timber with portable sawmills. Research Question Four was designed to provide a description of the forest product informal market in PNG. The answer to Research Question Four will identified financially viable management models that are already being practiced, despite being conducted in the informal market. These findings will build on the answers of Research Questions One and Two, and further assist in identifying the best approach to small-scale native forest management. The answer to this question also identified the factors that are causing people to participate within the informal market instead of conducting legal operations within the formal market. Recognition of these factors will aid in further potential revisions to existing forest policies.

1.3 Justification for the Research

This dissertation is concerned with identifying a model for small-scale native forest management in PNG that will be successful in terms of economic sustainability, maintaining the environmental integrity of the forests, and improving the livelihoods of forest resource owners (FROs). Over 80% of the population in PNG lives in the rural areas of the country (PNGFA 2009). While most of the people in PNG are customary landowners, relatively few can realize the economic benefits available to them through sustainable forest management. This investigation is important because it seeks to find a forest

management model that can improve the livelihoods of PNG communities while also producing positive social and environmental outcomes.

Research Question One, which assesses whether the current eco-forestry model is viable, provides the foundation for identifying the best approach to small-scale native forest management in PNG. Research Question Two determines if using portable sawmills in tropical forests is financially viable through the application of a total-cost accounting analysis. Research Question Three will determine if revisions to forest policy are needed for improving timber resource rents received by the FROs. Research Question Four will assist in identifying forest policy recommendations to improve the legality of the informal market and identify small-scale forest management models that are already being pursued that have achieved financial viability.

1.4 Research Methods

The research methods for each of the research questions is discussed in the sub-sections below.

1.4.1 Research Question One

Six eco-forestry organizations have been identified as being involved in small-scale forest management activities that involved portable sawmills in PNG. Data has been collected from a literature review and interviews with key informants. The literature review includes peer-reviewed journal articles, conference papers, reports discussing the eco-forestry organizations, external evaluations of the eco-forestry organizations, strategic plans, and operational reports produced by the eco-forestry organizations. An interview protocol has been designed based on the preliminary results of the literature review. The interview questions have been designed to identify the management activities implemented by the eco-forestry organizations, their accomplishments, the destinations of the milled lumber, and the funding received to implement the eco-forestry activities. The interviewees are six eco-forestry organization employees and 10 employees from the PNG Forest Authority (PNGFA) that were knowledgeable of the eco-forestry operations.

A summary of each of the six eco-forestry organizations has been completed that provides; a) year of commencement, location in PNG and objectives, b) management activities, c) accomplishments, and d) year of ceasing operations and why. A thematic analysis has been conducted to identify patterns in the data using methods outlined by Boyatzis (1998). Twenty-one thematic codes have been developed for the thematic analysis, which are classified into three groups; (1) eco-forestry organization management model activities, (2) challenges experienced by the eco-forestry organizations, and (3) challenges experienced by portable mill producers. All the materials used in the thematic analysis have been reviewed to determine the presence or absence of the thematic codes for each eco-forestry organization.

Patterns have been identified from the thematic codes that had the highest occurrences among the six eco-forestry organizations. The identified patterns have been used to determine the effectiveness of eco-forestry based on the following criteria; (1) the financial viability of operations; (2) the ability to accomplish management objectives; and (3) their ability to adhere to the principles that the eco-forestry management model was based on.

1.4.2 Research Question Two

Answers to Research Question Two were provided by a discounted cash flow (DCF) analysis that has been conducted to estimate the net present value of NGO-facilitated portable sawmill operations. Data for the analysis has been collected during interviews with key informants in the cities of Madang and Lae. An interview protocol has been designed to identify the activities and associated costs of the NGO facilitation process, portable sawmill operations, small-scale lumberyard operations, and the prices received in domestic and international lumber sales. The interviewees are four current and former employees of one of the eco-forestry NGOs, the Foundation for People and Community Development (FPCD), three forest product businesses in the city of Madang, and two employees from the Timber and Forestry Training College (TFTC) in the city of Lae. All the DCF model variables have been identified during these interviews.

The DCF model has been developed following the principles of capital budgeting of investment projects set out in Dayanandra et al. (2002) and Harrison and Herbohn (2017). The model variables have been categorized as being capital flows and operational flows. All the monetary variables incorporated in the DCF model have been converted to 2017 USD currency equivalents using consumer price indices and foreign exchange rates collected from the Bank of Papua New Guinea (BPNG 2018), and the Reserve Bank of Australia (RBA 2018). A five-year time horizon has been selected for the DCF analysis. The discount rate selected for the DCF model is 10.5%, which is the current yield of long-term (5.5-year loan duration) debt financing issued by the Bank of PNG on behalf of the PNG government (BPNG 2018). The DCF model has been constructed with Microsoft Excel software. Monte Carlo risk analysis simulation has been used to account for uncertainty associated with key variables. The software selected for the Monte Carlo risk analysis simulation is '@RISK,' which is a Microsoft Excel Add-in software program produced by the Palisade Corporation. The risk analysis simulation follows methods outlined by Winston (2008) in which all cash flow variables determined to have values with inherent uncertainty have been assigned normal or triangular distributions. The number of iterations selected for the Monte Carlo risk simulation is 100,000.

Descriptive statistics (mean, minimum, maximum, median, mode, and standard deviation) have been determined for the sawmill productivity variables and the NPV values produced from the Monte Carlo simulation. An NPV probability distribution curve has also been created. A sensitivity analysis has

been conducted of the model variables with inherent uncertainty to identify the variables that were most likely to affect the mean NPV. The sensitivity analysis is a report function of the @Risk software that determines the impact that each input variable will have on the range of values for a selected output.

1.4.3 Research Question Three

To determine if the timber royalties provide an equitable distribution of log value to FROs, three research objectives have been identified; 1) to estimate previous timber harvest cash flow distributions in PNG; 2) to evaluate the inflation-induced erosion of the real values of the fixed-rate royalties per species; and 3) to determine how the livelihoods of PNG's FROs could be improved if royalty payments were calculated as a percentage of market value. The three research objectives have been addressed through an analysis conducted using Microsoft Excel software. All the revenue, duty, levy and royalty values have been converted to 2017 USD using consumer price indices and foreign exchange rates retrieved from BPNG (2018).

Data has been collected from log export reports produced by Sociele Generale de Surveillance (SGS), (SGS 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018). SGS is an independent log export auditor that works on behalf of the PNGFA. The information extracted from the log export reports is the log export volumes by species, the FOB value of logs exported, and the duty and levy payments paid to the PNG government by the logging companies. Data on levy payment requirements has been collected from the PNGFA employees. The fixed-rate royalty payment rates by species has been extracted from a PNG National Forest Service (PNGNFS) document titled 'Form 221' (NFS 2008).

For this analysis, a log export revenue cash flow distribution has been produced for the years 2007-2017. Log volumes and FOB export values have only been collected from the SGS report sections labelled 'Saw/Veneer logs' and 'Low-grade logs', which represent the native forest log exports. The SGS report sections labelled 'Plantation logs' are not subject to duties, levies and royalties, and therefore have not been included in this study. The erosion of the real value of royalty payments has been calculated for the years 1991-2017. This has been done by using inflation rates collected from BPNG (2018). For each year before 2017, the royalty payment real values have been increased in proportion with the accumulated inflation. A projection of potential royalty payments that could have been received by FROs has been developed by using market value percentages between 8% and 20%, with 2%-unit increments. This has been done for years 2007 to 2017. These market value percentages have been chosen to demonstrate what FROs could have received if royalties had been larger than the current fixed-rate. With this projection, it is assumed that all harvest volumes remain the same. Estimates have been generated for the total additional royalty revenues that would have been received, additional royalties per m^3, and the additional royalties received by each province in PNG.

1.4.4 Research Question Four

A descriptive case study has been conducted to understand the processes and of the small-scale forestry informal market, the regulations which govern the market and its operatives and how these impact on their field operations. A single-case design with multiple sources has been used, following methods outlined by Yin (2009). The multiple sources are participants involved in small-scale wood product market in PNG. A total of 19 sources have been arranged into three groups; 1) FROs, 2) portable saw-millers, and 3) value-add businesses. The saw-millers only produce rough-sawn lumber. The manufacturing businesses undertake additional processing to the rough-sawn lumber to produce wood products, such as dressed structural lumber, mouldings, and tongue & groove (T&G) flooring that command a higher sales price per unit relative to the rough-sawn lumber.

Data has been collected through interviews, personal observations, and documents. The documents collected are governmental reports, technical reports produced by other research organizations, wood product sales price sheets produced by the value-add businesses, peer-reviewed journal articles, and newspaper articles. Data collection has occurred during years 2016 to 2018, with 38 people interviewed. Fifteen of the interviewees are key informants made up of employees of the PNGFA, the FPCD, and the TFTC. The key informants have been selected for interview because they are familiar with the informal market. The remaining twenty-three interviewees are FROs, business owners, or business employees associated with the 19 sources. These interviewees have been selected with assistance from the key informants. The initial interviews with key informants helped develop an interview protocol which has been designed to identify the functional operations of the 19 sources. The questions asked are; why participants choose to operate without the necessary permits; their perceptions of the permit regulations, their perceptions on the size of the informal market, where timber/wood products were sold and to whom; the type of equipment used to harvest the trees and process the timber; the cost of production; how sale agreements were arranged; volumes produced; and prices received from sales. At least one key informant has been present at all the interviews to provide their post-interview perspective to the interviewer.

The data collected during the interviews has been organized into a case study database using Microsoft Excel Software. Pattern recognition analysis has been conducted to address internal validity of the data by arranging the rows of the database to represent the individual cases and the columns of the database to represent the questions asked to the interviewees. To ensure construct validity, the interview data has been triangulated with the additional evidence collected and key informants have reviewed drafts of the case study report. The identified patterns and triangulated data have been used to provide a description of the informal market participants and explain the causal links of the participants activities. Included in the description, is an estimate on the size of the informal market. The size of the informal

market has been estimated with data collected from technical reports, a portable mill number survey, and annual production data of portable mills gathered during interviews.

A financial analysis has been conducted to compare the values paid/received by the informal market participants at four stages of the value-chain; pre-harvested timber; rough-sawn lumber at the harvest site; rough-sawn lumber delivered to the mill; and finished wood products located at the mill. The analysis has been performed with data collected during interviews with the cases and key informants, as well as sales price sheets for finished products collected from the manufacturing businesses. The market values of the wood products produced at each value-chain have been averaged. The number of assorted products sold by the manufacturing businesses typically exceed 100, due to multiple species, product types, dimensions, and if the timber have been chemically treated or not. For this analysis, four products have been selected for this comparison. They are; tongue and groove (T&G) flooring (*Intsia bijuga* 95 x 20mm); treated architrave moulding (Mixed hardwoods 70 x 20mm); treated structural lumber (Mixed hardwoods 100 x 50mm); and treated weatherboard (Mixed softwoods 145 x 20mm). Since the sales transaction between FROs and saw-millers are typically paid as Kina per m^3 of lumber, the lumber price has been converted into pre-harvest log values. To do this, a lumber recovery rate of 45% has been assumed and applied to the government royalty rates per m^3 of log. Since the sales prices for finished timber products for the manufacturing business is listed as price per lineal meter, the prices have been converted to m^3 of lumber product. For the T&G flooring product (Intsia bijuga 95 x 20 mm), the values received by the informal market participants have been compared to the cumulative cost of production at each stage of the value-chain. The production costs have been collected during interviews and from key informants. These costs have been averaged for each stage of the value-chain. The production costs include royalties paid to FROs, felling and transporting the log to the mill, milling the lumber, transporting the lumber to a value-add business, sorting/grading the lumber, machining the lumber into flooring, and overhead costs per m^3 of flooring produced for the value-add business.

1.5 Limitations

The limitations on the reliability and validity of the research design have primarily stemmed from the challenges of working in PNG. These challenges include the limited availability of in-country data, the slow speed of task completion by in-country research partners, and difficulties of in-country travel due to the poor quality of infrastructure and safety concerns. An additional constraint of this research has been the high cost of traveling to and around PNG. The high travel costs have limited the amount of in-country data that the author was able to collect. To mitigate these challenges, the author has maintained digital correspondence with multiple key informants in PNG to review and validate research findings that could not be performed in person by the author.

1.6 Research Ethics

The methods for conducting this research have involved the participation of multiple people in PNG. This participation has primarily occurred during interviews conducted by the author. These interviews have been conducted on a voluntary basis. All the people that participated in these interviews will remain confidential to everyone outside of the research project. All reports and publications that are an output of this research will not disclose the names of people or businesses that participated. The methods of this research have been approved by the University of the Sunshine Coast Ethics Office and given the Ethics approval number: A/14/588.

1.7 Overview of the Thesis

The thesis is comprised of eight chapters (Table 1.1). Chapters two and three provide background information on PNG's culture and forests. Chapter two is titled 'Overview of the socio-economic factors influencing forestry-based economic development,' and is a description of the social-economic characteristics and cultural norms. Chapter 3 is titled 'Review of the forestland, management policies, and the timber industry,' and is a description of the history and current state of the forests, forest policy, the forest product industry, and the domestic wood product market in PNG.

Chapter four is titled 'The failure of eco-forestry as a small-scale native forest management model in Papua New Guinea.' This chapter represents Research Question One and has been published in the journal of Land Use Policy, Volume 77, Year 2018, pages 696-704. Chapter five is titled 'Are portable sawmills a financially viable option for economic development in tropical forests?' This chapter represents Research Question Two and has been published in the journal of Forest Policy and Economics, Volume 100, Year 2019, pages 188-197. Chapter six is titled, 'Timber royalty reform to improve the livelihoods of forest resource owners in Papua New Guinea.' This chapter represents Research Question Three and has been published in the journal of Forest Policy and Economics, Volume 100, Year 2019, pages 113-119. Chapter seven is titled, 'Addressing informal economies through forest policy: A case study in Papua New Guinea.' This chapter represents Research Question Four and is under review with the journal of Land Use Policy.

Chapter eight discusses the key findings from each of the research questions. Recommendations have been made for improving current small-scale forest management operations and revising forest policies. These recommendations have been directed toward small-forestry participants, PNGFA employees, and PNG politicians to assist in providing improved livelihoods for FROs while adhering to environmentally sustainable principles and maintaining financial viability.

Table 1.1: Thesis chapters and publication status

Chapter	Title	Publication Status
One	Introduction to research objectives and methods	
Two	Overview of the socio-economic factors influencing forestry-based economic development	
Three	Review of the forestland, management policies, and the timber industry	
Four	The failure of eco-forestry as a small-scale native forest management model in Papua New Guinea	**Published**: Land Use Policy
Five	Are portable sawmills a financially viable option for economic development in tropical forests?	**Published**: Forest Policy and Economics
Six	Timber royalty reform to improve the livelihoods of forest resource owners in Papua New Guinea	**Published**: Forest Policy and Economics
Seven	Addressing informal economies through forest policy: A case study in Papua New Guinea	**Under Review**: Land Use Policy
Eight	Discussion and conclusion	

1.8 Conclusion

In PNG, there is an interest in identifying successful models for small-scale native forest management. It is essential that the future management model be environmentally sustainable and able to achieve better economic outcomes that past approaches. This research discusses four key research questions designed to discover a management model and forest policy revisions that can achieve these desired outcomes. The goal of this research is to identify options for improving the livelihoods of FROs in PNG, while maintaining balance between human needs and environmental functions.

Chapter Two

Overview of the Socio-Political Factors Influencing Forestry-based Economic Development

2.1 Introduction

This chapter provides information on the social and political factors that have an influenced forestry-based economic development of PNG. Some of these factors are ingrained in the historical Melanesian cultures of the people and some of them are due to the intrusion of external forces. These socio-political factors are vastly different to other countries outside of Melanesia and need to be considered during forestry-based economic development planning. Section 2.2 provides a description of the subsistence agricultural practices in PNG. In section 2.3, the system of customary land ownership is described. Section 2.4 illustrates the use of religion in PNG prior to Western influence. Section 2.5 discusses economic and socio-political trade practices prior to Western influence. Section 2.6 chronicles the changes that took place in PNG society after the arrival of Europeans and Australians. The current state of affairs is discussed in section 2.7. Finally, the conclusion is in section 2.8.

2.2 Origins of Subsistence Agriculture in PNG

PNG is a Melanesian country that occupies the eastern half of the island of New Guinea, in the southwestern region of the Pacific Ocean. It has been estimated that the first humans arrived in Melanesia around 50,000 years ago, traveling from South-east Asia (Sillitoe 1998). It is believed that the first people evolved from being strictly hunter/gatherers to domesticating plants as early as 7000-6500 cal BC (Denham et al. 2004). There were high degrees of regional and temporal variability in Melanesia regarding the domestication of plants and animals (Denham 2011). The oldest known plant cultivation site was identified in the Upper Wahgi Valley of the Highlands, which consisted of mounded plant cultivations (Denham 2011). By 4000 cal BC, the degree of domestication increased to include ditched field systems (Denham 2011). Lawrence (1971) and Sillitoe (1998) refer to the initial subsistence agricultural systems as swidden agriculture, with the people rotating between multiple garden sites to allow previous sites to fallow before a decline in crop yields was experienced. The garden sites were typically established in sites comprised of secondary forest or grasslands that had been cultivated in the past by their ancestors (Sillitoe 1998). The primary crops grown were banana, breadfruit, sago, sugarcane, taro, yam, and eventually, sweet potato (Sillitoe 1998, Denham 2011). Herding pigs was also an important aspect of Melanesian culture and required supplying the pig with food; usually sweet potato and discarded vegetable waste (Sillitoe 1998). People that resided along the coastal regions incorporated fish as a primary or supplementary portion of their diet (Lawrence 1971, and Whiteman 1983). Swidden agriculture and pig herding is still an important source of food production for people residing in rural areas of the country.

2.3 Customary Land Ownership

In PNG, approximately 97% of all land is held under customary land ownership by clan groupings (Filer and Sekhran 1998, PNGFA 2009). Land tenure systems vary widely in PNG. Approximately 75% of clans in PNG pass land tenure through patrilineal lines with tenure passing from fathers to sons (Koian 2010). One example of the intricacies of this system is discussed by Holzknecht (1974), in a description of land tenure in the Markham Valley. The villages can consist of several clans or just one clan. Since land tenure organized as patrilineal, the male members are able to prove descent from the male ancestor that originally settled the area. Sub-clans are made up of men that can claim descent of a common ancestor that is less remote than the original founder and are typically a group of brothers, their sons, and families. Men and women from the same clan can never marry each other, since they are perceived to be brother and sister and will typically marry individuals from other clans. These marriages can occur within the village, or they can be with an individual from another village. A person born into a clan will have rights to certain parts of their father's land. An individual that plants a tree for cultivation will own that tree and be able to pass ownership on to their descendants. One member of the clan is the controller of the land for the group, which is usually the oldest male. While the controller has decision making authority, he can never sell the land or alienate a member of the clan from the land. However, land tenure has occasionally changed when one clan has gone to war against another clan, with the victorious clan expanding their land ownership (Lamb 1990).

Within PNG culture, there is a non-governmental system referred to as the 'wontok system.' The word 'wontok' translates to, 'one talk,' and refers to the language of the tribe or clan that a person belongs to. The wontok system is a wide-ranging system of social ties that involves mutual obligations of support and assistance. Clan members that have accumulated more wealth than others are expected to share this wealth with other members of their wontok that are in need (Prideaux and Beg 2008). In some cases, the mutual obligations can be political in nature and even involve individuals that are not kin based. This system is deeply entrenched into the clan culture throughout PNG.

2.4 Religion Prior to Western Influence

Before the arrival of European missionaries, religion in PNG was essentially a pragmatic spiritual technology, which has been studied by Lawrence (1971) and Sillitoe (1998). Their findings indicate that people regarded the cosmos as a finite physical realm, and within that realm, man was the focal point of two systems of relationships; those between other people and those between spirits of the dead. The spirits appeared to men in dreams and taught them techniques that became part of their culture. The people believed that all the valuable parts of their culture were given to them by the spirits of the dead, who taught the techniques and ritual procedures for these processes. These rituals were applied to all aspects of life, including gardening, hunting, and war. Before any serious undertaking, a specific

ritual was performed to ensure success. It was believed that if the rituals were performed correctly, the spirit had no choice but to grant success.

In Melanesian society, every person is believed to have a soul, but not all souls become an object of worship after the people die (Whiteman 1983). Typically, only the ghosts of men are worshiped, and usually only those that were significant during life. For example, if a person had been skilled in hunting, fishing, or fighting, they would be called upon to help the living with those pursuits. The ghost would continue to be worshiped if it was deemed to effective in helping the living with those pursuits. If not, the people would try something else. Eventually, a ghost would be forgotten for the most recent dead when there were no more people that were living when he was alive.

A person skilled at accessing the realm of spirits and invoking their power is called a sorcerer (Van Heekeren 2016). Van Heekeren (2016), provides the followed description of sorcery in PNG, based on interviews of the Vula people. In the past, sorcery was an inherited craft that was passed down orally. More recently, the knowledge is purchased from another sorcerer. In some cases, sorcerers have been described as hired assassins and received large sums of money for their work. A sorcerer made an attack using personal belongings from the victim, such as clothing, cigarette butts, or betel-nut leavings. One example of a ritual, is a sorcerer putting a piece of the victim's clothing in a container and burying it. As the clothing decomposed, the victim's affliction supposedly began to take hold until they died. Sorcery is effective form of control, because it fosters a culture of fear. People will often hide wealth to avoid sorcery attacks aroused by jealousy. Before the introduction of Christianity by missionaries, sorcerers were considered to be neither good nor evil, but rather believed to have great power, which commanded fear and respect. Sorcerers began to embody the concept of evil after it was imported from Christianity and colonialism.

2.5 Economic and Socio-Political Trade Prior to Western Influence

In Melanesian society, the two primary types of wealth were pigs and portable valuables, such as objects made from shells, porpoise teeth, dogs' teeth, curved boars tusks, pierced stone discs, and others (Whiteman 1983). Additional forms of wealth were non-material wealth, such as labour, magical charms, and specialized knowledge, which were tradeable commodities (Whiteman 1983). In Melanesia, there was both economic exchange and social exchange. While the same articles were exchanged, there were different transactional contexts; one is economic and the other was socio-political (Sillitoe 1998). Economic exchange occurred when people in certain locations had access to valuable goods that did not exist in other places. An example of economic trade between people on the Rai Coast of Madang and other people further inland consisted of the exchange fish, salt, and dried coconuts for wood bowls and bark cloth (Lawrence 1971). Sillitoe (1998), described socio-political

trade as an exchange system designed to maintain social order. Members of the society observed cultural norms that were valued to engage in continuous rounds of exchange of valuables with others. For this to work, they had to remain on amicable terms. If people stole and fought with others, no one would exchange with them.

Within socio-political exchange system, there was a level of competition in that if someone gave more than they received, they attained a higher social standing. In the Highland region, these men were referred to 'big-men'. When an individual became a big-man, they received admiration and respect from others, which was essentially political capital and control of the people around them. A big-man could challenge another big-man in transactional superiority by giving a feast for the others honour. The other big-man was expected to reciprocate with another feast that was at least equal in splendour. If he failed to do this within one to two years, the other big-man was deemed superior. A big-man was not elected, chosen, or related to political groups, but was rather a personal power that was achieved through a series of acts that elevated him above the others.

This socio-economic exchange system, the view of religion as a technology, and the customary land ownership system, were the primary tenants of the socio-economic dynamics of PNG culture, prior to western contact. The relationship of these dynamics is illustrated in Figure 2.1.

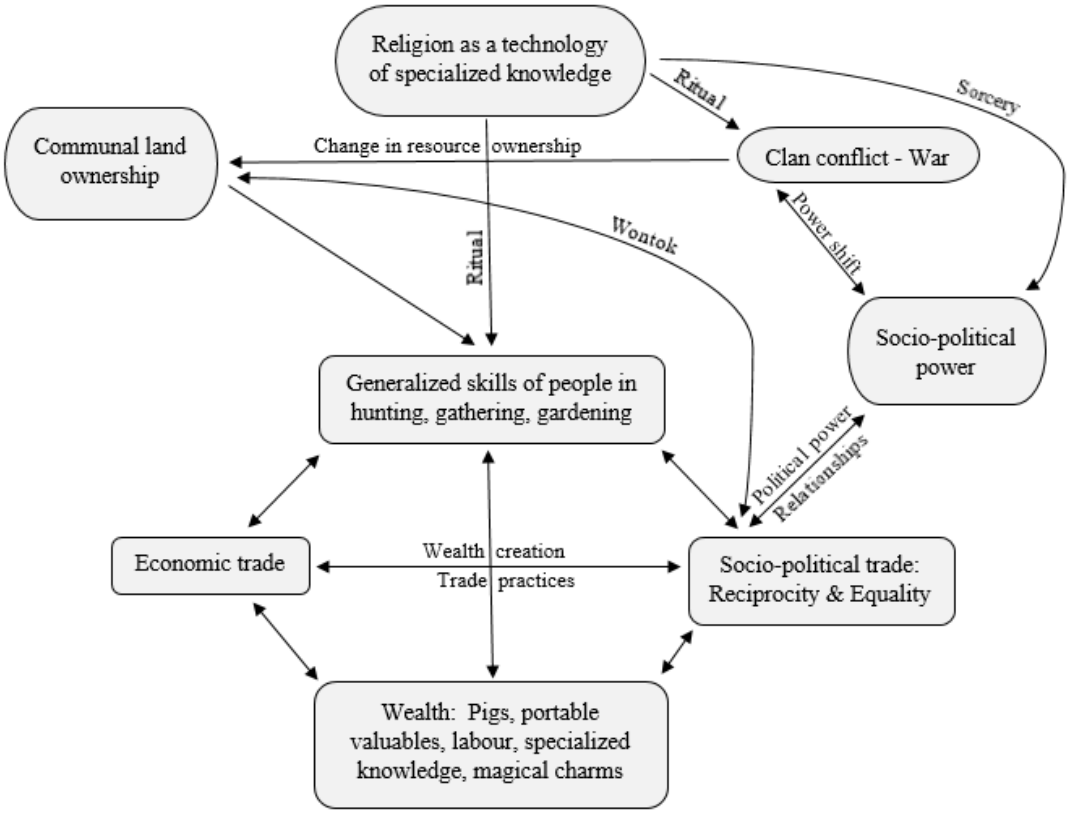

Figure 2.1: Socio-economic dynamics of PNG culture

2.6 Western Contact & the Shift of Socio-Political Norms

The first European visitors to Melanesia were Portuguese and Spanish explorers in the 16th century (Soukup 2010). In 1824, the Dutch claimed the western half of New Guinea mainland. Between 1871 and 1873, a Russian ethnographer, Nicholas Miklouho Maclay made multiple visits to the Rai Coast in the current province of Madang (Lawrence 1971, Soukup 2010). After these visits, the Europeans began to show a greater interest in the area. A German colony was established on the northern part of the eastern half of New Guinea in 1884 to manage copra plantations (Soukup 2010). About the same time, the British established a colony in the southern part of the eastern half of the island of New Guinea. Australia took over the administration of Papua in 1902, but it remained a British colony. In 1905, British New Guinea was renamed the Territory of Papua. During World War I, the German colonial administration was displaced by Australian forces and Australia was granted a trusteeship over former German New Guinea. (Britannica 2018).

Western contact introduced the native people to modern goods and a system of commercial enterprise that dramatically altered their society. The native people had no concept of global market demand, nor how businesses utilized natural resources and specialized labour to produce modern goods. The PNG

natives initially referred to western goods as 'cargo,' which typically included items such as steel tools, machinery, luxury foods, cotton and cloth (Lawrence 1971). The primary means for the people to access the cargo was by trading their natural resources or working as indentured labourers on copra plantations, gold mines, and within the newly developed Western towns (Lawrence 1971). Very few of the native people had an understanding of the purposes of the work they performed or the value of the commodities that they helped the Europeans/Australians to produce (Lawrence 1971). Furthermore, they did not appreciate that the Europeans/Australians did anything to earn their livings other than directing the work of native employees (Lawrence 1971). It was not until after World War II that the meaning of these activities was explained to the native employees (Lawrence 1971). As a result, the indentured labourers were neither enabled nor encouraged to pursue businesses of their own. When the people were unable to grasp the concept of western commercial enterprise, they returned to their use of religion as a form of specialized knowledge to gain help from special deities. Lawrence (1971), described the series of cargo cults and associated ritual activities that subsequently followed. The rituals attempted to produce the cargo for native people and were in a continuous state of change. When rituals were found to be unsuccessful at producing the desired results, they were modified or replaced by new rituals.

By the 1920s, many of the people in the coastal and sub-coastal areas had lost their old skills and acquiring western goods had become a necessity rather than a luxury (Lawrence 1971). These people had become dependent on western goods and were forced into a symbiotic relationship with the Europeans/Australians that required trading their labour and natural resources for additional western goods. While the native people retained many of the socio-cultural systems that they had possessed prior to Western contact, their socio-economic paradigm had been permanently changed (Figure 2.2).

In 1942, the Japanese military invaded and controlled the northern part of New Guinea (Lawrence 1971, Britannica 2018). By 1943, the Australian military, with the help of the U.S. military, regained control of New Guinea from the Japanese (Lawrence 1971, Britannica 2018). The civil administration of Papua and New Guinea were combined in an administrative union called the Territory of Papua and New Guinea (Britannica 2018). In the 1960s, Australia began the preparations for decolonization. These preparations included the introduction of general elections of the native people and the formation of a self-government (Britannica 2018). In 1972 the territory was renamed to Papua New Guinea (PNG), and in 1975, PNG became an independent nation.

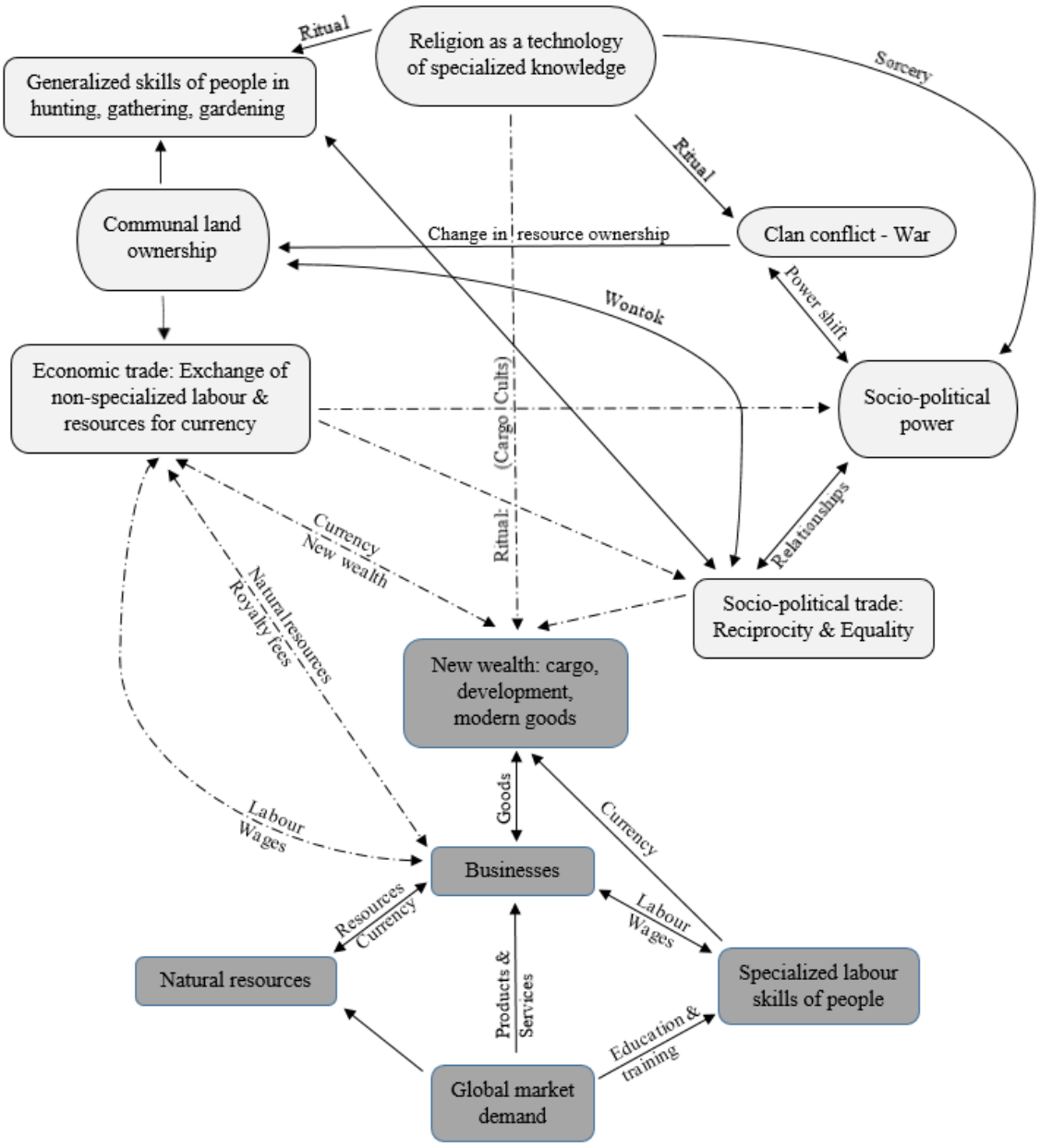

Figure 2.2: Socio-economic dynamics of PNG culture post-Western settlement

2.7 Current State of Affairs

It has been just over 40 years since PNG became an independent nation. There have been many advances in the economic development of the country, which has further integrated PNG into the international economy. The country is governed as a constitutional monarchy with a Governor General acting as the representative of Queen Elizabeth II and a Prime Minister acting as head of the government. The PNG Parliament consists of 89 elected Members and 22 Governors elected from the Provincial electorates, with national elections held every five years (PNGP 2018). The 2018 national

government budget was approximately $3.8 billion USD (PNGDT 2018). PNG's economy is still dominated by natural resource extraction. The gross domestic product was estimated to be $23.6 billion USD in 2017, which was primarily driven by exports (CIA 2018). In 2016, the total value of PNG's exports was $8.2 billion USD (OEC 2018). Petroleum products made up the largest portion of PNG's exports (41.3%), followed by gold (24%), logs (7.4%), copper ore (4.8%), palm oil (4.3%), fish (4.1%), nickel mattes (2.5%), coffee (2.3%), and cocoa beans (1.8%). Australia is the primary recipient of PNG's exports (32%), followed by Japan (22%), and China (18%) (OEC 2018).

In the face of self-governance and growth in natural resource exports, many of the challenges experienced by the native people during colonial times have persisted. There is widespread distrust of elected politicians, due to unethical disbursement of government resources and poor financial accountability (Filer and Sekhran 1998). The natural resource extraction businesses and even small-local businesses are still primarily owned by foreign entities (PNGFA 2009, Britannica 2018, CIA 2018). Subsistence agriculture is still the primary livelihood for most of the population (85%), who reside in the rural areas of the country (Britannica 2018, CIA 2018). Approximately 60% of the population still live in traditional-style homes constructed of bamboo and other materials collected from the forest, and less than 17% of households have access to electricity (NSO 2011). On average, only 22% of the people have received an education that extends beyond primary school (Grades 1-6) (NSO 2011).

There has been an ongoing debate among development anthropologists regarding customary landownership and economic development in the SE Pacific. One view, is that customary landownership has been a barrier to economic development in PNG and that individual land titles are necessary for economic growth (Hughes 2003, Gosarevski et al. 2004a, Gosarevski et al. 2004b, Hughes 2004a, Hughes 2004b). This view is founded on the premise of the 'Tragedy of the Commons' by Hardin (1968), who argues that open access to resources will almost always result in over-exploitation. The view that individual land titles are necessary for economic development has been disputed by Fingleton et al. (2005), and Sukot (2010), who provide multiple examples of successful small-scale agricultural production occurring in PNG on customary lands. Sukot (2010), argues that a transition from customary land to individual land titles is an opportunity for foreign companies and wealthy PNG elites to take advantage of rural landowners, who have limited literacy and a limited understanding of business transactions. Fingleton et al. (2005), describes communal land as an important social safety net that enables people to take risks in the pursuit of education, employment, and investments. If the people fail in their endeavours, they are always able to return to their land and provide for themselves through subsistence agriculture. Despite the recognition of the benefits that customary tenure provides to the people, it has been recognized that customary tenure can increase the complexities of implementing economic development projects (Lamb 1990, Filer and Sekhran 1998, Fingleton 2005,

Bird et al. 2007, Baynes et al. 2017). Fisher (1994), suggests that the reason that effective common property resource management fails to occur is due to the absence of shared norms about the resource use and a high level of social interdependence not being present. Common property resource management is more likely to be successful when it is built on existing social relationships and when the process of consensus building occurs through the aid of external intervention (Fisher 1994).

The wontok system has also been recognized as a factor that increases the complexity of economic development in PNG. This system has been identified as one of the causes for political corruption and a potential reason native-owned business struggle to survive (Prideaux and Beg 2008). Elected officials have often used their political power to reward wontok members that helped them get elected (Filer and Sekhran 1998, Prideaux and Beg 2008). Native owned businesses have often donated profits and business inventory to wontok members, which ultimately resulted in the financial failure of the business (Prideaux and Beg 2008). This highlights the importance for understanding how the wontok system is embedded in society and the potential impacts it may have on forestry-based economic development projects.

Sorcery related violence continues to be a large social phenomenon in present-day PNG (Bouscaren 2018). Sorcery related violence typically occurs when individuals or families are accused of sorcery and then attacked, tortured, and often killed (Urame 2015). Historically, sorcery related violence was not common, but this has changed. The violence is typically initiated and executed by young people, outside the view of the surrounding community. The level of sorcery related violence has increased in recent years, which has been attributed to a lack of economic development in rural areas, the collapse of traditional Melanesian social structures, and growing economic inequalities (Urame 2015).

2.8 Conclusion

The integration of the western cash economy system with PNG's historical socio-economic system has not been an easy transition. Increased prosperity has continued to elude the native people amid the natural resource extraction, despite them owning 97% of the land and the associated natural resources. The Indigenous people that typically have attained the best economic situation are the recipients of royalty payments from large natural resource extraction projects and those that have completed an upper-level education and obtained employment in the developed centres of the country. The western economic system emphasis on capitalism and private property is at odds with the principles of the customary landownership and the wontok system. Improving the livelihoods of the forest-residing communities is going to require an understanding of the best approaches to further integrate PNG's socio-economic historical system with modern development practices.

Chapter Three

Review of Forestland, Management Policies, and the Timber Industry

3.1 Introduction

This chapter provides information of PNG's forestland, management policies, and the timber industry. Section 3.2 provides a description of the forestland. Section 3.3 provides a brief history of PNG's forest policies. Section 3.4 provides a description of the timber industry. This section is divided into six sub-sections; historical timber industry; current timber industry; logging operations; log exports, timber industry corruption allegations; and the small-scale forestry sector. Finally, the conclusion is in section 3.5.

3.2 Description of Forestland

The total land area of Papua New Guinea (PNG) is approximately 46.2 million hectares, with 29 million hectares estimated as forestland (PNGFA 2009). The structure and composition of PNG's forests are a highly diverse with over 2,000 large tree species across a broad geographic and climatic spectrum (Kambuou 1995). Shearman et al. (2008), identified six types of forestland; lowland rainforest, lower montane rainforest, upper montane rainforest, swamp forest, dry evergreen forest, and mangrove forest (Table 3.1). The elevation ranges for the three rainforest groups are; <1,000m for lowland rainforest; 1,000–2,800 m for lower montane rainforest; and >2,800 m for upper montane rainforests (Shearman et al. 2008). Whitmore (1998), describes lowland rainforests as generally having three canopy layers; a top layer of emergent trees reaching 60-80 m in height; a main stratum canopy at 25-45 m in height; and smaller shade dwelling trees existing below. Lower montane rainforests typically have much fewer emergent trees than lowland rainforests and a main canopy height of 15-33 m (Whitmore 1998). Upper montane rainforests are usually absent of emergent trees with the main canopy height typically between 1.5 and 18 m (Whitmore 1998). Combined, these rainforest groups represent approximately 86% of the total forestland in PNG (Table 3.2) and are part of the second largest block of tropical rainforest on the planet; the Indo-Malayan Tropical Rain Forest (Whitmore 1998). The remaining forest types identified by Shearman et al. (2008) represent approximately 14.3% of the total forest area and are swamp forest (10.3%), dry evergreen forest (2.3%), and mangrove forest (1.7%).

Table 3.1: Forest types of Papua New Guinea by hectare

	Lowland Rainforest	Lower montane Rainforest	Upper Montane Rainforest	Swamp Forest	Dry Evergreen Forest	Mangrove Forest
Hectares	18,639,067	8,910,600	702,300	3,409,018	750,309	574,867
Percent	56.5	27.0	2.1	10.3	2.3	1.7

Source: Shearman et al. (2008).

Table 3.2: Percentage of forest type by region and province

Region - Province	Rainforest	Swamp Forest	Dry Evergreen Forest	Mangrove Forest	Total Forest Area
Lowland Region					
Central	6.0	0.2	-	0.2	6.3
East Sepik	6.2	3.2	-	0.1	9.5
Gulf	7.2	1.5	-	0.8	9.5
Madang	6.0	0.3	-	-	6.3
Milne Bay	2.8	0.0	-	0.1	3.0
Morobe	6.4	0.2	-	-	6.5
Oro	4.7	0.6	-	-	5.4
West Sepik	8.3	0.6	-	-	8.9
Western	13.9	3.3	2.3	0.4	19.8
Total Lowlands	61.4	10.0	2.3	1.6	75.2
Highland Region					
Chimbu	1.1	-	-	-	1.1
Eastern Highlands	1.7	-	-	-	1.7
Enga	2.4	-	-	-	2.4
Southern Highlands	5.7	0.1	-	-	5.7
Western Highlands	1.5	-	-	-	1.5
Total Highlands	12.5	0.1	-	-	12.5
Islands Region					
Bougainville	1.4	0.1	-	-	1.6
East New Britain	3.5	-	-	-	3.5
Manus	0.4	0.1	-	-	0.5
New Ireland	2.0	-	-	0.1	2.1
West New Britain	4.5	0.1	-	-	4.7
Total Islands	11.7	0.3	-	0.2	12.2
Grand Total	85.6	10.3	2.3	1.7	100.0

Source: Shearman et al. (2008).

The rainforests in PNG differ from the rest of the Indo-Malayan Tropical Rainforest in that they are not dominated by the dipterocarp family and have been partially replaced by species such as *Pometia pinnata, Ficus* spp*., Alstonia scholaris, Terminalia* spp*., Intsia* spp., and *Pterocarpus indicus.* (FAO 2000). Forestland in PNG has historically been frequented by numerous disturbances in the form of earthquakes, landslides, cyclones, fire, and shifting agriculture. The associated affect is a substantial proportion of the forest being composed of pioneer and strong-light demanding species, such as *Albizia* spp*., Paraserianthes* spp*., Serianthes* spp*., Eucalyptus degulpta, Campnosperma* spp*., Pometia pinnata,* and *Terminalia* spp. (Whitmore 1998).

3.3 Land Ownership and Use

Approximately 97% of the forest is held under customary land ownership by clan groupings (PNGFA 2009). Traditional uses of the forest by the customary land owners include food and material collection, hunting, shifting agriculture, places of spiritual and cultural values, and wood collection (PNGFA 2009). The primary use of wood by the people is for energy to cook food and to provide warmth. Wood and other forest materials are collected from the forest to make traditional style homes with

bamboo/matting. It is estimated that 72.2% of rural dwellings are made this way (Aka and Drapuluvik-Tinabar 2011). A key forestry issue recognized in the report by PNGFA (2009), is a desire of the customary landowners for development of basic services such as healthcare, education, general infrastructure, and employment. With limited development and few employment opportunities in rural areas, people sell the rights of their timber resources to logging companies to earn an income and have access to the goods and services available in urban areas.

Non-timber forest products (NTFP) used by the people include resins, oleoresins, gums, oils, tannins, fibres, cork, medicines, and dye material (Chatterton et al. 2000). The most significant commercial NTFPs are resins collected from *Gyrinops ledermannii* (Eaglewood or agarwood) and oil from *Melaleuca* spp. (PNGFA 2009). The resin from *Gyrinops ledermannii* is used for incense, perfume, and small carvings. The essential oils form the leaves of *Melaleuca* spp. is used to produce tea tree oil. Rattan was previously an important commercial NTFP that was harvested and exported by rural communities, but this declined by the end of the 1980s (PNGFA 2009).

The PNG government owns very little of the forestland. Approximately 500,000 hectares has been designated as wildlife management areas, which are largely managed by NGOs since the government does not have sufficient resources (PNGFA 2009). Approximately three million hectares was declared as 'protected areas' when the PNG government signed the Convention on Biodiversity. These areas are under the management of the Department of Environment and Conservation.

3.4 Forest Policies

The first forest policies enacted occurred during early colonial days and were the Timber Ordinance 1909-1920 and the Timber regulations 1918 (PILII 2018). These laws were passed under the authority of the British Commonwealth and included the procedures for harvest permits and royalty payments. In 1951, the Timber Rights Purchase (TRP) agreement was introduced as a method for the administrative government (Australia) to access timber held under customary clan ownership (Bird et al. 2007). Under the TRP agreement, after the state had acquired the rights to the timber, these rights were granted to an investor to be logged. In 1971, the Forestry Private Dealings Act was passed, which allowed customary land owners to bypass the TRP procedures by setting up a company and selling their timber directly to outside individuals or businesses (Bird et al. 2007). In 1974, the Land Groups Incorporation Act was passed, which allowed customary landowners to aggregate their timber interests into a single legal entity called an Incorporated Land Group (ILG). The ILG or 'landowner company' could acquire the timber rights from customary landowners and sell the rights to a foreign logging company. The use of the Forestry Private Dealings Act allowed for timber harvests to take place without a permit and with minimal government supervision (Taylor 1997).

In 1987, Prime Minister Paias Wingti established a Commission of Inquiry to address persistent criticism of the timber industry. The inquiry was chaired by Judge Thomas Barnett and was completed in 1989. The findings of the Barnett Inquiry revealed rampant corruption within the timber industry that was traced to a number of government officials (Marshall 1990). This revelation of corruption within the government resulted in the suppression of the final report. A summary of the Barnett Inquiry by Marshall (1990), indicated that the foreign logging companies were responsible for environmental degradation due to poor logging practices, corruption, and tax evasion. Contracts between the customary landowners, landowner companies, and the logging companies were often made without landowner knowledge or consent. The royalty payments received by the customary landowners were found to be quite low relative the value of the logs harvested. The logging companies were found to be miss-declaring the species of logs being exported and selling the logs at artificially low prices relative to market values. The disclosed lower profits or losses allowed the logging companies to pay less in taxes and store the hidden profits in off-shore accounts (Marshall 1990). The Barnett Inquiry also revealed that multiple government officials and elite citizens had established large ownership shares in the landowner companies. Many of these individuals were complicit in the tax evasion strategies and amassed large profits at the expense of the customary landowners and the PNG government.

One of the recommendations of the Barnett Inquiry, was the formation of a national forestry policy with revised forestry legislation. In (1991), the National Forestry Act was passed, along with its associated National Forest Policy. The new Act called for the establishment of the PNG Forest Authority (PNGFA) to regulate the timber industry. The PNGFA was created to replace the former Department of Forests and to unify the 19 provincial forest departments that were already in existence. The PNGFA is overseen by the National Forest Board, who advises the Minister for Forests and provides direction for the PNGFA. The operational arm of the PNGFA is the Forest Service. Under the revised legislation, the Forestry Private Dealings Act was repealed, re-establishing state control of all industrial-scale timber harvests.

Under the Forestry Act (1991), there are two primary methods for implementing timber harvests on customary land; a Forest Management Agreement (FMA); and a Timber Authority (TA). An FMA transpires when the PNGFA enters into an agreement with the customary landowners for access to timber rights, which are vested into an ILG. These rights are then assigned by the PNGFA to a 'forest industry participant' to exercise the timber rights through harvest. The Forestry Act (1991) defines an FIP, as, "Any person engaging in, or intending to engage in, forest industry activities (otherwise than as an employee of a forest industry participant or in the capacity of a common carrier) where the timber harvested, bought, sold or arranged or procured to be sold or purchased, by that person in a calendar year exceeds 500 m^3 in volume." These harvesting rights acquired by the FIP are often referred to as

timber concessions. All timber concessions issued as FMAs are for selective logging and expire after 50 years and are designed to have a second harvest after the first 35-year rotation. There are five types of TAs; domestic processing, road clearing, agricultural conversions, other forest products, and plantations. The TA for domestic processing is the primary method for conducting small-scale timber harvests. This TA allows an FIP to harvest up to 5,000 m^3 annually from lands existing within a 10-km radius over the duration of one year.

The Forestry Act (1991) requires that persons or logging companies operating with an FMA or TA make royalty payments to the customary landowners for all timber harvested. The royalty payment amounts are minimum fixed rates and vary between 10 and 35 Kina (PGK) per m^3, depending on the tree species. This is equivalent to $3.13 and $10.96 in 2017 USD using a conversion rate of 0.31 (NFS 2008) (Table 3.3). These timber species in PNG are categorized into four groups, with Group 1 representing the most sought-after species. The minimum fixed-rate royalties have been in effect since 1 March 2008. Prior to this date, the minimum fixed-rate was 10 Kina (PGK) per m^3 for all species, which was set by the PNG Forestry Act (1991).

Table 3.3: PNG timber royalty rates per m^3 (2017 PGK and USD)

Group/Species	PGK	USD
Group 1		
Intsia bijuga	35.00	$11.22
Palaquium spp.	20.00	$6.41
Dracontomelon dao	20.00	$6.41
Remaining Group 1 species	15.00	$4.81
Groups 2, 3 and 4 species	10.00	$3.20

3.5 Timber Industry

3.5.1 Historical Timber Industry

Industrial logging in PNG largely began after the second world war, as there was a need for sawn timber to rebuild war damaged urban centres and establish new rural centres (Bird et al. 2007, PNGFA 2009, PNGFIA 2010a). In the 1940s, government owned sawmills were established near the cities of Lae and Rabaul (Bird et al. 2007). In 1955, a plywood mill began operating in Bulolo (Bird et al. 2007). In 1974, a woodchip export development project was established in Madang and operated by the Japan and New Guinea Timbers ltd (JANT) (Lamb 1990, Bird et al. 2007). Most of the forest industry operators were foreign, because they had the necessary expertise to undertake large-scale harvests and processing, as well as access to capital (Bird et al. 2007). During this era, log export volumes remained low, but exports of manufactured wood products continued to grow, which was primarily comprised of plywood. (Bird et al. 2007).

3.5.2 Current Timber Industry

It has been estimated that there are 25 foreign logging companies in PNG, with the majority of them being Malaysian in ownership (PNGFA 2009). Most of these companies are subsidiaries of one large conglomerate, Rimbunan Hijau (RH), which controls approximately 45% of the logging and forest product exports in PNG (PNGFA 2009). This large conglomerate and four other companies control about 80% of the log export market (PNGFA 2009). The down-stream wood processing sector in PNG is comprised of 28 saw mills, one plywood mill, one veneer mill, one woodchip manufacturer, and eight furniture manufacturers (PNGFIA 2010c, PNGDL 2015). In 2016, PNG's wood processing sector produced approximately 82,000 m^3 of sawn wood, 29,000 m^3 of plywood, and 62,800 m^3 of veneer (ITTO 2017). It has been estimated that PNG's forest industry employs a total 9,390 staff, with 67% working in log harvesting, 11% working in log exports, and 22% working in domestic processing (Smith 2019).

RH is a Malaysian company, founded in 1975 as a timber contractor, by Tiong Hiew King (RHG 2016). The company began harvesting timber in PNG in 1989 (RHG 2016). In 1997, the company established a veneer mill in the Western Province (Bird et al. 2007, RHG 2016). Additional down-stream wood product processing owned by RH includes five sawmills located in the Gulf, Western, Central, and Milne Bay Provinces (RH 2016). Since the company's founding, RH has expanded its operations to 16 countries and into multiple industries, including oil palm plantations, media, and hospitality. A consulting report commissioned by RH indicates that in 2005, in PNG, the company employed approximately 5,300 people, with 4,200 of them working in forestry operations (ITSGC 2006). In 2009, Tiong Hiew King was knighted by Queen Elizabeth II (Kiala 2009). In 2018, the net-worth of Tiong Hiew King was estimated to be $1.1 billion USD (Forbes 2018).

3.5.3 Logging Operations

The PNG Logging Code of Practice, developed in 1996, requires selective logging of trees only greater than 50 centimetres in diameter at breast height (PNFGA 1996). The size of the forest gaps after felling are typically 20 to 40 meters in diameter, with harvests typically occurring over 80,000 hectares (Yosi et al. 2011). Research on the effect of conventional logging to forest stand dynamics found that post-harvest, a higher proportion of non-commercial species occupy the gaps created during harvest immediately and up to about 20 years after harvest (Yosi et al. 2011).

The forests in PNG have been described as low yielding and expensive to harvest, with timber removals ranging between 15-25 m^3 per hectare (FORTECH 1998). The limited road access and quality of existing roads has also been attributed to the high costs for accessing timber (FORTECH 1998). Furthermore, the forests of PNG are characterized by a high diversity of species, many of which were

not well known in international markets (FORETECH 1998). The most recent logging cost study in PNG was conducted in 1997, which found that the average cost per m^3 was $126.34 in 1997 USD (Table 3.4) (FORTECH 1998). An alternative study that assessed logging and processing found that the average cost break-down was; logging (9%); processing (31%); transport (18%); taxation (27%); and royalty payments to landowners (15%) (PwC 2006).

Table 3.4: Average PNG logging costs in 1997 per m^3

Activity	Average Cost	Percent
Operations	$44.66	35.3
Camps/Head office	$15.18	12.0
Overhead	$4.78	3.8
Subtotal	$64.62	51.2
Royalty	$18.35	14.5
Export tax	$43.36	34.3
Total	$126.34	100.0

Source: FORTECH (1998).

3.5.4 Log Exports

Beginning in 1980s, the foreign timber operators transitioned from being most Australian companies to south-east Asian companies (Holzknecht and Golman 2009). There was also a large transition in the direction of forest policy, characterized by a reduction in processed wood exports and a substantial increase in log exports (Bird et al. 2007). In 1979, log exports were just below 500,000 m^3 (Bird et al. 2007). By 1992, logs exports had grown by 280% (Figure 3.1) (PNGFIA 2010b). The average annual growth rate in logs exports between 1992 and 2017 was 2.6%, with the largest export volume occurring in 2015 at 3.8 million m^3 (PNGFIA 2010b, SGS 2006-2018). The PNGFA believes that approximately 90% of all logs harvested in PNG are exported (PNGFA 2009).

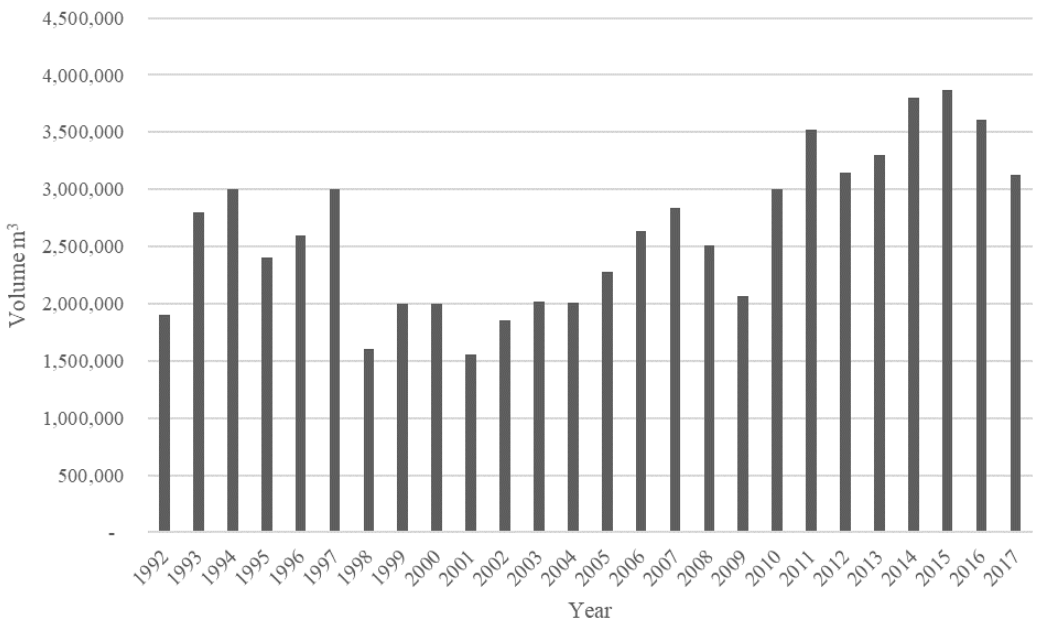

Figure 3.1: Log exports from PNG, 1992-2017
Source: PNGFIA 2010b, SGS 2006-2018.

During the last decade, logs exported have predominantly originated from six provinces; West New Britain (24%); West Sepik (18%); East New Britain (16%); Gulf (10%); Western (9%); and New Ireland (7%) (Figure 3.2) (SGS 2008-2018). While the West New Britain and East New Britain Provinces contain about 8% of the total rainforest in PNG, they represent the origin for approximately 40% of log exports during the last decade. The primary log species exported from PNG during the last decade was *Pometia pinnata*, representing an average annual percentage of 15.9% of the total exports. This was followed by *Intsia bijuga* (9.9%), *Homaliun foetidun* (8.4%), *Calophyullum* spp. (6.7%), and *Terminalia* spp. (4.9%) (SGS 2008-2018). During this time, China was the primary destination for PNG's log exports receiving an average of 84.5% of the annual total (SGS 2008-2018). This was followed by India (5.0%), Japan (2.8%), Vietnam (2.5%), and South Korea (2.4%) (SGS 2008-2018).

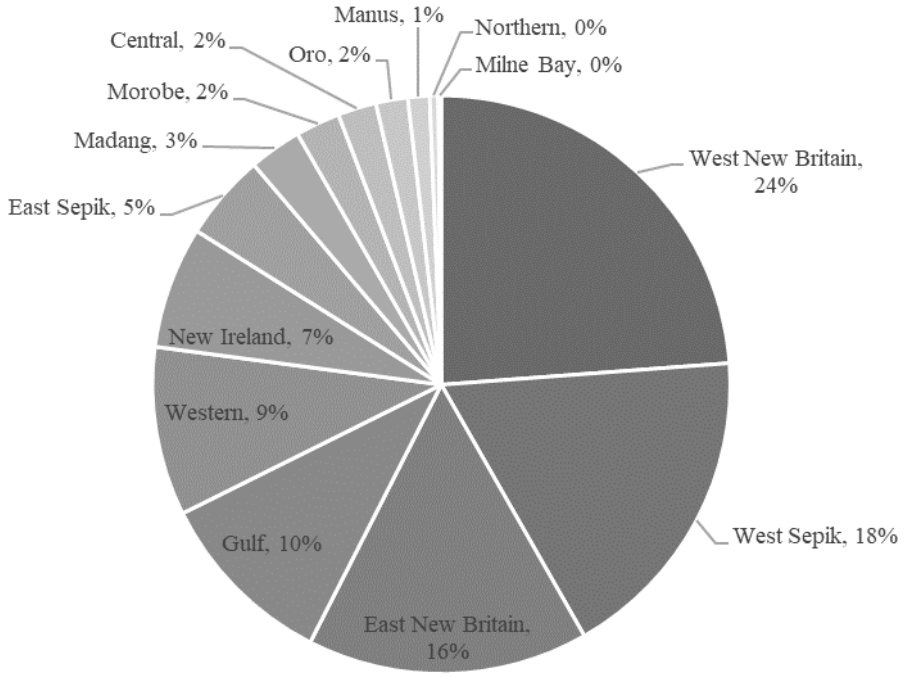

Figure 3.2: Percentage of provincial origin of log exports years 2007-2017
Source: Derived from SGS (2008-2018).

3.5.5 Timber Industry Corruption Allegations

The timber industry in PNG has continued to be the target of corruption allegations despite the passing of the (1991) Forest Act following the Barnett Inquiry. Illegal logging has been reported to be widespread in PNG due to licences being issued despite a breach in regulations (Greenpeace 2006, Lawson 2014). The breaches in regulations include the failure of logging companies to follow harvesting regulations, the failure to follow landowner consultation regulations, and the abuse of licenses for clear-felling for agricultural plantations (Lawson 2014, Mousseau and Lau 2016). The licenses for clear-felling for agricultural plantations are referred to as a 'Special Agriculture and Business Leases' (SABLEs). In 2011, a commission of inquiry was implemented to assess the abuse of SABLEs, which resulted in the investigation of 25 individual SABLEs throughout the country (Laurance 2011, Mirou 2013). The commission of inquiry found abundant regulation violations by the logging companies and a failure of government administrators to conduct proper due diligence prior to the issuance of licenses (Mirou 2013). Additional corruption allegations indicate that at some of the logging camps men and women have been subjected to forced labour and prostitution and are compelled to continue working through debt-bondage schemes (USDOS 2016). The enforcement of the law for regulation breaches by the PNG government has been described as non-existent (Lawson 2014, USDOS 2016).

It has also been alleged that the timber industry has continued to employ tax evasion strategies. In a 2006 report prepared for the PNG Forest Industries Association, PricewaterhouseCoopers (PwC), stated that 'Logging companies themselves appear to be in a contradictory position. While current official log prices indicate that the industry has been unprofitable for a number of years, logging continues and companies still seek access to new forest areas and make significant investments in other areas of the economy' (PwC, 2006, p.9). Furthermore, an investigative report by Mousseau and Lau (2016) found that logging companies in PNG declare little to no profits by artificially inflating logging costs and under-pricing their logs relative to log exports in other tropical countries. The practice of under-pricing logs is a form of 'transfer pricing,' which is often done to reduce the amount of taxes paid. The practice of transfer pricing in PNG has also been reported by Grynbert et al. (1988), Marshall (1990), and Hunt (2002). During the years 2012 - 2016, PNG's non-coniferous log export price was 30% to 76% less than the average price of other Asia-Pacific island nation log exporters (Fiji, Indonesia, Malaysia, Philippines and Vanuatu) (ITTO 2017).

3.5.6 Small-scale Forestry Sector

In PNG, the small-scale forestry sector is made up of Indigenous communities and small businesses that utilize portable sawmills to harvest and mill lumber on clan lands. Beginning in the 1970s, church groups and NGOs imported portable sawmills so that Indigenous communities could mill lumber for their own needs. Advances in the mill designs in the 1980s improved portability, resulting in widespread adoption throughout the country (Bun and Scheyvens, 2007; Holzknecht et al., 2012). Little is known about the number of operators or the harvest volumes associated with this sector or the destinations of the timber, as the PNG government does not have the resources to track or regulate this sector. Visual evidence suggests that most of the participants operating in this sector do not have a harvest permit and are technically operating illegally.

3.6 Conclusion

PNG's forests are primarily highly diverse rainforest, with a high proportion of the species being composed of pioneer and strong-light demanding species. Approximately 97% of the forestland is held under customary land ownership, with the Indigenous landowners relying on the forest for subsistence agriculture, hunting, and gathering. Forest management policies were first enacted in the early 1900s and have continued to evolve during the last century. Since the 1980s, forest management has primarily focused on large-scale timber harvests to produce export logs to stimulate national economic growth. The small-scale forestry sector is made up of Indigenous communities using portable sawmills to produce lumber from timber on their lands.

Chapter Four

The Failure of Eco-forestry as a Small-scale Native Forest Management Model in Papua New Guinea

Abstract:

Deforestation and forest degradation are problems common to many tropical countries, including Papua New Guinea (PNG). These problems are often a result of the environmentally unsustainable logging practices of industrial logging companies. Beginning in the 1990s, six organizations attempted to mitigate the deforestation and forest degradation occurring in PNG by facilitating small-scale native forest management by Indigenous forest landowners. All six organizations utilized an 'eco-forestry' approach, involving selective harvesting of timber combined with the milling of timber by Indigenous forest landowners using portable sawmills. The lumber produced was sold into local and international markets as sustainable certified under Forest Stewardship Council (FSC) principles. The use of portable sawmills was also intended to provide the landowners with a greater financial return compared to the timber royalty payments they could receive from logging companies. This study used a literature review and interviews with key informants from the eco-forestry organizations and the PNG Forest Authority to assess the effectiveness of variants of the portable sawmilling model. We found that each of the six organizations were unsuccessful in developing a financially viable model for small-scale native forest management by Indigenous forest landowners in PNG. All the Indigenous landowners were unable to continue their portable sawmill operations once the donor funding of the eco-forestry organizations ceased. In addition, the operators of portable sawmills struggled to produce lumber that met the quality and quantity demands of buyers, who ultimately ceased purchasing the lumber. Furthermore, the Indigenous landowners struggled to adhere to the FSC principles, resulting in a loss of FSC certification. The study identifies a need for a new small-scale native forest management model in PNG. We recommend that future research involve collaboration with private sector businesses and professionally trained operators to inform the development of a small-scale forest management model which is financially profitable while also adhering to the principles of eco-forestry.

Keywords: community forestry; native forest harvesting; portable sawmills; reduced impact logging; small-scale forestry; sustainable tropical forestry

4.1 Introduction

Papua New Guinea (PNG) has one of the largest remaining continuous areas of tropical forest in the world. There are approximately 29 million hectares of forest with 97 percent of the forest held under customary land ownership by Indigenous clan groups (PNGFA 2009). Large-scale industrial logging companies operating in PNG export approximately 90 percent of the logs harvested in the country (PNGFA 2009). Just over 3.4 million m^3 of non-coniferous logs were exported from PNG in 2016 (SGS 2017). This amount represents 8.5 percent of total non-coniferous log exports from all tropical countries in the world in 2016 (ITTO 2017). The PNG Government imposes export duties on exported logs, which totalled approximately $95.5 million USD in 2016 (SGS 2017). The customary landowners receive royalty payments as compensation for the harvested timber, which varies between $3.30 and $11.55 per m^3 in 2016 USD, depending on the tree species (NFS 2011).

The harvest methods of the large-scale logging companies operating in PNG have been widely criticised, especially in respect to the widespread environmental damage resulting from noncompliance with the PNG Logging Code of Practice (PNGFA 1996), (e.g. Bun and Scheyvens 2007; Fox et al. 2011; Bun 2012). In addition, the timber harvests have resulted in social inequalities due to the royalty payments received by the landowners being disproportionately small relative to the value of the timber being removed. Furthermore, the system for distributing royalty payments to landowners lacks financial transparency, causing landowners to question if they have been paid the amounts they were owed (Bird et al. 2007). These issues provided the impetus for PNG's customary landowners and supporting non-governmental organizations (NGOs) to explore alternative forest management methods such as 'eco-forestry.'

'Eco-forestry, as a form of forest management is poorly defined with limited performance metrics established. It has been described by the Food and Agricultural Organization (FAO) of the United Nations as an ecologically sustainable and economically viable alternative to conventional logging. The key principles of eco-forestry were derived from the 'Sustainable Forest Management' (SFM) and the 'Ecosystem Approach' (EA) to forest management (Scialabba and Williamson 2004). The 15 principles of SFM were originally promulgated by outputs of the United Nations Conference on Environment and Development (UNCED) (1992). The objectives of the 15 SFM principles was to provide guidance for the management, conservation and sustainable development of all forest types to meet the ecological, economic, social, cultural and spiritual needs of society (Wilkie et al. 2003). The 12 principles of the EA approach to forest management also originated as an outcome of the UNCED, and were developed by the Convention on Biological Diversity to provide a holistic approach to forest management aimed at conserving ecosystem services (CBD 2000). While SFM and the EA had different starting points - forest management versus conservation ecology - they are sufficiently similar to be combined for planning purposes (Wilkie et al. 2003, Sayer and Maginnis 2005). Thus, eco-forestry became a forest

management model based on the principles of these two forms of forest management. The Commission on Sustainable Development (CSD) was established by the United Nations General Assembly to ensure effective follow-up of the outputs of UNCED. It was recognized by the CSD that the development of criteria and indicators (C&I) would be a crucial step for evaluating the performance of sustainable forest management (Szaro et al. 2005). Third party sustainability certification emerged as a tool for establishing C&I and verifying the occurrence of the required indicators (Sayer and Maginnis 2005). In PNG, the primary organization for third party certification is the Forest Stewardship Council (FSC). The current FSC principles, criteria, indicators and verifiers for PNG were established in 2010 (FSC 2010).'

In PNG, eco-forestry as a forest management model has been linked to the use of portable sawmills. Beginning in the 1970s, church groups and NGOs imported portable sawmills so that Indigenous communities could mill lumber for their own needs. Advances in the mill designs in the 1980s improved portability, resulting in widespread adoption throughout the country (Bun and Scheyvens 2007, Holzknecht et al. 2012). Beginning in the 1990s, multiple NGOs facilitated small-scale native forest management which followed the principles of eco-forestry. The NGOs incorporated portable sawmills into this forest management model, with the mills being operated by the Indigenous forest landowners. While the use of portable sawmills as an alternative to conventional logging and log processing for rural development has been practiced in Vanuatu, the Solomon Islands, the Philippines and Brazil (World Bank 1996), PNG is the only tropical country that has specifically linked eco-forestry and portable sawmills as a forest management model. For the remainder of this paper the entities involved in eco-forestry projects in PNG will be referred to collectively as the 'eco-forestry organizations.'

There have been few rigorous attempts to critically assess the success of eco-forestry projects in PNG, and whether portable sawmills are an appropriate technology for use in such projects. In addition, there is a lack of information about whether there are opportunities to scale-up the existing small-scale forest management activities utilizing the eco-forestry management model with portable sawmills. The aim of this study was to assess the effectiveness of eco-forestry using portable sawmills as a model for small-scale native forest management by PNG's Indigenous landowners and determine if it is a viable model that can be further developed and scaled-out to additional communities in the country. The criteria by which we assess the of the eco-forestry organizations in this study were; (1) the financial viability of their operations; (2) their ability to accomplish their management objectives; and (3) their ability to adhere to the principles that the eco-forestry management model was based on.

4.2 Methods

4.2.1 The Eco-forestry Organizations

Six eco-forestry organizations have been involved in facilitating small-scale forest management activities with Indigenous forest landowners in PNG using portable sawmills since the early 1990s. Most of these organizations were structured as NGOs. Only two of these organizations are currently operational. They are the Foundation for People and Community Development (FPCD) and FORCERT. The eco-forestry organizations discussed in this paper were headquartered in the cites of Kimbe, Lae, Madang and Rabaul in PNG (Figure 4.1). Key features of these organizations are presented in Table 4.1.

Table 4.1: Key features of the eco-forestry organizations

Name	Start year	End year	Institutional framework	Number of mills
Village Development Trust	1990	2010	NGO	4
Pacific Heritage Foundation	1992	2003	NGO	12
Islands Region Environmental & Community Development Programme	1995	2001	NGO/Government	40
PNG Eco-forestry Programme	2002	2005	Government	15+
Foundation for People and Community Development	1996	-	NGO	6
FORCERT	2004	-	NGO	40

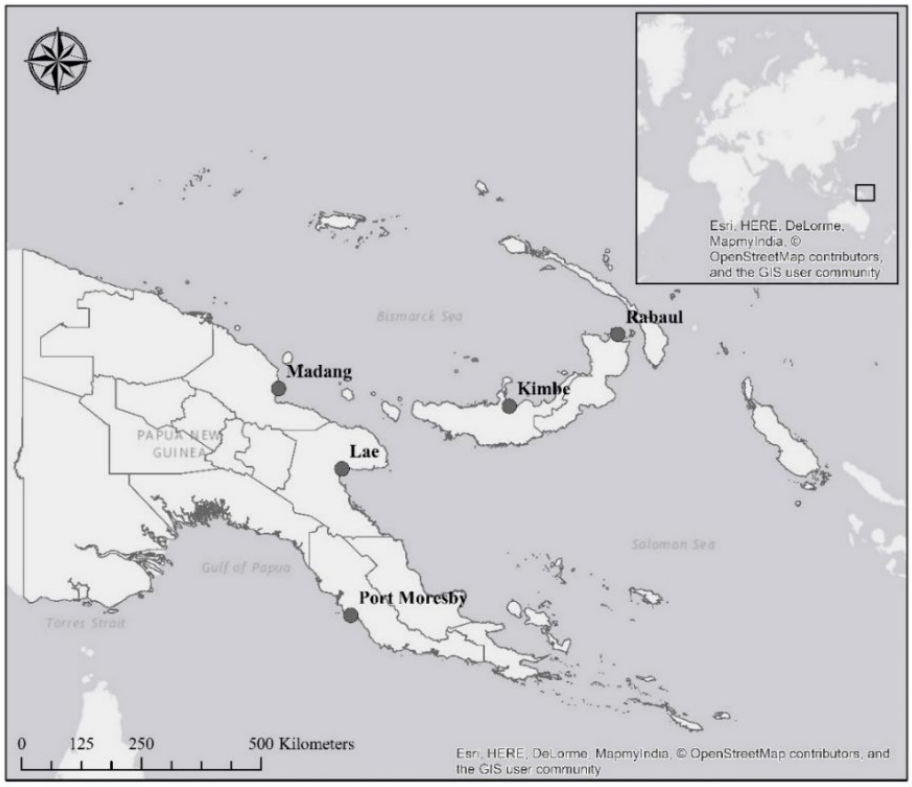

Figure 4.1: Data collection sites and headquarter sites for the eco-forestry organizations and the PNGFA

4.2.2 Data Collection

Data was collected from a literature review and interviews with key informants. A literature search was first conducted using Google Scholar, JSTOR and ProQuest search engines to locate relevant journal articles, conference papers and reports discussing eco-forestry organizations in PNG. The keywords used in the literature search were; Papua New Guinea; eco-forestry; and portable sawmills. The initial literature search yielded 101 documents. Of these documents, only 10 provided information specific to the operations of the eco-forestry organizations. Three trips were made to PNG in 2016 to the cities of Lae, Madang and Port Moresby to conduct interviews with key informants from the eco-forestry organizations and the PNG Forest Authority. During these visits, additional documents relating to the eco-forestry organizations were collected, comprising four external evaluations of the eco-forestry organizations, a strategic plan for one of the eco-forestry organizations and eight operational reports produced by the eco-forestry organizations. The eight operational reports were only available as paper-copies and were in the PNG Forest Research Institute library in Lae and from current or former employees of the eco-forestry organizations.

An interview protocol was designed based on the preliminary results of the literature review. The interview questions were designed to identify the management activities implemented by the eco-

forestry organizations, their accomplishments, the destinations of the milled lumber, and the funding received to implement the eco-forestry activities[1]. The interview format was similar for all interviewees. The initial question asked during the interview was; 'What are the specific activities that were implemented by (the NGO being interviewed) to facilitate eco-forestry with the Indigenous landowners'? Follow up questions focused on; training provided to the landowners; if forest management plans had been completed; lumber volumes produced; transporting the lumber to market; lumber sales; accomplishments; challenges experienced; and sources of funding for NGO activities. All the interviews were conducted by the first author, with hand-written notes taken during the interviews. The length of the interviews varied between 30 minutes and two hours. The initial interviews were with four current and former employees of one of the eco-forestry organizations, the Foundation for People and Community Development (FPCD). Only one current employee of FORCERT was willing to participate in an interview. This person was also a former employee of IRECDP. It was not possible to conduct interviews with three of the eco-forestry organizations discussed in this paper because these organizations had ceased their operations and no former employees could be contacted. Additional interviews were conducted with 10 employees of the PNGFA that had knowledge of the past operations of the eco-forestry organizations. Details of the key informants interviewed for the study are presented in Table 4.2.

Table 4.2: Description of the key informants interviewed

Organization	Number of people	Interviewee expertise
PNG Forest Authority		
National headquarters	4	Forest management
Madang Provincial office	3	Forest management
Lae Forest Research Institute	3	Forest management
Eco-forestry organizations		
FORCERT	1	NGO & forest management
Foundation for People and Community Development	4	NGO & forest management
Islands Region Environmental & Community Development Programme	1	NGO & forest management

4.2.3 Data Analysis

We completed our data analysis in two steps. The first step was a summary of each of the six eco-forestry organizations is provided in the following sections. The summaries outline each organization's:

[1] Total funding estimates were collected from four of the eco-forestry organizations. Partial estimates for two of the organizations were collected from reports and news articles. All the data estimates were inflated to 2016 USD values. To address privacy concerns, data related to specific organizations and the sources utilized has been kept confidential.

a) year of commencement, location in PNG and objectives, b) management activities, c) accomplishments, and d) year of ceasing operations and why.

The second step was a thematic analysis to identify patterns in the data using methods outlined by Boyatzis (1998). The materials used in the thematic analysis were the ten documents identified in the literature search, the four external evaluations of the eco-forestry organizations, the strategic plan of one of the eco-forestry organizations, the eight operational reports produced by the eco-forestry organizations and the notes written by the first author during interviews. A thematic code was developed by the first author from a sub-sample of these materials. The sub-sample was the four external evaluations of the eco-forestry organizations. Twenty-one recurring themes were identified during the review of the sub-sample. The twenty-one themes were classified into three groups; (1) eco-forestry organization management model activities, (2) challenges experienced by the eco-forestry organizations, and (3) challenges experienced by portable mill producers. From these themes, twenty-one thematic codes were developed (Table 4.3). All the materials used in the thematic analysis were reviewed by the first author to determine the presence or absence of the thematic codes for each eco-forestry organization. Patterns were identified from thematic codes that had the highest occurrences among the six eco-forestry organizations.

Table 4.3: Thematic code labels and descriptions

Thematic code label	Description of thematic code
Group one themes	Did the eco-forestry organizations provide these services?
Community development	Construction of buildings and training to improve health of community.
Forest management plan	Completed forest management plan with inventory, objectives and activities.
Sawmill operator training	Trained portable mill producers in the use and maintenance of portable sawmills.
Business training	Trained portable mill producers in business fundamentals.
FSC certification	Assisted portable mill producers in getting FSC certification.
Harvest set-up	Marked harvest trees and appropriate sites to set-up the sawmills.
Oversee harvest and milling	Were present during harvest and milling operations to assist portable mill producers.
Marketing and sales of lumber	Identified foreign buyers for the milled lumber and completed sales contracts.
Operated CMU	Aggregated the lumber milled by multiple portable mill producers at a lumber yard.
Group two themes	Did the eco-forestry organizations experience these challenges?
Business management	Maintaining the business functions of the organization.
Financial sustainability	Loss of donor funding or inability to generate revenues required for operations.
Sales requirements (quality)	Lumber quality did not meet the requirements of the buyers.
Sales requirements (quantity)	The volume of lumber produced did not meet the production demands of the buyers.
Maintaining FSC certification	Failure to consistently meet the FSC certification requirements.
Overextension of resources	Not enough employees/resources to meet the needs of the portable mill producers.
Group three themes	Did the portable mill producers experience these challenges?
Financing	Landowners could not obtain financing for a portable sawmill.
Lumber quality targets	Lumber quality did not meet the requirements of the buyers.
Production targets	Failure to meet lumber production targets set by the eco-forestry organizations.
Sawmill maintenance	Inability to get proper mechanical maintenance or spare parts for sawmills.
Transporting lumber	Transportation being prohibitively expensive due to poor road infrastructure.
Business concepts	Business concepts were difficult for portable mill producers to comprehend.

4.3 Results

4.3.1 Village Development Trust

The Village Development Trust (VDT) is an NGO established in 1990 in Lae in Morobe Province. VDT's primary objective was to encourage small-scale forestry with management performed by the landowners (Fox et al. 2011). A long-term objective of VDT was to establish a lumber yard and re-sawing facility in Lae dedicated to the production eco-forestry wood products (Bun and Scheyvens 2007). VDT's management model facilitated eco-forestry by providing support to portable sawmill owners, but no forest management standard was ever applied (Bun and Scheyvens 2007). VDT facilitated sales of the milled lumber to private merchants in Lae for a 10 percent commission fee (Chatterton et al. 2000). VDT was one of the first organizations to accomplish the export of eco-forestry

lumber, which occurred in 1992/1993 (Chatterton et al. 2000). VDT, with the assistance of Habitat for Humanity[2], also facilitated the milling and construction of 30 homes in the Waria Valley, which lies in the south-eastern corner of the Morobe Province (Chatterton et al. 2000). A report by Fox et al. (2011) indicates that VDT was in the process of assessing a new eco-forestry project for approximately 20,000 ha of forest in the adjacent province of Madang just before it ceased all its operations in 2010. The exact reason for the VDT's cessation of operations is unknown, but it is assumed to have occurred due to a loss of donor funding support (Subendranathan 2008; Fox et al. 2011; Nerius et al. 2011).

4.3.2 The Pacific Heritage Foundation

The Pacific Heritage Foundation (PHF) is an NGO that started in 1992 and was based in Rabul in East New Britain Province (Henderson 1997, Chatterton et al. 2000). A British DIY chain store called B&Q subsidized PHF's operations (Henderson 1997, Bun and Scheyvens 2007, Scheyvens et al. 2007, Subendranathan 2008). The objective of PHF was to provide B&Q with a line of certified sustainably-sourced lumber. In 1994, the PHF became the first eco-forestry organization in PNG to receive Forest Stewardship Council (FSC) certification, with 12,500 hectares certified (Chatterton et al. 2000). PHF began marketing the lumber in 1995, but the certification lapsed in 1996 (Bun and Scheyvens 2007). At its peak, the organization had 12 portable mill producers in PNG. The PHF ended its operations in 2003, due to a loss of funding and other management problems (Bun and Scheyvens 2007, Scheyvens et al. 2007). Salafsky et al. (1998) and Subendranathan (2008) indicated that the struggles that PHF experienced were a combination of challenges, including the managerial and financial requirements needed for its operations. The organization struggled to meet the requirements for export sales including timely delivery and maintenance of the quality and quantity of the eco-forestry lumber required by the buyers. The second challenge was adhering to the FSC standards and corrective action requests, which ultimately led to the cancelation of the annual FSC monitoring visit and withdrawal of FSC certification.

4.3.3 Islands Region Environmental and Community Development Programme

Information on the Islands Region Environmental and Community Development Programme (IRECDP) was collected from the "End of Programme Report" (EU-IRECDP 2001), Hunt (2002) and Scheyvens et al. (2007). The IRECDP was founded in Kimbe in West New Britain Province and operated from 1995 to 2001. The IRECDP received funding from the European Union's (EU) Economic Development Fund and was nominally under the administration of PNG's Department of Environment and Conservation, making it an NGO/Government hybrid. The objective of the programme was to develop income earning opportunities for landowners through sustainable forest

[2] Habitat for humanity is a global non-profit organization that helps people build affordable homes. See www.habitat.org.

management using portable sawmills. The management model of IRECDP utilized an 11-step process for facilitating small-scale community forestry based on management guidelines (see Annex 4 of EU-IRECDP 2001) and lessons learned from the programme (see Salafsky 1997). Each eco-forestry project was managed by the landowners as a village business. The "End of Programme Report for Marketing Unit" by Maniho (2001) indicated that the IRECDP utilized two central marketing units (CMUs) in East and West New Britain. These CMUs acted as timber yards and purchased 80 to 90 percent of all lumber produced by the eco-forestry projects. These CMUs were intermediaries between the eco-forestry producers and the major local buyers and overseas markets.

The accomplishments of IRECDP include the facilitation of approximately 40 eco-forestry projects throughout seven provinces in PNG. In 1998, the programme received FSC Group Certification, allowing IRECDP to determine which eco-forestry projects qualified for certified status. By the year 2000, approximately 10,000 ha of forests had received certification. In 2001, IRECDP ended their role as eco-forestry facilitators, which was determined to be phase one of the programme. It was determined that phase one was successful at initiating income earning opportunities through sustainable forest management for landowners, with the assistance of donor funds. The challenges experienced by the IRECDP were primarily related to maintaining the quality, consistency of supply and timely delivery of the eco-timber to markets. Maniho (2001) recommended that phase two of the project implement cost of production studies to identify the break-even production volumes and set monthly production targets.

4.3.4 PNG Eco-forestry Programme

Information on the PNG Eco-forestry Programme (EFP) was collected from the EFP annual reports for the years 2002, 2003 and 2004 (EFP 2003, 2004, 2005). The EFP was the second phase of the EU-funded IRECDP, and received additional funding from the EU. In addition to continuing the objectives of phase one, a new objective of the second phase of the programme was to improve business intelligence and the profitability of operations. EFP managers believed that in the past, IRECDP had kept the operations competitive with subsidization, which resulted in community groups' excessive financial dependency on the programme. The EFP continued to manage the eco-forestry projects and CMUs developed by IRECDP, but also introduced new activities. A second, medium-scale project was initiated in the Western Highlands Province. This project was designed to increase economies of scale and increase value-added processing. The harvest plan for this project was based on Reduced Impact Logging (RIL) techniques estimated to produce approximately 12,000 m^3 of lumber annually, using a D7 dozer, tractor and two semi-portable mills.

Annual reports indicate that the EFP undertook a forest inventory, prepared a forest management plan and conducted operational training for the medium-scale project in the Western Highlands, but there is no information available if any harvest operations ever took place. Minimal data was found on the accomplishments related to the carryover projects from IRECDP, but it is known that the FSC certification was withdrawn. Additional accomplishments of the EFP were the establishment of 25 nurseries, a reforestation support scheme and the drafting of a national eco-forestry policy. This policy draft was submitted to the National Forest Board in 2004 for approval, but it never resulted in changes to national legislation and remains in 'draft' form. The EFP shut down in 2005 when funding from the EU ceased. A review undertaken at the end of the programme by Ducenne and Rollinson (2005) determined that the EFP structure was not sustainable from a financial perspective because there was no organization capable of administering the programme after the EU funding was exhausted. The report indicated that the involvement of the private sector in future eco-forestry activities would be a key aspect for mitigating this funding challenge. Ducenne and Rollinson (2005, p.10) stated that "The biggest misunderstanding about eco-forestry and EFP has been to associate eco-forestry with portable mills! This has been a simplistic and incomplete assimilation of the eco-forestry concept." This view is due to the low productivity levels common with portable sawmills, and the challenges of conducting a commercial portable sawmill enterprise within the socio-cultural context of clans, tribes and wantoks[3].

4.3.5 Foundation for People and Community Development

The Foundation for People and Community Development (FPCD) is an NGO that began in 1996, and was established to take over the PNG-based projects of the NGO known as the Foundation for the Peoples of the South Pacific (FSP) (Nerius et al. 2011). FSP had numerous projects in PNG related to community development. These included health, sanitation, nutrition, business, carpentry, food security, disaster preparedness and small-scale sustainable forestry projects. When the FPCD took over from FSP, the FPCD Director, Mr Yati Bun, made eco-forestry projects in Madang Province the primary objective of their activities, but continued to facilitate FSP's previous projects out of a sense of obligation (Nerius et al. 2011). The management model utilized by FPCD to facilitate the eco-forestry projects involved conducting forest inventories, preparing forest management plans, sourcing and financing portable sawmills, and marketing the milled lumber through a CMU timber yard (Nerius et al. 2011).

The FPCD conducted forest inventories and developed forest management plans for six Indigenous community groups. With the assistance of Greenpeace, the FPCD completed eco-forestry lumber exports to New Zealand and Australia (Bun and Bazakie; Bun and Scheyvens 2007). In 2007, FPCD

[3] When translated to Tok-pidgin, wantok means 'One talk.' The term refers to the social obligations of an individual to their family, clan or community.

achieved FSC Group Certification for 2,705 ha of forest (Bun and Scheyvens 2007, Scheyvens et al. 2007). After receiving certification, an additional 64 m^3 of milled lumber was exported to Australia (Nerius et al. 2011). Due to a decline in funding, the FPCD's support for eco-forestry operations has diminished and there are currently no milling projects in operation. An external evaluation of FPCD by Nerius et al. (2011) identified several challenges. The low lumber production volume of the Indigenous communities resulted in slow or stagnant re-payments to FPCD for the previously supplied mills. The funds tied up in these repayment contracts caused a dramatic reduction in the expected number of new portable mill operations. The low level of lumber production was also a source of frustration for international buyers of the lumber, who then turned to alternative sources of FSC-certified tropical lumber. In 2012, FPCD's FSC certification lapsed. Other challenges included community disputes over the misuse of timber income, unrealistic production and profit expectations, and the lack of understanding of appropriate business practices. The external evaluation recommended that FPCD develop a stronger focus on understanding and implementing various approaches to community development and that FPCD reduce the number of projects being pursued so that the positive impacts of the remaining projects could be improved.

4.3.6 FORCERT

Information on FORCERT was collected from external evaluation reports completed in 2007, 2010 and 2013, as well as a strategic plan developed by FORCERT in 2015 (Titus et al. 2007; Rosenbaum et al. 2010; Ericho et al. 2013; FORCERT 2015). FORCERT was established as an NGO in 2003 and began its operations in 2004 in Kimbe in West New Britain Province. FORCERT's objective was to enable eco-forestry by providing FSC Group Certification and developing a Group Certification Service Network. FORCERT's management model focused on connecting NGOs and their portable mill producers to timber yards/CMUs and then to the overseas timber markets. The CMUs were private enterprises that purchased "A Grade"[4] milled lumber from the portable mill producers and then exported the aggregate lumber to international buyers. FORCERT's role was to assist the landowners and eco-forestry NGOs with meeting the requirements for FSC certification. FORCERT sought to be a self-sustaining entity by charging levies on the exported timber to both the CMUs and the portable mill producers.

FORCERT's accomplishments were greatest in 2008 with 40 portable mill affiliates and 5 CMU affiliates throughout PNG. In that year, a total of 1,023 m^3 of sawn timber was produced and 420 m^3 of sawn timber was exported. There were then dramatic declines in the eco-forestry lumber export

[4] Interviews with eco-forestry organization employees revealed that "A Grade" lumber is of a higher quality than B grade lumber due to reduced imperfections such as knots, wane, checking, warping and cupping. The B grade lumber could be sold in domestic markets, but only the A grade lumber could be exported.

volumes, which ceased altogether by the end of 2009. A review of FORCERT's external evaluation reports revealed multiple challenges. One primary international buyer of lumber from FORCERT-affiliated CMUs ceased making purchases because the quality and quantity requirements were not consistently met, and the lumber was not always properly air-dried before shipment. The CMUs stated that the problems with meeting the quality and quantity requirements were due to the portable mill producers not meeting the agreed-upon minimum annual target of 60 m^3 of "A Grade"[3] lumber. In addition, the CMUs stated that portions of the lumber supplied by producers were incorrectly graded, incorrectly measured, and labelled as the wrong species. When CMUs provided payments to the portable mill producers based on the quality and grade of the lumber provided, the producers were often upset and ceased their operations. Common problems cited by portable mill producers were obtaining financing to purchase a portable sawmill, accessing spare parts for mill maintenance, the high wages demanded by labourers for mill operations, the prohibitive cost of transporting the milled lumber to the CMU, and the lack of transparency and distrust of the privately-operated CMUs. The external evaluations of FORCERT also identified challenges in FORCERT's structure and operations. FORCERT often found itself in the position of facilitating every aspect of eco-forestry operations that were supposed to be the role of other NGOs. This cost was not anticipated and it overextended the organization's resources. The 2013 external review suggested that FORCERT direct its resources to specific member communities. FORCERT's new strategic plan is focused on forest-based community development rather than facilitating and certifying eco-forestry operations.

4.3.7 Thematic Analysis: Common Factors Behind the Failure of the Eco-forestry Organizations

The thematic analysis identified the patterns in each of the three thematic code groups; (1) the management activities performed by the eco-forestry organizations; (2) the challenges experienced by the eco-forestry organizations; and (3) the challenges experienced by them and their affiliated portable mill producers (Table 4.4).

Table 4.4: Thematic analysis of the eco-forestry organizations and affiliated portable mill producers

GROUPS	THEMATIC CODES	VDT	PHF	IRECDP	EFP	FPCD	FORCERT
Eco-forestry organization management model activities	Community development	X		X		X	X
	Forest management plan			X	X	X	
	Sawmill operator training	X	X	X	X	X	
	Business training	X		X	X	X	
	FSC certification		X	X		X	X
	Harvest set-up			X		X	
	Overseeing harvest and milling operations	X	X	X		X	
	Marketing and sales of lumber	X	X	X	X	X	X
	Operated CMU		X	X	X	X	
Challenges experienced by eco-forestry organizations	Business management		X				X
	Financial sustainability	X	X	X	X	X	X
	Sales requirements (quality)		X	X		X	X
	Sales requirements (quantity)		X	X		X	X
	Cessation of FSC certification		X		X	X	X
	Overextension of resources				X	X	X
Challenges experienced by portable mill producers	Financing					X	X
	Lumber quality targets		X	X		X	X
	Production targets		X	X		X	X
	Sawmill maintenance		X			X	X
	Transporting lumber		X			X	X
	Business concepts		X			X	X

There were two themes present in group 1. The first theme was a focus on international marketing and sales by the eco-forestry organizations. All six of the organizations conducted marketing and sales on behalf of the portable mill producers. Four of the organizations were involved in managing the CMUs. Four of the organizations obtained FSC certification on behalf of their portable mill producers to improve the marketability of the lumber to foreign buyers. The second theme present in group 1 was a focus on training the portable sawmill producers. Five of the eco-forestry organizations provided sawmilling training and four of them oversaw the harvesting and milling operations. In addition, four of the organizations provided basic business training to the portable mill producers.

There three themes present in group 2. The first theme was financial challenges which were caused by a loss of funding and/or insufficient revenue. These financial challenges were experienced by all the eco-forestry organizations. The second theme was a struggle to fulfil export sales requirements for the quality and quantity of lumber demanded by overseas customers. This theme was present in four of the eco-forestry organizations. The third theme was the inability to maintain FSC certification, which was experienced by four of the eco-forestry organizations.

In group 3, the primary theme was the struggle of the portable mill producers to meet the quality and quantity lumber production targets. This them was present in four of the eco-forestry organizations. Ultimately, the inability to meet these production requirements led to the cessation of eco-forestry lumber exports. The factors identified as causing the low lumber production by the portable mill producers included:

- Inability to acquire the necessary capital to access or purchase a portable sawmill, chainsaws and other required equipment;
- Inadequate sawmill training;
- Low availability of mechanical parts and low implementation of maintenance by operators;
- Limited available time due to physiological need requirements such as garden tending;
- Transport difficulties due to non-existent or poor road infrastructure and in some cases the long distance from the mill to the market;
- Lack of business skills, low knowledge of markets and poor fiscal management practices;
- Strong reliance by landowners on the eco-forestry organizations to facilitate all forest management and marketing activities; and
- Limited NGO experience in profit-generating activities, with most skillsets being forest management focused and not related to business management.

4.4 Discussion

We found that all six eco-forestry organizations ultimately failed to facilitate sustainable small-scale native forest management in PNG using the eco-forestry management model. Financial viability was the greatest challenge experienced by all organizations and the failure to establish a financially sustainable eco-forestry business ultimately resulted in all the organisations failing. All organizations received funding from donors to facilitate their operations over the period of two decades. Total funding was estimated to be in excess of $26.8 million (2016 USD). Some of the organizations developed revenue streams through commission or levy payments to assist with meeting operational costs. However, none of these revenue streams were sufficient to enable the eco-forestry organizations to attain financial sustainability and ultimately, they all ceased to operate when the donor funding declined. The cessation of operations by the portable mill produces quickly followed, due to their strong reliance on the eco-forestry organizations for support.

The second challenge experienced by the six organizations was related to the quality and quantity of the lumber produced. The issue of lumber quality is likely related to the numerous portable mill producers involved. Invariably, each of these producers had varying degrees of training and experience, and the type and condition of portable sawmills was also likely to be highly variable throughout these

operations. With these variations, a lack of consistency in the quality of the aggregate lumber is to be expected. Furthermore, the lumber produced by the eco-forestry operations was competing against lumber produced by industrial-scale sawmills utilizing modern processing technology and equipment. In the global marketplace, lumber is considered a commodity product and meeting standard moisture and grade specifications of the market is the minimum requirement for lumber producers to participate. The low productivity of milling operations by communities can be attributed to a management model focused on portable sawmills with low production capacities in comparison to industrial-scale mills utilizing modern technology and equipment. The eco-forestry organizations pursued this approach because it was believed that increasing the number of portable mills in operation would eventually allow for economies of scale that would be competitive with other industry producers. The problem with this approach is the distance between each portable mill site and the inadequate road infrastructure in PNG severely limited the access for essential mill mechanical maintenance and facilitative support from the eco-forestry organizations. The Indigenous landowners received limited training in forest management, milling, lumber markets and business management, which created a strong reliance on the eco-forestry organizations for support. As the number of portable mill operations increased, this support became overextended and most of the portable mill producers subsequently failed to reach production targets or ceased altogether.

The final challenge identified in our analysis was the inability of the eco-forestry organizations to maintain FSC certification status. The primary factor identified as the cause for the lapses in certification was the inability or indifference of the Indigenous landowners in adhering to the FSC corrective action requests (Nerius et al. 2011). As FSC certification is the primary tool in PNG for evaluating the performance of sustainable forest management, it is implied that eco-forestry organizations failed in adhering to the principles that define eco-forestry. This begs the question; 'Is FSC certification the appropriate tool for evaluating the performance of Indigenous small-holder forestry in PNG?' Perhaps, third party certification as a sustainability evaluation tool is more appropriate for larger-scale forest management operations.

The challenges experienced by the eco-forestry organizations in achieving financial viability, lumber production quality and quantity, and an adherence to the eco-forestry principles highlight the failure of the eco-forestry approach to small-scale native forest management. The eco-forestry organizations were unable to develop the required capacities for a commercial operation. This includes the capacities of maintaining FSC certification, wood processing and business management. Even with substantial subsidization, the eco-forestry organizations were not always able to meet their management objectives. The ability to meet any of their management objectives ceased when their external funding concluded. Furthermore, they were not able to maintain adherence to the eco-forestry principles. Based on these

findings, we conclude that this model for small-scale native forest management is not effective and it should not be scaled out to other communities in PNG.

4.5 Key Themes Emerging from the Study, Recommendations, and Conclusion

Our findings indicate that in PNG, the strategy of utilizing multiple portable sawmills to produce export oriented, FSC certified lumber, has failed. In contrast to earlier research findings by Hunt (2000), Fox et al. (2011) and Grigoriou (2011), our more recent evidence indicates that pursuing the international markets were not the best strategy for eco-forestry in PNG. Our analysis indicates that as a model of native forest management, eco-forestry is not financially viable in the long-term despite substantial financial subsidies. Listed below are the key themes that emerged from this analysis and our recommendations to assist in the development of future small-scale native forest management in PNG.

1) *The eco-forestry management model should re-focus to serve domestic markets.* This current model has been the primary approach supported by the PNG Government and NGOs operating in the country and our analysis has shown that this approach experienced significant challenges. Future operations for existing portable sawmills in PNG should focus on providing lumber for community development projects and, when appropriate, for local markets. It will be easier for future small-scale timber harvest operators to identify and meet the demands for local markets than international markets.
2) *Competency-based training is required for people who participate in future small-scale native timber harvests and processing should be developed prior to implementing commercial activities.* While most of the eco-forestry organizations provided sawmill and business training to the Indigenous landowners, the required capacities for commercial operations were never reached. We suggest that future small-scale commercial harvests utilize professionally trained portable sawmill operators that have already developed the necessary capacities required.
3) *Future small-scale native forest management timber harvests in PNG should conduct feasibility studies prior to management activities to filter out projects that are not financially viable.* Further research is needed to identify the methods and harvesting parameters for financially viable small-scale native forest management in PNG. We suggest that this research involve collaboration with small/medium-scale private sector forest product businesses in PNG that have developed financially sustainable business models.
4) *FSC certification should be re-assessed in regard to its usefulness as a performance evaluation tool for small-scale native forest management in PNG.* This is not to say that small-scale forest managers should not strive to adhere to the FSC's sustainability principles as they are important guidelines for maintaining the integrity of forest ecosystems. Rather, it should be evaluated if FSC certification is an appropriate standard to apply to Indigenous landowners in PNG. Our

analysis indicates that the FSC C&I may not be appropriate, given the land-use priorities and forest management capacities of Indigenous landowners in PNG.

This study found that utilizing portable sawmills to undertake small-scale native forest management (i.e. eco-forestry) in PNG has not been financially successful. All six of the eco-forestry organizations assessed in this study failed to achieve profitability and ultimately ceased all their eco-forestry operations. Even with substantial subsidies, lumber produced facilitated by these organizations did not meet the quality and quantity specifications of the buyers. Furthermore, the eco-forestry organizations struggled to maintain an adherence to principles that define eco-forestry. There is a need for a new small-scale native forest management model in PNG. Further research is required to identify a harvesting, processing and marketing model that incorporates collaboration with private sector businesses and professionally trained operators to achieve improved financial viability and adherence to forest management principles.'

Chapter Five

Are Portable Sawmills a Financially Viable Option for Economic Development in Tropical Forests?

Abstract:
Community forest enterprises facilitated by non-governmental organizations (NGOs), using portable sawmills to produce rough-sawn lumber is one approach being pursued by tropical forest indigenous communities to improve their livelihoods. To investigate the profitability of portable sawmills operated by community forest enterprises, we developed a discounted cash flow model with a Monte Carlo risk analysis simulation. We populated this model using forest inventory data from six forest sites in Papua New Guinea, combined with cost and revenue data collected in country. We found that the application of this small-scale native forest management model has a high likelihood of producing a negative net present value (NPV). The cash outflows to produce the lumber are found to be consistently greater than the cash inflows from lumber sales, resulting in a probability of achieving a positive NPV of 0.04. If only the most valuable species are harvested the probability of achieving a positive NPV increased to 0.56. However, the communities would be at risk of overexploiting or high-grading their forests. We recommend that future community forestry projects utilizing portable sawmills explore value adding opportunities for rough-sawn lumber to overcome the high costs of portable sawmill operations and reduce the potential occurrence of forest high-grading.

Keywords

Capital budgeting; community forestry; financial analysis; native forest harvesting; small-scale forestry.

5.1 Introduction

During the last few decades there has been increased international attention to reducing global deforestation by transitioning forest management, including harvesting, to indigenous communities (White and Martin 2002). Community-based forestry (CBF) emerged in the 1970s and 1980s as an alternative to industrial forestry that characterized forest management in much of the global south during the colonial and early post-colonial periods (Gilmour et al. 1989). There are approximately 60 million indigenous people living within the world's tropical forests, with an additional 400 to 500 million people that are directly dependent on tropical forest resources for their livelihoods (White and Martin 2002). In many countries, CBF began with a focus on providing subsistence goods to communities and has since transitioned to a greater focus on commercial forest products (Gilmour 2016). A key challenge of CBF management is identifying commercialization strategies that will enable communities to realize the full economic benefits of their forests (Gilmour 2016). The use of portable sawmills to mill rough-sawn lumber is one commercialization strategy that has been adopted by Community Forest Enterprises (CFEs) in many tropical forest countries (Kilkki 1992, Chatterton et al. 2000, Macqueen 2008, Humphries 2012). The capital requirements and operational training required for portable sawmills is low, relative to fixed-site sawmills, which is one factor that helps CFEs to participate in commercial lumber markets. CFEs that successfully market their timber and non-timber products can increase the financial capital entering their communities relative to communities that only use their forests for subsistence. The additional financial capital can be used for acquiring essential goods and services, which can support community economic development.

Despite the extensive implementation of CBF throughout tropical forests, there have been few studies that have evaluated the effectiveness of CFEs (Charnley and Poe 2007). Specifically, there have been few studies conducted on the changes of community financial capital resulting from CFE portable sawmill activities. Failing to assess the financial viability of these CFEs makes it difficult to determine if using portable sawmills is a financially viable option that should be pursued for small-scale native forest management by forest-dependent indigenous communities. To address this gap in the literature, we assessed the operational model of CFEs using portable sawmills for commercial activities in PNG.

In PNG, there are approximately 29 million hectares of forest with 97% of the forest held under customary land ownership by indigenous clan groups (PNGFA 2009). Portable sawmills were initially imported into PNG in the 1970s, by church groups and NGOs to provide indigenous communities with the means to mill lumber for their own needs. Advances in the design of these mills in the 1980s improved portability, resulting in widespread adoption of portable sawmills throughout the country (Bun and Scheyvens 2007). It is estimated that there are approximately 2,000 portable sawmills in PNG that are operational as of 2016 (Jenkin 2016). Beginning in the 1990s, multiple NGOs began supporting CFEs by providing timber felling and mill operation training. The lumber milled by each CFE was

transported to small lumber yards operated by the NGOs or private businesses that aggregated the lumber and facilitated sales to domestic and international markets. It was found that by 2010 all the NGOs had ceased their lumber export operations, which resulted in the cessation of CFEs affiliated with the NGOs as well (Scudder 2017). This suggests that the business model under which these CFEs operated was flawed.

Previous financial assessments of portable sawmilling in PNG found that this can be financially viable if production targets are achieved (Chatterton et al. (2000), Hunt (2000) and Grigoriou (2011). However, none of these analyses included costs of NGO facilitation and of operating associated small-scale lumber yards. These expenses would normally be included in a 'total cost accounting' evaluation of the forest management model. The absence of a total cost accounting is a study limitation that has been identified in multiple other portable sawmill CFE financial analyses conducted in other tropical countries (Humphries et al. 2012). To address this research gap, we conducted a financial analysis of the profitability of portable sawmill CFEs. The analysis incorporated a total cost accounting approach. We modelled NGO-facilitated portable sawmill operations and small-scale lumberyards to estimate the expected operational costs and revenues. The results of this modelling are used to analyse the potential of portable sawmills operating under this forest management model. In the next section of this paper, we discuss the methods we used to undertake the analysis. In the following section, we present our results and finally, we present our key findings and provide recommendations for future CFEs.

5.2 Research Methods

5.2.1 Data Collection

Data were collected from interviews with key informants in the cities of Lae and Madang in PNG during three trips in 2016 and 2017. An interview protocol was designed to identify the activities and associated costs of the NGO facilitation process, portable sawmill operations, small-scale lumberyard operations, and the prices received in domestic and international lumber sales. All the interviews were conducted by the first author with hand written notes taken. The initial interviews were with four current and former employees of one of the CFE NGOs, the Foundation for People and Community Development (FPCD). The purpose of the FPCD interviews was to identify the activities and associated costs of the NGO facilitation process, portable sawmill operations, and small-scale lumberyard operations. The second round of interviews was with representatives of three forest product businesses in the city of Madang. The purpose of these interviews was to ascertain the domestic prices being received for milled lumber according to tree species milled. The third round of interviews was with two employees from the Timber and Forestry Training College (TFTC) in the city of Lae. The purpose of these interviews was to identify capital equipment costs for new and used equipment and the annual maintenance costs for the equipment.

5.2.2 Developing the Financial Model

We conducted a discounted cash flow (DCF) analysis to estimate the net present value (NPV) of cash flows generated by portable sawmill CFEs facilitated by an NGO in PNG. In developing the model, we followed the principles of capital budgeting of investment projects set out in Dayanandra et al. (2002) and Harrison and Herbohn (2017). We categorised model variables as being capital flows and operational flows (Table 5.1). A five-year time horizon was selected for the DCF analysis based on the life expectancy of the capital equipment, which was assumed to never exceed five years due to the harsh operating conditions in PNG. The discount rate selected for the DCF model was 10.5%[5], which is the current yield of long-term (5.5 year loan duration) debt financing issued by the Bank of PNG on behalf of the PNG government (BPNG 2018). All the monetary variables incorporated in the DCF model were converted to 2017 USD currency equivalents using consumer price indices and foreign exchange rates collected from the Bank of Papua New Guinea (BPNG 2018), and the Reserve Bank of Australia (RBA 2018).

Table 5.1: Financial model cash flow variables

Cash flow categories	Cash flow variables	
	Cash inflows	Cash outflows
Capital flows	Salvage value	Capital outlay
Operational flows	Lumber revenue	Portable sawmill operations
		Portable sawmill labour
		Lumber transport lumberyard
		Lumber export shipping
		NGO overhead
		NGO labour
		NGO business licences & harvest permit
		Forest Stewardship Council (FSC) certification
		Taxes

The DCF model was constructed in Excel. Monte Carlo risk analysis simulation was used to account for uncertainty associated with key variables. We used '@RISK' software for the Monte Carlo risk analysis simulation, which is a Microsoft Excel Add-in software program produced by the Palisade Corporation. The risk analysis simulation followed methods outlined by Winston (2008) in which all cash flow variables determined to have values with inherent uncertainty were assigned normal or triangular distributions. The variables assigned a normal distribution had a mean value based on our data collection and were assigned a standard deviation of that mean value. The variables assigned a triangular distribution were given minimum, most likely and maximum values. The DCF model was designed to randomly select a value within the assigned distribution range of each uncertain variable

[5] The high yield rate of BPNG's long-term debt financing (10.5%) reflects the high degree of risk associated with conducting business in PNG.

for each iteration of the simulation. The number of iterations selected for the Monte Carlo risk simulation was 100,000.

5.2.3 Capital and operating cash flow variables

Cash flow variables for capital outlays

The key informants from FPCD determined that the required capital equipment for portable sawmill operations would be two portable sawmills, two chain saws, two winches, a tractor/skidder and a truck (Table 5.2). The portable mill model selected was an 8" Lucas mill 200mm X 200mm. The chainsaw model selected was a Stihl AV 072. The winch model selected was a Tugger 3 ton. The tractor/skidder model selected was a Massey Ferguson Dyna 4, 5455 Series 92 HP. The truck model selected was a Hino FT/GT 500 Series w/20' Steel Tray. Additional required equipment for NGO facilitation activities were a computer, printer, and office furniture. All the capital equipment was estimated to have a life expectancy of 5 years. All the capital equipment was estimated to have a salvage value of 10% of the purchase price.

Table 5.2: Assumed probability distributions of uncertain cash flow variables for capital outlays (2017 USD)

Capital equipment items				
	Form of distribution	Min.	Mean	Max.
Portable Mill (8" Lucas Mill 200mm X 200mm)	Triangular	$19,672	$20,033	$20,395
Stihl AV 072 chainsaw and accessories	Triangular	$2,399	$2,745	$3,091
Tugger winch (3 ton)	Triangular	$1,037	$1,404	$1,755
Truck (Hino FT/GT 500 Series w/20' Steel Tray)	Triangular	$72,000	$85,000	$100,000
Tractor (Massey Ferguson Dyna 4, 5455 Series 92 HP)	Triangular	$40,236	$53,649	$67,061
Computer/Printer/Office Furniture	Triangular	$800	$1,000	$1,200

Merchantable log species distribution

Log species percentage distributions were calculated based on FPCD forest inventories and forest management plans for six sites in the Madang Province (FPCD 2005, 2006a, 2006b, 2006c, 2007, and 2011). The log species were separated into nine categories, eight represented individual species and one was an aggregate of all remaining species (mixed hardwoods). Only the eight individual species were exported to international markets. These nine categories were selected based on the domestic and export markets price categories for PNG lumber. All the mixed hardwoods were sold to domestic markets in PNG. These price categories were identified from interviews with key informants and from Subendranathan (2008) and Grigoriou (2011). The DCF model was designed to randomly select a species distribution from one of the six sites for each iteration of the model simulation. The model assumes that all milled lumber is evenly distributed between the species that exist on each site for the duration of the five-year time horizon. The even distribution by species was chosen to reflect the harvest

designs discussed in the forest management plans produced by FPCD. The objectives of these management plans were to conduct harvests that did not alter the species composition and structure of the forest or transform the forest to an earlier successional stage.

NGO management activities

The interviews with the key informants from FPCD determined how the NGO management process would be modelled for this study. The NGO activities required four employees; a manger, an administrative assistant/driver, and two foresters. NGO management activities included the purchase of all required licenses, permits, and capital equipment. In year zero, the NGO was modelled to conduct a forest inventory, develop a forest management plan, provide sawmill training to the FROs and initiate Forest Stewardship Council (FSC) sustainability certification. In years one through five, the NGO and CFEs were modelled to conduct timber harvesting, milling, and transport of the lumber to a lumberyard. For the harvest and milling operations, we modelled the use of two portable sawmills and one tractor for log skidding/snigging, which all operated simultaneously. The interviews with key informants from FPCD revealed that two portable sawmills were the maximum number of mills that four NGO employees could effectively manage.

Portable sawmill operation parameters

Three critical parameters were identified by key informants for the portable sawmill operations; annual days of operation, daily log throughput, and rate of recovery of sawn timber. For this study, we used a triangular distribution for annual days of operation with a value range of 100 (Minimum), 200 (Most likely) and 250 (Maximum). The maximum possible days of annual operation were based on a five-day work week with two weeks of holiday leave. The most likely days of operation range were chosen to reflect two months of likely inoperable periods due to the wet season. The annual days of operation for the two portable sawmills were determined to be positively correlated and assigned a correlation coefficient of 0.7. The daily log throughput of individual sawmills was modelled with a triangular distribution with values ranging from 1 m3 (minimum), 5 m3 (most likely) and 6 m3 (maximum).

For this study, we used a rate of recovery of the sawn timber that was between 35% and 50% to reflect the variation in skill among mill operators. Interviews with key informants revealed that recovery is separated between ‘A grade’, ‘B grade’, and ‘C grade lumber’. The A grade lumber was defined by the key informants as being of higher quality than the B grade due to reduced imperfections such as knots, wane, checking, or warping and cupping of the lumber. The B grade lumber could be sold in domestic markets, but only the A grade could be exported. The C grade lumber has no market value and was used internally by the CFEs or discarded. The selected lumber recovery percentage for each lumber grade was based on a report by Nerius et al. (2011) and interviews with key informants. We used a

triangular distribution for lumber recovery with total recovery values being between 35% (Minimum), 45% (Most likely) and 50% (Maximum).

The portable sawmill operational costs identified by key informants were CFE labour, mill fuel, mill oil, chainsaw oil and fuel, tractor fuel, annual mill maintenance, and annual tractor maintenance. The labour requirements for portable sawmill operations were determined to be two trained mill operators and four assistants for each portable sawmill. It was determined that the CFE labour would be sourced from the community where the timber harvests were occurring.

Lumber transport and lumberyard sales

A public motor vehicle (PMV) was modelled for transporting the lumber from the harvest site to the lumberyard. The PMVs are capable of transporting approximately 6 m^3 per trip. PMV prices were collected from interviews with key informants. Shipping costs for the exported lumber were collected from key informants based on previous export shipments.

Cash inflows from lumber sales

Lumber prices by species for the exported A grade lumber were based on previous prices paid by an Australian buyer, collected from Subendranathan (2008) and Grigoriou (2011)[6]. These values were inflated to 2017 USD values using consumer price indices and foreign exchange rates collected from the Reserve Bank of Australia (RBA 2018). The domestic lumber sales were comprised of A grade mixed hardwoods lumber and B grade lumber of all species groups. The prices for domestic lumber sales were collected during interviews with key informants. A weighted average lumber price was generated for A grade and B grade lumber for each forest inventory site using species distribution percentages and the prices discussed above. We assigned a normal distribution to the weighted average lumber prices for each site with a standard deviation of 8.4% of the weighted average price. The standard deviation was chosen based on the standard deviation of Australian tropical lumber import prices for years 2012 to 2016, which was collected from ITTO (2017). The weighted average prices for A grade and B grade lumber were determined to be positively correlated and assigned a correlation coefficient of 0.9.

Annual inflation rate

All the monetary variables were initially based on current price data. We designed the model to reflect annual growth in lumber revenues and operational costs caused by inflation. For each year of the DCF model, an inflation percentage was generated for Australia and PNG. These inflation values were

[6] At the time of this study, all exports to Australia had ceased making it impossible to identify a current market price. The Australian buyer was not able to comment on what the potential current price would be.

generated from minimum, average, and maximum inflation values during the last five years as reported by the Reserve Bank of Australia (RBA 2018) and the Bank of Papua New Guinea (BPNG 2018).

Depreciation and taxes

For this analysis, we depreciated all the capital purchases using the straight-line depreciation method. This was done to calculate the taxable income after subtracting depreciation. It was assumed that all taxes would be paid by the CFE forest landowner. CFEs in PNG can range from a single family to an entire community. The model assumes a single family owns the land being harvested. Tax outflows were based on PNG's progressive tax bracket system with tax rates collected from the PNG Internal Revenue Commission (IRC 2018). After calculating taxable income and net income after tax, our model adds back the depreciation expenses to calculate the after-tax net operating cash flow.

Table 5.3: Cash flow variables for operating activities (2017 USD)

Merchantable log species distribution by site						
Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Celtis spp.	6%	21%	4%	8%	4%	8%
Dracontomelon dao	5%	3%	3%	0%	3%	2%
Instia bijuga	21%	2%	19%	14%	2%	0%
Pometia pinnata	5%	34%	15%	11%	7%	75%
Pterocarpus indicus	4%	0%	0%	2%	0%	0%
Terminalia spp.	0%	3%	16%	8%	3%	1%
Toona soreni	0%	0%	5%	0%	4%	2%
Vitex cofassus	0%	0%	9%	1%	0%	6%
Mixed Hardwoods	59%	37%	29%	55%	78%	7%

NGO annual operation expenses (Certain values)	
Labour	$43,462
Harvest setup and facilitation supplies per mill per day	$30
Vehicle maintenance (% of purchase)	7%
Office rent	$13,079
Internet & phone credit	$2,616
Utilities	$4,360
Office supplies	$1,308
Marketing	$2,906
Post Office Box	$181
Business registration [1]	$84
Forest industry participant license [1]	$184
Timber Authority performance bond [2]	$6,286
FSC certification year 1	$10,031
FSC certification year 2	$4,360
FSC certification every following year	$2,348

[1] Paid once in year zero

[2] The performance bond is cash paid in year zero and a cash received in year ten.

NGO annual operation expenses (Uncertain values)			
	Distribution	Mean	SD
Vehicle fuel	Normal	$1,743	$350

Portable mill operation parameters (Uncertain values)				
	Distribution	Min.	Mean	Max.
Annual days of sawmill operation	Triangular	100	200	250
Daily m3 log input of sawmill	Triangular	1	4.5	6
A grade lumber recovery	Triangular	18%	24%	27%
B grade lumber recovery	Triangular	14%	16%	18%
Mill fuel per m3 of log input	Triangular	$10	$13	$17
Mill oil per m3 of log input	Triangular	$0.68	$1.04	$2.07
Chainsaw fuel/oil per day	Triangular	$5	$6	$7
Tractor fuel per m3 of log input	Triangular	$14	$15	$17
Portable mill labour (Daily)	Triangular	$90	$100	$110
Lumber transportation to lumberyard per m3	Triangular	$72	$80	$88
Annual mill maintenance (% of purchase)	Triangular	27%	30%	33%
Annual tractor maintenance (% of purchase)	Triangular	10%	15%	20%

Revenue from lumber sales (Uncertain values with normal distribution)						
	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Weighted average A grade price (Mean)	$482	$441	$472	$419	$327	$585
(SD)	$40	$37	$40	$35	$27	$49
Weighted average B grade price (Mean)	$156	$185	$196	$161	$130	$226
(SD)	$13	$16	$16	$17	$11	$19

Annual Inflation (Uncertain values)				
	Distribution	Min.	Mean	Max.
Australian inflation	Triangular	1.3%	1.9%	2.5%
PNG inflation	Triangular	4.6%	5.5%	6.7%

Interest on long-term debt (Certain value)	
Annual percentage rate	10.5%

Taxes (Certain values)	
Income range	Tax rate
$0 - $2,200	0%
$2,201 - $5,657	22%
$5,658 - $10,372	30%
$10,373 - $22,001	35%
$22,002 - $78,575	40%
$78,576 - No limit	42%

5.2.4 Data Analysis

During the data analysis, we found that only four of the tree species (*Dracontomelon dao, Intsia bijuga, Pometia pinnata* and *Pterocarpis indicus*) had a sales value per m^3 that was greater than the mean cost of milling per m^3 (i.e. cash outflows from sawmill operations and sawmill labour). The interviews with key informants revealed existence of an informal sector of portable mill operators that primarily harvest these species due to the high sales prices. This equates to essentially high-grading the forest. Little is known about this sector, because the PNG government does not have the resources to track or regulate it. We decided to compare the effect high-grading the forest to the results of our original DCF model that assumed a harvest composition uniformly distributed across species. To do this, we changed the harvest percentages to 25% for each of the four species mentioned above. The sales prices for these species are presented in Table 5.4. All the other variables were unchanged. In the results, we refer to our original model as 'Model 1' and the high-grading model as 'Model 2.'

Table 5.4: Sales prices by species per m^3 (2017 USD)

Species	A grade	B grade
Dracondomelon dao	$833	$235
Instia bijuga	$910	$235
Pometia pinnata	$666	$235
Pterocarpus indicus	$958	$235

Descriptive statistics (Mean, minimum, maximum, median, mode, and standard deviation) were determined for the sawmill productivity variables and the NPV values produced from the Monte Carlo simulation of both models. An NPV probability distribution curve was created for both models. A sensitivity analysis was conducted of the model variables with inherent uncertainty to identify the variables that were most likely to affect the mean NPV. The sensitivity analysis is a report function of the @Risk software that determines the impact that each input variable will have on the range of values for a selected output. We also conducted an additional sensitivity analysis on the discount rate. The discount rate was increased and decreased by 30% to assess the changes to mean NPV for both models. These discount rates were 7.35% and 13.65%.

5.3 Results

5.3.1 Lumber production

Table 5.5 presents the descriptive statistics for productivity variables of each mill. The total mean annual lumber production estimated by our model was 572 m^3 or 286 m^3 per mill. The lumber production results were the same for both mills in both models.

Table 5.5: Descriptive statistics of sawmill productivity

Productivity variables	Mean	Minimum	Maximum	Median	Mode	Standard deviation
Days of operation	183	100	250	187	200	31
Daily log input	4 m^3	1 m^3	6 m^3	4 m^3	5 m^3	1 m^3
Lumber recovery	43%	36%	49%	43%	44%	2%
A grade lumber production	169 m^3	26 m^3	370 m^3	168 m^3	171 m^3	56 m^3
B grade lumber production	117 m^3	19 m^3	247 m^3	117 m^3	106 m^3	38 m^3

5.3.2 NPV and Mean Cash Flow Assessment

In Model 1, the mean NPV was -$700,535 2017 USD (Table 5.6). This was due to the net cash flows being negative for every year of the operation (Table 5.7). The mean cash inflows from lumber sales were always less than the mean cash outflows for operating activities. As a result, the probability of achieving positive NPV was 0.04 (Figure 5.1). The variables that had the greatest impact on the mean NPV for Model 1 were; (1) daily log input of the sawmills; (2) the percentage of A grade lumber recovery; and (3) the weighted average A grade and B grade lumber prices for site 6. The first two variables were related to sawmill productivity and determined how much A grade lumber was produced daily. Site 6 had a weighted average price per m^3 of A grade lumber that was $104 to $258 (2017 USD) higher than the other five sites. This higher weighted average price was due to the site being comprised of 75 % *Pometia pinnata*, which had a specific price of approximately $666 (2017 USD) per m^3 of lumber.

The operational activities that resulted in the highest cash outflows were related to the portable sawmill production. Portable sawmill operations and portable sawmill labour together, represented 43% of mean total operational cash outflows. The mean cash outflows for NGO facilitation (NGO overhead and labour) represented 34% percent of mean total operational cash outflows. This amount represents the expected cost of an NGO to facilitate the CFE operations. When the cash outflows for NGO activities was removed to represent subsidized funding for the NGO, the mean total net cash flow values for operating activities remained negative. Cost of transport of lumber to the lumberyard also comprised a substantial percentage of cash outflows, being 20% of mean total cash outflows. This reflects the high costs of shipping/transportation in PNG due to poor road infrastructure. The remaining operational cash outflows were approximately 3% of mean total cash outflows.

Table 5.6: Descriptive statistics for NPV of Models 1 and 2 (Thousands 2017 USD)

Model	Mean	Minimum	Maximum	Median	Mode	Standard deviation
Model 1 (Even distribution harvest)	-700.5	-1,300.0	278.7	-747.8	-809.1	235.7
Model 2 (High-grading)	24.0	-638.7	710.7	29.0	-88.4	200.4

Table 5.7: Mean cash flows of Model 1 (Thousands 2017 USD)

Year	0	1	2	3	4	5
Capital flows						
Capital outlay	-188.7					
Salvage value						18.9
Operating flows						
Lumber sales		136.2	140.2	144.3	148.4	152.5
Portable sawmill operations		-62.7	-66.1	-69.4	-72.7	-76.0
Portable sawmill labour		-38.7	-40.8	-42.8	-44.9	-46.9
Lumber transport lumberyard		-48.3	-50.9	-53.4	-56.0	-58.6
Lumber export shipping		-4.1	-4.3	-4.6	-4.8	-5.0
NGO overhead	-32.7	-34.0	-35.8	-37.6	-39.4	-41.2
NGO labour	-43.5	-45.9	-48.3	-50.8	-53.2	-55.6
NGO business licences & harvest permit	-6.6					6.2
FSC certification	-10.0	-4.6	-2.6	-2.7	-2.9	-3.0
Taxes		-0.4	-0.4	-0.3	-0.3	-0.3
Net cash flow	-281.5	-102.6	-108.9	-117.3	-125.7	-109.0

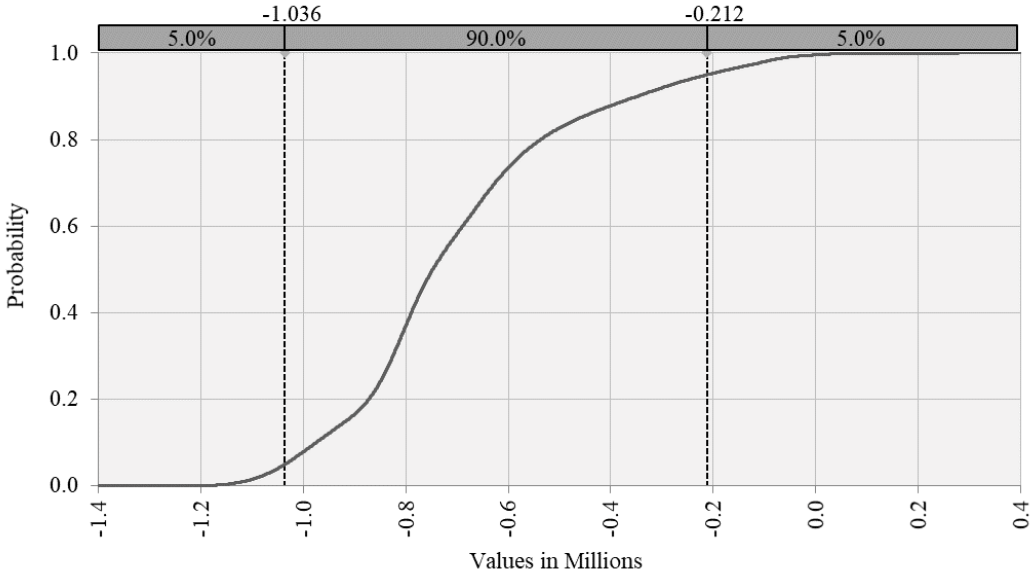

Figure 5.1: NPV probability distribution curve of Model 1

In Model 2, the mean NPV was $24,023 2017 USD. The mean net cash flows were positive during years one through five (Table 5.8). As a result, the probability of achieving a positive NPV was 0.56 (Figure 5.2). The variables that had the greatest impact on the mean NPV of Model 2 were; (1) daily log input of the sawmills; (2) annual days of operation; and (3) and the percentage of A grade lumber recovery. This differed from the Model 1 results because the annual days of operations was not a variable that had a profound impact on mean NPV of Model 1. The reason for this is that the sawmill

production costs (operations & labour) of Model 1 were much higher relative to lumber revenue cash inflows. Operating less days during the year did not have as great of an impact on mean NPV as the amount of A grade lumber produced on the days that the mills did operate. The operational cash outflows were similar to Model 1, with the difference being increased export shipping cash outflows and increased tax cash outflows. These changes were due to the species harvested having a larger international market volume than Model 1 and larger taxable revenues. The four species used in Model 2 were exported to international markets. The 'Mixed hardwood' species in Model 1 were only marketed domestically.

Table 5.8: Mean cash flows of Model 2 (Thousands 2017 USD)

Year	0	1	2	3	4	5
Capital flows						
Capital outlay	-188.7					
Salvage value						18.9
Operating flows						
Lumber sales		350.5	362.0	373.5	384.9	396.4
Portable sawmill operations		-62.7	-66.1	-69.4	-72.7	-76.0
Portable sawmill labour		-38.7	-40.8	-42.8	-44.9	-46.9
Lumber transport lumberyard		-48.3	-50.9	-53.4	-56.0	-58.6
Lumber export shipping		-8.1	-8.5	-8.9	-9.4	-9.8
NGO overhead	-32.7	-34.0	-35.8	-37.6	-39.4	-41.2
NGO labour	-43.5	-45.9	-48.3	-50.8	-53.2	-55.6
NGO business licences & harvest permit	-6.6					6.2
FSC certification	-10.0	-4.6	-2.6	-2.7	-2.8	-3.0
Taxes		-29.4	-29.8	-29.6	-29.4	-31.0
Net cash flow	-281.5	78.7	79.1	78.1	77.0	99.2

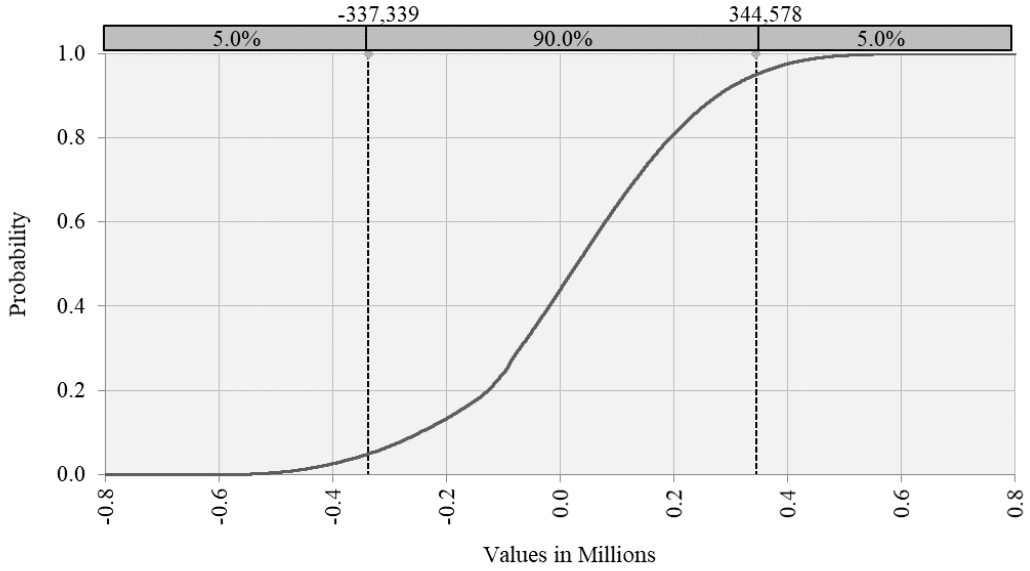

Figure 5.2: NPV probability distribution curve of Model 2

Our sensitivity analysis of the discount rate revealed that increasing or decreasing the discount rate by 30% did not result in Model 1 achieving a positive mean NPV. The higher discount rate of 13.65% resulted in Model 1 receiving a less-negative mean NPV than the lower discount rate of 7.35% because the cash flow losses had been further discounted. In Model 2, the reduced discount rate of 7.35% increased the mean NPV to $51,020 2017 USD. When the discount rate was increased to 13.65% the mean NPV of Model 2 decreased to $686 2017 USD. Descriptive statistics of this sensitivity analysis are provided in Table A.1, located in the appendix.

5.4 Discussion

We found that CFEs using portable sawmills to produce rough-sawn lumber for export from an even distribution of the tree species found at the harvest site are highly unlikely to be financially viable. The characteristics of the forest being harvested has a major impact on profitability. Our study was unique in that we used actual data from six community forests, whereas all past studies have not accounted for this as a factor affecting profitability of portable sawmills. Only four of the tree species (*Dracontomelon dao, Intsia bijuga, Pometia pinnata* and *Pterocarpis indicus*) had a sales value per m^3 that was greater than the mean cost of milling per m^3 (i.e. cash outflows from sawmill operations and sawmill labour). This indicates that the variable processing costs are very high and/or the sales prices are low and as a result, the variable costs are not being covered. As such, the species composition of the forest stand plays an important role in determining the financial viability of CFEs. Not all forests will be able to support CFE operations and the nature of the forest resource available is an important consideration in

assessing whether CFEs are a viable option. These findings illustrate that not all forest sites will be suitable for sawn timber production. In addition, difficult site terrain and long distances to markets can negatively impact on the suitability of a forest area for CFEs.

If CFEs only harvest a small selection of species which produce positive gross margins as was done in Model 2, the probability of achieving financial viability is greatly improved. However, this may result in 'high grading' of the forest, with the resulting negative impacts on sustainability and biodiversity conservation. Our interviews with key informants revealed that *Intsia bijuga* is the most sought-after timber species in PNG. Its primary uses are for house posts, beams, structural lumber and furniture. The popularity of this species is due to extremely dense heartwood (641-961 kg/m^3), limited shrinkage insect repellent properties, and the rich dark colour of the heartwood (Thaman et al. 2006). Due to its high popularity, *Intsia bijuga* has been recognized as being seriously threated from overexploitation in the South Pacific (Thaman et al. 2006). This species is also a shade-tolerant and slow growing species that can take 75 to 80 years to reach maturity (Thaman et al. 2006). If this species continues to be over-harvested in PNG, it is likely to be replaced by less valuable early successional pioneer species. Research by Louman (1996), identified that many of the portable sawmill owners in PNG select the species and quantity of trees to be cut in response to market demand rather than following a prepared management plan. If CFEs only harvest the most valuable species and do so at an unsustainable level, it is likely that future members of these communities will inherit forests with a reduced commercial value.

The volume of lumber produced by the sawmill per year had a substantial impact on financial viability. The main variables affecting volume of lumber produced in Model 1 were daily log input, and A grade lumber recovery. This finding is corroborated by research on portable sawmill operations in northern Queensland, Australia, which found that short-run average cost curves were highly responsive to daily log throughput and the rate of lumber recovery (see Smorfitt et al. 2006). Lumber productivity also had a substantial impact on the financial viability of Model 2. Despite only harvesting the four most valuable species, 44% of the model iterations resulted in a negative NPV. This indicates that selectively harvesting the most valuable species will not guarantee profitability. Typically, CFEs employ members of local communities, who have little or no training in sawmilling operations. This contributes to low levels of efficiency compared to commercial sawmilling operations, including low rates of throughput and low recovery rates, especially for A grade lumber. Other socio-cultural issues may also negatively impact of CFE operations. Many rural communities in PNG are transitioning from subsistence agriculture to a cash-economy and have an embedded culture of reciprocal trade and wealth sharing between families, clans, and communities (Kaitilla 1995, Jacobsen 1997, Gesch 2007). Interviews with FPCD employees revealed that the concept of investing profits back into the CFE business for maintenance and consumables was difficult for many communities to comprehend. An expression that

was commonly heard by the FPCD employees from members of the CFEs was, 'the strangeness of business thinking.' Training and capacity building is an essential requirement for the successful operation of CFEs.

Our study clearly suggests that a new model for sustainable forest management is required for CFEs. The model of harvesting timber evenly between species present at the site and using portable sawmills to produce rough-sawn lumber for export is not financially viable. The variable processing costs per unit of lumber are prohibitively high relative to the sales prices per unit received. Overcoming the high costs of portable sawmill operations and improving potential profitability will require further research into value-add opportunities for country-specific species and associated markets. Further research will also be required to see if adding additional value to lesser-value tree species will result in a profitable outcome, thus reducing the potential occurrence of high-grading. We also recommend that supporting organizations assess the operational and business management capacities prior to implementing commercial activities. Contracting out some or all the CFE activities to professionally trained operators until CFEs have developed the necessary capacities is a strategy that other CFEs have pursued (Macqueen 2008). The process of adding additional value to rough-sawn lumber presents an additional requirement for capacity development that may or may not be appropriate for indigenous CFEs. A case-by-case implementation decision process will be required.

To determine if the conditions in PNG unique or comparable to other areas, we compared PNG's estimated number of tree species to other tropical countries. To do this, we collected data on the number of tree species of each tropical country from the Global Tree Search Database (GTSD 2018)[7]. The list of tropical countries was based on the International Tropical Timber Organization's (ITTO) statistical database of international tropical forest product producers (ITTO 2017). The ITTO categorized the tropical countries into three regions; Africa; Asia-Pacific; and Latin America. The average number of tree species per country by region was 1,293 for Africa, 3,019 for the Asia-Pacific[8], and 3,227 for Latin America. When all tropical countries were compared together, the average number of tree species per country was 2,333. By comparison, the estimated number of tree species in PNG was 2,843 (GTSD 2018). When all the tropical countries were assessed for greatest number of tree species biodiversity, PNG ranked number ten. This indicates that the tree species diversity of PNG is similar to many other tropical countries, especially in the Asia-Pacific and Latin American regions. The other primary condition that we found to be vital for achieving financial viability with portable sawmills was the operational capacities of the saw millers. While the average level of completed education is low in

[7] The Global Tree Search Database did not have any data for Columbia, the Democratic Republic of Congo, and Vietnam.
[8] The island countries of Fiji and Vanuatu were not included in the Asia-Pacific average because the data was dramatically different from the other Asia-Pacific countries, which skewed the average by 20%.

PNG, the capability of the people to achieve proficiency in portable saw milling with proper training is no different than any other tropical country. The implication is that our research findings are relevant to other tropical forest locations and should be considered in the design of future CFEs.

5.5 Conclusion and Recommendations

Modelling of NGO-facilitated portable sawmill CFE in PNG revealed that this small-scale sustainable native forest management model has a high probability of failure because operational costs are typically larger than sawn lumber revenues. We determined that achieving financial viability will require the use of professionally trained and experienced sawmill labour, as well as limiting timber harvests to sites with species distributions that have a high commercial value and are located within a reasonable distance to markets. We recommend that future community forestry projects identify opportunities to create value-added products from the rough-sawn lumber to improve the probability of achieving financial viability and reducing the overexploitation of the most valuable commercial species. We also recommended that future organizations which support the commercialization of CBF products conduct a financial/business analysis prior to implementing any activities to conserve resources for financially viable forest management opportunities. We conclude that NGO facilitated portable sawmill and small lumber yard CFEs should not be pursued as a small-scale native forest management model unless adequate human capacities required for commercial activities have been developed and a feasibility assessment indicates a high probability of sustainable profitability.

Chapter Six

Timber Royalty Reform to Improve the Livelihoods of Forest Resource Owners in Papua New Guinea

Abstract:
Inequitable timber resource rents are a problem that has plagued tropical forest management in countries throughout the world, including Papua New Guinea (PNG), which exported 21% of the world's tropical hardwood logs during the last decade. Rural tropical forest resource owners (FROs) often have limited economic resources and resource rents from timber harvests can help them access goods and services that they otherwise cannot afford. This paper uses historical log export data and timber royalty rates to compare the timber resource rents received by FROs in PNG to log export duties and levies collected by the PNG government and the residual cash flows collected by logging companies from log exports. Between 2007 and 2017, PNG's FROs received an annual average of 6.1% of the market value of the logs harvested. By comparison, the PNG government received an annual average of 42.3% from duties and levies and the logging industry received 51.6% for its costs/profits. We also found that the real value of royalties for different timber species has declined by between 32% and 66% since 1991 due to the use of the fixed-rate system. We recommend that future royalty payments in PNG be calculated as a percentage of market value and that there be greater public participation in the determination of the appropriate income split to provide a more equitable distribution of timber harvest revenues between different actors.

Keywords
Fair market value; forest policy; log exports; native forest harvesting; stumpage prices

6.1 Introduction

Resource rents from timber harvests are a critical source of revenue for poor forest-dwelling communities in many tropical countries, including Papua New Guinea (PNG). Timber resource rents represent the surplus value of logs after the harvesting costs and normal returns have been accounted for (Repetto 1990). As the livelihoods of many rural tropical forest resource owners (FROs) are heavily dependent on subsistence agriculture, the rents received from timber harvests provide a significant source of additional income to support their access to economic goods and services. In PNG, approximately 97% of the forests are held under customary land ownership by rural tribal clan groupings (PNGFA 2009). It is estimated that 42% of the rural population in PNG live below the national poverty line (World Bank 2009). Gaining access to basic services such as general infrastructure, education and healthcare is a crucial issue for the country's forest-dwelling communities (PNGFA 2009). Due to the limited development and few employment opportunities in rural areas, customary landowners have resorted to selling their forest resources to industrial logging companies to gain access to essential goods and services (Filer and Sekhran 1998, Bird et al. 2007, PNGFA 2009).

Approximately 90% of the logs harvested by logging companies in PNG are exported (PNGFA 2009). In 2001, approximately 1.6 million cubic metres (m^3) of non-coniferous topical logs were exported from PNG (PNGFIA 2010), and by 2017 this volume had nearly doubled to just over 3.1 million m^3 (SGS 2018). PNG's log exports represented 21% of the total non-coniferous log exports from all tropical countries during the years 2001 to 2016 (ITTO 2017). It has been estimated that there are roughly 25 foreign logging companies operating in PNG, with most being from Malaysia (PNGFA 2009). Most of these companies are subsidiaries of one large Malaysian conglomerate, which controls approximately 45% of the logging and log exports in PNG. This conglomerate and four other companies control about 80% of the PNG log export market. All logs exported from PNG are subject to export duties. The duties for log exports are calculated with a progressive tariff rate based on the Free on Board (FOB) market value[9] of the log exports (PNGC 2012). In addition to the log export duties, the PNG Forestry Act (1991), under Section 120, describes conditions for levy payments to the PNG government and timber royalty payments to the FROs to be made by all entities conducting timber harvests. The current timber royalty rate system uses a minimum fixed-rate per m^3 of timber harvested. This minimum fixed-rate per m^3 varies between species. The timber royalties are collected by the PNG government from the logging companies and then redistributed to the FROs.

[9] FOB market value is the monetary value of the log delivered to a mill or port of export. In this paper, the term 'market value' is a reference to the FOB market value of the timber.

The timber resource rents received by FROs in many tropical countries are considered inequitable (Ascher 1998; Dauvergne 1999; Thanakvaro 2002; Amacher et al. 2007; Sinclair 2008). Being denied fair resource rents from industrial timber harvests can be an impediment to the economic development of FROs because few other small-scale forest management opportunities are available to them (Scudder et al. 2018). No published information exists on how the total annual timber royalty payments revenue received by PNG's FROs compares to log duties and levies received by the PNG government and the net returns to the logging industry. Without this information, it is not possible to determine if the current royalty rates represent an equitable resource rent for the timber harvested. In this study, we estimate the royalty payments made to FROs and compare these to the export duties and levies received by the PNG government and the estimated net returns to logging companies. The three research objectives were to; 1) estimate previous timber harvest cash flow distributions in PNG; 2) evaluate the inflation-induced erosion of the real values of the fixed-rate royalties per species; and 3) determine how the livelihoods of PNG's FROs could be improved if royalty payments were calculated as a percentage of market value.

In the next section of the paper, we discuss the methods used to address our research objectives. We then present our results of estimated timber harvest cash flow distributions, the erosion of the real value of timber royalties, and how cash flow distributions would change if royalties were calculated as a percentage of market value. Finally, we present our key findings and provide recommendations to improve the existing timber royalty payment system in PNG.

6.2 Methods

6.2.1 Data Collection

We collected log export reports produced by Sociele Generale de Surveillance (SGS), (SGS 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018). SGS is an independent log export auditor that works on behalf of the PNGFA. The information extracted from the log export reports was the log export volumes by species, the FOB value of logs exported, and the duty and levy payments paid to the PNG government by the logging companies. We collected additional data on the levy payment requirements from the PNGFA (2018). The levy payment requirements for log exports total 35.5 (PGK) per m^3. The PNG government uses these levies to fund a variety of activities; provincial and local-level government (LLG) infrastructure and business development (45%); reforestation and monitoring (17%); administrative expenses (16%); education (11%); home construction (6%); and spiritual activities (6%) (PNGFA 2018). The fixed-rate royalty payment rates by species were extracted from a PNG National Forest Service (PNGNFS) document titled 'Form 221' (NFS 2008). Data on consumer price indices and foreign exchange rates was retrieved from the Bank of Papua New Guinea (BPNG) website (BPNG 2018).

6.2.2 Data Analysis

For this analysis, we completed a log export revenue cash flow distribution for the years 2007-2017. We calculated the erosion of the real value of royalty payments for the years 1991-2017. We calculated the royalty rates as a percentage of market value for the years 2007-2017. We addressed the three research objectives through an analysis conducted using Microsoft Excel software.

For the log export revenue cash flow distribution analysis, log volumes and FOB export values were only collected from the SGS report sections labelled 'Saw/Veneer logs' and 'Low-grade logs', which represent the native forest log exports. The SGS report sections labelled 'Plantation logs' are not subject to duties, levies and royalties, and therefore were not included in this study. Royalty payments were calculated using the SGS log export volumes by species and the minimum-required fixed-rate royalty payments by species, which was extracted from the PNGNFS's 'Form 221' (NFS 2008) (Table 6.1). These timber species in PNG are categorized into four groups, with Group 1 representing the most sought-after export species. The fixed-rate royalties have been in effect since 1 March 2008. Before this date, the minimum fixed-rate was 10 Kina (PGK) per m^3 for all species, which was set by the PNG Forestry Act (1991). The effect of inflation is such that the real value of fixed-rate royalties become eroded over time.

We calculated the erosion of the royalty payment real values by using inflation rates collected from BPNG (2018) and the royalty rate amounts extracted from NFS (2008). For each year before 2017, the royalty payment real values were increased in proportion with the accumulated inflation. We also developed a projection of potential royalty payments that could have been received by FROs by using market value percentages between 8% and 20%, with 2%-unit increments. These market value percentages were chosen to demonstrate what FROs could have received if royalties had been larger than the current rate. With this projection, we assumed that all harvest volumes remained the same. Estimates were generated for the total additional royalty revenues that would have been received, additional royalties per m^3, and the additional royalties received by each province in PNG. All the revenue, duty, levy and royalty values were converted to 2017 USD using consumer price indices and foreign exchange rates retrieved from BPNG (2018).

Table 6.1: PNG timber royalty rates per m^3 (2017 PGK and USD)

Group/Species	PGK	USD
Group 1		
Intsia bijuga	35.00	$11.22
Palaquium spp.	20.00	$6.41
Dracontomelon dao	20.00	$6.41
Remaining Group 1 species	15.00	$4.81
Groups 2, 3 and 4 species	10.00	$3.20

6.3 Results

6.3.1 Timber harvest cash flow distributions

We found that the total timber royalty payments that PNG's FROs received during the years 2007-2017 was $196.6 million (real 2017 USD). Proportionally, this amounted to an average of 6.1% of the total annual log export revenues. By comparison, the PNG government received $913 million (real 2017 USD) from log export duties. This represents an average annual proportion of 27.8% of the log export revenues. Levy payments to the PNG government were $479 million (real 2017 USD), which amounted to an average of 14.6%. The annual average proportion remaining for logging company costs/profits was 51.6%. The average value that FROs received in royalty payments was $6.03 per m^3 in real 2017 USD. By comparison, an average of $41.78 per m^3 went to the PNG government in the form of duty and levy payments. The average remaining portion retained by the logging industry for costs and profits was $50.44 per m^3. Tables 6.2 and 6.3 provide details of the total distribution of cash flows and distributions by m^3 for the years 2007-2017.

Table 6.2: Total cash flow distributions for PNG log exports during the years 2007-2017 (millions of real 2017 USD and % of total revenue)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Log export cash distribution (millions of 2017 USD)											
Total log export revenues (FOB)	295.1	225.8	202.3	311.5	312.7	245.0	287.1	361.5	375.2	367.4	306.1
Forest resource owner royalty payments	14.1	16.3	14.6	19.7	21.8	19.0	19.6	20.8	19.7	18.1	15.4
PNG government											
Duties	80.4	61.4	55.2	85.6	86.3	66.4	78.2	98.9	101.8	99.3	99.4
Levies	49.9	41.1	32.5	45.2	51.2	43.3	43.8	48.7	46.8	41.0	35.5
Logging industry residual return for cost/profit	150.7	107.0	100.0	160.9	153.4	116.3	145.4	193.2	206.9	209.1	155.7
Log export cash flow distribution (%)											
Total log export revenues	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Forest resource owner royalty payments	4.8	7.2	7.2	6.3	7.0	7.7	6.8	5.8	5.3	4.9	5.0
PNG government											
Duties	27.3	27.2	27.3	27.5	27.6	27.1	27.2	27.3	27.1	27.0	32.5
Levies	16.9	18.2	16.1	14.5	16.4	17.7	15.3	13.5	12.5	11.2	11.6
Logging industry residual return for cost/profit	51.1	47.4	49.4	51.7	49.1	47.5	50.7	53.4	55.1	56.9	50.9

[1] FOB (Free on Board) refers to the value of the logs at the port of loading.

Table 6.3: Average revenues received per m^3 during the years 2007-2017 (real 2017 USD)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Log export revenues (FOB)[1]	$108.52	$94.25	$101.84	$107.96	$92.66	$82.87	$92.15	$100.13	$102.60	$107.88	$89.86
Royalties	$5.17	$6.82	$7.35	$6.84	$6.46	$6.42	$6.31	$5.76	$5.39	$5.31	$4.53
Log export duty	$29.58	$25.61	$27.81	$29.69	$25.57	$22.47	$25.09	$27.39	$27.84	$29.15	$29.18
Log harvest levy	$18.36	$17.13	$16.35	$15.67	$15.17	$14.64	$14.07	$13.48	$12.80	$12.04	$10.43
Logging industry residual	$55.41	$44.68	$50.33	$55.77	$45.46	$39.34	$46.68	$53.50	$56.57	$61.39	$45.72

[1] FOB (Free on Board) refers to the value of the logs at the port of loading.

6.3.2 Erosion in real value of royalty payments

We found that the erosion in real value of the royalty payments was different for all timber species groups. PNG has experienced an average annual inflation rate of 7.4% between the years 1991 and 2017 (BPNG 2017). In 1991, the real value of royalties for all species groups was \$9.42 per m^3 (2017 USD). By the end of 2007, the real value for all species groups had declined to \$5.18 per m^3 (2017 USD). In early 2008, the royalty rates for Group 1 species were re-set by the PNG Forest Minister. Under the new rates, the real value in 2017 USD in 2008 was \$16.93 per m^3 for *Intsia bijuga*, \$9.67 per m^3 for *Dracontomelon dao* and *Palaquium* spp., and \$6.92 per m^3 for all remaining Group 1 species. The royalty rates for Groups 2, 3 and 4 species were not changed and further declined to \$4.84 per m^3. By 2017, the real value of royalty rates for all species groups had declined by 34% of their 2008 values (Figure 6.1).

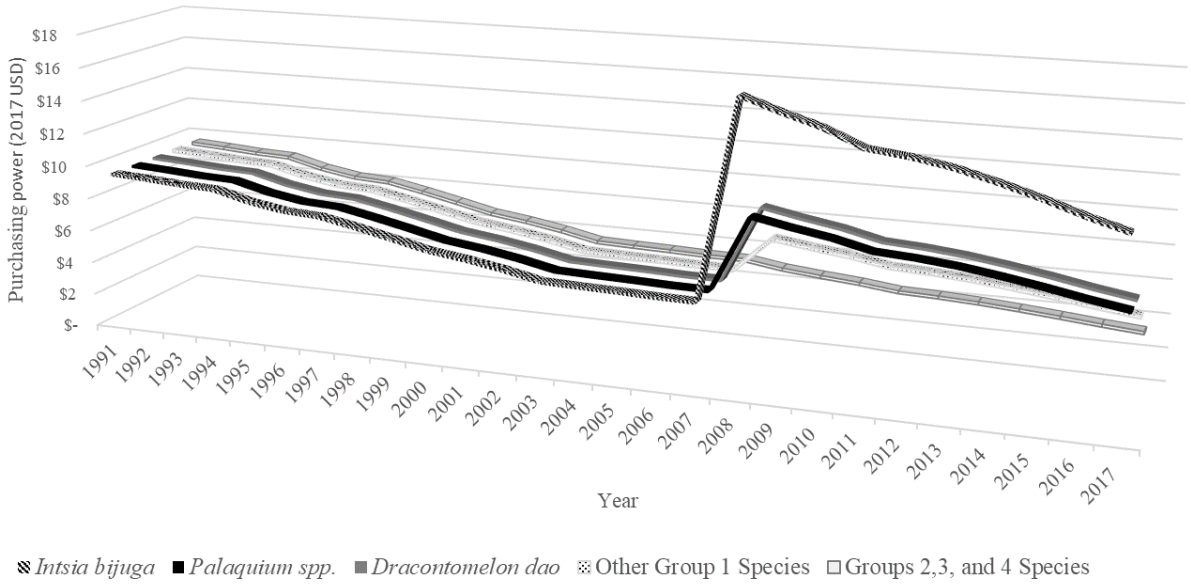

Figure 6.1: Erosion of the real value of royalty payments by species for the years 1991-2017 (2017 USD)

6.3.3 Royalty payments as a percentage of market value

We found that calculating royalty payments as a percentage of market value at ranges of between 8% and 20% for the years 2007-2017 would have resulted in PNG's FROs receiving additional revenues of between \$267.0 and \$667.7 million (real 2017 USD). As the FROs had received only a relatively small portion of the harvested timber values, the 2% incremental increases in the royalty rates would equate to substantial growth in revenues received (Figure 6.2). For example, the royalty revenues

received by the FROs for the years 2007-2017 in real 2017 USD would increase by 32% (8% royalty rate), 65% (10% royalty rate), 98% (12% royalty rate), 131% (14% royalty rate), 164% (16% royalty rate), 197% (18% royalty rate) and 230% (20% royalty rate). Furthermore, the total additional revenues would have remained in the provinces where the timber was harvested (Figure 6.3).

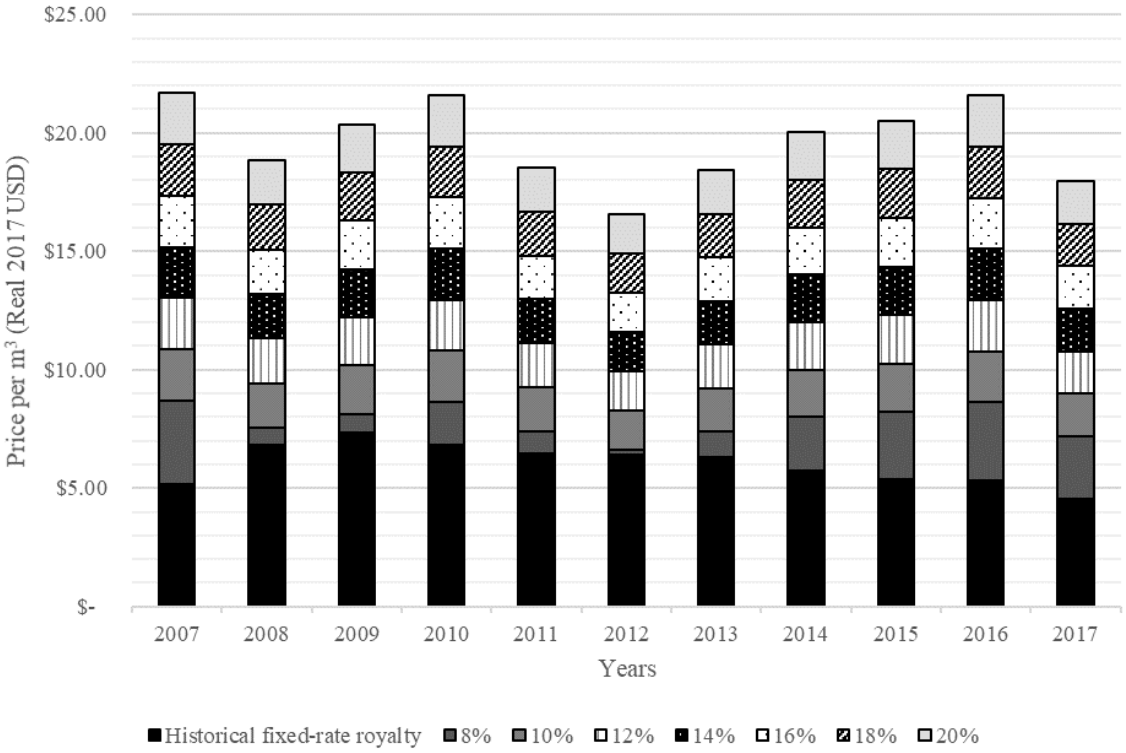

Figure 6.2: Additional revenues that would have been received with the incremental increases in royalties as a percentage of market value

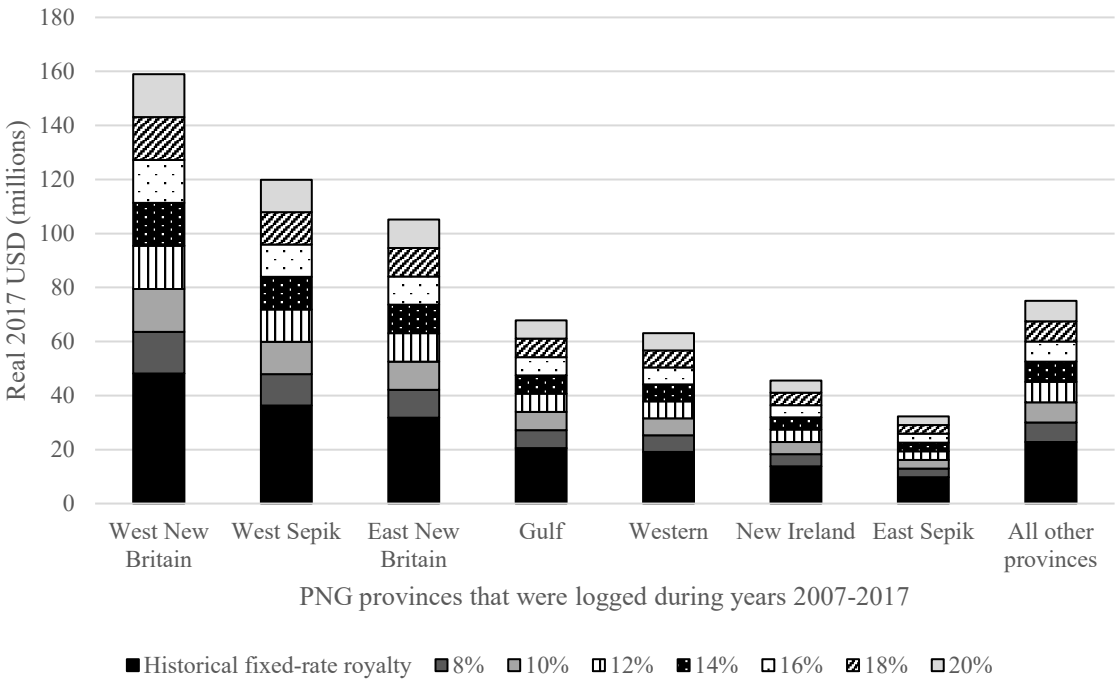

Figure 6.3: Additional revenues that would have been received by province with the incremental increases in royalties as a percentage of market value

6.4 Discussion and Recommendations

Our analysis indicates that PNG's FROs have received little compensation for timber harvested on their lands. Despite owning the timber resources, the FROs have only received an average of 6% of the market value of the timber harvested from their lands. Almost all (94% on average) of the value of the logs has been captured by the PNG government and the logging industry. As the log export duties flow to the PNG central government, a substantial portion of the cash flows generated by timber harvests are not staying within the control of PNG's rural communities. The PNG government designates a majority portion of the levies collected to projects designed to benefit FROs at the provincial and LLG areas. However, the FROs usually do not have control over how these monies are spent. The levy payments designated for local development are typically received by provincial and LLG governments, LLG committees, and Landowner companies. Politicians in PNG are often accused of rewarding a very small portion of their constituents to ensure their political survival (Filer and Sekhran 1998). The landowner companies have been found to be deficient in their financial representation of FROs (Filer and Sekhran 1998, Bird et al. 2007). Even when levy payments are used to fund prudent development projects, it does not aid FROs in accessing crucial needs, such as healthcare, school fees, and store-bought goods. The existing arrangement appears to be skewed in favour of the government and the logging companies, rather than the FROs.

There has been a substantial erosion in the real value of the royalty payments to PNG's FROs between 1991 and 2017. This is a direct result of the fixed-rate royalty system. The real value of royalties for over 90% of the timber volume harvested during the last decade has been eroded by 32-66% of the real values in 1991. By comparison, log export duties collected by the PNG government are calculated with a progressive tariff rate based on the FOB value of the log exports, which protects the tariff rate from the erosion of real values caused by inflation.

An unintended consequence of the low royalties paid to communities and/or poor enforcement capacity has been the creation of an informal sector of illegal small-scale timber harvesting in the country's native forests. Little is known about the harvest volumes associated with this informal sector or the destinations of the timber, as the PNG government does not have the resources to track or regulate this sector. Anecdotal evidence suggests that the illegally harvested timber is milled with portable sawmills by individuals lacking the financial means to obtain a harvest permit, but wanting a better return for their timber than that can be received from royalty payments. Potential negative externalities of the informal sector are forest degradation from poor logging practices, timber theft and over-harvest of species with high economic values.

Royalty payments based on a percentage of FOB market value (like the current system of log export duty calculations in PNG) can help address the inequity that has arisen through PNG's current system of a fixed-rate for royalties. Our analysis found that if royalties were calculated at rates of between 8% to 20% of market value, the additional cash flows received by PNG's FROs during the years 2007-2017 would have increased by between approximately 32% and 230%. Increasing royalty payments to communities would also mean that a higher proportion of the resources rents would be retained within local communities, thus giving FROs greater capacity for self-funded economic development. Furthermore, if the percentage of the market value selected for the royalties was greater than timber prices offered in the informal market, the scale of the smallholder illegal logging and the associated negative externalities could be reduced. Under the current system in PNG, the administrative costs for estimating royalties owed are shared by SGS (Independent log export auditor) and the PNG government. SGS estimates the log volume exports by species. The PNG government uses this data and their own internal data to calculate and collect royalties owed from the logging companies, and then re-distributes the royalties to the landowners. We believe that increasing the royalty amounts should not result in additional costs to SGS or the PNG government, since these activities are already being performed.

An increase in royalty paid to communities in PNG would need to be funded by either: (1) a reduction in duty/levy payments retained by the PNG government and reallocation of this to communities, either through a direct payment to communities or indirectly through increased royalty rates on a stumpage

basis, and/or (2) a reduction in the residual cash flows to the logging industry and a redistribution of this money to communities through increased royalty payments. In terms of the first option, the PNG government has collected an average of 42% of the export FOB log values during the last decade, which could effectively meet the percentage of market value royalties modelled in this study (8-20%). For instance, a 13% decrease in duties would be required to fund a 13% increase in royalties, resulting in both duties and royalties being approximately 18% of the export FOB log values.

Determining whether logging companies could pay higher royalties to communities and remain profitable is difficult. There is little publicly available data on the operational costs of companies, and there are also issues with transfer pricing, and whether log export prices accurately reflect revenues and profits of the logging industry. In the most recent logging cost study in PNG, it was estimated that the average total logging cost (not including royalties, duties and levies) was \$160.83 per m^3 (expressed in real 2017 USD) (FORTECH 1998). Our analysis found that the average residual return for logging companies after paying royalties, duties and levies was \$50.44 per m^3 (expressed in real 2017 USD). This suggests that either the logging industry has been operating at a loss for many years or that the reported logging costs have been inflated and/or revenues deflated. In a 2006 report prepared for the PNG Forest Industries Association, PricewaterhouseCoopers (PwC), stated that 'Logging companies themselves appear to be in a contradictory position. While current official log prices indicate that the industry has been unprofitable for a number of years, logging continues and companies still seek access to new forest areas, and make significant investments in other areas of the economy' (PwC, 2006, p.9). Furthermore, an investigative report by Mousseau and Lau (2016) found that logging companies in PNG declare little to no profits by artificially inflating logging costs and under-pricing their logs relative to log exports in other tropical countries.

The practice of under-pricing logs is a form of 'transfer pricing,' which is often done to reduce the amount of taxes paid. The practice of transfer pricing in PNG has also been reported by Grynbert et al. (1988), Marshall (1990), and Hunt (2002). During the years 2012 - 2016, PNG's non-coniferous log export price was 30% to 76% less than the average price of other Asia-Pacific island nation log exporters (Fiji, Indonesia, Malaysia, Philippines and Vanuatu) (ITTO 2017). One possible further cause for the low log prices relative to other Asia-Pacific island nations is higher export shipping prices in PNG. However, the shipping pricing system in PNG is so opaque that it is not possible to discern if this is the reason for the low log export prices. While these reports indicate that un-reported income is being accrued, they do not show if total profits represent a fair financial return typical of tropical forest logging companies. In the absence of accurate logging cost and pricing data, it is not possible to determine if logging industry profits are excessive and whether some of these profits could be applied to increase royalty payments to communities.

We also analysed the changes in price elasticities for each of the log species/groups for years 2007-2017, to see how increases in royalty rates would affect log demand for logging companies. We found that an increase or decrease in price did not result in a discernible pattern of corresponding increases or decreases in harvest volumes. The average elasticity across all species over ten years was -0.14, indicating timber harvests in PNG are inelastic. We believe that the reason log demand appears to be inelastic in PNG is the high level of species diversity in PNG's forests. Logging companies are harvesting all the trees within their timber concessions that have a diameter greater than 50 cm DBH, regardless of species. A change in the per unit market price of an individual species is not altering the harvesting practices of the logging companies. It is likely that fluctuations in harvest volumes by species is due to the random species distributions within the timber concessions. In the absence of accurate logging cost and pricing data, it is not possible to determine if increased royalties would reduce the logging industries demand for logs.

Other Melanesian countries (i.e. Fiji, the Solomon Islands and Vanuatu) have acted to correct similar inequities in payments made to communities associated with sales of their timber resources. The Solomon Islands Forests Bill (SIFB) requires that timber royalties shall, at a minimum, be the greater of either 10% of the determined timber value or the amount fixed by the Forest Commissioner (SIFB 2004). Furthermore, the SIFB states that the determined timber value estimates will be based on world prices and not the actual sale price of the timber to avoid a reduction in royalty payments caused by transfer pricing (SIFB 2004). In Fiji, the Forestry Bill requires that the timber royalty rates be reviewed every five years with new rate decisions based on consultation with all stakeholders (FFB 2016). In Vanuatu, the most recent revision of the National Forest Policy was completed with public participation from landowners, private businesses, NGOs, provincial governments, and national government agencies (VFP 2011). The objective of the broad public participation was to develop a new forest policy that represented a negotiated agreement amongst all stakeholders (VFP 2011).

It should be noted that increasing the timber royalties paid to FROs will not necessary result in them attaining improved long-term livelihoods. One potential challenge to the economic development of FROs is their capacity to manage personal finances. Only 15% of the population in PNG has a bank account (Bakani 2018). In the absence of a bank account, the majority of FROs do not have a safe place to store their money. Furthermore, in the rural areas of PNG, the levels of attained education are low relative to the rest of the country. The highest level of education attained by approximately 49.3% of rural people is elementary (Ages 6-8 years) (NSO 2011). Approximately 33% have completed primary education (Ages 9-14 years), and just 13% go on to complete secondary education (Ages 15-18 years) (NSO 2011). Less than 5% of the rural population goes on to achieve additional tertiary education (NSO 2011). This indicates that the capacity for managing personal finances may need to be improved.

Increasing royalties for FROs without addressing personal finance education would likely result in little change towards improving FRO livelihoods over the long-term.

Our findings indicate that the existing royalty rate system in PNG has resulted in the country's FROs receiving an inequitable share of forest resource rents. Based on our findings and the reforms of other Melanesian countries, we make the following three recommendations for a fairer distribution of timber harvest revenues and improvements in the future management of PNG's forest resources.

1) *Existing forest policy be reformed to require timber royalty payments be changed to the greater of either the minimum fixed-rate as set by the Forest Minister, or to a percentage of FOB market value, as reported by Sociele Generale de Surveillance.* This change to royalty payment policy would protect PNG's FROs from the real value of future royalties being eroded by inflation.

2) *The minimum percentage of market value selected for the royalty-rates should represent an equitable distribution of log export revenues.* In 2017, PNG's FROs received royalties that averaged 5% of the value of the country's export log market. Between 2007 and 2017, the percentage of market value that FROs received varied by species and ranged between 2.7% and 13.1%. It is recommended that a percentage of market value be selected that, at a minimum, is equivalent to historical market distributions and equates to a value per m^3 that is greater than those being received by participants in the informal sector. Further research will need to be conducted to identify variations of informal sector prices throughout PNG.

3) *Increased public awareness of existing forest rent distribution and increased public involvement for determining the percentage of the market value for timber royalties.* It is important that all stakeholders are fully informed on the existing forest rent distributions, so that an informed dialogue can take place. Increased participation by all stakeholders is an approach that focuses on reaching a negotiated agreement that best meets the interests of all parties. Participation could take a variety of forms, including landowner consultations, local and national discussion forums, and public review of government decisions. One initiative that is positioned to aid in facilitating increased public participation on royalty reform is the Papua New Guinea Governance Facility (PGF). This initiative is being spearheaded by the PNG and Australian governments and it is dedicated to improving governance in PNG, including increased citizen participation (DFAT 2015).

6.5 Conclusion

This study found that the fixed-rate royalty payments received by FROs in PNG are small when compared to the duties and levies collected by the PNG government and the residual returns of the logging industry. Furthermore, the real value of these royalties has been eroded. Forest policies in

other Melanesian countries present options for policy reform that could be applied in PNG. Reforming the existing royalty payment policies to reflect a fairer percentage of market value will improve the livelihoods of PNG's FROs, and protect future royalty payments from further real value erosion. Incorporating public participation into the timber royalty decision-making process in PNG will allow for the identification of fairer timber royalty payments that are balanced between the needs of the country's FROs, the national government and the logging industry.

Chapter Seven

Addressing small-scale forestry informal markets through forest policy: A case study in Papua New Guinea

Abstract:

Small-scale forestry informal markets can be vital to the development of rural economies in many tropical developing countries. In Papua New Guinea (PNG), knowledge of the small-scale forestry informal market is limited, since the government does not have the resources to track or regulate it. Casual observation suggests that the market is comprised of individuals or businesses using portable sawmills for the commercial production of rough-sawn lumber. We used a descriptive case study approach to discover how this market functions, why participants choose to operate in it, how efficient it is, and if it could be improved with government regulation. We found that log harvests occurring in the informal market to be in the order of 560,000 cubic meters (m^3) annually, which is equivalent to 17% of PNG's log exports in 2017. This informal market is being driven by small-scale commercial timber sales by forest resource owners to pay for their personal needs. The current distribution of forest resource rents in this market is skewed in favour of small-scale timber product manufacturers, resulting in the forest resource owners receiving an inequitable share of the timber value. People choose to participate in this market because the existing forest polices governing small-scale operators are not appropriate to the needs of informal market participants and reflect operations more suited to industrial-scale harvests. We recommend that the existing harvest regulations be revised to include a new small-scale harvest permit of 500 m^3 per site per annum, along with improved timber royalty rates for the resource owners. In addition, we recommend increased government support be provided through extension foresters to improve the sustainability and productivity of the small-scale forest products market.

Keywords

Forest product processing, informal sector; native forest harvest; portable sawmills; small-scale timber harvest

7.1 Introduction

There are approximately 60 million Indigenous people living within the world's tropical forests, with an additional 400 to 500 million people that are directly dependent on tropical forest resources for their livelihoods (White and Martin 2002). Small to medium forest enterprises (SMFEs) are entities that engage in forest-based activities and employ a relatively small number of people (1-250) (Kozak 2007). These jobs are an important source of income to rural communities. The global annual economic contributions of SMFEs are estimated at over $130 billion USD (Mayers 2006). Many of these small-scale forestry participants operate within informal markets, where production is not regulated by governmental authorities. Globally, it has been estimated that 140 million people are involved in informal forestry markets (Mayers 2006). These informal markets often empower local communities through increased wage earnings and assist with community development by providing forest products that can be used for local construction projects (Mayers 2006).

Many informal market participants are technically operating outside the jurisdiction of the local forestry authority, which hinders their ability to gain access to finance and technical support (Hoare 2016). Furthermore, by avoiding government taxes and licensing requirements, governments view them as incompatible with forest industry development programs and not a priority for support (Hoare 2016). Because access to finance is limited, many informal market operators often use old or outdated equipment that may be inefficient or unsafe to operate (Hoare 2016). This reduces their productivity and the production of processed wood products that command higher sales prices than rough-sawn lumber. Because information about the volume and value of forest products which are produced by these operations is not reported to or collected by most governments, it is difficult to ascertain the number of market participants, causal links between the participants, and the destination of the timber or the timber products at the country level.

In Papua New Guinea (PNG), there are approximately 29 million hectares of forest, of which approximately 97% are held under customary land ownership by Indigenous communities (PNGFA 2009). The total size of PNG's informal economy has been estimated to be approximately 36% of the country's total economic output (Schneider et al. 2010). The contribution which is derived from informal forest harvesting and wood processing is unknown, as the PNG government does not focus on regulating or tracking this market. Anecdotal evidence based on the many trucks transporting portable sawmills and milled lumber throughout the country suggests the existence of a large informal market associated with small-scale timber harvests. We conducted a descriptive case study to understand the processes of this informal market, the regulations which govern the market operatives, and how these impact on their field operations. Our specific research questions were; why do participants choose to operate within the small-scale forestry informal market, how does the market function, how efficient is the informal market, and would government regulation of this market be beneficial to the participants?

In the next section of this paper, we discuss the methods we used to undertake this analysis. This is followed by our case study results, discussion, and conclusion. Our discussion section includes recommendations for improving the legality of the informal market.

7.2 Methods

We used a case study methodology to investigate the informal timber market. A mixed methods approach was used for data collection, which included interviews, personal observations and documents. Data collection occurred during multiple trips to PNG during years 2016 to 2018. Our case study used a single-case design with multiple sources of analysis following methods outlined by Yin (2009). In this paper, we refer to the sources of analysis as informal market participants. We had a total of 19 informal market participants that were classified into three primary groups; 1) forest resource owners (FROs), 2) portable saw-millers, and 3) small-scale manufacturing businesses. The saw-millers only produced rough-sawn lumber. The manufacturing businesses processed rough-sawn lumber into other wood products, such as dressed structural lumber, mouldings, tongue & groove (T&G) flooring that commanded a higher sales price per unit relative to the rough-sawn lumber. We conducted interviews with each of the informal market participants. In some instances, the informal market participants were individual people and in other instances the participants were comprised of multiple people. The total number of informal market participant interviewees was 23 (Table 7.1).

We also interviewed an additional 15 non-participant stakeholders that were familiar with how the informal small-scale forestry market functioned. These fifteen interviewees were employees of the PNG Forest Authority (PNGFA), the Foundation for People and Community Development (FPCD), the Timber and Forestry Training College (TFTC), and an agricultural equipment distributor named Farmset (Table 7.1). The PNGFA is the government agency tasked with the management of PNG's forest resources. The FPCD is a Non-Governmental Organisation (NGO) that has implemented small-scale forestry projects involving portable sawmills in communities in PNG (Scudder et al. 2018). The TFTC provides vocational and technical training in use of portable sawmills and in value-add wood product processing equipment. Farmset is a distributor of chainsaws and portable sawmills with nine branches through-out PNG.

Table 7.1: Descriptions and number of interviewees

Informal market participants	Participants	Interviewees
Forest Resource Owner (No mills)	2	3
Forest Resource Owner (With mills)	4	5
Sawmill owner only	6	6
Small-scale manufacturing business (No mills)	1	1
Small-scale manufacturing business (With mills)	6	8
Total	19	23
Non-participant stakeholders	Organizations	Interviewees
PNG Forest Authority	1	4
Foundation for People and Community Development	1	3
Timber and Forestry Training College	1	7
Farmset (Portable sawmill distributor)	1	1
Total	4	15

7.2.1 Data Collection

Documents collected included governmental reports/documents, technical reports produced by other research organizations, wood product sales price sheets produced by the manufacturing businesses, peer-reviewed journal articles, and newspaper articles. Thirty-eight people were interviewed between years 2016 to 2018. The fifteen non-participant stakeholders were initially interviewed because they were familiar with the informal market. The remaining twenty-three interviewees were with FROs, saw millers, manufacturing business owners, or manufacturing business employees associated with the 19 informal market participants. These interviewees were selected with assistance from the non-participant stakeholders.

The 19 informal market participants were located within the Momase Region of PNG, which comprises the East Sepik, Madang, Morobe, and West Sepik Provinces. The exact geographic location and names of the 19 informal market participants and associated interviewees have been omitted to ensure confidentiality. The initial interviews with non-participant stakeholders helped us develop an interview protocol which was designed to identify the functional operations of the 19 participants. The questions asked were; why participants choose to operate without the necessary permits; their perceptions of the forest policies, their perceptions on the size of the informal market, where timber/wood products were sold and to whom; the type of equipment used to harvest the trees and process the timber; the cost of production; how sale agreements were arranged; volumes produced; and prices received from sales. The interview format was similar for all interviewees. The interviews were primarily conducted by the first author, with participation also provided by the third author and a former research forester of the Tropical Forestry and People Research Centre. Hand-written notes were taken by the three interviewers during all interviews. The length of the interviews varied between 30 minutes and one hour. At least one non-participant stakeholder was present at all the interviews to provide their post-interview perspective to the interviewer.

7.2.3 Data Analysis

We began our data analysis by describing the forest policies that impact small-scale timber harvest operators. This description was based on data collected from the PNG Forest Policy Act (1991) and multiple National Forest Service documents (NFS 1991a, NFS 1991b, NFS 1991c). Interview data was compiled into a case study database using Microsoft Excel Software. To improve external validity, we used replication logic to study a total of 19 informal market participants; six were FROs, six were saw-millers, and seven were small-scale manufacturing businesses. To address internal validity, we conducted a pattern recognition analysis of the data by arranging the rows of the database to represent the individual participants and the columns of the database to represent the questions asked to the interviewees. When we identified similar responses to interview questions we calculated the percentage of responses relative to the total. We also assessed patterns within the case study groups by filtering the data for; FROs with no mills, FROs with mills, saw-miller only, small-scale manufacturing business with no mills, and small-scale manufacturing businesses with mills. We triangulated the interview data by collaborating it with additional evidence in the documents we collected and by having non-participant stakeholders review drafts of our case study. We used the identified patterns and triangulated data to provide a description of the informal market participants. We estimated the size of the informal market with data collected from technical reports, a portable mill number survey, and annual production data of portable mills gathered during interviews.

We conducted a financial analysis to compare the values paid/received by the informal market participants at four stages of the value-chain; standing trees prior to harvest; rough-sawn lumber at the harvest site; rough-sawn lumber delivered to the manufacturing businesses; and finished product located at the manufacturing businesses. The analysis was performed with data collected during interviews with the 19 informal market participants and the non-participant stakeholders, as well as sales price sheets for finished products collected from the manufacturing businesses. We averaged the market values of the wood products produced at each value-chain stage. The number of assorted products sold by the manufacturing businesses typically exceeded 100, due to multiple species, product types, dimensions, and whether or not the timber have been chemically treated. For this analysis, we selected four products, which we were informed were timber products with high demand. These products were; tongue and groove (T&G) flooring (*Intsia bijuga* 95 x 20 mm); treated architrave moulding (Mixed hardwoods 70 x 20 mm); treated structural lumber (Mixed hardwoods 100 x 50 mm); and treated weatherboard (Mixed softwoods 145 x 20 mm). Since the sales transaction between FROs and saw-millers were typically paid as Kina per m^3 of lumber, we converted the lumber price into pre-harvest log values. To do this, we assumed a lumber recovery rate of 45% and applied this to the government royalty rates per m^3 of log (Table 7.2). Since the sales prices for finished timber products for the manufacturing business were listed as price per lineal meter, we converted the prices to m^3 of lumber product.

For the T&G flooring product (*Intsia bijuga* 95 x 20 mm), we also compared the values received by the informal market participants to the cumulative cost of production at each stage of the value chain. The production costs were collected during interviews with the 19 market participants and from non-participant stakeholders. These costs were averaged for each stage of the value-chain. The production costs included royalties paid to FROs, felling and transporting the log to the portable mill, milling the lumber, transporting the lumber to the manufacturing business, sorting/grading the lumber, machining the lumber into flooring, and overhead costs per m^3 of flooring produced for the manufacturing business. In addition, we assessed if the stumpage prices paid to FROs equate to an equitable portion of timber resource rents. Timber resource rents are defined as the residual value of round-wood produced after subtracting the costs of round-wood production (Gray 1983). To identify what could constitute an equitable rent distribution to FROs, we compared data from the most recent logging cost study in PNG produced by FORTECH (1998), to the average export value of round-wood in PNG for the same year as stated by the ITTO (2018). All the price data that we present is in PNG's currency, which is called Kina (PGK). The PGK exchange rate to USD is 0.2970 (BPNG 2018).

7.3 Results

7.3.1 Existing forest policies that impact small-scale timber harvests in PNG

In the amended PNG Forestry Act (1991), there are no sections that clearly define the legal requirements for timber harvests that are less than 500 cubic meters (m^3) per annum. Interviews with non-participant stakeholders revealed that there is a general understanding that FROs can harvest up to 500 cubic meters (m^3) per annum for personal uses without a harvest permit issued by the PNGFA, but the harvested timber cannot be used for commercial activities. However, what comprises 'commercial activities' is not clearly defined by the Forestry Act (1991) or universally agreed upon. If FROs choose to harvest timber specifically for commercial activities, they must comply with a number of requirements. The first requirement is for an individual to register as a 'forest industry participant' (FIP). The PNG Forestry Act (1991) defines an FIP, as, "Any person engaging in, or intending to engage in, forest industry activities (otherwise than as an employee of a forest industry participant or in the capacity of a common carrier) where the timber harvested, bought, sold or arranged or procured to be sold or purchased, by that person in a calendar year exceeds 500 m^3 in volume." The registration process requires the creation of a legal business entity, a completed registration form delivered to the Managing Director of the PNG Forest Authority (PNGFA), and an application fee of 100 Kina by way of bank cheque (Forestry Act 1991).

To obtain a small-scale commercial harvest permit, the second requirement is for the registered FIP to apply for a Timber Authority (TA) harvest permit for domestic processing[10]. A TA for domestic processing allows a FIP to harvest up to 5,000 m^3 from land occurring within a 10-km radius over the duration of one year (Forestry Act 1991). The application process requires a map and description of the proposed harvest area, the harvest commencement date, the expected harvest volume, a 275 Kina application fee, and the submission of a 20,000 Kina performance bond that is only released after the submission of a harvest completion report and verification that all terms and conditions of the TA were met (NFS 1991a). In addition to the application of the TA for a harvest permit, the FIP is also required to submit two additional forms to the Managing Director of the PNGFA. The first form is a verification of ownership and consent of landowners is listed as Form 165 (NFS 1991b). This form needs to be completed by every incorporated land group, or individual having ownership rights over timber or forest products within the proposed harvest area. This form must be signed in the village where the landowners live and be witnessed by a Village Court Magistrate or Land Mediator. The second form is a Sales and Purchase Agreement and is listed as Form 166 (NFS 1991c). This form is a sales contract that provides the names and signatures of all parties involved in the agreement and the terms of the agreement. After all the required documents and fees have been submitted to the PNGFA Managing Director, the application is processed. Non-participant stakeholders revealed that the time required to process an application is typically several months.

The Forestry Act (1991) requires that persons or logging companies operating with a TA make royalty payments to the FROs for all timber harvested. The royalty payment amounts are minimum fixed rates and vary between 10 and 35 Kina (PGK) per m^3, depending on the tree species. This is equivalent to $2.97 and $10.40 in 2018 USD using a conversion rate of 0.2970 Kina per 1.0 U.S. Dollar (NFS 2008, BPNG 2018) (Table 7.2). The timber species in PNG are categorized into four groups, with Group 1 representing the most sought-after species. The fixed-rate royalties have been in effect since 1 March 2008. Prior to this date, the minimum fixed-rate was 10 Kina (PGK) per m^3 for all species, which was set by the PNG Forestry Act (1991).

Table 7.2: PNG timber royalty rates per m^3 (2018 PGK and USD)

Group/Species	PGK	USD
Group 1		
Intsia bijuga	35.00	$10.40
Palaquium spp.	20.00	$5.94
Dracontomelon dao	20.00	$5.94
Remaining Group 1 species	15.00	$4.46
Groups 2, 3 and 4 species	10.00	$2.97

[10] There are five types of TAs; domestic processing, road clearing, agricultural conversions, other forest products, and plantations. The TA for domestic processing is the most appropriate existing permit for small-scale operators.

7.3.2 Description of informal market participants

The informal market was separated into three groups; 1) FROs, 2) saw-millers, and 3) manufacturing businesses. One third of the FROs that we interviewed owned their own sawmills and harvested timber from their own lands. The remaining FROs interviewed sold their timber to individuals or manufacturing businesses that owned their own portable sawmills. Six out of the nineteen market participants only operated portable sawmills. We found that these six participants typically arranged harvest agreements with relatives that owned forest resources. The saw-millers sold the lumber they produced to manufacturers that further processed the rough-sawn lumber. We found that the saw millers had limited knowledge of rough-sawn lumber dimensions and species desired by the manufacturers. The saw millers had to frequently visit the manufacturing businesses to ascertain the current demand for various species and lumber dimensions.

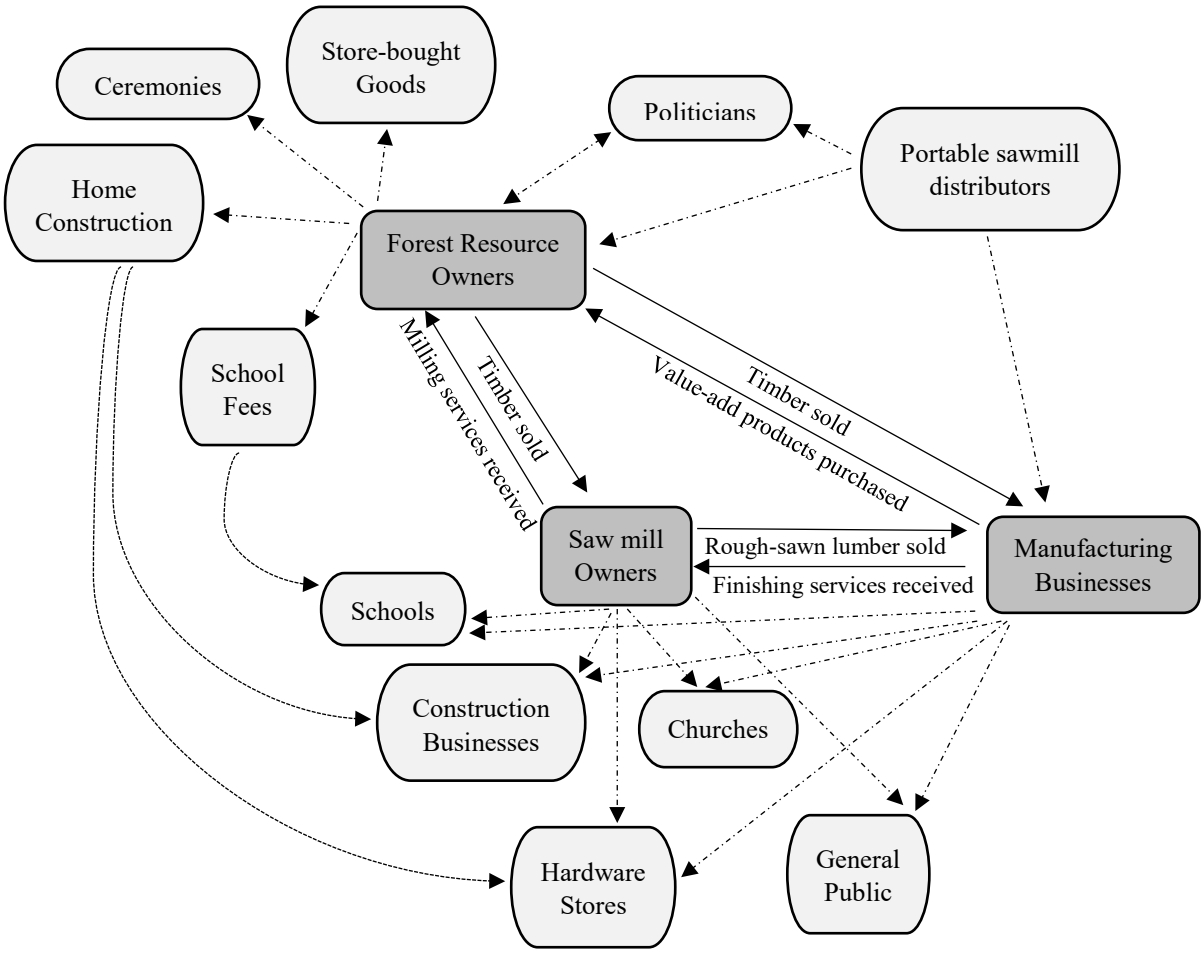

Figure 7.1: Diagram of informal market participants and causal linkages

All the manufacturing businesses purchased rough-sawn lumber from portable sawmill owners. Six of the seven manufacturing businesses also owned their own portable sawmills and also entered into harvest agreements with FROs. None of the manufacturing businesses were owned by FROs. The rough-sawn lumber milled by the manufacturing businesses was transported back to the business shop to produce further processed wood products. The most sought-after species of the manufacturing business were *Celtis* spp., *Dracontomelon dao, Intsia bijuga, Pometia pinnata, Pterocarpus indicus, Terminalia* spp., and *Vitex cofassus.* The remaining species purchased were aggregated into groups and referred to as 'Mixed hardwoods' or 'Mixed-softwoods.' The most common products produced were dressed structural lumber, T&G flooring, decking, weatherboard, and mouldings. Other products produced were furniture and coffins. The additional processing generally involved the use of moulding machines and thicknessers/planers, most of which were not of high quality. Three of the seven manufacturing businesses provided lumber dressing services to individuals that only owned a portable mill. The finished products were typically sold to hardware stores, construction companies, churches, schools, and the general public. These manufacturing businesses have operated in both the informal and formal markets in that they purchased raw materials from informal market operators, may or may

not have paid taxes themselves, and have sold their products to individuals/businesses that also may or may not have paid taxes.

7.3.3 Commercial transaction arrangements between informal market participants

There were three types of arrangements that portable mill owners used when harvesting FRO timber. The most common arrangement was referred to as the '2 for 1 agreement.' The 2 for 1 agreement allocated two thirds of the milled lumber to the mill owner and one third of the milled lumber to the FRO. Usually, this arrangement was applied to the volume (m^3) of lumber produced, but sometimes it was based on number of trees harvested and milled. The FROs were typically given the opportunity to sell their portion of the lumber to the sawmill owner at an agreed rate. The 2 for 1 arrangement was used by 50% of the informal market participants for timber purchases[11]. The remainder of timber purchases involved a set-rate paid to the FRO for the volume (m^3) of lumber produced. These set-rates varied by species. In some cases, only the A grade[12] lumber was purchased with the B grade lumber left at the harvest site for the FROs. We were informed that the set-rate arrangement was sometimes calculated for the volume (m^3) of logs harvested following the government royalty rates (Table 1), but FROs usually preferred the set-rates for volume of lumber produced. The final milling arrangement made between FROs and portable mill owners was a service fee for the volume in m^3 of lumber produced. Under this arrangement, the FROs kept all the lumber and paid the portable mill owner for services rendered.

7.3.4 Reasons FROs choose to sell their timber

FROs decided to sell timber to obtain cash to be used for one of five main purposes: school fees; store bought goods; ceremonies; to build a home; and for Christmas celebrations. School fees were the most common response, being mentioned by 53% of the informal market participants and corroborated by six of the non-participant stakeholder interviewees. This was initially misleading, because the PNG government passed legislation for Tuition Fee Free (TFF) education policy in 2012 (DOE 2012). The purpose of the TFF policy was to abolish school fees for elementary and primary students, reduce fees for secondary students, and devolve the responsibility of fiscal management from the central government to the local schools and the district administrations. This policy also banned schools from charging additional fees to increase access to education for impoverished families. However, distribution of TFF subsidy funds from the central government to schools were often late or not able to cover all the school's expenses due to increased student enrolment (Paraide 2015 and Walton 2018). Research on educational attainment in PNG has found that 50% of households with school-aged

[11] This calculation did not include the four FROs that owned their own mills and harvested their own timber.
[12] Non-participant stakeholders defined A grade lumber as being of higher quality than the B grade due to reduced imperfections such as knots, wane, checking, or warping and cupping of the lumber.

children had difficulty in sending at least some of their children to school and only a small amount of families did not pay any school fees (Ryan et al. 2017). Interviews with non-participant stakeholders revealed that the schools adapted to the lateness or shortage of TFF subsidies by continuing to charge fees under a different name, such as 'project fees.' The PNG Education Plan 2015-2019 projected that parent-paid project fees would range from 145 to 178 Kina per student during years 2016 to 2019 (DOE 2016). An online article by the PNG Education News Website (PNGENW 2018), discussed the increase of project fees in the East New Britain Province for years 2018 to 2020. The fees were increased to 150 Kina for elementary students (Grades 1 & 2), 300 Kina for primary students (Grades 3-8), 1,000 Kina for secondary students (Grades 9-12), and 800 Kina for technical and vocational school students. The article indicated that 60% of the fees were due upon enrolment, with the remainder due by the second term. Interviews with non-participant stakeholders revealed that school enrolment occurred during January. The non-participant stakeholders also explained to us that the term 'school fees' is often used to describe all expenses related to school; the actual school fees, project fees, stationary, uniforms, and transportation to school.

The second most common reason that FROs sold their timber was to get money for the purchase of store-bought goods, which was mentioned by 42% of the informal market participants. Store-bought goods refer to consumables that FROs cannot provide for themselves, such as clothing, packaged rice, and canned meats. The remaining reasons mentioned by the cases as reasons that FROs sold their timber were ceremonies (21%), home construction (16%), and Christmas celebrations (11%). Ceremonies were typically referred to as weddings and funerals. Timber sold for home construction was either the 2 for 1 arrangement to provide FROs with lumber for construction, or the sale of timber to provide cash for the purchase of other construction materials. One of the FROs we interviewed was in the process of building a new home. We were told that the non-lumber home construction materials that he needed to purchase were nails, plywood, metal siding, roofing materials, doors, windows, and window screens. The additional cost to purchase these materials and hire a carpenter was approximately 7,500 Kina. Money needed for Christmas celebrations was for the purchase of food to be shared with family members.

7.3.5 Reasons why portable sawmill owners conduct harvests without a TA

We found that all 19 informal market participants had been involved in commercial timber harvests without a TA harvest permit, and only two of the participants had ever acquired a TA and 50% of the participants that were not manufacturing businesses were even aware of the PNGFA TA regulations. Those that were aware of the TA regulations indicated that FROs were not concerned about government regulations because they owned the land and would use it in any way they chose. Another common reason given for not applying for a TA was the requirement of the 20,000 Kina performance bond.

None of the sawmill operators that were aware of the TA regulations had the financial means to pay the bond. This challenge has been identified by others and included as part of a policy brief to the government (Bun 2012).

Additional reasons for not applying for a TA were that the volumes harvested by all the portable sawmill owners were substantially lower than the TA harvest allotment of 5,000 m^3. We found that the majority of saw millers produced less 100 m^3 of lumber annually. Assuming a recovery rate of 45%, this equates to less than 225 m^3 of logs harvested. Only two of the saw millers that were not also manufacturing businesses produced an annual volume that was greater than 300 m^3 of lumber. With a recovery rate of 45%, this equates to less than 670 m^3 of logs harvested. One of the FROs we interviewed told us that using the TA harvest permit was problematic because there is an expectation by the FROs that 5,000 m^3 will be harvested. If production targets were not achieved, which was usually the case, it resulted in disappointment and often conflict.

Two of the manufacturing businesses owned multiple mills and were capable of milling much larger volumes of lumber. However, they only conducted harvests at sites owned by individual families to avoid payment distribution conflicts that were common on sites owned by multiple families or clans. We were told that the individual family harvest sites were typically between 20 to 50 hectares and not able to supply 5,000 m^3 of logs. We estimated that if a sawmill owner operating one mill could secure an agreement with a family that had forest land capable of supplying 5,000 m^3, it would take 1,250 days to complete the harvest and milling, assuming a daily log input of 4 m^3. This is well beyond the one-year timeline of the current requirements of the TA and would require more than six portable sawmills to reach the 5,000 m^3 production target, assuming 200 operating days per year and 4 m^3 of log input per day.

7.3.6 Size of the informal market and the sourcing of portable sawmills

The size of the informal market is difficult to quantify because the exact number of portable mills that are operating and the volumes of lumber produced on average by these mills is unknown. A portable sawmill survey conducted in 1995 estimated that there were 2,500 operating portable mills throughout the country but had little information on volumes produced (FPCD 1995). A technical report by Jenkin (2016), suggested that approximately 4,000 portable sawmills have been imported, with approximately 2,000 currently operational. Of the 2,000 operating mills, it is estimated that approximately 100 to 300 operate on a full-time basis (Jenkin 2016). Two of the manufacturing businesses indicated that their mills produced an average of 2 m^3 of lumber per day and sought to operate 250 days a year, weather allowing. Two of the saw millers said they operated full-time and produced an average of 300 m^3 of lumber per year. Five of the saw millers indicated they produced between 50 and 100 m^3 of lumber per

year. Interviews with non-participant stakeholders revealed that lumber recovery rates typically varied between 35% and 50%, depending on the skill of the operators. Using this data, we estimated the total volume of log inputs and lumber outputs of the informal market. Our assumptions on which the estimates are derived are presented in Table 7.3 and the results are presented in Table 7.4. Our estimate indicates that the total volume of logs harvested annually within the informal market could be in the order of 560,000 m^3 and the total volume of lumber produced in the order of 230,000 m^3. This estimated log volume is equivalent to approximately 17% of the total logs exported from PNG in 2017 (SGS 2018).

Table 7.3: Assumptions used to estimate size of the informal market

Mill operator production	Number of mills	Daily lumber output (m^3)	Annual days of operation	Annual lumber output (m^3)	Recovery rate
Low	1,000	1.0	50	50	35%
Low-moderate	1,000	1.5	67	100	40%
Moderate	100	1.5	200	300	45%
High	100	2.0	250	500	50%

Table 7.4: Estimated size of the informal market (m^3 of log input and m^3 of lumber output)

Mill operator production	Total log inputs (m^3)	Total lumber outputs (m^3)
Low	142,857	50,000
Low-moderate	250,000	100,000
Moderate	66,667	30,000
High	100,000	50,000
Total	559,524	230,000

A non-participant stakeholder employed by a portable sawmill distributor indicated that portable sawmills are evenly purchased by businesses, families, and politicians. An additional twelve non-participant stakeholder interviewees corroborated that donations to FROs by politicians are a common way that that FROs and communities receive portable saw mills. We were told that funding for these donations typically originated from Provincial and District Services Improvement Programme (PSIP) and (DSIP). The PSIP fund annually allocates five million Kina to each of the provinces. The fund is managed by the Joint Provincial Planning Budget Priority Committees, which are typically chaired by the governors of the provinces (Howes et al. 2014). The DSIP fund annually allocates ten million Kina to each of the 89 electorates in PNG and are managed by the Joint District Planning Budget Priority Committees, which are typically chaired by the Members of Parliament of the electorate or district (Howes et al. 2014). We found 14 newspaper articles to corroborate this finding (National 2012, 2013a, 2013b, 2014a, 2014b, 2014c, 2014d, 2014e, 2015a, 2015b, 2016a, 2016b, 2016c and Muri 2014).

According to these articles, more than 87 portable mills were gifted by politicians between years 2012 and 2016. Approximately 85% of the articles said that the primary purpose of the donations was for the construction of homes. Secondary purposes were for additional income generation and the construction and maintenance of churches, classrooms, aid posts, bridges, and police houses. Interviews with non-participant stakeholders revealed that the donation of mills by politicians can sometimes be used as a political bargaining tool, with mill donations contingent on the politician receiving enough votes to win an election. Our non-participant stakeholders explained to us that the portable sawmill distributors in PNG are not regulated and can sell mills to anyone able to pay for them. As such, they are enabling the growth of the informal market.

7.3.7 Cost and revenues paid/received by informal market participants

The greatest value-adding for all species occurred in the fourth stage after the rough-sawn lumber was further processed (Table 7.5). The species with the highest price paid at all stages of the value-chain was *Intsia bijuga*. Our comparative analysis between the prices paid and cumulative production cost of T&G flooring indicates that prices paid to FROs at the second stage of the value chain are quite low, but then experience substantial growth at the third and fourth stages of the value-chain. At stage two, the average price paid was 61% less than production costs, but in stages three and four the prices paid were 56% and 522% larger than the cumulative production costs (Figure 2). The substantial increase in price paid relative to cumulative cost of production at the fourth stage of the value-chain highlights the potential profitability that the manufacturing businesses gain by making investments in additional processing equipment.

We found that the stumpage prices paid to FROs for *Intsia bijuga* is equivalent to a timber resource rent of 9% of the formal export market value based on log export market data produced by SGS (2018). The SGS (2018) data indicated that the average export value of an *Intsia bijuga* log was 772 PGK per m^3 in 2017. By comparison, we estimated that an equitable timber resource rent would be approximately 36% of the formal market value. The logging cost analysis by FORTECH (1998) estimated that the average total logging cost (includes operations, camps/head office, overhead, and export taxes), was \$108 per m^3 (expressed in 1997 USD) (FORTECH 1998). The average export value of non-coniferous tropical round-wood in PNG in 1997 was \$168 per m^3 (expressed in 1997 USD) (ITTO 2018). If the FROs had been paid the equivalent of 36% of the formal market value for *Intsia bijuga* harvested and milled on their lands, the price received for rough-sawn lumber would have been approximately 618 PGK per m^3 rather than 150 PGK per m^3, which is a more equitable distribution of timber resource rents across the value-chain (see Figure 7.2).

Table 7.5: Comparison of value by product/species at various stages of the value-chain (PGK per m^3)

Value-chain stage	T&G flooring (*Intsia bijuga*)	Treated moulding (Mixed hardwoods)	Treated structural lumber (Mixed hardwoods)	Treated weatherboard (Mixed softwoods)
Log standing on the stump	78	33	33	22
Lumber at harvest site	500	450	450	450
Lumber delivered to business	1,058	750	750	750
Finished product at business	4,702	3,352	2,133	2,667

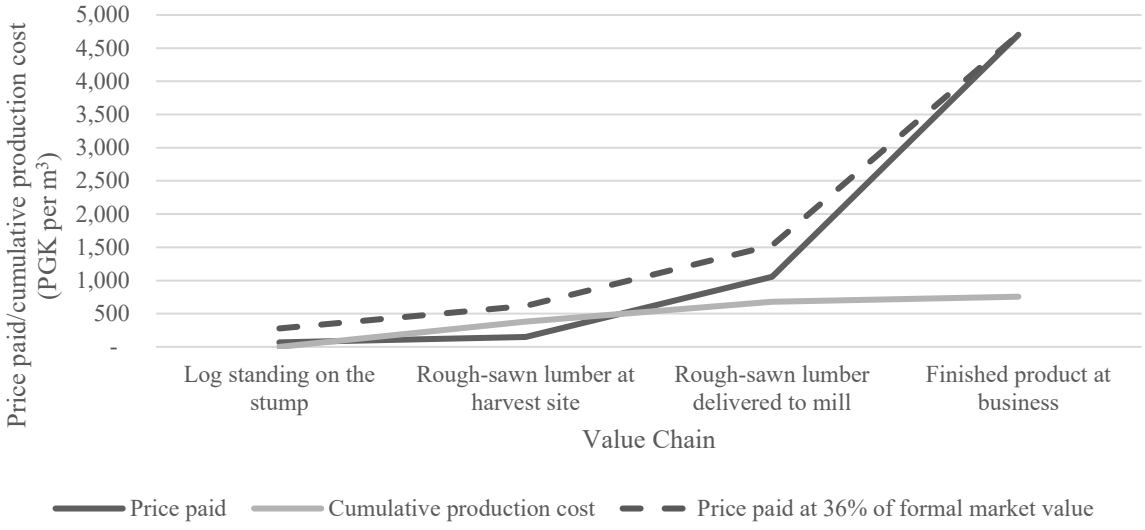

Figure 7.2: Comparison of price paid and cumulative production cost of *Intsia bijuga* T&G flooring at different stages of the value-chain (PGK per m^3)
Note: The PGK to USD exchange rate is 0.2970.

7.4 Discussion

Our findings suggest that there is a large informal market for timber from small-scale harvest activities in PNG, comprising around 17% of current round wood exports. We found that the FROs sell their timber to access cash to pay for immediate needs that occur throughout the year. This is collaborated by a technical report on the legality of small-holder timber production in PNG, which indicates that FROs view their forests as automatic teller machines (ATMs) and make withdraws (sell timber) when they have immediate financial needs such as school fees (Jenkins 2016). The existing forest policies state that FROs can harvest up to 500m^3 per annum without a harvest permit for non-commercial personal needs, implying that personal needs never require monetary transactions. We determined that informal market timber sales are indeed commercial activities conducted to fund the personal needs of FROs that can only be acquired through cash payments.

The current informal market distribution of resource rents is skewed to the latter stages of the value-chain, resulting in an inequitable share of timber resource rents to FROs. The timber resource rents of 9% received by FROs is slightly better than the rents being paid to FROs through fixed-rate royalties by industrial-scale logging companies, which averaged 5% of the formal export market value in 2017 (Scudder et al. 2019a). However, our analysis indicates that this is not an equitable distribution of the timber resources rents, with the bulk of the timber value having been captured by the small-scale manufacturing businesses. Based on our interviews of the informal market participants, we surmised that the informal market rough-sawn lumber prices paid to FROs are based on the existing formal market fixed-rate timber royalties set by the government. If the formal market fixed-rate royalties are not increased it is unlikely that the informal market prices paid to FROs will increase much above the current rates.

The ambiguous government regulations discussing the legal requirements and definition of 'commercial activities' for timber harvests less than 500 m^3 per annum creates a question of informal market participant legality, which is an impediment to the economic development of the small-scale forest products market in PNG. Most of the sawmill owners are unable to finance the purchase of machining equipment and therefore are not able to realize the gains in profitability being captured by the small-scale manufacturing businesses. The question of legality caused by the ambiguous regulations makes it difficult for informal market operators to obtain outside financing, which is a problem that has been identified in forest product informal markets throughout the world (Hoare 2016). A financial analysis of portable sawmill operations in PNG by Scudder et al. (2019b) found that the operational costs per unit of lumber typically exceeded the per unit lumber sales prices for most tree species, highlighting the importance of additional processing. If more saw millers could incorporate further processing of the rough-sawn lumber, the competition within the small-scale manufacturing businesses would increase. In the absence of increased competition, it is unlikely that the true value of the FRO's timber will be recognized, allowing FROs to receive larger per unit payments for their timber. In addition, since most of the sales transactions have been out of view of the PNG government, values normally paid to the government in the form of taxes has not occurred.

The current TA harvest permit system does not meet the needs of the FROs, portable saw-millers, and manufacturing businesses because it does not match the size of harvests being conducted or the immediate monetary needs of the FROs. The volume of logs typically harvested with the portable sawmills is substantially smaller than the TA allotment of 5,000 m^3. The performance bond regulations of the TA are an additional hindrance to most informal market operators because they do not have the financial means to adhere to them. The time required to plan for a TA and get it approved by the government can take several months, which does not fit with the FROs planning timeframe, which is usually dictated by the immediate need for cash. In addition, the revenues that FROs would receive

from a timber harvest using a TA permit would be much larger than their immediate cash needs. For example, if 5,000 m^3 were harvested and the average payment per m^3 of log was 15 Kina, the total payment would be 75,000 Kina. Only 15% of the population in PNG has a bank account (Bakani 2018). In the absence of a bank account, the majority of FROs do not have a safe place to store their cash. Furthermore, the FROs would have to wait for the forest to regrow before they could conduct another harvest for their cash needs.

During data collection interviews in May 2018, we were made aware that the PNG government is planning to ban all log exports by year 2020. This was corroborated by non-participant stakeholders and a recent newspaper article, which describes the reason for the ban being to promote increased processing and jobs within the country (National 2018). Approximately 90% of all logs harvested legally in PNG are exported (PNGFA 2009), with logs exports in 2017 estimated to be 3.1 million m^3 (SGS 2018). If the government follows through with the log ban, then either future log harvests will dramatically decline from present levels, or there will need to be a substantial increase in domestic processing businesses. A review of the PNG Forest Industries Association (PNGFIA) membership listing and the PNG business directory, indicates that there are 28 fixed-site sawmills in PNG, one plywood manufacturer, one woodchip manufacturer, and eight furniture manufacturers (PNGFIA 2010, PNGDL 2015). Data collected from (ITTO 2018), indicates that in 2016, PNG manufacturers produced approximately 82,000 m^3 of sawn wood, 29,000 m^3 of plywood, and 62,800 m^3 of veneer. This indicates that if the log export ban occurs, the existing domestic processers will not have the operational capacity to process the log volumes that were historically destined for export. Two of the small-scale manufacturing businesses that we spoke with believed that the log export ban would be good for their businesses and had begun to position themselves for increased production. However, FROs will likely face increased competition and reductions in prices received if a glut in logs overwhelms the formal and informal markets. A further reduction in timber resource rents to FROs would further exacerbate the already skewed rent distributions.

Our results suggest a need for revising the existing small-scale timber harvest permits and increased governmental assistance provided to small-scale wood product processors. We estimated that 90% of the informal market operators harvest less than 500 m^3 annually and the remaining 10% of operators harvest between 500 m^3 and 1,000 m^3 annually. However, these harvests occur at multiple sites and are unlikely to ever exceed 500 m^3 per site. Therefore, we recommend that forest policies be revised to include a new small-scale harvest permit of 500 m^3 per site per annum. We also recommend that the performance bond requirements be adjusted to 2,000 Kina to reflect the change in harvest volume. This change in the performance bond amount maintains the ratio of required Kina per m^3 harvested in the existing TA harvest permit performance bond. Furthermore, recommend that the formal market timber royalty payments to FROs be revised to reflect a fair distribution of timber resource rents. We suggest

that timber royalties be revised for all existing timber harvest permits and applied to our recommended small-scale timber harvest permit (see Scudder et al. 2019a).

Our research has also revealed that there is a need for additional support, such as forest management plans, harvest plans, disbursement of market data (prices, lumber species and dimensions), sawmill training, training for further processing, and channels to access financing. This type of assistance is typically provided by extension foresters. Funding for extension forestry could be provided by fees or levies linked to a new small-scale harvest permit. Towards the end of our data collection, we began to ask FROs and portable sawmill operators their viewpoint on paying a fee/levy for a small-scale harvest permit that would legalize their operations and take them out of the informal market. Their responses indicated that they would be willing to pay a fee, if it resulted in additional government support that would improve their productivity and profitability.

7.5 Conclusion

The existing small-scale timber harvest permit regulations provided disincentives for the FROs, and saw millers, and small-scale manufacturing businesses to operate within the law and to contribute substantially to the formal PNG economy. FROs chose to participate in the informal small-scale forestry market to acquire money for immediate financial needs that did not match the time-line of the TA process. The size and duration of the harvests conducted by portable saw-millers was typically dictated by the economic situation of the FROs rather than the TA harvest permit regulations. We recommend that forest policies be revised to include a new small-scale harvest permit (500 m^3 per site per annum), along with improved timber royalty rates for FROs. We also recommend that additional assistance be provided by the government extension foresters to aid in the sustainable development of small-scale wood product processing businesses.

Chapter Eight

Discussion and Conclusion

8.1 Introduction

The purpose of this thesis was to address the following research problem; What is the best approach to small-scale native forest management in PNG to improve forest landowner livelihoods?' The following four subsidiary research questions were developed and addressed in separate manuscripts which have either been published or currently under review.

1) Is the eco-forestry management model a viable option for small-scale native forest management in PNG?
2) Are portable sawmills a financially viable option for economic development in tropical forests?
3) Do timber royalties provide an equitable distribution of forest resource rents to FROs?
4) How does the forest products informal market in PNG function and why do participants choose to operate in this market?

This chapter reviews the findings of the four subsidiary research questions discussed in chapter one and provides recommendations that address the main research question of the thesis. In section 8.2, the factors that led to the failure of eco-forestry are discussed. In section 8.3, the key requirements for achieving successful portable sawmill operations are presented. Section 8.4 explains the inequitable distributions of timber royalties. Section 8.5 reviews policy revisions to improve the legality of the informal market. Section 8.6 provides recommendations for future small-scale native forest management in PNG to improve FRO livelihoods. The thesis conclusion is in section 8.7. Section 8.8 discusses future research needs.

8.2 Eco-forestry is not a Viable Management Option for Small-scale Native Forest Management[13]

The objective of research question one was to determine if the eco-forestry management model is a viable option for small-scale native forest management in PNG. The research found that the eco-forestry model for small-scale native forest management has failed. This model was based on Indigenous communities using portable sawmills to produce sustainably certified rough-sawn lumber for export. The research found that this approach to small-scale forestry was not financially viable in the long-run despite massive subsidization by the NGOs. The Indigenous communities did not possess

[13] Scudder, M.G., Herbohn, J., & Baynes, J. (2018). The Failure of eco-forestry as a small-scale native forest management model in Papua New Guinea. Land Use Policy 77: 696-704.

the required milling and business capacities for meeting the quantity and quality production targets necessary for financial viability. The eco-forestry organisations assumed that quantity targets could be met by increasing the number of portable sawmill operations. This ultimately over-extended the eco-forestry organization's ability to provide adequate facilitation services to the portable mill operators. The research found that increasing the number portable sawmills is not an efficient approach for increasing economies of scale, because modern industrial-scale sawmills are able to produce the same products at lower costs. The author determined that future portable sawmill operations in PNG should re-focus to serve domestic markets. Furthermore, future portable sawmill operators should complete necessary training prior to implementing commercial milling activities. In addition, harvesting and milling projects should be assessed for financial feasibility prior to implementation to filter out non-viable projects.

8.3 Key Requirements to Achieve Financial Viability with Portable Sawmills[14]

Research question two was closely linked with to research question one and was focused on discerning if portable sawmills are a financially viable option for economic development in tropical forests. The research results revealed that using portable sawmills to produce rough-sawn lumber is highly unlikely to be financial viable if an even distribution of the trees at the harvest site were milled. The variable processing costs of portable sawmills are very high relative to the average sales prices of rough-sawn lumber. During the analysis, the author discovered that only a small selection of timber species had per unit sales prices that were greater than the per unit production costs. This finding illustrated that the species composition of the harvest site was a critical factor for achieving financial viability. The high level of species diversity of PNG's forests emphasized the importance of harvest site selection. Harvest site selection was also affected by the distance to market due to high lumber transportation costs.

The research also discovered that maximizing daily log input and A grade lumber recovery were also critical factors for achieving financial viability with portable sawmills. The advent of a desired timber species composition at the harvest site did not guarantee financial viability. This finding highlighted the importance of competency-based training for small-scale timber harvests and portable mill operations. This factor was also identified while addressing research question one as a crucial un-met component that led to the failure of the eco-forestry organizations.

[14] Resubmitted to the journal of Forest Policy and Economics.

8.4 Timber Royalties Have Not Provided an Equitable Distribution of Resource Rents[15]

Research question three addresses the issue of whether the timber royalties provided an equitable distribution of forest resource rents to FROs. The results show that that the FROs received little compensation for the timber harvested on their lands, which averaged just 6% during the last decade. Almost all the value (94%) has been captured by the government and the logging industry. Furthermore, the real value of the fixed-rate royalties has been substantially eroded by the inflation. The log export duties collected by the government were calculated with a progressive tariff rate based on the FOB value of the logs. If the royalties to FROs had been calculated based on a percentage of the FOB value (8% to 20%), the FROs would have received between $267 and $668 million (real 2017 USD) in additional royalties. Unfortunately, it was not possible to determine if increased royalty rates would have caused a decline in timber harvests due to the absence of accurate logging cost and log price data. During the last decade, the PNG government has collected an average of 42% of the log values through export duties and levies. From this amount, it would have been possible to re-allocate increased royalty payments to FROs. The author also found that a side effect of the fixed-rate royalties was the formation of an informal market, made up of small-scale participants operating outside of the forest policy regulations.

8.5 Addressing informal market legality through policy revision[16]

The final research objective of this thesis was to identify how the informal market functioned and why participants chose to operate within the market. The author determined that the root cause of the informal market is the existing forest polices, which were unsuitable to the needs of the small-scale forest management operators and FROs. The existing small-scale harvest permits were designed for industrial-scale logging operations and were not the appropriate scale for the small-scale harvests that were conducted by portable sawmill operators. The research results demonstrate that that FROs sold their timber to informal market operators for immediate cash needs. These immediate cash needs also did not fit the time-line for the existing small-scale harvest permits that took several months to receive government approval and lasted one year in duration. The research also found that small-scale wood product manufacturers operating in the informal market have captured most of the value of the harvested timber relative to the FROs and portable sawmill operators that only produced rough-sawn lumber. Most of the portable saw millers had not been able to acquire the financing necessary to purchase equipment that would have allowed them to process the products beyond rough-sawn lumber. One of the factors that hindered the financing of these operators is the illegal nature of the informal market. The FROs inability to capture a larger share of the timber value was similar to the findings of research

[15] Scudder, M.G., Baynes, J., and Herbohn, J. (2019). Timber royalty reform to improve the livelihoods of forest resource owners in Papua New Guinea. Forest Policy and Economics 100: 113-119.
[16] Under review with the journal of Land Use Policy.

question three. The implication of this analysis was that the small-scale timber harvest policies should be revised to accommodate the actual operations that have occurred.

8.6 Small-scale forest management recommendations for improving FRO livelihoods

The research conducted for this thesis identified several challenges experienced during past small-scale native forest management activities in PNG. The best approach for future management that improves the livelihoods of FROs will require addressing these challenges. Mitigating these challenges will necessitate; improved land use planning by FROS; FROs receiving a greater distribution of the forest resource rents from timber harvested on their lands; increasing the market knowledge of FROs and portable sawmill operators (e.g., log values and timber species/product types demanded by construction markets); and increasing the number of small-scale manufacturers that process wood products beyond rough-sawn lumber. The following four recommendations are made:

1) *Revise forest policies to require timber royalty payments to be changed to the greater of either the minimum fixed-rate as set by the Forest Minister, or to a percentage of FOB market value, as reported by Sociele Generale de Surveillance.* The research conducted for this thesis identified that FROs have received an inequitable share of the forest rents from industrial logging companies and from the small-scale informal market operators. In both cases, the market value of the harvested timber is substantially higher than the amounts paid to FROs in the past.

2) *Revise forest policies to address small-scale harvest permits to reflect the scale and duration of small-scale timber harvests being conducted by portable sawmill operators.* The introduction of a harvest permit that matches the operational activities of informal market operators would give these operators the opportunity to shift their operations into the legal formal market. Improving the legality of these operators would improve access to financing for the purchase of equipment to further process the rough-sawn lumber.

3) *Explore opportunities for an extension forestry programme to serve the small-scale forestry market.* In the past, government foresters have focused their activities on harvests conducted by the industrial-scale logging companies. NGOs have previously provided forest management support to FROs, but most them have ended their operations due to inadequate funding. The TFTC does provide some forest management and portable sawmill training to FROs, but they are limited in the scope and scale of extension forestry support that they can provide, due to limited funding. The need for extension foresters at the small-scale level is three-fold:

a. *Assisting FROs in the development of forest management plans.* There is a need for trained foresters to assist FROs in developing management plans that reflect FRO interests and values, are environmentally sustainable, and financially viable to implement. The eco-forestry organizations were successful in developing procedures for creating management plans for Indigenous communities. This work could be built on to develop systems for evaluating the financial viability of timber harvests prior to implementation. The complexities that can exist with customary land ownership should be addressed when developing the management plans. This should include the identification of user rights and obligations at the group level and individual level, as well as using a process for building consensus among the FROs that builds on the existing social relationships within the forest site.

b. *Provide FROs with accurate knowledge of timber values and connect FROs with trained, experienced, and legal small-scale timber harvesters.* Increased knowledge of fair market values and linking FROs to verified legal and capable timber harvesters would allow FROs to acquire a greater distribution of forest resource rents. Having their services marketed to FROs would also incentivise portable sawmill operators to work within the formal market.

c. *Provide capacity development training/workshops to FROs, sawmill operators, and manufacturing businesses.* There is a need for improved operational capacities by all small-scale forest market participants. Capacity development needs include; management planning; wood product market knowledge; reduced-impact-logging (RIL) techniques; improved operational efficiencies in harvesting, milling, processing; and fiscal management. Capacity development focused on improved fiscal management should address the challenge of re-investing profits back into a business while continuing to meet wontok obligations. Further research is needed to understand how both of these needs can be met without negatively impacting on the other.

Multiple options exist for administering and funding an extension forestry programme in PNG. Administration options include the PNGFA, other public institutions similar TFTC, small-scale forestry focused NGOs, or combination of the three. Funding options include a re-allocation of government funds collected from export log duties and levies, international publicly funded aid grants, and private donations to finance NGO efforts to support extension forestry. Further research is needed identify the scope and scale of potential forestry extension opportunities.

4) *Enact forest policies that develop government-backed financial lending programs for small-scale forestry operators that have demonstrated adequate operational competency.* There is a need for increased small-scale wood product manufacturing businesses, which will require financing for operators to purchase new equipment. Some examples of adequate operational competency are completed training programs with valid certificates, validated operational hours of equipment use, an approved businesses plan, and legal forest industry participant (FIP) verification. The TFTC has been the primary option for portable mill and value-add processor training in PNG. Training is provided for students at TFTC, in the city of Lae, and at alternative sites for large groups when arranged with TFTC staff.

Addressing the above recommendations should greatly improve the way that small-scale native forest management is undertaken in PNG, resulting in better forest landowner livelihoods. FROs would gain assistance from trained foresters to develop forest management plans that reflect their interests, values, social relationships, and land use rights/obligations. All timber harvests and portable milling operations would be pre-assessed for financial viability and conducted by trained operators. Revisions to forest policy would allow for a greater number of saw millers to expand into additional wood processing activities. Increased competition in the small-scale wood processing market and revisions to timber royalty rates would allow for FROs to capture a greater portion of resource rents from timber harvested on their lands. In locations where timber harvests and milling are determined to be financial unfeasible, lumber would only be milled for FRO homes and other community buildings. Profit generating activities for these locations would be focused on generating revenue from non-timber forest products.

If these recommendations are not adopted, it is likely that the current approach to small-scale forest management will continue. The majority of small-scale timber harvests would likely occur in the informal market, with the small-scale manufacturers capturing most of the timber value relative to the FROs. If the government moves forward with a log export ban, it is expected that informal market will experience a glut of logs formerly destined for the export market, which will result in FROs receiving reduced prices for their timber. It is also probable that timber harvests would continue to focus on small selection of species currently desired by the market until all accessible areas have been harvested.

8.7 Conclusion

In the past, forest management in PNG has focused on large-scale timber harvests for log exports to achieve economic growth. There was an interest in identifying small-scale native forest management models that could provide greater benefits to FROs than they had received from the timber harvests conducted by industrial logging companies. The small-scale management model that had been primarily practiced in the past was eco-forestry, but the effectiveness of this approach was unknown.

The objective of this research was to identify the best approach to small-scale native forest management in PNG to improve FRO livelihoods.

The research undertaken as part of this thesis found that the current eco-forestry management model was not successful. This model ultimately failed because it was not financially viable, and the indigenous participants were not able meet the quality and quantity lumber production targets. This research found that using portable sawmills in tropical forests is could be financially viable if trained operators were used and only high-value timber species were harvested and milled. However, only a small selection of timber species were determined to be financially viable and tropical forests have a high level of timber species diversity. If saw millers continue to only harvest these species it is likely that the forest will continue to be high-graded until all the accessible high-value trees have been removed. The research found that this challenge could be mitigated if the portable saw millers harvested additional lesser-known species and further processed the rough-sawn lumber to produce products with higher value. Most of the saw millers operate within the informal market, which is not technically legal and impedes their ability to access financing. Revisions to the existing forest policy harvest permits that allow these saw millers to become legal operators could mitigate the financing challenge. Revising forest policies to improve the timber royalty rates could increase the portion of timber revenues collected by the FROs. Making these changes would be substantially improve small-scale native forest management in PNG.

8.8 Future research requirements

Two areas were identified as needing further research. The marketing of the applicability of lesser-known timber species is needed to reduce the potential of over-harvesting a small selection of timber species. During the addressment of research questions two and four, it became evident to the author that past small-scale timber harvests have primarily focused on a small selection of timber species. The cause has been high market demand for these species that has resulted in these timber species receiving the highest per unit rough-sawn lumber prices in the small-scale timber markets. Most of the lesser-known species received per unit rough-sawn lumber prices that were lower than the variable portable sawmill production costs. Identifying alternative timber species with similar product applicability and disseminating the market knowledge should be pursued to reduce the harvesting pressure of the most desire species.

Additional research is also needed in identifying opportunities for improving the cost-accounting management of small-scale forestry market operators. During the addressment of research questions one, two, and four, it became evident that there is limited knowledge of cost-accounting practices among the majority of the small-scale forest market participants. Most of the participants had received minimal

formal education and little to no training in personal fiscal management. Identifying simple cost-accounting methods for timber harvesting and processing activities that could be taught to small-scale forest market operators will improve the profitability of these market participants and help to reduce the implementation of timber harvest projects that are not financially viable.

References

Amacher, G. S., E. Koskela and M. Ollikainen (2007). "Royalty reform and illegal reporting of harvest volumes under alternative penalty schemes." *Environmental and Resource Economics* 38(2): 189-211.

Ascher, W. (1998). "From oil to timber: The political economy of off-budget development financing in Indonesia." *Indonesia* (65): 37-61.

Bakani, L. M. (2018). Bank of Papua New Guinea Quarterly Economic Bulletin, September Quarter 2017. Port Moresby, Bank of Papua New Guinea. Retrieved on 29/8/2018 from: https://www.bankpng.gov.pg/media-releases/

Baynes, J., J. L. Herbohn and W. Unsworth (2017). "Reforesting the grasslands of Papua New Guinea: The importance of a family-based approach." *Journal of Rural Studies* 56: 124-131.

Bird, N., A. Wells, F. V. Helden and R. Turia (2007). What can be learnt from the past? A history of the forestry sector in Papua New Guinea. London, Overseas Development Institute.

Bouscaren, D. (2018). In Papua New Guinea's Sorcery Wars, A Peacemaker Takes on Her Toughest Case. National Public Radio. Washington DC. Accessed on 30/11/18 from: https://www.npr.org/sections/parallels/2018/05/24/612451247/in-papua-new-guineas-sorcery-wars-a-peacemaker-takes-on-her-toughest-case

Boyatzis, R.E. (1998). Transforming Qualitative Information, Thematic Analysis and Code Development. Thousand Oaks, Sage Publications.

BPNG (Bank of Papua New Guinea) (2018). Retrieved 3/1, 2018, from https://www.bankpng.gov.pg/.

Britannica. (2018). "Papua New Guinea." 2018. Encyclopedia Britannica, Inc. Accessed on 21/9/2018 from: https://www.britannica.com/place/Papua-New-Guinea

Bun, Y. and B. Bazakie (2006). Community Forestry Benefits Customary Landowners: Case Study on Madang Province Papua New Guinea. Port Moresby, Papua New Guinea, Foundation for People and Community Development.

Bun, Y. A. and H. Scheyvens (2007). Forest Certification in Papua New Guinea. Progress, Prospects and Challenges. Kanagawa, Japan, Institute for Global Environmental Strategies: 26.

Bun, Y. (2012). Current forestry laws do not allow Papua New Guineans to develop their own forest resources. Port Moresby, Foundation for People and Community Development Inc.: 8.

Boyatzis, R.E., 1998. Transforming qualitative information. Thematic Analysis and Code Development. Sage Publications, Thousand Oaks.

CBD (Convention on Biological Diversity) (2000). The 12 Principles of the ecosystem approach and their rationale. Convention on Biological diversity. Retrieved on 02/10/2017 from: https://www.cbd.int/cop/.

Charnley, S. and Poe, M.R. (2007). Community forestry in theory and practice: where are we now? *Annual Review of Anthropology* 36: 301-336.

CIA (Central Intelligence Agency). (2018). CIA World Factbook, Papua New Guinea. Accessed on 21/9/2018 from: https://www.cia.gov/library/publications/the-world-factbook/geos/pp.html

Chatterton, P., Bun, Y., Hunt, C., Whimp, K. and Eddowes, P. (2000). A future for our forests, Strategies for community-based forstry and conservation in Papua New Guinea. Fiji, World Wildlife Fund.

Dauvergne, P. (1999). "Corporate power in the forests of the Solomon Islands." *Pacific Affairs* 71(4).

Dayananda, D., Irons, R., Harrison, S., Herbohn, J., and Rowland, P. (2002). Capital Budgeting, Financial Appraisal of investment projects. Cambridge, United Kingdom, Cambridge University Press.

Denham, T., S. Haberle and C. Lentfer (2004). "New evidence and revised interpretations of early agriculture in Highland New Guinea." *Antiquity* 78(302): 839-857.

Denham, T. (2011). "Early Agriculture and Plant Domestication in New Guinea and Island Southeast Asia." *Current Anthropology* 52(S4): S379-S395.

DFAT (Department of Foreign Affairs and Trade) (2015). Promoting effective governance in Papua New Guinea. Australian Government, Canberra. Retrieved on 16/11, 2018 from: https://dfat.gov.au/geo/papua-new-guinea/development-assistance/Pages/governance-assistance-png.aspx

DOE (Department of Education). (2012). Report on the implementation of the Tuition Fee Free Policy. Port Moresby, Department of Education.

DOE (Department of Education) (2016). National Education Plan 2015-2019. Port Moresby, Department of Education.

Drescher, J. (1997). The Economics of Ecoforestry. Ecoforestry, The Art and Science of Sustainable Forest Use. A. Drengson and D. Taylor. Stony Creek, CT, USA, New Society Publishers.

Ducenne, Q. and Rollinson, S. (2005). End of Mission Report. Lae, Papua New Guinea, PNG Eco-forestry Programme.

EFP (Eco-forestry Programme) (2003). Annual Report 2002. Lae, PNG Eco-forestry Programme.

EFP (Eco-forestry Programme) (2004). Annual Report 2003. Lae, PNG Eco-forestry Programme.

EFP (Eco-forestry Programme) (2005). Annual Report 2004. Lae, PNG Eco-forestry Programme.

Ericho, J., Nigints, R. and Barcham, R. (2013). External Evaluation of FORCERT, FORCERT, Forest Management & Product Certification Service. Internal Report.

EU-IRECDP (European Union-Islands Region Environmental and Community Development Programme) (2001). End of Programme Report. Kimbe, West New Britain, European Union Islands Region Environmental and Community Development Programme.

FAO (2000). Papua New Guinea Country Report. FAO Workshop Data Collection for the Pacific Region. Apia, Samoa, FAO Forestry Department. Collected on 3/09/2017 from: http://www.fao.org/docrep/006/AD672E/ad672e00.htm#TopOfPage

FFB (Fiji Forest Bill) (2016). Forest Bill 2016. Parliament of the Republic of Fiji. Suva.

Filer, C. and N. Sekhran (1998). Loggers, donors and resource owners. Policy that works for forests and people series no. 2. J. Mayers. London, International Institute for Environment and Development.

Fingleton, J., M. Bourke, M. Mosko, C. Lightfoot and R. Fisher (2005). Privatising Land in the Pacific, A defence of customary tenures. Discussion Paper Number 80.J. The Australia Institute, Canberra.

Fisher, R. (1994). Indigenous Forest Management in Nepal: Why Common Property is Not a Problem. International Conference on the Anthropology of Nepal, Kathmandu, Mandala Publications.

FORCERT (2015). Strategic Plan 2015-2019, FORCERT, FORCERT Forests for Certain: Forests for Life! Internal Report.

FPCD (Foundation for People and Community Development). (1995) The 1993 Papua New Guinea Portable Sawmill Survey, Report presented to PNG Forest Authority. NCD, Papua New Guinea.

FPCD (Foundation for People and Community Development) (2005). Eco-forestry portable mill operator photograph. Madang, FPCD.

FPCD (Foundation for People and Community Development) (2006a). Forest Management Plan for Awane Forest Management Area. Madang, FPCD.

FPCD (Foundation for People and Community Development) (2006b). Forest Management Plan for Niat Forest Management Area. Madang, FPCD.

FPCD (Foundation for People and Community Development) (2006c). Forest Management Plan for Yate Forest Management Area. Madang, FPCD.

FPCD (Foundation for People and Community Development) (2007). Forest Management Plan for Dawen Forest Management Area. Madang, FPCD.

FPCD (Foundation for People and Community Development) (2011). Forest Management Plan for Malas Forest Management Area. Madang, FPCD.

Forbes. (2018). "2018 Malaysia's 50 Richest Net Worth, #16 Tiong Hiew King." Accessed on 9/9/2018 from: https://www.forbes.com/profile/tiong-hiew-king/#258c7cf81fb0

Forestry Act (1991). Papua New Guinea Forestry Act. Port Moresby.

FORTECH (Forestry Technical Services Pty Ltd) (1998). Marketing of Papua New Guinea Forest Products Final Report. Canberra, Dames & Moore Company.

Fox, J.C., Keenan, R.J., Saulei, S., Nimiago, P., Lavong, K. and Inude, F. (2011). Assment, management and marketing of goods and services from cutover native forests in Papua New Guinea. Canberra, Australia, Australia Centre for International Agricultural Research: 43.

FSC (Forest Stewardship Council) (2010). Forest Stewardship Council National Forest Management Standards for Papua New Guinea, Version 1.1 May 2010. Retrieved on 15/06/2016 from: http://ic.fsc.org/download.fsc-png-national-standards-v1-1-04-10-approved-0510.269.htm.

Gesch, P.G. (2007). Working Out of Two Mindsets: Critical Methodology and PNG Village Traditional Ways. Contemporary PNG Studies: *DWU Research Journal* 7: 17-34.

Gilmour, D. (2016). Forty years of community-based forestry, A review of its extent and effectiveness. FAO Forestry Paper 176. Rome, Food and Agriculture Organization of the United Nations.

Greenpeace (2006). Rimbunan Hijau Group: Thirty Years of Forest Plunder. Forest Crime File. Amsterdam, The Netherlands, Greenpeace International.

Gosarevski, S., H. Hughes, and S. Windybank. (2004a). "Is Papua New Guinea viable?" *Pacific Economic Bulletin* 19(1): 134-148.

Gosarevski, S., H. Hughes, and S. Windybank. (2004b). "Is Papua New Guinea viable with customary land ownership?" *Pacific Economic Bulletin* 19(3): 133-136.

Gray, J. (1983). Forest Revenue Systems in developing countries, Forestry Paper 43. Food and Agricultural Organization of the United Nations, Rome.

Grigoriou, J. (2011). Production and supply options for community forest enterprises in Papua New Guinea. Canberra, Australia Centre for International Agricultural Research: 40.

Grigoriou, J. (2015). From Little Things, Big Things Grow; The Business for a PNG Community Forest Enterprise, Foundation for People and Community Development.

Grynberg, R., D. Wigston and S. R. Vemuri (1988). "Transfer pricing and trade malpractice in the Papua New Guinea (PNG) log export industry." *Journal of Interdisciplinary Economics* 2(3).

Hammond, H. (1997). "What is ecoforestry?" Global Biodiversity 7(2): 3.

Hardin, G. (1968). “The Tragedy of the Commons.” *Science* 162: 1243-1248.

Harrison, S.R. and Herbohn, J.L. (2017). Financial evaluation of forestry investments: Common pitfalls and guidelines for better analysis. Small-scale Forestry 15(4): 463-479.

Hoare, A. (2016). Improving Legality Among Small-Scale Forest Enterprises, The Role of National-Level Indicators Within the Sustainable Development Goals. Energy, Environment and Resources. London, Chatham House. Retrieved on 10/11, 2017, from: https://www.chathamhouse.org/publication/improving-legality-among-small-scale-forest-enterprises-role-national-level-indicators

Holzknecht, H., Ryde, J., Kanowski, P., Sairusi, B., Groves, K. and McGregor, A. (2012). A review of the use of portable sawmills in Papua New Guinea and Solomon Islands. T. Bartlett, Australian Centre for International Agricultural Research.

Howes, S., A. A. Mako, A. Swan, G. W. Walton, T. Webster and C. Wiltshire (2014). A Lost Decade? Service Delivery and Reforms in Papua New Guinea 2002-2012. Canberra, The National Research Institute and Development Policy Centre, Australian National University.

Hughes, H. (2003). “Aid has failed the Pacific.” Issues Analysis, No. 33, Centre for Independent Studies, Sydney.

Hughes, H. (2004a). “Can Papua New Guinea Come Back from the Brink?” Issues Analysis, No. 49, Centre for Independent Studies, Sydney.

Hughes, H. (2004b). “The Pacific is Viable!” Issues Analysis, No. 53, Centre for Independent Studies, Sydney.

Humphries, S., Holmes, T.P., Kainer, K., Koury, C.G.G., Cruz, E., and Rocha, R. de M. (2012). "Are community-based forest enterprises in the tropics financially viable? Case studies from the Brazilian Amazon." *Ecological Economics* 77: 62-73.

Hunt, C. (2000). Marketing Eco-Timber in Papua New Guinea. Developing Policies to Encourage Small-Scale Forestry, Kuranda, Australia, IUFRO Research Group.

Hunt, C. (2002). Economic benefits of forest certification. Production, privatisation and preservation in Papua New Guinea Forestry. C. Hunt. London, International Institute for Environment and Development: 75-92.

Incorporated Land Group Act. (1974). Papua New Guinea Incorporated Land Group Act. Port Moresby.

ITSGC (ITS Global Consultants) (2006). The World Bank and Forestry in PNG, Report for Rimbunan Hijau (PNG) Group. Melbourne, ITS Global – Consultants on Global Issues.

IRC (Internal Revenue Commission). (2018). "Income Tax - Taxation of Individuals." Port Moresby, Papua New Guinea Internal Revenue Commission. Retrieved 10/2, 2018, from http://irc.gov.pg/.

ITTO (International Tropical Timber Organization) (2017). Statistics Database, Biennial Review Statistics. Yokohama. Collected on 14/09/2017 from: http://www.itto.int/about_itto/.

Jacobsen, M. (1997). Vanishing nations and the infiltration of nationalism: the case of Papua New Guinea. In: Foster R. (ed). Nation Making: Emergent Identities in Postcolonial Melanesia. Ann Arbor, University of Michigan Press.

Jenkin, B. (2016). PNG 11.2: Developing a legality framework for community and small-holder timber production. Pacific Horticultural and Agricultural Market Access (PHAMA) Program Technical Report 111. Adelaide, AECOM Services Pty Ltd. Retrieved on 13/3, 2018, from: http://phama.com.au/wp-content/uploads/2018/02/TR111-Developing-a-legality-framework-for-community-and-smallholder-timber-production.pdf

Kaitilla, S. (1995). Principles, Practices, and Conflicts of Customary Land-use Rights: Emerging Socioeconomic Exchange Systems in Papua New Guinea. *Pacific Studies* 18(4): 95-119.

Kambuou, R. N. (1995). Papua New Guinea: Country Report to the FAO International Technical Conference on Plant Genetic Resources. Konedobu, Food and Agriculture Organization.

Kiala, W. (2009). Three knighted. The National. Port Moresby. Accessed on 10/9/2018 from: https://www.thenational.com.pg/three-knighted/

Kilkki, R. (1992). Reduction of Wood Waste by Small Scale Log Production and Conversion in Tropical High Forest. FOPH Publication 1992.05. Rome, Food and Agricultural Organization of the

United Nations, Forest Harvesting and Transport Branch. Retrieved 2/6, 2018, from http://www.fao.org/docrep/u7890E/u7890e00.htm#TopOfPage

Koian, R. (2010). Women in patrilineal and matrilineal societies in Melanesia. In Defence of Melanesian Customary Land. T. Anderson and G. Lee. Sydney, AID/WATCH.

Kozak, R. (2007) Small and medium forest enterprises: instruments of change in a developing world. Rights and Resources Initiative, Washington, USA.

Lamb, D. (1990). Exploiting the tropical rain forest: an account of pulpwood logging in Papua New Guinea. Paris, Unesco.

Laurance, W. (2011). "Special Agricultural and Business Leases" imperil forests in Papua New Guinea. *Pacific Conservation Biology* 17(4): 297-298.

Lawrence, P. (1971). Road Belong Cargo; A study of the cargo movement in the Southern Madang District, New Guinea. Prospect Heights, Illinois, USA, Waveland Press Inc.

Lawson, S. (2014). Illegal logging in Papua New Guinea. Energy, Environment and Resources EERPP 2014/04. London, Chatham House.

Maniho, A. (2001). European Union Islands Region Environmental & Community Development Program (IRECDP) End of Program Report for Marketing Unit. Kimbe.

Macqueen, D. (2008). "Forest connect: reducing poverty and deforestation through support to community forest enterprises." *International Forestry Review* 10(4): 670-675.

Marshall, G. (1990). The Barnett Report, A summary of the Report of the Commission of Inquiry into Aspects of the Timber Industry in Papua New Guinea. Hobart.

Mirou, N. (2013). Commission of Inquiry into Special Agriculture and Business Lease (C.O.I. SABL). Port Moresby, National Gazette.

Mayers, J. 2006. Small and Medium-Sized Forestry Enterprises. International Tropical Timber Organization (ITTO) Tropical Forest Update 16/2(2006):10-11. Retrieved on 3/6, 2018, from: http://www.itto.int/tfu/id=15910000

Mousseau, F. and P. Lau (2016). The Great Timber Heist, The Logging Industry in Papua New Guinea. Oakland, CA, The Oakland Institute.

Muri, D. (2014). District saw own timbers for home. 26/6/2014. Post Courier. Port Moresby. Pg. 34.

National. (2012). Hagen Central starts project. 17/4/2012. The National. Port Moresby. Accessed on 8/13/2018 from, https://www.thenational.com.pg/hagen-central-starts-project/

National. (2013a). Association acknowledges projects to communities. 6/11/2013. The National. Port Moresby. Accessed on 8/13/2018 from, https://www.thenational.com.pg/association-acknowledges-projects-to-communities/

National. (2013b). PM confirms Enga trip. 11/12/2013. The National. Port Moresby. Accessed on 8/13/2018 from, https://www.thenational.com.pg/pm-confirms-enga-trip/

National. (2014a). K12m for road, school. 8/1/2014. The National. Port Moresby. Accessed on 8/13/2018 from, https://www.thenational.com.pg/k12m-for-road-school/

National. (2014b). Governor gives sawmill to association to build homes. 11/2/2014. The National. Port Moresby. Accessed on 8/13/2018 from, https://www.thenational.com.pg/governor-gives-sawmill-to-association-to-build-homes/

National. (2014c). Development and progress in Sandaun. 7/5/2014. The National. Port Moresby. Accessed on 8/13/2018 from, https://www.thenational.com.pg/development-and-progress-in-sandaun/

National. (2014d). District to get rural housing scheme. 4/6/2014. The National. Port Moresby. Accessed on 8/13/2018 from, https://www.thenational.com.pg/district-to-get-rural-housing-scheme/

National. (2014e). Sawmill to empower people. 28/8/2014. The National. Port Moresby. Accessed on 8/13/2018 from, https://www.thenational.com.pg/sawmill-to-empower-people/

National. (2015a). MP delivers seven portable sawmills. 2/26/2015. The National. Port Moresby. Accessed on 8/13/2018 from, https://www.thenational.com.pg/mp-delivers-seven-portable-sawmills/

National. (2015b). MP's housing scheme to benefit 40,000. 15/7/2015. The National. Port Moresby. Accessed on 8/13/2018 from, https://www.thenational.com.pg/mp%E2%80%99s-housing-scheme-to-benefit-40000-people/

National. (2016a). Pruaitch salutes MP. 11/2/2016. The National. Port Moresby. Accessed on 8/13/2018 from, https://www.thenational.com.pg/pruaitch-salutes-mp/

National. (2016b). Soso opens impact projects in LLG. 25/8/2016. The National. Port Moresby. Accessed on 8/13/2018 from, https://www.thenational.com.pg/soso-opens-impact-projects-llg/

National. (2016c). Sawmill machine supports SME. 20/10/2016. The National. Port Moresby. Accessed on 8/13/2018 from, https://www.thenational.com.pg/sawmill-machine-supports-sme/

National. (2018). Round log exports to stop by 2020. 31/7/2018. The National. Port Moresby. Accessed on 9/5/2018 from, https://www.thenational.com.pg/round-log-exports-to-stop-by-2020/

Nerius, S. D., Guman, Y., Teves, L. and Farrow, D. (2011). FPCD Evaluation Report. Foundation for People and Community Development Inc. Internal Report.

NFS (National Forest Service). (1991a). Form 156, Application for a Timber Authority for Domestic Processing up to 5,000 Cubic Meters Per Year. Sec. 88. Port Moresby, Papua New Guinea Forest Authority.

NFS (National Forest Service). (1991b). Form 165, Timber Authority – Verification of Ownership and Consent of Landowners. Sec. 88, Reg. 160, 162, 164, 166, and 168. Port Moresby, Papua New Guinea Forest Authority.

NFS (National Forest Service). (1991c). Form 166, Sales and Purchase Agreement. Sec. 88, Reg. 160, 162, 164, 166, and 168. Port Moresby, Papua New Guinea Forest Authority.

NFS (National Forest Service). (2008). Form 221, Timber Variation by the Minister for Forest of Royalty Payable Under a Timber Permit. Act, Sec. 120, Reg. 222. Port Moresby, Papua New Guinea Forest Authority.

NFS (National Forest Service). (2011). Form 155 Timber Authority Permit. Port Moresby, Papua New Guinea Forest Authority.

NSO (National Statistical Office). (2011). 2009 - 2010 Papua New Guinea Household Income and Expenditure Survey. Port Moresby.

NSO (National Statistical Office). (2013). 2011 National Population and Housing Census of Papua New Guinea - Final Figures. Port Moresby.

OEC (Observatory of Economic Complexity). (2018). Papua New Guinea. MIT. Accessed on 21/9/2018 from: https://atlas.media.mit.edu/en/profile/country/png/

Paraide, P. (2015). "Challenges with the tuition fee free education policy implementation in Papua New Guinea." Contemporary PNG Studies: DWU Research Journal 23(November): 47-62.

PILII (Pacific Islands Legal Information Institute). (2018). Papua New Guinea - The Laws of the Territory of Papua 1888-1945 (Annotated) - Alphabetical Index of Subject Headings. Port Vila, Vanuatu, University of the South Pacific School of Law. Accessed on 8/9/2018 from: http://www.paclii.org/pg/indices/legis/papua_annotated.html

PNGC (Papua New Guinea Customs) (2012). Papua New Guinea Import & Export Customs Tariff. Port Moresby, PNG Customs Service.

PNGDL (PNG Directories Limited) (2015). 2015 PNG Telephone Directory. Port Moresby, Yellow Pages.

PNGDT (Papua New Guinea Department of Treasury). (2018). 2018 National Budget. Department of Treasury, Port Moresby. 1. Accessed on 9/21/2018 from: http://www.treasury.gov.pg/html/national_budget/2018.html#

PNGENW (PNG Education News Website). (2018). Parents to Pay 60pc Upfront School Fees. Accessed on 20/8/2018 from, https://edu.pngfacts.com/education-news/parents-to-pay-60pc-upfront-school-fees

PNGFA (Papua New Guinea Forest Authority). (1996). Papua New Guinea Logging Code of Practice. Port Moresby, Papua New Guinea Forest Authority, Department of Environment and Conservation.

PNGFA (Papua New Guinea Forest Authority). (2004). National Eco-forestry Policy Draft. P. N. G. F. Authority. Port Moresby, Ministry of Forests.

PNGFA (Papua New Guinea Forest Authority). (2009). Papua New Guinea Forestry Outlook Study. Asia-Pacific Forestry Sector Outlook II. Bangkok, Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific.

PNGFA (Papua New Guinea Forest Authority). (2018). Type of Levies collected from Forest Management Agreement Projects. Port Moresby. Personal communication on 16/8/2018.

PNGFIA. (Papua New Guinea Forest Industries Association). (2010a). "History of the Forest Industries Association. “Retrieved 8/9, 2017, from http://www.fiapng.com/fiapng_history.html.

PNGFIA. (Papua New Guinea Forest Industries Association). (2010b). "Log Exports." Retrieved 8/9, 2017, from http://www.fiapng.com/log exports_comb_2001_2004.pdf.

PNGFIA. (Papua New Guinea Forest Industries Association). (2010c). "Membership List." Retrieved 15/9, 2017, from http://www.fiapng.com/fiapng_membership_list.html.

PNGP (Papua New Guinea Parliament). (2018). National Parliament of Papua New Guinea. Accessed on 21/9/2018 from: http://www.parliament.gov.pg/index.php

Prideaux, M. and R. A. Beg (2008). "Exploring Leadership Issues in Papua New Guinea." *Gading Business and Management Journal* 12(1): 1-21.

PwC (PricewaterhouseCoopers) (2006). Economic Analysis and Potential of PNG Forestry Industry. Port Moresby, PNG Forest Industries Association.

RBA (Reserve Bank of Australia). (2018). Retrieved 3/1, 2018, from, https://www.rba.gov.au/.

RHG (Rimbunan Hijau Group). (2016). Company Website. Accessed on 9/9/2018 from: http://rhg.com.my/rhg_v2/en/welcome/

Rosenbaum, H., Ericho, J., and Diave-Nerius, S. (2010). External Evaluation of FORCERT, FORCERT Forest Management & Product Certification Service. Internal Report.

Ryan, S., G. Koczberski, G. N. Curry and E. Germis (2017). "Intra-household constraints on educational attainment in rural households in Papua New Guinea." *Asia Pacific Viewpoint* 58(1).

Salafsky, N. (1997). Eleven Steps for Setting up Community-Based Harvesting Enterprises. Biodiversity Support Programme. Kimbe. Islands Region Environment and Community Development Programme.

Salafsky, N., B. Cordes, M. Leighton, W. Watt, M. Henderson and R. Cherry (1998). Chainsaws as a Tool for Conservation? A Comparison of Community-based Timber Production Enterprises in Papua New Guinea and Indonesia. Washington DC, Rural Development Forestry Network.

Sayer, J. A. and S. Maginnis (2005). New Challenges for Forest Management. Forests in Landscapes, Ecosystem Approaches to Sustainability. J. A. Sayer and S. Maginnis. New York, Earthscan: 1-16.

Scheyvens, H., K. Harada and K. Hyakumura (2007). Incorporating Certification into a Pro-poor Forestry Agenda: Lessons from and Options for the Asia-Pacific Region. International Conference on Poverty Reduction and Forests. Bangkok.

Schneider, F., Buehn, A., and Montenagro, C.E. (2010). Shadow Economies All over the World, New Estimates for 162 Countries from 1999 to 2007. Policy Research Working Paper 5356. The World Bank, Development Research Group, Poverty and Inequality Team.

Scialabba, N. E.-H. and D. Williamson (2004). The scope of organic agriculture, sustainable forest management and ecoforestry in protected area management. Rome, The Food and Agricultural Organization of the United Nations.

Scudder, M. G. (2017). A Feasibility Study on Implementing an Eco-forestry Central Marketing Unit in the Madang Province of Papua New Guinea. ACIAR FST/2011/057. Canberra, Australian Centre for International Agricultural Research.

Scudder, M. G., J. L. Herbohn and J. Baynes (2018). "The failure of eco-forestry as a small-scale native forest management model in Papua New Guinea." *Land Use Policy* 77: 696-704.

Scudder, M. G., J. Baynes and J. Herbohn (2019). “Timber royalty reform to improve the livelihoods of forest resource owners in Papua New Guinea.” *Forest Policy and Economics* 100: 113-119.

SIFB (Solomon Islands Forests Bill) (2004). The Forests Bill 2004. National Parliament of the Solomon Islands. Honiara.

Sinclair, D. (2008). "State-Building in a Post-Colonial Society: The case of Solomon Islands." Chicago *Journal of International Law* 9(1): 51-78.

SGS (Sociele Generale de Surveillance) (2006). SGS Log Export Monitoring Monthly Report for December 2005. Port Moresby, SGS PNG Ltd.

SGS (Sociele Generale de Surveillance) (2007). SGS Log Export Monitoring Monthly Report for December 2006. Port Moresby, SGS PNG Ltd.

SGS (Sociele Generale de Surveillance) (2008). SGS Log Export Monitoring Monthly Report for December 2007. Port Moresby, SGS PNG Ltd.

SGS (Sociele Generale de Surveillance) (2009). SGS Log Export Monitoring Monthly Report for December 2008. Port Moresby, SGS PNG Ltd.

SGS (Sociele Generale de Surveillance) (2010). SGS Log Export Monitoring Monthly Report for December 2009. Port Moresby, SGS PNG Ltd.

SGS (Sociele Generale de Surveillance) (2011). SGS Log Export Monitoring Monthly Report for December 2010. Port Moresby, SGS PNG Ltd.

SGS (Sociele Generale de Surveillance) (2012). SGS Log Export Monitoring Monthly Report for December 2011. Port Moresby, SGS PNG Ltd.

SGS (Sociele Generale de Surveillance) (2013). SGS Log Export Monitoring Monthly Report for December 2012. Port Moresby, SGS PNG Ltd.

SGS (Sociele Generale de Surveillance) (2014). SGS Log Export Monitoring Monthly Report for December 2013. Port Moresby, SGS PNG Ltd.

SGS (Sociele Generale de Surveillance) (2015). SGS Log Export Monitoring Monthly Report for December 2014. Port Moresby, SGS PNG Ltd.

SGS (Sociele Generale de Surveillance) (2016). SGS Log Export Monitoring Monthly Report for December 2015. Port Moresby, SGS PNG Ltd.

SGS (Sociele Generale de Surveillance) (2017). SGS Log Export Monitoring Monthly Report for December 2016. Port Moresby, SGS PNG Ltd.

SGS (Sociele Generale de Surveillance) (2018). SGS Log Export Monitoring Monthly Report for December 2017. Port Moresby, SGS PNG Ltd.

Shearman, P. L., Bryan J.E., Ash J., Hunnam P., Mackey B. and Lokes B. (2008). The State of the Forests of Papua New Guinea. Mapping the extent and condition of forest cover and measuring the drivers of forest change in the period 1972-2002, University of Papua New Guinea.

Sillitoe, P. (1998). An Introduction to the Anthropology of Melanesia. Cambridge, Cambridge University Press.

Smith, B. (2019). Estimates of the potential contribution and distribution of economic impacts to national and local economies from enhanced value-added wood processing. ACIAR FST/2012/092 – Research Report on Objective 3. 61pp. Canberra, Australian Centre for International Agricultural Research.

Smorfitt, D.B., Harrison, S.R., Herbohn, J.L. (2006). Short-run and long-run costs for milling rainforest cabinetwood timbers. *Australian Forestry* 69 (3): 223-232.

Soukup, M. (2010). "Anthropology in Papua New Guinea: History and Continuities." *Anthropologian Integra* 1(2): 45-54.

Subendranathan, V. (2008). Lessons from trade in community forest products - Papua New Guinea. Distinguishing community forest products in the market, Industrial demand for a mechanism that brings together forest certification and fair trade. D. Macqueen. United Kingdom, International Institute for Environment and Development: 57-72.

Sukot, S. (2010). Downplaying defects in state-systems and overemphasising customary land tenure conversion for development in Papua New Guinea. In Defence of Melanesian Customary Land. T. Anderson and G. Lee. Sydney, Aid/Watch.

Szaro, R. C., P. Angelstam and D. Sheil (2005). Information Needs for Ecosystem Forestry. Forests in Landscapes, Ecosystem Approaches to Sustainability. J. A. Sayer and S. Maginnis. New York, Earthscan: 31-46.

Taylor, R. 1997. The state versus custom: regulating Papua New Guinea's timber industry. The Political Economy of Forest Management in Papua New Guinea, ed. C. Filer, 249–268. NRI Monograph 32. Boroko: The National Research Institute and London: International Institute for Environment and Development.

Timber Rights Purchase (1951). Papua New Guinea Timber Rights Purchase Act. Port Moresby.

Titus, A., Rosenbaum, H., and Palei, M.R. (2007). External Evaluation of FORCERT, FORCERT Forest Management & Product Certification Service. Internal Report.

Thaman, R. R., L. A. Thomson, R. DeMeo, R. Areki and C. R. Elevitch (2006). Instis bijuga (vesi) ver. 3.1. Species Profiles for Pacific Island Agroforestry. C. R. Elevitch. Holualoa, Hawaii, Permanent Agriculture Resources (PAR).

Thanakvaro, T. L. (2002). "Natual resource exploitation in Cambodia: An examination of use appropriations and exclusion." *Journal of Environment and Development* 11(4).

UNCED (United Nations Conference on Environment and Development) (1992). The Rio Declaration on Environment and Development. The United Nations Conference on Environment and Development, Rio de Janeiro

Urame, J. 2015. The Spread of Sorcery Killing and its Social Implications. In M. Forsyth and R. Eves (eds.) Talking it Through: Responses to Sorcery and Witchcraft Beliefs and Practices in Melanesia. Canberra: ANU E Press, 23-32.

USDOS (United States Department of State). (2015). Trafficking in Persons Report. Washington DC, United States of American Department of State: 274-276.

Van Heekeren, D. (2016). "Hiding Behind the Church: Towards an Understanding of Sorcery in Christian Papua New Guinea." *The Asia Pacific Journal of Anthropology* 17(1): 1-16.

VFP (2011). Vanuatu Forest Policy 2013 - 2023. Port Vila, Department of Forests.

Walton, G. W. (2018). "Fee-free education, decentralisation and the politics of scale in Papua New Guinea." Journal of Policy Education, DOI: 10.1080/02680939.2017.1422027

White, A. and A. Martin (2002). Who Owns the World's Forests? Forest Tenure and Public Forests in Transition. Washington DC, Forest Trends. Center for International Environmental Law.

Whiteman, D. (1983). Melanesians and Missionaries, An Ethnohistorical Study of Social and Religious Change in the Southwest Pacific. Pasadena, William Carey Library.

Whitmore, T. C. (1998). An Introduction to Tropical Rain Forests. Oxford, Oxford University Press.

Wilkie, M. L., P. Holmgren and F. Castaneda (2003). Sustainable forest management and the ecosystem approach; Two concepts, one goal. Working Paper FM25. Rome, Food and Agricultural Organization of the United Nations, Forest Resources Development Service, Forest Resources Division, Forestry Department. Retrieved on 10/02/2017 from: http://www.fao.org/forestry/6417-0905522127db12a324c6991d0a53571fa.pdf

Winston, W. (2008). Financial Models 2, Using simulation and optimization. Ithaca, Palisade Corporation.

World Bank (2009). World Development Indicators. Retrieved on 14/3, 2018, from: https://datacatalog.worldbank.org/dataset/world-development-indicators

Yin, R. (2009). Case Study Research, Design and Methods. Thousand Oaks, Sage Publications.

Yosi, C. K., R. J. Keenan and J. C. Fox (2011). "Forest dynamics after selective timber harvesting in Papua New Guinea." *Forest Ecology and Management* 262: 895-905.

Appendix A: Table A.1

Table A.1: Discount rate sensitivity analysis descriptive statistics for Models 1 and 2 (Thousands 2017 USD)

Discount rate of 7.35%						
Model	Mean	Minimum	Maximum	Median	Mode	Standard deviation
Model 1 (Even distribution harvest)	-737.4	-1,427.8	343.9	-787.9	-842.9	254.9
Model 2 (High-grading)	51.02	-657.6	816.3	57.4	-71.2	217.3

Discount rate of 13.65%						
Model	Mean	Minimum	Maximum	Median	Mode	Standard deviation
Model 1 (Even distribution harvest)	-668.6	-1,199.2	269.1	-712.9	-746.2	218.1
Model 2 (High-grading)	0.6	-603.2	655.9	5.8	-102.9	184.6