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project

Improving the Papua New Guinea balsa value chain to enhance smallholder livelihoods

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2 Executive summary

Balsa (*Ochroma pyramidale*) is a fast-growing plantation tree grown by both companies and smallholders in East New Britain Province (ENB) of Papua New Guinea (PNG). Balsa is a relatively low labour-input crop with competitive returns, and so adoption by smallholders has increased as the area under cocoa production has decreased. The ENB balsa industry is entirely export-oriented, producing 9% of the world's processed balsa. Balsa products have outstanding strength-for-weight qualities and an increasing market in high-technology composite materials, such as wind turbine blades and transportation applications. There are an estimated 1500 smallholder balsa growers, and an estimated workforce of 2500 - 3000 engaged in balsa harvest, transport, processing and export. These activities operate under the regulatory oversight of the PNG Forest Authority, which also plays an 'honest broker' role in transactions between companies and smallholders.

The ENB balsa industry also faces challenges, the most significant of which relate to productivity and sustainability, market access (driven by certification and legality verification), and the market issues of product development and diversification. ACIAR project researchers worked with major processors, research and training organisations, smallholder organisations, and national and district government agencies, to address each of these challenges.

The aim of the project was to enhance the value, value recovery and international competitiveness of the ENB balsa industry and, by doing so, optimise its benefits for smallholder growers. The key research activities in this context comprised:

- Investigating market and product development prospects for balsa, the role of smallholders in the balsa value chain, and the role of balsa in smallholder livelihoods;
- Establishing what extension, communication and capacity building activities could best support development of the balsa industry in ENB;
- Optimising germplasm and crop management for smallholder balsa growers;
- Assessing the regulatory environment along the ENB balsa value chain.

The principal research findings in relation to these objectives are that:

- Global demand for balsa is likely to continue to remain strong, reflecting the growth in and diversification of high-technology applications for balsa products. Project research identified new balsa products that could further expand the market for balsa;
- Expansion in balsa production in ENB is dependent primarily on smallholder growers, as there is little prospect of major expansion in company estates;
- Smallholders for whom balsa growing is most likely to be attractive and profitable are those who are relatively close to processing facilities, who have sufficient land or income to allow them to establish a minimum area (c. 0.2 ha) of a crop that does not return income for 5-6 years, and who can undertake a threshold level of management;
- Smallholder balsa growers would benefit from access to better germplasm, enhanced knowledge and skills in balsa management, and a clearer understanding of the drivers of product value and price. Processors would benefit from a better-managed and characterised smallholder resource. The project addressed each of these constraints;
- Communication of knowledge about balsa management and markets, and the development of growers' capacity to improve their management and value recovery, are best delivered as part of broader agricultural extension programs in ENB;
- Targeted reform of the regulatory environment for balsa growing, processing and export would strengthen the comparative advantage of ENB balsa with little risk to environmental or social sustainability criteria.

The project identified stronger partnerships between key actors in the value chain – smallholder growers, processing companies, government, and knowledge and training providers – as central to the success of the ENB balsa industry, and contributed to building these partnerships.

3 Background

ACIAR's Country Strategy for PNG recognises the importance of improving returns from smallholder production systems in forestry and agroforestry (ACIAR 2016). The established balsa industry in the Gazelle Peninsula area of East New Britain Province (ENB) is the best example nationally of a successful value-adding forest industry drawing significant supply from smallholder tree growing. Smallholders engage in balsa growing both individually and, increasingly since around the year 2000, as groups working collaboratively, both independently and with processors. Growth in demand for balsa products, and the strengthening position of the PNG industry in international markets, associated with industry innovation and investment, offer encouraging prospects for improving smallholder growers' livelihoods. Concomitantly, since the mid-2000s, cocoa - the principal smallholder crop in ENB – has been significantly impacted by the cocoa pod borer pest. It has been estimated that as much as half (c. 30 000 ha) of the area of cocoa in ENB may be withdrawn from production as a result; balsa growing offers one of the most attractive alternatives for smallholders in ENB (Midgley et al 2010).

The ENB balsa industry represents around 9% of global production and value, estimated at 213,00m^3 and $USD123M, respectively (2014 data; Midgley 2015). The balsa industry in ENB has a number of competitive advantages, including the excellent growing conditions for balsa, the location of most plantations close to roads linking growers to processing facilities and the container port of Rabaul, and the favourable shipping times to major markets. Balsa produced in PNG enjoys a reputation in international markets for good quality and uniform colour and density (Midgley et al 2010). All ENB balsa products are exported; in 2011, the last date for which statistics are available, the principal export destinations by volume were China (61%), India (16%), England (12%) and Australia (9%) (Midgley 2015).

The ENB balsa industry comprises both large corporate and small-medium processors, of varying capacity, product focus and sophistication; and corporate and smallholder growers. Two international corporations, 3A Composites and Coconut Products Ltd, are the largest processors; in 2016, there were 8 other balsa processors. The area planted with balsa has expanded rapidly since 2000, increasing from 700 ha in 2003 to 3500 ha in 2009 (Midgley et al 2010); the current estimate is 5,000 - 5,500 ha. In 2009, it was estimated that smallholders were responsible for around 75% of the area planted with balsa (Midgley et al 2010). At the time of project initiation, processors representing c. 75% of total ENB balsa processing capacity undertook to work with the ACIAR project.

A Scoping Study commissioned by ACIAR (Midgley et al 2010) identified a suite of research and development needs and opportunities that formed the basis of the project. Scientific and technical needs and opportunities identified by the Scoping Study were categorised as those associated with growing balsa, harvesting and haulage, primary processing, and secondary manufacture and product development. The Scoping Study also identified a suite of governance, community, social and environmental issues, some of which would be informed by further research and development.

The project was developed by a team led by the Australian National University, in partnership with two PNG universities, the University of Natural Resources and Environment and the University of Technology; it also included researchers from the PNG Forest Research Institute, the University of Melbourne, and the University of New South Wales; a number of Australian research consultants; staff of the PNG Forest Authority; and staff of three ENB balsa processors. Subsequently, researchers from Swinburne University of Technology also joined the project team. The project commenced in June 2011, and an Inception Meeting was held in ENB in September 2011.

4 Objectives

The project aim, overall objective, and specific objectives were (Bull et al 2011):

Project aim: To enhance the value, value recovery and international competitiveness of the PNG balsa industry and, by doing so, optimise its benefits for smallholder growers.

Overall project objective: To enhance the livelihoods of smallholder balsa growers, improve value recovery for balsa growers and processors, and provide the basis for strengthening PNG's position in the international balsa market.

Specific project objectives: Three specific objectives were developed in this context. They and associated research activities are listed in Table 1.

Table 1. Specific project objectives and associated research activities

No.	Objective	Associated research activities
1	To enhance the livelihoods of smallholder balsa growers	1.1 Define relationships between stakeholders, understand and illustrate the benefit distribution and identify opportunities to address inefficiencies along the balsa value chain to improve outcomes for smallholder balsa growers
		1.2 Investigate how smallholders make decisions about resource use in the context of their livelihood goals and strategies
		1.3 Recommendations for developing effective balsa smallholder organisational and communication structures
		1.4 Review current extension, communication and capacity building activities and propose mechanisms to effectively support growth of the balsa industry in ENB
2	To improve value recovery to balsa growers and processors	2.1. Optimise value recovery for the balsa industry by improving delivery logistics to processing facilities
		2.2 Optimise value recovery in balsa processing an emphasis on optimising value recovery
		2.3 Optimising germplasm and crop management for smallholders
		2.4 Development of systems to facilitate product certification
3	To strengthen the global market position of the ENB PNG balsa industry	3.1 Develop medium and long term market development options for the ENB balsa industry

5 Methodology

The methodology applied in each of the project activities is summarised below. All field-based activities were conducted in East New Britain Province, and some plant- and soil-related analyses at UNRE laboratory facilities, Vudal, ENB. Some laboratory and studio work conducted under Activity 2.2 was undertaken at the University of Melbourne and Swinburne University of Technology, Melbourne.

Objective 1: Enhance the livelihoods of smallholder balsa growers

Activity 1.1: Define relationships between stakeholders, understand and illustrate the benefit distribution, and identify opportunities to address inefficiencies along the balsa value chain to improve outcomes for smallholder balsa growers

This research activity used value chain mapping (Collins et al 2015), the results of a survey of the ENB balsa sector (Anon 2016), and results from other activities. The Scoping Study (Midgley et al 2010) provided the basis for much of this work. It was led by Braden Jenkin (Sylva Systems); Lyndall Bull (ANU), Hamish Crawford (Cailum), Michael Blyth (Four Scenes), Peter Kanowski (ANU), Stephen Midgley (Salwood Asia-Pacific), Kulala Mulung (UniTech) and Simon Rollinson (Pacific Island Projects) contributed variously to the work.

Activity 1.2: Develop understanding of how smallholders make decisions about their resource use and livelihoods

This research activity was based on household surveys of ENB landowners conducted in 2012 and 2013. It was led by Kulala Mulung (UniTech), with design and analytical support from Michael Blyth (Four Scenes), with field support from Jaupo Minimulu (UNRE). A total of c 100 households were surveyed. Methods and survey implementation are described by Blyth and Mulung (2012) and Blyth (2013). Results from the household survey were complemented by those from a survey of the ENB balsa sector, described below under Activities 1.3 and 1.4.

Activity 1.3: Development of effective balsa smallholder organisational and communication structures

This activity comprised literature review, consultation with stakeholders through the project's Local Advisory Group, and a survey of the ENB balsa sector. The survey (Anon 2016) was conducted in 2014 and 2015, and comprised five elements (number of respondents shown in brackets for each): farmers' needs for extension (140) and market information (166); extension service providers (9); grower groups (6); and processors (7). The work was led by Simon Rollinson (Pacific Island Projects), with analytical support from Michael Blyth (Four Scenes), Braden Jenkin (Sylva Systems) and Peter Kanowski (ANU).

Activity 1.4: Review of extension, communication and capacity building activities

This activity complemented and drew from that described for Activity 1.3, and on the project's work with UNRE's Integrated Agriculture Training Program (IATP). IATP's established "Train the Trainer" program provided the framework for a Training Needs Analysis for balsa, and the subsequent development of training course material. The extension and communication work was led by Michael Blyth (Four Scenes) and Simon Rollinson (Pacific Island Projects); the training needs and material development work were led by Braden Jenkin (Sylva Systems), with support from Jaupo Minimulu (UNRE) and Neville Howcroft (UNRE) and, in conjunction with Hosea Turbarat (UNRE – IATP) and Owen Ngala (UNRE – IATP).

Objective 2: Improve value recovery to balsa growers and processors

Activity 2.1: Optimising value recovery for balsa processing industries

This activity comprised an assessment of harvesting residues following established methodology (see Ghaffariyan et al 2016) with the assistance of 3A Composites PNG/ PNG Balsa Ltd, assessment of portable sawmill recovery following established methodology, and of log sales processes through surveys of key informants. The work on harvesting residue was led by Mark Brown and colleagues (University of the Sunshine Coast) and Braden Jenkin (Sylva Systems), that on portable sawmills by Braden Jenkin (Sylva Systems) with the assistance of Jaupo Minimulu (UNRE) and UNRE students, and that on log sales by UNRE students guided by Braden Jenkin.

Activity 2.2: Optimising value recovery from processing

This research activity comprised four complementary elements. The first, an assessment of processing technologies and systems in ENB, was led Barbara Ozarska (U of Melbourne). The second, which comprised a suite of balsa product development activities, was led by Blair Kuys (Swinburne University), colleagues (see, eg, Kotlarweski et al 2015) and with 4th year students (Swinburne University); Evgeny Morozov (UNSW), colleagues and postgraduate students also conducted other design-related work (Barnes et al 2015). The third, which assessed balsa wood properties as they relate to product development, followed standard methods (see Kotlarewski et al 2014, 2016), and was led by Nathan Kotlarewski (Swinburne University), with support from Benson Gusamo (UniTech) and Barbara Ozarska; and by Evgeny Morozov (UNSW) with support from UNSW/ADFA students. The fourth element, assessing within- and between-tree density variation, was led by Braden Jenkin (Sylva Systems) with the assistance of Jaupo Minimulu (UNRE).

Activity 2.3: Optimising germplasm and crop management for smallholders

This activity comprised both genetic and silvicultural components. The genetic component used conventional forest genetics methods to identify candidate superior trees in plantations, and test their qualities in a progeny trial replicated across four sites. One of these sites (PNG FRI/FA) was lost to fire; the three surviving trials (3A Composites – 5.4 ha; CPL – 4 ha; UNRE – 3.2 ha) were subsequently converted through genetic thinning to seedling seed orchards, and are being managed by the site owners. This work was led by Braden Jenkin (Sylva Systems) with the assistance of Neville Howcroft (UNRE) and colleagues, Peter Kanowski (ANU) and Russell Haines, and staff of 3A Composites/ PNG Balsa Ltd, Coconut Products Ltd, PNG Forest Research Institute and PNG Forest Authority staff.

Silvicultural research investigated establishment practices, plant nutrition, weed management, pruning and thinning regimes, and defect management practices, using established silvicultural research methods. This work was led by Braden Jenkin (Sylva Systems) with the assistance of Neville Howcroft and Jaupo Minimulu (UNRE) and numerous UNRE 3rd year students, and with the assistance of staff of 3A Composites PNG/ PNG Balsa and Coconut Products Ltd. It was also informed by the balsa sector survey conducted under Activity 1.3. The major silvicultural investigations were:

- ***Stocking and spacing:*** A 1.6 ha spacing trial established by UNRE in 2009 was thinned, capturing yield, stem analysis, and wood properties data. The trail was subsequently assessed and harvested at rotation, capturing yield and wood properties data;
- ***Yield:*** A 0.06 ha plot was assessed and harvested to determine yield and recovery rates. A 6-month student trial quantified the above ground biomass allocations in mature balsa, including elemental content in relation to residue management and sustainability;
- ***Nutrition:*** A series of 6-month student projects from 2013 – 2015 identified and confirmed boron deficiencies and tested remedial actions;

- ***Weed control:*** In conjunction with the investigation of boron nutrition, a series of replicated 6-month student trials were establish to test weed profiles, control methods (slashing and chemical), and boron application. Impacts on the weed profile and tree growth were assessed;
- ***Pests:*** A 6-month student project monitored and documented insect species in balsa stands of different ages;
- ***Intercropping:*** A 6-month student project conducted an initial exploration of intercropping under balsa.

Activity 2.4: Development of systems to facilitate product certification

This activity was conducted through field research, literature review and dialogue with key stakeholders, including policy makers. The research, made available to project partners in 2012, identified options for pursuing certification in the particular context of the ENB balsa sector. A parallel analysis of the regulatory framework applicable to balsa in ENB reviewed this context for the balsa value chain, and provided the basis for dialogue with policy makers and stakeholders that continued throughout the project, including in two ACIAR-facilitated national policy workshops. This work was led by Hamish Crawford (Cailum Ltd) and Braden Jenkin (Sylva Systems), with support from Peter Kanowski (ANU), PNG Forest Authority staff, and staff of the then PNG Balsa Ltd and Coconut Products Ltd.

Objective 3: Strengthen the global market position of the PNG balsa industry

Activity 3.1: Market and product development options for the ENB balsa industry

This activity comprised research on balsa markets and products, led by Stephen Midgley (Salwood Asia-Pacific); and the conduct of a multistakholder scenarios workshop in April 2012, using established scenarios methodologies (see Blyth 2012), led by Michael Blyth (Four Scenes). All project partner organisations, and many other stakeholders, participated in the workshop.

6 Achievements against activities and outputs/milestones

Objective 1: To enhance the livelihoods of smallholder balsa growers

no.	activity	outputs/ milestones	completion date	comments
1.1	Define relationships between stakeholders, understand and illustrate the benefit distribution and identify opportunities to address inefficiencies along the balsa value chain to improve outcomes for smallholder balsa growers	1. Map of the ENB balsa value chain, including review of estimates of numbers of smallholders, enterprises and employees at various stages (to be updated annually) 2. Assessment of product value chain performance 3. Prioritisation of elements of the value chain where opportunities exist to improve competitiveness of the balsa industry value chain and returns to smallholders 4. Activity report, incorporating value chain methodology, baseline impact monitoring data and recommendations for activities within the project to help improve competitiveness, completed 5. Presentation made to project team and report to project partners	30 September 2011 Balsa sector data presented in project annual reports	Internal project report completed and circulated 30 September 2011; outputs used in Scenarios Workshop, April 2012 (Activity 3.1)
1.2	Investigate how smallholders make decisions about resource use in the context of their livelihood goals and strategies	1. Completion of pilot and subsequent main quantitative and qualitative surveys, to inform the project about smallholder decision making associated with participation in balsa growing 2. Analysis and reporting of survey outputs within livelihoods and farming systems frameworks, including clear identification of landowner resource and livelihood priorities 3. Activity report and workshop with ENB stakeholders completed 4. Report on experiences related to changes in landholder decision making as a result of project activities	Activity 1.2.1 completed November 2013 Activities 1.2.2, 1.2.3, 1.2.4 not yet completed: planned completion for Activities 1.2.2 & 1.2.3: October 2016	Survey work for 1.2.1 undertaken in 2012 and 2013; interruption caused by disruption to project staffing. Analysis for 1.2.2 and report for 1.2.3 currently being undertaken. Results will be communicated to partners and stakeholders through the report and via Pacific Islands Projects ongoing communications activities. Activity 1.2.4 was not completed, but results from Activities 1.3 and 1.4 are relevant.

1.3	Recommendations for developing effective balsa smallholder organisational and communication structures	1. Field visits completed with smallholders, processors and other appropriate stakeholders 2. Suite of relevant organisational and communication structures identified 3. Workshop with stakeholders to agree on best methods for implementation 4. Activity report completed 5. Facilitation of implementation of organisational and communication structures 6. Preparation of 3 information leaflets in Pidgin on planting, management and harvesting of balsa 7. Preparation of 3 information leaflets in Pidgin on silviculture, environment protection and expected returns from balsa growing	Activities 1.3.1 – 1.3.5 undertaken as part of regular (at least bi-annual) Local Advisory Committee meetings, and through Balsa Sector Survey; completed May 2016. Information leaflets (Activities 1.3.6-7) in English and Pidgin completed August 2016	Consultations and survey work found little interest in establishing organisational structures beyond those that already exist. Work therefore focused on the most effective means of communication within and about the balsa sector.
1.4	Review of extension and capacity building activities; Development and delivery of balsa module within IATP training program.	1. Summary of project activities to date 2. Discussions with relevant stakeholders completed 3. Impacts of extension activities to date assessed and documented 4. Effective extension activities and approaches for the remainder of the project identified and reported annually 5. Activity report completed; results discussed with extension staff, other industry stakeholders, and Project Manager 6. Balsa module developed within IATP program. 7. Balsa train – the – trainer training conducted within IATP program 8. Farmer group training (minimum 8 groups) conducted within IATP program.	Activities 1.4.1 - 5 completed 31 December 2014 Activities 1.4.6 – 7 completed 31 March 2015 Activities 1.4.8 completed 30 June 2016	These activities and outputs were integrated with IATP's activities and program. A full training the trainer program was developed and implemented. 15 Local trainers have been trained. A farmer training program in tok pisin has been developed. 5 X 3 day farmer training programs have been conducted.

Objective 2: To improve value recovery to balsa growers and processors

no.	activity	outputs/ milestones	completion date	comments
2.1	Optimise value recovery for balsa processing industries by improving delivery logistics to processing facilities	1. Visits to processors, harvesting sites and landowners, to understand and characterise current approach to harvesting and delivery, completed 2. Options for improving value recovery for forest owners investigated and characterised 3. Options for improving delivery logistics, that consider local conditions and limitations, documented 4. Activity report and workshop with key stakeholders completed	Activities 2.1.1 – 2 completed 30 Sept 2012 Activity 2.1.3 completed in modified form 31 December 2014 Activity 2.1.4 completed June 2015	Activity 2.1.3 modified after dialogue with stakeholders; outcomes published by Ghaffariyan et al (2016) and in internal project and student documents. Biological stem and merchantable volumes were assessed and indicated greatest benefits were possible from improved stemwood recovery rather than trying to increase growth.
2.2	Optimise value recovery for balsa processing industries	1. Visit processors to assess and describe current processing capabilities 2. Undertake gap assessment in sawing and drying methods, manufacturing processes, production efficiency, waste utilization, quality control procedures and product quality. 3. Identify opportunities for improvement in value recovery 4. Activity report and workshop 5. Report on changes in value recovery as a result of project activities	Activities 2.2.1- 2 completed 31 May 2012 Activity 2.2.3 – 4 completed 30 June 2016 Activity 2.2.5 not completed.	Balsa processors were able to use outputs of this work to improve processing strategies and technologies. Activity 2.2.3 generated work that won a number of design awards. The potential benefits of this work are yet to be realised by the ENB balsa industry. Within and between tree wood density variation was documented and communicated to industry.

2.3	Optimising germplasm and crop management for smallholders	1. Existing data and information regarding balsa germplasm and crop management in ENB and internationally, including outcomes from ITTO and FACT Projects, reviewed. 2. Options for balsa breeding cooperative developed and reviewed, and model preferred by stakeholders agreed and initiated 3. Project work coordinated with that being undertaken by FACT Project and other ENB actors, and complementary, mutually-supportive, germplasm improvement activities established 4. Priorities for silvicultural and management trials, based on assessment of information needs and improved management opportunities, determined 5. Smallholder approaches to crop management reviewed 6. Silvicultural and management trials established 7. Activity report completed and distributed; breeding cooperative underway and improved germplasm becoming available; recommendations made for improved smallholder crop management; associated communications activities implemented 8. Production of updated *Balsa Manual*	Activities 2.3.1 & 2.3.3 completed 31 March 2013. Development work for Activity 2.3.2 completed 31 March 2013, but project partners and others elected not to proceed to completion. Activities 2.3.4 – 7 progressively completed from 30 September 2013 to 30 June 2016. Activity 2.3.8 completed 31 December 2015.	The three surviving seed orchards established and thinned by the project will produce substantial quantities of improved seed from 2017. Knowledge from silvicultural and management trials has been incorporated in project knowledge products and training materials. The training materials developed include silvicultural manuals.

2.4	Development of systems to facilitate product certification	1. Liaison undertaken with national initiative and prior scoping work, to ensure collaboration and establish context. 2. Pre certification assessment, to understand requirements of ENB industry to achieve forest certification, conducted. 3. Systems and practices necessary for the ENB balsa industry to achieve forest certification identified. 4. Activity report and stakeholder workshop completed. 5. Outcomes of project work integrated into development of PNGFA Balsa Code of Practice. 6. Outcomes communicated to ENB balsa industry communications and organisation structures to ensure ongoing dissemination.	Activities 2.4.1- 4 completed 31 March 2013 Activities 2.4.5 – 6 undertaken in a variety of ways (reports, briefings, policy fora) between April 2013 and June 2016. Carriage of the Balsa Code of Practice rests with PNGFA.	The project work raised awareness of certification prior to industry response to market demand for certified products. Certification has been adopted by one of the major ENB processors. While the initial goal was certification of smallholders supply, that goal has been varied to that of FSC MIX (70% FSC Certified from company plantations and 30% FSC Controlled Wood from smallholder growers). . The other main processor is currently seeking certification. The project presented detailed analyses of balsa regulatory regimes and options to PNG forest policymakers.

Objective 3: To strengthen the global market position of the PNG balsa industry

no.	activity	outputs/ milestones	completion date	comments
3.1	Market and product development options for the ENB balsa industry	1. Key international balsa industry actors and businesses interviewed 2. Industry and market analysis conducted, to provide up to date information on prospects for the balsa industry in the medium to long term 3. Possible balsa industry development options identified and analysed. 4. Activity report and workshop with stakeholders completed.	Activities 3.1.1 – 2 delivered primarily through two reports, completed September 2011 and August 2015. Activities 3.1.3 – 4 completed following Balsa Scenarios workshop, April 2012.	The ENB balsa industry continues to be well-positioned in global markets. Balsa from ENB is well regarded by the market due to product quality, including colour and density. Purchase of PNG Balsa Ltd by the international company 3A Composites can be seen as a significant vote of confidence in the ENB balsa industry.

7 Key results and discussion

Key contexts

The aim of the project was *to enhance the value, value recovery and international competitiveness of the PNG balsa industry and, by doing so, optimise its benefits for smallholder growers*. Given that the PNG balsa sector remains, as it was at the time of project planning and initiation, entirely export-oriented; that smallholder growers necessarily continue to operate in an environment in which market access and demand are mediated by local processors; and that the East New Britain balsa sector continues to be regulated by the PNG Forest Authority and subject to relevant export regulations, it is necessary to frame project results in these contexts. Therefore, key contexts for the project over its life are summarised below.

International market conditions have fluctuated significantly during the life of the project; they were initially strong, deteriorated in the middle years of the project, and have now recovered substantially; these market conditions inevitably impact on smallholder growers, in terms of both demand and price. Some markets for PNG-produced balsa also began requiring certification during the life of the project.

While some elements of the structure of the ENB balsa sector have remained broadly consistent during the life of the project – there remain two major processors, one with their own estate and the other with a similar base of joint venture plantation (a land lease arrangement with a crop share payment); these plantations are the 'resource of first resort' for these processors. Their demand for smallholder wood has varied during the life of the project, reflecting the gap between market demand and their own resource supply, and periods of market downturn have impacted adversely on smallholder growers. A rise in demand for certified products initially created a barrier to smallholder resources, but a conscious change to include FSC Controlled Wood allowed smallholder participation. The stumpage paid for the smallholder resources, which reflects global market prices, was c. PNG K40/m^3 at the start of the project, collapsed to less than K10/m^3 around the mid-period of the project, and has now recovered to c. K20/m^3. The ownership and/or management objectives of these major processors has also changed during the life of the project, and there has similarly been some flux amongst the smaller processors or purchasers of smallholder wood.

The current situation is one in which both major processors have become more sensitive to their relationship with smallholder growers, and in which there are a more diverse range of smaller-scale processors than previously. Major processor responses have included exploration of arrangements to buy sawn timber from small-scale portable millers and processors; however, due to quality issues, these arrangements have not yet been implemented. In general, changes instituted by the major processors have been positive for smallholders. Conversely, while balsa remains for smallholders an attractive complementary crop to other established ENB commodities, such as cocoa; there is now increasing competition from oil palm as both an estate and smallholder crop. In general, however, the fundamental assumptions of project design and focus remained relevant throughout the life of the project. Similarly, the domestic policy and regulatory contexts for ENB balsa production remain much as they were at project initiation.

Summary of key results for project objectives and activities

The key results for each project objective and activity are presented in Table 7.1

Table 7.1. Summary of key results by objective and activity

Objective	**Associated activities**	**Key results**	**Main outputs** (Annex 1)
1. To enhance the livelihoods of smallholder balsa growers	1.1 Define relationships between stakeholders, understand and illustrate the benefit distribution and identify opportunities to address inefficiencies along the balsa value chain to improve outcomes for smallholder balsa growers	ENB balsa supply and value chains chain mapped. ENB balsa sector survey completed. Potentials for improved smallholder tree yield, wood recovery & returns identified.	PI17, PC3, PC4, PC6, PC7
		Baseline and industry data for the ENB balsa sector	AS4, AS9, PR9
	1.2 Investigate how smallholders make decisions about resource use in the context of their livelihood goals and strategies	Major household survey completed	PR2, PR3, PI1, PC14, PI4, PI5
		Methodological improvements identified.	PI23, PR3, PS5, PS6, PS8, PS9, PS10
	1.3 Recommendations for developing effective balsa smallholder organisational and communication structures	Market information needs, grower groups, and processors surveys completed. Data analysis undertaken and reported.	PC13, PR12
	1.4 Review current extension, communication and capacity building activities and propose mechanisms to effectively support growth of the balsa industry in ENB	Extension needs and extension service provider surveys completed and reported.	PI2, PC14, PC13, PR11
		Training Needs Analysis completed utilising an advisory group with IATP. The required technical information was documented based on project outcomes, industry knowledge and published information.	TM2
		‘Train the trainer’ manual developed, and ‘train the trainer’ program delivered (15 trainers trained).	TM1, TM4 - TM18
		Tok pisin farmer manual developed; 5 farmer training programs conducted	PI4, PI18
		Feedback provided by farmers as to the most important (and empowering) information from the training.	PI4, TM3, PS28, PI18
		Six information leaflets summarising “balsa as a crop” prepared in English and *tok pisin*	TM18 – TM23

2. To improve value recovery to balsa growers and processors	2.1 Optimise value recovery for the balsa industry by improving delivery logistics to processing facilities	Smallholders' principal concerns (perceived log waste) identified.	PI7
		Harvest residue assessment methods developed and applied. Stemwood recovery rates documented. Analysis undertaken and residue profile developed and reported. Biomass nutrient profile developed, providing insights into harvest residue management and productivity sustainability.	JP1, PC1, PC13, PI16
		Portable sawmills studied and effective stumpage rates estimated.	PS27
		Smallholder log sales processes documented and compared to those for other crops.	PS7, PS8, PS17, PS18, PS23
	2.2 Optimise value recovery in balsa processing with an emphasis on optimising value recovery	Review of processing confirms major gains likely from product development rather than processing improvement.	PR8, PR10, PI20, PI21
		Balsa wood properties analysed and documented.	PR7, JP2, JP3, AS1, AS2, AS7, AS8.
		Award-winning balsa-based product development	PC12, PC14
		Other balsa product development projects	AS1, AS2, AS3, AS5, AS6, JP2, JP3, JP4
		Within and between tree basic density variation under different silvicultural regimes documented as a key product quality parameter.	PI15

	2.3 Optimising germplasm and crop management for smallholders	Biological growth and yield determined, revealing that log recovery rate (50% of stem wood) is due to stem defects, some of which can be managed. Stem defects levels and impacts quantified.	PI7
		110 candidate plus trees identified, seed collected and seedlings raised. 4 replicated progeny trials, intended for subsequent conversion to seed orchards, established; establishment and subsequent development successful at 3 sites.	PI24, PI24
		All 3 trials assessed for volume and form, and first thinning undertaken. Final thinning to be undertaken, including analysis of wood samples for density.	PI8, PI17, PI29, PI30
		Draft seed supply agreement prepared. Seed distribution strategy has been developed and a realistic price for the seed determined. No improved seed yet available due to tree age.	PI26
		Smallholder and *status quo* silviculture documented. Critical issues identified: refilling, initial spacing, a reluctance to thin to waste, weed control options, jorquette pruning, and boron deficiency.	PI7
		Genetics trial refilling data analysed and recommendations developed.	Report to be completed
		UNRE initial spacing trial was assessed and harvested capturing yield and stem defect data, individual stem analysis and wood properties data.	PI15
		Weed control trials undertaken by UNRE 3rd year students comparing nil, slashing and chemical weed control.	PS11, PS12, PS15, PS21, PS22, PS24

		Trials of levels of nutrients in balsa at different stages of growth undertaken by UNRE 3rd year students.	PS1, PS2,
		The impact of jorquette defects has been documented. Company-developed pruning regimes have been documented.	TM1, TM2, TM3
		Boron deficiency has been confirmed and a remedial treatment developed and tested by UNRE 3rd year students.	PS1, PS2, PS3, PS4, PS13, PS14, PS16, PS25
		The main insect pests and other risks (e.g. wind and fire) to balsa were documented by UNRE 3rd year students..	PS19, PS20
		An smallholder-friendly silviculture regime has been developed and implemented: 4x4 spacing + nil thin to waste.	PC5, PC11, PS26, PI15
		A comprehensive review undertake of certification strategies and options for inclusion of smallholders have been undertaken.	PR4, PC14, PC2, PC9, PI6,
		Legal and policy frameworks for forestry in PNG reviewed and impediments identified.	PR5, PC2, PC10,
		The draft Balsa Code of Practice was reviewed and revisions proposed with PNGFA and industry inputs.	PR6, PC10
3. To strengthen the global market position of the PNG balsa industry	3.1 Develop medium and long term market development options for the ENB balsa industry	Global industry and market assessment reported to local stakeholders.	PR9
		Scenarios workshop conducted to build a shared vision of possible futures.	PR1, PI3, PI31, PI32, PI33
		Smallholder farmer market information needs survey undertaken and reported	PR12

Overview and discussion of key results

Characterisation of the ENB balsa sector and future sector development options

The project conducted major surveys of balsa growing households and of the sector more generally. The results of these surveys provide an important information base for balsa sector stakeholders at provincial and national level, and for subsequent project interventions. A scenarios workshop conducted by the project in 2012 promoted discussion and developed a shared vision of the future for the PNG balsa sector.

The general conclusions of this work are that the ENB continues to be favourably situated in the global context, but that it would benefit from policy reform and from stronger partnerships between key sector actors (processors, smallholder growers, national and provincial governments, knowledge and training providers, and non-government and civil society actors), and from greater levels of smallholder grower knowledge about and management of balsa as a crop. Smallholder growers remain crucial to the success and any further expansion of the ENB balsa sector.

Smallholder balsa growers

ENB smallholders for whom balsa growing is most likely to be attractive and profitable are those who have road access to the site, are relatively close to processing facilities, who have sufficient land or income to allow them to establish a minimum area (c 0.2 ha) of a crop that does not return income for 5-6 years, and who can undertake a threshold level of management. Many smallholders in ENB, particularly in the Gazelle Peninsula region within economic haul distance to processors, satisfy these criteria.

However, as the scoping study (Midgley et al 2010) noted, smallholder market and value chain information systems about balsa have not been well-developed in ENB. The consequences of this were evident during the life of the project, when a downturn in global markets led to greatly reduced demand for smallholder balsa, with limited communication along the value chain to inform smallholder growers of the reasons or prospects for market recovery. The associated loss of trust and confidence in balsa as a crop impacted on the adoption plans of many smallholders. Project outputs, and more recent approaches to building partnerships by major processors, address this issue. Conversely, some growers who were relatively well-informed by project or related activities demonstrated a high degree of adoption and innovation.

Project research also found that smallholder balsa growers were generally not well-informed about how best to integrate balsa growing with their farming systems and livelihoods, and that they would welcome more extension advice and support about these issues, and about how to manage balsa crops well. They would also benefit from access to better germplasm, the value of which many recognise; and a clearer understanding of the drivers of product value and price, which would inform their management.

Partnerships and organisations in the balsa sector

Smallholder growers would benefit in a number of ways from stronger partnerships – with each other, with processors, and between key balsa sector actors, including national and provincial government agencies. The presence of the project catalysed some of these, but the project was not successful in its original ambition to catalyse enduring balsa-specific organisational structures for smallholder balsa growers. This is largely because such structures already exist for smallholders in many ENB localities, catalysed by their participation in other production activities. It was evident from project research that integration of balsa production into existing organisational arrangements is likely to be a more effective approach than seeking to establish separate balsa-specific organisations.

The project was able to both capitalise on and further support the central role of the Integrated Agricultural Training Programme, based at ENB's University of Natural Resources and Environment, as an effective knowledge broker and training provider. Project activities confirmed that knowledge about balsa management and markets, and

the development of growers' capacity to improve their management of and value recovery from balsa, are best delivered as part of broader agricultural training programs already well-established in East New Britain.

Genetics and silviculture

In collaboration with project partners, the project made significant contributions to the genetic quality of future balsa crops, and to the silvicultural management of current and future crops. The genetic benefits will be realised progressively as seed from the three seed orchards established and managed by project partners (3A Composites, Coconut Products Ltd, and UNRE) becomes available from 2017, and as smallholders undertake better management of their balsa crops. However, mechanisms to ensure smallholders can access improved balsa seedlings may need further development.

Major outcomes of the silvicultural research were incorporated into the Balsa Manual and training material. In particular, results demonstrated the importance of managing and minimising stem defects to volume and value recovery, and that most loss was associated with jorquette (stem forking) formation. This criterion informed selection of candidate seed orchard trees, and stand management recommendations. A 'smallholder-friendly' silvicultural regime, which does not require thinning to waste, was identified and communicated. The outcomes of each of the genetic and silvicultural research can, in conjunction with capacity development, be expected to enhance returns, on investment of money and labour, to smallholders; and to strengthen the competitiveness of the ENB balsa industry.

Harvesting, processing and products

Project research was also able to clarify levels of defect typical of balsa crops, and levels of loss of volume due to these and harvesting systems between standing trees and the mill. These findings suggest that current harvesting and transport systems are efficient, and thus that improvements in genetic quality and silvicultural practice are the most likely arenas for gains in volume and value recovery for growers and processors. Project research on the impacts of stem defects on recovery and value demonstrated that processors are not disadvantaging smallholders through current harvesting and measurement practices.

Project analysis of balsa processing and products identified that there was already a high level of expertise in the sector in relation to the former, and thus that the greatest contribution the project could make was in the identification of new product streams. The project made significant contributions in this latter context. Nevertheless, improved knowledge of within-tree and management-induced variation in wood density generated by the project allows improvement in processing efficiency through batching logs of like density, and better prediction of the relationship between balsa crop characteristics, management and product value.

The mechanical, acoustic and thermal properties of balsa were also investigated and reported as part of development of novel balsa products. The participation of Australian product design researchers added considerable value to project work, and identified potential new product streams for the ENB balsa sector, and for the balsa industry globally. Such products could make use of balsa containing within-board defects (e.g. knots and red heart stain), which is not accepted for current products. Awards received by project researchers for this work helped to generate a higher profile for balsa products and their sustainability credentials.

Policy and regulation

The policy-related research conducted by the project suggests that the levels of regulation of production systems could be relaxed, and that administrative processes governing exports streamlined, without adverse economic, environmental or social impacts. Project research facilitated the adoption by the major processors of FSC certification, as well as exploration of measures to facilitate the certification of balsa grown by smallholders. The

project team prepared a review of relevant legislation and a revision of the Balsa Code of Practice, both of which were provided to the PNG Forest Authority for consideration. Each of these outputs support the sustainability-related objectives of forestry regulation. Export markets, and thus value chains in ENB, have become segregated into certified and non-certified product streams. However, FSC certification, oriented towards native forests in PNG and challenged by the unique characteristics of PNG land ownership, has not yet been able to accommodate the certification of wood produced by smallholder growers, except through use of FSC MIX (FSC Controlled Wood from smallholders combined with company-managed FSC 100% wood). Consequently, smallholders are constrained in the benefit they can derive from demand for certified balsa wood.

The local PNG Forest Authority office continues to play an important role as intermediary and honest broker in payments from processors to smallholders, as required by the *Forest Act 1991 and Regulations*; while in principle this role could be played by other organisations, or become superfluous, it appears necessary for the sector for the moment, as levels of trust between many smallholders and some processors are generally not sufficient for more direct relationships to become the default mode of interaction. Project activities contributed knowledge and training (e.g. log volume measurement) that will assist in addressing this constraint but it was not fully resolved within the life of the project.

Capacity-building

The project made important contributions to the knowledge and skills base of smallholder balsa growers, through the finalisation of a Balsa Manual and module and its integration into the smallholder farmer training system delivered by IATP. As noted above, the role of IATP in delivering training to better inform smallholder adoption of balsa growing and management of balsa crops is fundamental to the continuing success of the ENB balsa sector, as most smallholders are not currently well-informed about these issues. A total of 5 famer training programs have been delivered to 112 participants (c. 60% male and 40% female). The project directly trained 15 ENB farmers (c. 80% male and 20% female) as trainers to deliver the balsa module.

The project has also contributed significantly to the capacity development of students in PNG and Australia. In PNG, this was principally by involving 18 3rd-year UNRE (11 males & 7 females) students in project research under the UNRE industry placement program; in Australia, two PhD students, a Masters student and ten undergraduate students (7 males and 6 females) completed research projects associated with the project.

8 Impacts

8.1 Scientific impacts – now and in 5 years

The major scientific impacts realised by the project are summarised by objective below, and discussed subsequently.

Objective 1 – enhance smallholder livelihoods

- Enhanced knowledge of smallholder grower characteristics and needs, and of motivations for balsa growing, provide a platform for more informed policy or extension interventions. The timing of realisation of these impacts depends on that of policy development, extension activities and the impacts of global markets on demand and prices paid. The main information generated from project research activities remains accessible to smallholders, the IATP program, project partner companies, PNG government agencies and other interested parties through the PIP website.

Objective 2 – improve value recovery

- Determination of balsa wood and log properties
- A structured approach to balsa product development (journal publications JP2, JP3, JP4 & JP5 – see 10.2)
- Quantification of defect and harvest losses (journal publication JP1 – see 10.2)
- Improved genetic quality of future balsa crops
- Improved smallholder silvicultural management regimes
- Identified balsa stand nutrient deficiency and remediation measures

These impacts can be realised immediately, other than for genetic quality, as genetically-improved seed will not become available until 2017. The scale of impacts depends in part on the scale of farmer training (see 8.2 below), and in part on adoption of project outputs by processors.

Objective 3 – strengthen market position

- All stakeholders across the sector have been informed by market assessment and scenarios development.
- The new products developed could utilise balsa rejected by current markets.
- Facilitation of the introduction of certification.

Certification has already been adopted by one of the major processors, and is likely to be adopted by the other. Certification has maintained access to high-value markets. Market adoption of new products is likely over the next 5 years.

Cross-project impacts

- Greater awareness on the part of policymakers of options for improvement to relevant policy and policy instruments.
- Development of balsa training materials in the context of the integrated agriculture training framework provides a template for the development of similar materials for other tree crops.
- Project activities informed the development of a balsa strategy for Timor Leste.

The timing of realisation of these impacts depends very much on that of government policy initiatives and strategy development, and of IATP partnerships with those working on other tree crops.

8.2 Capacity impacts – now and in 5 years

The major capacity impacts realised by the project are summarised by objective below, and discussed subsequently.

Objective 1 – enhance smallholder livelihoods

- IATP, which is focused on improving smallholder livelihoods, now has the capacity to deliver balsa grower training module and manual for smallholders, and incorporate that knowledge in the ongoing development of IATP training.
- Smallholders who access project outputs and undertake IATP training will have the capacity to better integrate balsa growing into their livelihood portfolios, and will be able to manage balsa to achieve higher returns. These benefits are currently being realised by 112 growers (67 males & 45 females) who have accessed training provided through 5 deliveries of the module in local community facilities; over 5 years, IATP would typically expect to reach a further 500 growers (4 courses annually with 25 participants; subject to the availability of external funding).
- IATP trained 15 balsa trainers (12 male and 3 female), with the added benefit of enhancing their income- earning potential.
- Smallholders who access project outputs and undertake IATP training will have a better understanding of how to manage balsa stands and trees to provide logs suited to processors' needs, and which will therefore be more valuable.

Objective 2 – improve value recovery

- Project staff and participating smallholders' capacity to assess balsa harvest residues was developed.
- Smallholders trained through the IATP balsa grower training module are able to manage their balsa to improve value recovery
- Australian knowledge of and research capacity relevant to balsa wood properties and products was enhanced.
- Smaller- scale ENB processors are better informed of glue requirements for balsa products.

Objective 3 – strengthen market position

- ENB partner processors have been provided with market assessments and methods developed by the project.

Cross-project impacts

- Project officer capacity was developed to high level, and Masters degree commenced.
- Enhanced UNRE project staff capacity in project administration and management.
- Enhanced UNRE administrative staff capacity in project budget management skills.
- Unitech and UNRE staff members have improved capacity in conducting research relevant to project activities, including: forest genetics, harvesting, household surveys, silviculture, and wood science.
- 18 UNRE final year undergraduate students completed student projects that enhanced their capacity.
- 13 Australian students (10 undergraduate, 1 Masters, 2 PhD) completed student projects that enhanced their capacity.

8.3 Community impacts – now and in 5 years

The major community impacts realised by the project are summarised by objective below, and discussed subsequently.

8.3.1 Economic impacts

Objective 1 – enhance smallholder livelihoods

- Smallholder growers can realise immediate benefits from the quantification of defects, residues and stumpage, which facilitates informed transactions between grower and processor.
- Economic benefits from improved genetic material and tree and stand management will progressively enhance smallholder income. These benefits will be realised over the next 5-10 years as new balsa crops are established with genetically-improved plants, and better managed (in terms of spacing, nutrition and pruning).
- Smallholders trained under the 'train the trainer' have a supplementary income stream as well enhanced transferable skills.

Objective 2 – improve value recovery

- Improved understanding of variation in wood density within and between trees allows processors to improve recovery immediately.
- Improved understanding of the relationship between management regimes, crop characteristics and wood qualities provides the basis for improved value recovery from future balsa crops, over a 5-10 year period.
- Trialling of use of portable sawmills by local entrepreneurs to supply sawn wood to major processors can enhance value recovery by these actors.

Objective 3 – strengthen market position

- Balsa product development and promotion activities may foster adoption of new balsa products, with consequent benefits to the ENB balsa industry, and thus to growers and processors.
- Implementation of certification has allowed the ENB balsa industry to retain market share through accessing markets requiring certification.

Product development should be realised over the next 5 years. Certification impacts have already been realised.

8.3.2 Social impacts

Objective 1 – enhance smallholder livelihoods

- Better smallholder (including women and youth) knowledge and awareness of characteristics of balsa as crop, including its integration with other key elements of ENB farming systems and livelihoods, facilitates appropriate adoption of balsa by smallholders in the context of their land, labour and financial resources; and so minimises adverse social outcomes associated with poor adoption or management decisions.

Objective 2 – improve value recovery

- Project-generated information about log measurement and levels of harvesting waste, has improved levels of trust by smallholder growers in fair treatment by processors.

Cross-project impacts

- Implementation of certification has strengthened elements of social sustainability through identification and compliance with specified social criteria. These impacts can be expected to be ongoing.
- IATP-trained trainers are available to contribute to programs about other tree crops.

The non-certification impacts are already being realised at a project-scale; they will be realised on an increasing scale as training reaches more smallholder growers (see 8.2). The certification impacts are already being realised for that part of the sector in the value chain of the certified processor.

8.3.3 Environmental impacts

Objective 2 – improve value recovery

- The identification of nutrient profiles of harvest residues, and of nutrient deficiency and remediation measures in balsa crops, allows improved environmental management both on- and off-site.

Cross-project impacts

- Implementation of certification and further development of the Balsa Code of Practice ensures environmental impacts associated with balsa growing, harvesting and processing are compliant with those requirements.

These impacts can be realised immediately.

8.4 Communication and dissemination activities

Project communication and dissemination activities are summarised below:

Primary audience	**Communication & dissemination activities** (Outputs as listed in Appendix 1)
ENB smallholders	▪ IATP Balsa manual and module (TM3) ▪ UNRE radio broadcasts (M4, M5) ▪ Tok pisin Balsa fact sheets (6; TM18-23)
ENB farmer trainers, and smallholder farming and balsa sector professionals	As for smallholders, and: ▪ Balsa training materials (TM1-16) ▪ Website portal for balsa information (www.pip.com.pg/projects/completed-projects/27-balsa-project.html) ▪ Project outputs from Objective 1 Activities (see Table 7.1)
ENB balsa processors	▪ Website portal for balsa information (www.pip.com.pg/projects/completed-projects/27-balsa-project.html) ▪ Project reports from Objective 2 & 3 Activities (see Table 7.1)
UNRE staff and students	▪ Student project reports and UNRE seminars (PS1-28)
PNG and ENB policy makers	▪ Scenarios workshop and report (PR1) ▪ Policy-related project reports (PR4-6) ▪ Participation in and presentations to PNG Forest Authority/ ACIAR forest policy workshops 2015 and 2016 (PC2, PC9, PC10)
Forestry researchers and professionals	▪ Project reports and presentations (PR1-11, PI1-33, JP1-4, PC1-13, AS1-10,)
Global balsa industry	▪ Balsa market report (PR9) posted on Linkedin Balsaweb Group at: https://www.linkedin.com/groups/4101255

IATP will provide continuing access to the Balsa Manual and training module and materials as part of their portfolio of training and capacity development activities. The balsa sector survey undertaken by the project identified the value of radio broadcasts in reaching smallholder growers; the balsa sector should continue to capitalise on that medium. The Pacific Island Projects web portal (www.pip.com.pg/projects/completed-projects/27-balsa-project.html) will provide ongoing access to material directed at ENB balsa growers, extension agents, professionals and processors, and should continue to be developed as a repository of this material.

9 Conclusions and recommendations

The project, and the scoping study from which it was developed, were the first ACIAR investments in PNG's East New Britain-based balsa industry. The particular conjunction of climate, geography, history, infrastructure and land use in the Gazelle Peninsula region of East New Britain make balsa an attractive crop there. The scoping study identified a series of constraints to improving the livelihoods of smallholder balsa growers in the context of the East New Britain balsa value chain, and the project was developed to address these. The general contexts and premises for the project remained relevant over the life of the project, and are expected to continue post-project.

9.1 Conclusions

The principal conclusions from the project are summarised below.

Global demand for balsa is likely to continue to remain strong, reflecting the growth in and diversification of high-technology applications for balsa products. Project research identified new balsa products that could further expand the market for balsa. The East New Britain balsa industry continues to be well-placed to capitalise on this healthy market situation; this has been reflected in major investment in the East New Britain industry by large international corporations and some smaller actors during the life of the project.

Expansion in balsa production in East New Britain is dependent primarily on smallholder growers, as there is little prospect of major expansion in company estates. While balsa remains an attractive crop for both corporate and smallholder growers, it faces increasing competition for land from oil palm, and perhaps other crops new to East New Britain. A new suite of arrangements between smallholder balsa growers and individual companies is facilitating smallholder participation in the balsa value chain.

Smallholders for whom balsa growing is most likely to be attractive and profitable are those who have road access and are relatively close to processing facilities, who have sufficient land or income to allow them to establish a minimum area (c 0.2 ha) of a crop that does not return income for 5-6 years, and who can undertake a threshold level of management. Many smallholders in East New Britain satisfy these criteria.

Smallholder balsa growers would benefit from access to better germplasm, enhanced knowledge and skills in balsa management, and a clearer understanding of the drivers of product value and price. The majority of smallholders surveyed by the project would welcome more extension advice and support about these issues. Smallholder growers would also benefit from stronger partnerships – with each other, with processors, and between key balsa sector actors, including national and provincial government agencies.

Balsa processors will benefit in two principal ways. Firstly, they would benefit from a better-managed and characterised smallholder resource, and from smallholders having a clearer understanding of the drivers of product value and price. Secondly, provision of improved germplasm with reduced propensity for stem defects will increase harvest recovery rates and yields. Existing balsa harvesting and delivery systems are relatively effective and efficient, although the project identified some areas for improvement, including in mechanisms to build trust between processors and growers.

Communication of knowledge about balsa management and markets, and the development of growers' capacity to improve their management and value recovery, are best delivered as part of broader agricultural training programs already established in East New Britain. The Integrated Agricultural Training Programme, based at East New Britain's University of Natural Resources and Environment, has both an established and a central role in knowledge communication to smallholders.

The regulatory environment for the East New Britain balsa industry remains one that is defined largely by PNG's focus on regulating the harvesting of native forests and the

export of native forest logs. Project analysis of the policy and regulatory environment identified how reform could address the consequent constraints along the balsa value chain and other plantation tree crops without undermining the regulatory environment for native forestry operations. Targeted reform of the regulatory environment for balsa growing, processing and export, as identified by the project and discussed at two national policy workshops, would strengthen the comparative advantage of PNG balsa with little risk to environmental or social sustainability criteria. The introduction of certification to East New Britain's balsa sector has benefitted processors who have adopted it, and has collateral benefits to smallholders; but it has as yet delivered only limited direct benefits to smallholders, as certification systems have yet to accommodate PNG's land tenure arrangements.

9.2 Recommendations

To capitalise on the work of the project, ACIAR could:

- continue support, directly or by catalysing other funding arrangements, for the Integrated Agricultural Training Programme; and for its delivery of knowledge about balsa as a crop, and the optimal management of balsa, to smallholders. Lack of this knowledge remains a fundamental constraint to improving smallholder livelihoods from their participation in the balsa value chain;
- continue support for managing the seed orchards established by the project, and of mechanisms for facilitating access by smallholders to that improved genetic material. Lack of access to improved genetic material is a major constraint to both improving smallholder livelihoods and the East New Britain balsa industry;
- foster development of a variety of partnership arrangements to support ongoing smallholder participation in balsa value chains. Such partnerships include those between balsa processors and smallholders, between smallholder growers, and between national and provincial government agencies and balsa sector actors;
- continue support for the maintenance and development of communications portals about balsa as a smallholder crop, through Pacific Island Projects' website and complementary communications activities led by the University of Natural Resources and Environment and the Integrated Agricultural Training Programme;
- continue dialogue with the PNG Forest Authority, and other PNG agencies with relevant policy responsibilities, about targeted policy and regulatory reform in support of more sustainable and efficient balsa production regimes and value chains. Such reform could be achieved without undermining appropriate regulation of PNG's native forestry sector;
- foster dialogue with certification programs about the development of certification criteria and systems that recognise and accommodate the particular characteristics of PNG land ownership, as they apply to balsa production and other forestry activities.

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JP4 Barnes, R.H. Morozov E.V., Shankar K. (2015) ***Improved methodology for design of low wind speed specific wind turbine blades***. *Composite Structures* **119**: 677-684.

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PR1 Blyth, M. (2012) ***East New Britain Land Use Scenarios, 2012 to 2030 Opportunities and challenges ahead for the balsa industry 29 June.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 1.3 Report.

PR2 Blyth, M.J. (2012) ***Activity 1.2: Understanding how smallholders make decisions about their resource use livelihoods: Preliminary report on village meeting and household surveys in Wairiki No.2 village, April-May 2012.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 1.2 Report.

PR3 Blyth, M.J. (2014) ***Implementation effectiveness of a household survey in East New Britain to understand smallholder decision making in relation to resource use and livelihood improvement.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 1.2 Report. Working paper.

PR4 Crawford, H. & Jenkin, B.M. (2012) ***Forest and forest product certification.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.4 Report.

PR5 Crawford, H. & Jenkin, B.M. (2012) ***Review of PNG forestry legislation, regulations and logging code of practice in the context of the ENB balsa industry.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.4 Report.

PR6 Jenkin, B.M. (2011) ***A review of the Balsa (Ochroma lagopus) Industry Code of Practice.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.4 Report.

PR7 Kotlarewski, N.J., Gusamo, B. & Ozarska, B. (2013) ***Thermal conductivity of Papua New Guinea Balsa wood measured using needle probe procedure.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.2 Report.

PR8 Kuys, B., Ozarska, B. & Thong, C. (2012) ***Contribution of Product Design to the Papua New Guinea Balsa Project ACIAR FST/2009/016.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.3 Report.

PR9 Midgley, S. J. (2015). ***Balsa Industry, PNG: Market analysis and strategic development.*** ACIAR Project Report FST/2009/016 "Improving the Papua New Guinea balsa value chain to enhance smallholder livelihoods". Activity 3.1 report.

PR10 Ozarska, B. & Kuys, B. (2012) ***Report on the Assessment of Balsa Processing Companies in New East Britain, PNG, and Recommendations for Improvements.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.2 Report.

PR11 Anonymous. (2016) ***East New Britain Balsa Sector Surveys: Summary of Key Results.*** (ACIAR Project FST/2009/016).

11 Appendixes

11.1 Appendix 1: internal and student reports, presentations and publicity, and training material

Project internal reports

PI1 Blyth, M.J. & Mulung, K. (2012) ***Factors influencing smallholders' resource use decisions to achieve livelihood goals: Adoption of balsa production in East New Britain Province, Papua New Guinea.*** Project background, research methods and data collection procedures. ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 1.2 Report.

PI2 Blyth, M.J. & Mulung, K. (2012) ***Extension services in support of the ENB balsa industry.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 1.2 Report.

PI3 Blyth, M.J. (2011) ***Report on field trip and project inception workshop 1-2 September 2011.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 1.3 Report.

PI4 Minimulu, J. M.J. (2013) ***ACIAR Balsa Project Activities Brief – as at 15/11/2013: The Household Surveys.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 1.2 Report.

PI5 Blyth, M.J. (2013) ***Notes for the mid-term review, November 2013.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 1.3 Report.

PI6 Crawford, H. & Jenkin, B.M. (2013) ***Activity 2.4: Development of systems to facilitate product certification. Focus group meetings held 21st and 22nd March 2013.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.4 Report.

PI7 Jenkin, B.M. (2011) ***An update of the industry situation.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 1.1 Report. Draft to be finalised.

PI8 Jenkin, B.M. (2012) ***Activity 2.3: Optimising germplasm and crop management for smallholders.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.3 Report.

PI9 Jenkin, B.M. (2014) ***A field trip report for December 2014.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016).

PI10 Jenkin, B.M. (2014) ***ACIAR Balsa Project 3rd year student projects.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016).

PI11 Jenkin, B.M. (2014) ***The 2014 3rd year student projects.*** (Project introduction and report writing) Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Lecture delivered to 2014 3rd year students to enhance report writing skills.

PI12 Jenkin, B.M. (2015) ***The 2015 3rd year student projects.*** (Project topics) Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Projects.

PI13 Jenkin, B.M. (2015) ***The 2015 3rd year student projects.*** (Project introduction and report writing) Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Lecture delivered to 2015 3rd year students to enhance report writing skills.

PI14 Jenkin, B.M. (2015) ***The 2015 3rd year student projects.*** (Students allocated to project topics) Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Students.

PI15 Jenkin, B.M., & Minimulu, J. (2014) ***A pilot study of the within and between variation in balsawood tree stem-wood basic density.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.3 Report. Draft in preparation. Draft to be finalised.

PI16 Jenkin, B.M., Ghaffariyan, M., Mitchell, R. & Brown, M. (2014) ***Evaluating harvesting residues of a Balsa plantation in Papua New Guinea.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.1 Report.

PI17 Jenkin, B.M., Minimulu, J., Howcroft, N., Boas, M., & Ohana, J. (2014) ***Genetics trial assessment plan.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.3 Report. Draft to be finalised..

PI18 Minimulu, J. (2015) ***Balsa Farmer Training Brief Report, Farmer Training & Extension.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Activity 1.4 Report.

PI19 Minimulu, J. (2015) ***Field trip report: Attendance at the 2015 Joint IFA and NZIF Conference.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016).

PI20 Ozarska, B. & Kuys, B. (2012) ***Report on the Assessment of Balsa Processing Companies in New East Britain, PNG, and Recommendations for Improvements. Part 1: CPL.*** ACIAR FST/2009/016: Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.2 Report. [Confidential]

PI21 Ozarska, B. & Kuys, B. (2012) ***Report on the Assessment of Balsa Processing Companies in New East Britain, PNG, and Recommendations for Improvements. Part 2: Balsa and Co.*** ACIAR FST/2009/016: Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.2 Report. [Confidential]

PI22 Rowley, E.E. (2014) ***M&E Plan for the Australian Centre for International Agricultural Research PNG Balsa Value Chain Project (FST/2009/016).*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 1.2 Report. Working paper.

PI23 Blyth, M.J. (2014) ***Implementation effectiveness of a household survey in East New Britain to understand smallholder decision making in relation to resource use and livelihood improvement.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 1.2 Report. April 2014.

PI24 Haines, R, Doran, J. & Kanowski, P. (2012) ***Balsa progeny trial/SSO design.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 1.2 Report. April 2014.

PI24 Jenkin, B.M. (2013) ***Genetics trial snap shot.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Activity 2.3 NOTE.

PI25 Jenkin, B.M. (2013) ***The 2013 3rd year student industry placement.*** (Project topics) Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Projects.

PI26 Jenkin, B.M. (20143) ***Balsa improved germplasm (seed) cooperative supply agreement (resulting from ACIAR Project FST/2009/016 activities.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Draft agreement.

PI27 Jenkin, B.M. (20143) ***Field visit by Dr Nick Austin and Emily Flowers (ACIAR), November 28th, 2013.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Field visit supporting document.

PI28 Jenkin, B.M. & Blyth, M. (2014) ***Beyond the project life.*** A report on the workshop held on 14th October, 2014 at Kokopo, ENBP, PNG. Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016).

PI29 Jenkin, B.M., Minimulu, J., Howcroft, N., Boas, M., & Ohana, J. (2014) ***Tree improvement program and seed orchard management.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.3 Report.

PI30 Jenkin, B.M. (2012) ***Activity 2.3: Optimising germplasm and crop management for smallholders.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.3 Report.

PI31 Blyth, M. (2012) **Scenario planning workshop program.** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 1.3 Report.

PI32 Blyth, M. (2012) **Steps in creating future scenarios.** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 1.3 Report.

PI33 Blyth, M. (2012) **Scenario workshop background reading.** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 1.3 Report.

Presentations and conference papers:

PC1 Ghaffariyan, M., Jenkin, B.M., Mitchell, R. & Brown, M. (2014) ***Evaluating harvesting residues of a Balsa plantation in Papua New Guinea.*** In: IUFRO Small-scale Forestry Conference **Small-scale and Community Forestry and the Changing Nature of Forest Landscapes** 11 – 15 October 2015.

PC2 Jenkin, B.M, Blyth, M., Rollinson, S. & Kanowski, P. (2016) ***Policy issues for smallholder and value added forestry – lessons from the ACIAR balsa project.*** A presentation to the PNGFA / ACIAR PNG Forest Policy Workshop 2016, held at the Holiday Inn, Port Moresby, 16th February, 2015. Part of: Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016).

PC3 Jenkin, B.M. (2011) ***ENB balsa field work update.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Presentation in Canberra on 10th August, 2011.

PC4 Jenkin, B.M. (2011) ***ENB balsa field work update.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Presentation in EBNP on 1st September, 2011.

PC5 Jenkin, B.M. (2012) ***An integrated approach to species and regime selection in PNG: beginning with local people's needs.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Presentation to UNRE Farm Forestry students, 18th April, 2012.

PC6 Jenkin, B.M. (2014) ***Improving the PNG balsa value chain to enhance smallholder livelihoods.*** An Honorary Fellow presentation to the University of Melbourne on 29th August, 2014.

PC7 Jenkin, B.M. (2014) ***People's needs without borders: a PNG perspective.*** Presented at the Institute of Foresters of Australia's workshop Celebrating Australian forester's work abroad. Academy of Science, Canberra. Monday 24th November, 2014.

PC8 Jenkin, B.M. (2014) ***Project administration.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Presentation to PNG ACIAR Project Managers meeting, 1st April 2014.

PC9 Jenkin, B.M. (2015) ***Forest certification.*** A presentation to the PNGFA / ACIAR PNG Forest Policy Workshop 2015, held at the Holiday Inn, Port Moresby, 5th May, 2015. Part of: Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016).

PC10 Jenkin, B.M. (2015) ***Issues associated with legislation, codes of practice and forestry standards.*** A presentation to the PNGFA / ACIAR PNG Forest Policy Workshop 2015, held at the Holiday Inn, Port Moresby, 5th May, 2015. Part of: Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016).

PC11 Jenkin, B.M., & Minimulu, J. (2015) ***A collective knowledge approach to growing balsa as a cash crop in Papua New Guinea.*** A paper presented at the 2015 Joint IFA and NZIF Conference.

PC12 Kotlarewski, N.J., Thong, C. and Kuys, B. (2015) ***Industry feedback for academic product development: Influencing design decisions.*** Paper presented at IASDR 2015 Congress, 2-5 November, Brisbane Australia.

PC13 Rollinson, S. (2013) ***Activities 1.2, 1.3 & 1.4.*** A presentation to the Balsa Project Advisory Committee, November, 2013. Part of: Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016).

PC14 Kotlarewski, N., Kuys, B., & Thong, C. (2015**). Design innovation: a tool for value-adding to the Papua New Guinea Balsa Wood Industry**. Design for Business: Research Conference. Presentation in Melbourne on 12th May, 2015.

Publicity materials or activities:

M1 UNRE Campus Voice (2011) ***VC impressed with balsa project inception.*** Part of: Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016).

M2 UNRE Campus Voice (2013) ***If you go down to the woods today.*** Part of: Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016).

M3 UNRE Campus Voice (2014) ***Students perform exceptionally well.*** Part of: Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016).

M4 Uni Tokaut (2014) ***Radio interview 1.*** Part of: Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016).

M5 Uni Tokaut (2013) ***Radio interview 2.*** Part of: Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016).

M6 National Newspaper (2014) ***Balsa project.*** Part of: Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016).

M7 UNRE Campus Voice (2015) ***Minimulu attends IFA conference.*** Part of: Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016).

Training materials:

TM1 Jenkin, B.M. (2014) ***Options for growing balsa as part of a famer's livelihood strategy: A trainer's workbook.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Activity 1.4 output.

TM2 Jenkin, B.M. (2014) ***Train the trainer technical information.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Activity 1.4 output.

TM3 Jenkin, B.M., Minimulu, J. & Ngala, O. (2015) ***Growim balsa lo halivim sindaon long ples: Fama trening buk.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Activity 1.4 output.

TM4 Jenkin, B.M. (2014) ***Options for growing balsa as part of a famer's livelihood strategy: Train the trainer introduction.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Activity 1.4 output. PowerPoint presentation for trainer and farmer training.

TM5 Jenkin, B.M. (2014) ***Options for growing balsa as part of a famer's livelihood strategy: Unit 1: Balsa growing module introduction.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Activity 1.4 output. PowerPoint presentation for trainer and farmer training.

TM6 Jenkin, B.M. (2014) ***Options for growing balsa as part of a famer's livelihood strategy: Unit 2: The stages of growth of balsa trees.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Activity 1.4 output. PowerPoint presentation for trainer and farmer training.

TM7 Jenkin, B.M. (2014) ***Options for growing balsa as part of a famer's livelihood strategy: Unit 3: Deciding whether growing balsa fits with my family and land.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Activity 1.4 output. PowerPoint presentation for trainer and farmer training.

TM8 Jenkin, B.M. (2014) ***Options for growing balsa as part of a famer's livelihood strategy: Unit 4: Planting material and sources of planting materials.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Activity 1.4 output. PowerPoint presentation for trainer and farmer training.

TM9 Jenkin, B.M. (2014) ***Options for growing balsa as part of a famer's livelihood strategy: Unit 5: Preparing a balsa block for planting.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Activity 1.4 output. PowerPoint presentation for trainer and farmer training.

TM10 Jenkin, B.M. (2014) ***Options for growing balsa as part of a famer's livelihood strategy: Unit 6: Planting a balsa block.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Activity 1.4 output. PowerPoint presentation for trainer and farmer training.

TM11 Jenkin, B.M. (2014) ***Options for growing balsa as part of a famer's livelihood strategy: Unit 7: Field management of planted balsa.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Activity 1.4 output. PowerPoint presentation for trainer and farmer training.

TM12 Jenkin, B.M. (2014) ***Options for growing balsa as part of a famer's livelihood strategy: Unit 8: Selling balsa logs.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Activity 1.4 output. PowerPoint presentation for trainer and farmer training.

TM13 Jenkin, B.M. (2014) ***Options for growing balsa as part of a famer's livelihood strategy: Unit 9: Measuring the logs sold by the farmer.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Activity 1.4 output. PowerPoint presentation for trainer and farmer training.

TM14 Jenkin, B.M. (2014) ***Options for growing balsa as part of a famer's livelihood strategy: Unit 10: Balsa supply chain: harvesting a balsa crop.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Activity 1.4 output. PowerPoint presentation for trainer and farmer training.

TM15 Jenkin, B.M. (2014) ***Options for growing balsa as part of a famer's livelihood strategy: Unit 11: Balsa supply chain: processing the logs.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Activity 1.4 output. PowerPoint presentation for trainer and farmer training.

TM16 Jenkin, B.M. (2014) ***Options for growing balsa as part of a famer's livelihood strategy: Unit 12: Farmer returns from growing balsa.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Activity 1.4 output. PowerPoint presentation for trainer and farmer training.

TM17 Jenkin, B.M. (2014) ***Options for growing balsa as part of a famer's livelihood strategy: Recap day 1.*** Improving the PNG balsa value chain to enhance smallholder livelihoods (ACIAR Project FST/2009/016). Activity 1.4 output. PowerPoint presentation for trainer and farmer training.

Student project reports

Australian students – completed projects

AS1 Barnes, R. (2016) ***Structural design methodology for composite wind turbine blades using data mining techniques.*** PhD Thesis, UNSW /ADFA.

AS2 Gilfillan, N R (2014) ***Mechanical Response of Composite Panels with Balsa and Polymeric Cores.*** Final Year Project, University of NSW / ADFA..

AS3 Ingarfield, M., Nguyen, C. Q., Flores, D., N., Desai, M. K., Kotlarewski, N.J., Donis, S. K., Song, G., Ranee, B. & Duggan, R. (2012) ***Plant B.*** Swinburne University of Technology Design students. ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 3.1 Report.

AS4 Jones, D. (2012) ***Baseline data collection and M&E considerations report.*** Field trip report 23/01/2012 to 3/02/2012. Activity General report.

AS5 Kotlarewski, N.J. (2013) ***Papua New Guinea observations report.*** Nathan Kotlarewski PhD Student, Faculty of Health, Arts and Design, Swinburne University of Technology. Activity 2.1 & 2.2 report.

AS6 Kotlarewski, N.J. (2014) ***New and novel product development for Papua New Guinea grown balsawood, to improve smallholder livelihoods.*** Submission to the Swinburne University Innovation Cup. Nathan Kotlarewski PhD Student, Faculty of Health, Arts and Design, Swinburne University of Technology. Date: 25 September 2014

AS7 Kotlarewski, N.J., Gusamo, B.K., & Ozarska, B. (2014) ***Thermal Conductivity of Papua New Guinea Balsa wood.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.2 Report (subsequently as a published paper).

AS8 Kotlarewski, N.J., Gusamo, B.K., Belleville, B, & Ozarska, B. (2014) ***Mechanical Properties of Papua New Guinea Balsa wood.*** ACIAR FST/2009/016 Improving the Papua New Guinea balsa value chain to enhance smallholder livelihoods. Activity 2.2 Report (subsequently as a published paper).

AS9 Potter, S. (2012) ***Where's balsa? Detecting balsa using remote sensing in East New Britain Province, Papua New Guinea.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 1.4 Report/ paper for ANU Independent Research Project.

AS10 Kotlarewski, N.J. (2013) ***Papua New Guinea Observation Report ACIAR Project FST/2009/016.*** ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.1 & 2.2 Report.

UNRE 3rd year students – completed projects

PS1 Datieng, R. (2014) ***Levels of nutrients at different balsa planting sites, just after planting, just before harvesting and cocoa and coconut planting sites.*** 3rd Year student project, Bachelor in Tropical Agriculture (BTA3), Papua New Guinea University of Natural Resources and Environment. ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.3 Report. Report for examination.

PS2 Datieng, R. (2014) ***Levels of nutrients at different balsa planting sites, just after planting, just before harvesting and cocoa and coconut planting sites.*** 3rd Year student project, Bachelor in Tropical Agriculture (BTA3), Papua New Guinea University of Natural Resources and Environment. ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.3 Report. Presentation for examination.

PS3 Jambahavi, E. (2015) ***Sustainability and management of nutrient deficiencies (particularly boron) in balsa plantations in ENBP of PNG.*** 3rd Year student project, Bachelor in Tropical Agriculture (BTA3), Papua New Guinea University of Natural Resources and Environment. ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.3 Report. Presentation for examination.

PS4 Jambahavi, E. (2015) ***Sustainability and management of nutrient deficiencies (particularly boron) in balsa plantations in ENBP of PNG.*** 3rd Year student project, Bachelor in Tropical Agriculture (BTA3), Papua New Guinea University of Natural Resources and Environment. ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.3 Report. Report for examination.

PS5 Kaleh, K. (2014) ***Alternatives of data collection techniques to the Household Survey conducted in ENBP.*** 3rd Year student project, Bachelor in Tropical Agriculture (BTA3), Papua New Guinea University of Natural Resources and Environment. ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 1.2 Report. Report for examination.

PS6 Kaleh, K. (2014) ***Alternatives of data collection techniques to the Household Survey conducted in ENBP.*** 3rd Year student project, Bachelor in Tropical Agriculture (BTA3), Papua New Guinea University of Natural Resources and Environment. ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 1.2 Report. Presentation for examination.

PS7 Lebasi, C. (2015) ***A case study of the sales process of balsa logs supplied by smallholders in the Gazelle District, East New Britain Papua New Guinea.*** 3rd Year student project, Bachelor in Tropical Agriculture (BTA3), Papua New Guinea University of Natural Resources and Environment. ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Project Activity 21. Presentation for examination.

PS8 Lebasi, C. (2015) ***A case study of the sales process of balsa logs supplied by smallholders in the Gazelle District, East New Britain Papua New Guinea.*** 3rd Year student project, Bachelor in Tropical Agriculture (BTA3), Papua New Guinea University of Natural Resources and Environment. ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Project Activity 21. Report for examination.

PS9 Merenge, S. (2014) ***Effective Communication in Surveying with Smallholder Farmers.*** 3rd Year student project, Bachelor in Tropical Agriculture (BTA3), Papua New Guinea University of Natural Resources and Environment. ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 1.2 Report. Presentation for examination.

PS10 Merenge, S. (2014) ***Effective Communication in Surveying with Smallholder Farmers.*** 3rd Year student project, Bachelor in Tropical Agriculture (BTA3), Papua New Guinea University of Natural Resources and Environment. ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 1.2 Report. Report for examination.

PS11 Ngolo, E. (2014) ***Weed Control: Options and Costs of Weed Control in Balsa (Ochroma lagopus: Bombacaceae), Making use of the Broader Experience of Other Crops and Balsa Crop.*** 3rd Year student project, Bachelor in Tropical Agriculture (BTA3), Papua New Guinea University of Natural Resources and Environment. ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.3 Report. Presentation for examination.

PS12 Ngolo, E. (2014) ***Weed Control: Options and Costs of Weed Control in Balsa (Ochroma lagopus: Bombacaceae), Making use of the Broader Experience of Other Crops and Balsa Crop.*** 3rd Year student project, Bachelor in Tropical Agriculture (BTA3), Papua New Guinea University of Natural Resources and Environment. ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Activity 2.3 Report: report submitted for examination.

PS13 Pauria, D. (2015) ***Foliar analysis for boron in balsa plantations, ENBP.*** UNRE 3rd Year student project, Bachelor in Tropical Agriculture (BTA3), Papua New Guinea University of Natural Resources and Environment. ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Project Activity 2.3: presentation for examination.

PS14 Pauria, D. (2015) ***Foliar analysis for boron in balsa plantations, ENBP.*** UNRE 3rd Year student project, Bachelor in Tropical Agriculture (BTA3), Papua New Guinea University of Natural Resources and Environment. ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Project Activity 2.3: report submitted for examination.

PS15 Soli, K. (2014) ***The efficient use of systemic herbicide (glyphosate) in young balsa trees.*** 3rd Year student project, Bachelor in Tropical Agriculture (BTA3), Papua New Guinea University of Natural Resources and Environment. ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Project Activity 2.3. Presentation for examination. (Nil report provided).

PS16 Terap, J. (2015) ***Application of Boron to address boron deficiency in balsa plantations.*** 3rd Year student project, Bachelor in Tropical Agriculture (BTA3), Papua New Guinea University of Natural Resources and Environment. ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Project Activity 2.3: report submitted for examination.

PS17 Tomile, E. (2015) ***Marketing processes of small-holder cocoa and coconut farmers: possible intervention of similar practices for balsa farmers in the Gazelle District.*** 3rd Year student project, Bachelor in Tropical Agriculture (BTA3), Papua New Guinea University of Natural Resources and Environment. ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Project Activity 21: report submitted for examination.

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PS21 Walaun, W. (2015) ***Weed control and balsa (Ochroma lagopus) tree growth.*** 3rd Year student project, Bachelor in Tropical Agriculture (BTA3), Papua New Guinea University of Natural Resources and Environment. ACIAR FST/2009/016 Improving the PNG balsa value chain to enhance smallholder livelihoods. Project Activity 2.3. Report for examination.

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PS27 Kasup, F. (2016) ***An assessment of the use of portable sawmills for balsa harvesting and processing.*** 3rd Year student project, Bachelor in Tropical Agriculture (BTA3), Papua New Guinea University of Natural Resources and Environment. ACIAR FST/2009/016 Improving

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