



Australian Government

**Australian Centre for
International Agricultural Research**

Final report

Project full title

Advancing enhanced wood manufacturing industries in Laos and Australia

project ID

FST/2016/151

date published

17/07/2023

prepared by

Hilary Smith

*co-authors/
contributors/
collaborators*

William Leggate, Peter Kanowski, Ken Boer, Stuart Ling, Stephen Midgley, Benoit Belleville, Adam Faircloth, Rhianna Robinson, Bounchanh Lattavongkot, Latsamy Boupoua, Khamthan Phonetip

approved by

Dr Nora Devoe

*final report
number*

FR2023-035

ISBN

978-1-922983-38-1

published by

ACIAR
GPO Box 1571
Canberra ACT 2601
Australia

This publication is published by ACIAR ABN 34 864 955 427. Care is taken to ensure the accuracy of the information contained in this publication. However, ACIAR cannot accept responsibility for the accuracy or completeness of the information or opinions contained in the publication. You should make your own enquiries before making decisions concerning your interests.

© Australian Centre for International Agricultural Research (ACIAR) 2023 - This work is copyright. Apart from any use as permitted under the *Copyright Act 1968*, no part may be reproduced by any process without prior written permission from ACIAR, GPO Box 1571, Canberra ACT 2601, Australia, aci-ar@aci-ar.gov.au.

Contents

1	Acknowledgments	3
2	Executive summary	5
3	Background	6
4	Objectives	8
5	Methodology	9
6	Achievements against activities and outputs/milestones	14
7	Key results and discussion	29
8	Impacts	29
8.1	Scientific impacts – now and in 5 years	47
8.2	Capacity impacts – now and in 5 years	48
8.3	Community impacts – now and in 5 years	50
8.4	Communication and dissemination activities	51
9	Conclusions and recommendations	55
9.1	Conclusions.....	55
9.2	Recommendations	56
10	References	58
10.1	References cited in report.....	58
10.2	List of publications produced by project.....	58
11	Appendixes	65
11.1	Appendix 1:	65

1 Acknowledgments

The research team would like to acknowledge ACIAR for funding this research and the National University of Laos for their long-term collaboration.

The input of the Lao and Australian- based industry partners and collaborators in this project have been essential in transferring research into practice. These partners include:

- Burapha Agro Forestry Pty Ltd. (Laos),
- PML EasBeam (Laos),
- Mekong Timber Plantations (Laos)
- Sun Paper Limited (Laos)
- Robertson Brothers Sawmill (Australia),
- Jowat Adhesives (Australia & New Zealand),
- Maton Guitars (Australia)
- Niphone Sawmill (Laos)
- Khamla Wood Processing (Laos)

Thanks must go to the Ministry of Agriculture and Forestry – Department of Forestry and to the Provincial Offices of Agriculture and Forestry in the various provinces in which research was undertaken, especially the Luang Prabang Forestry Section; and the Ministry of Industry and Commerce - Departments of Industry and Handicraft and Import and Export and the provincial offices for their willingness to share information and take on board our research findings.

Colleagues and donor partners, including the GiZ-ProFEB team, FAO, World Bank, IFC, EFI, MRLG and CDE were instrumental in helping us to take our results into policy and related processes.

We would like to thank the many individuals, households, communities and enterprises who generously gave their time and shared their experiences with us while participating in our research throughout Laos. We hope that the research outcomes reported here will contribute towards improving their livelihoods.

The entire project team are acknowledged for their efforts, time and contributions throughout the duration of this project. Their ability to work together towards a common goal of furthering development in the sector is a testament to their skills and expertise in their respective fields of work. Thanks also to Simon Dorries for his monitoring and evaluation of the project throughout.

Finally, particular acknowledgement must go to Prof Barbara Ozarska who led this project, and its precursors, establishing the platform for project success.

Acronyms

ANU	Australian National University
DAF	Department of Agriculture and Fisheries
DoF	Department of Forestry
EWPs	Engineered Wood Products
EWPAA	Engineered Wood Products Association of Australasia
FAO	Food and Agriculture Organization of the United Nations
FLEGT	Forest Law Enforcement, Governance and Trade
FFS	Faculty of Forest Science
FSC	Forest Stewardship Council
GIZ	German Federal Enterprise for International Cooperation
GMS	Greater Mekong Subregion
GoL	Government of Laos
IFC	International Finance Corporation (World Bank Group)
ITC	International Trade Centre
JICA	Japan International Cooperation Agency
LFA	Lao Furniture Association
LFTP	Lao Forest and Trade Platform
LLL	Lao Landscapes and Livelihoods Project (World Bank)
LNWPA	Lao National Wood Products Association
LPTP	Luang Prabang Teak Program
MAF	Ministry of Agriculture and Forestry
MoIC	Ministry of Industry and Commerce
MONRE	Lao Ministries of Natural Resources and Environment
MST	Ministry of Science and Technology
NUoL	National University of Laos
PAFO	Provincial Agriculture and Forestry Office
PAREDD	Participatory Land & Forest Management Project for Reducing Deforestation
QDAF	Queensland Department of Agriculture and Fisheries
PEFC	The Programme for the Endorsement of Forest Certification
RECOFTC	Regional Community Forestry Training Center for Asia and the Pacific
UoM	The University of Melbourne
VALTIP2	Researchers involved in the current ACIAR project
VCA	Value Chain Analysis
VPA	Voluntary Partnership Agreement
WWF	World Wide Fund for Nature

2 Executive summary

In 2005, ACIAR began to invest in the plantation and wood products sector in Lao PDR. This project, FST/2016/151 'Advancing enhanced wood manufacturing industries in Laos and Australia' (VALTIP3) was the third in a series commencing in 2007 and built on the results, findings and lessons from its precursors and other ACIAR forest-related projects in Lao PDR.

The VALTIP3 project undertook a range of research activities spanning entire plantation-wood value chains. These activities comprised mapping plantations and understanding why and by whom they were planted, exploring the roles of various specific actor groups such as traders and women; examining potential options for the development of new and innovative wood products, installing and demonstrating new processing technologies; developing capacity in operationalising these technologies; and assessing the policy, regulatory and strategic setting across all areas bearing on the value chains.

The finalisation of the mapping of teak and rubber plantations in two provinces, an inventory of teak in Luang Prabang, analysis of plantation ownership and detailed studies into farmer decision making, are together providing a solid empirical basis for substantive contributions to emerging policies and programs for the sector in Laos. Value chain analysis for teak, rubber and eucalyptus, and research into the role of wood traders, micro and small enterprises, and labour and gender have been completed and disseminated. Outputs from the project have been channelled through collaborations with in-country and international partners and communicated into a number of important policy settings including the Forestry Sector Strategy 2035 and the Wood Processing Sector Roadmap. The project has contributed to the advancement of both the policy environment and tree plantation wood sector in Laos.

The installation of a new veneer peeling and plywood production facility at the National University of Laos' (NUoL) Faculty of Forest Science (FFS) has been a major success, facilitating ongoing research and scaling-out of training on plantation wood characterisation and the development of engineered wood products (EWPs). New investments by several partner companies in veneer and veneer-based wood-product facilities, agreements into which they have entered into with NUoL FFS and the interest of the Government and other stakeholders in establishing the facility as a training hub for the sector as a whole, suggests a bright future for the facility in its training and development roles.

Perhaps one of most enduring achievements of the projects is the local capacity it has built, both to meet the high demand of plantation-wood processing companies for NUoL FFS graduates in their expanding operations in Laos, and by that of Government and other stakeholders looking to VALTIP3 team members for their knowledge and contributions to deliberations about significant policy changes. The innovative research, development and support provided by the project to the Laos-based manufacturing industry regarding product type, material characterisation and increased understanding of EWPs has led to several companies now producing high quality products for local and international markets. Several of these companies have either gained or are in the process of obtaining certification status for their EWPs as a direct result of the work undertaken by the VALTIP3 project. In addition, a large range of prototype EWPs with supporting technical information have been developed for training, demonstration, and capacity building purposes. The work completed details practical methods and processes to achieve a range of value-added products that have the potential to be commercialised for both local and international markets into the future.

3 Background

In 2005, ACIAR started to invest in the plantation and wood products sector in Lao PDR. This project, FST/2016/151 'Advancing enhanced wood manufacturing industries in Laos and Australia' (VALTIP3) was the third in a series commencing in 2007 and built on the results, findings and lessons from its precursors.

The first project FST/2005/100 'Value-adding to Lao plantation timber products' (VALTIP1) which was completed in January 2011, focussed on establishing a centre for wood technology science and on building capacity in research and teaching at the Faculty of Forest Science (FFS) at the National University of Laos (NUoL), including through product development and testing. Building 'industry clusters' and providing training to these on key operational issues created important connections with the private sector and relevant Government organisations.

Project FST/2010/012 on 'Enhancing key elements of the value chains for plantation-grown wood in Lao PDR' (VALTIP2), which commenced in 2011, continued and broadened the wood technology research undertaken in VALTIP1 to include resource characterisation, standards, design and market research. The project scope was expanded to include more elements of plantation-timber value chains. It had a particular focus on teak plantations in Northern Laos and included resource mapping, governance, policy and legal analysis, research into the transaction costs and an evaluation of the roles, benefits and barriers to the formation of grower groups and the certification of smallholder-grown wood.

In the later stages of VALTIP2, the political environment in Laos with respect to forestry and the wood sector was very dynamic and the project was able to capitalise on this for the delivery of findings into regulatory, strategy and policy development processes. Partnerships with the private sector, which had commenced during VALTIP1, also developed further through collaborative research for product testing. New relationships emerged with government departments, which were consolidated through concurrent and complementary research being undertaken through ACIAR project ADP/2014/047 'Improving policies for forest plantations to balance smallholder, industry and environmental needs in Lao PDR and Viet Nam' (LVPPP) and ACIAR project FST/2012/041 'Teak-based agroforestry systems to enhance and diversify smallholder livelihoods in Luang Prabang Province of Lao PDR'. Together, team members from these two projects sustained the delivery of project results into important policy processes, to other development partners' programs and to the private sector which was working to expand investment in the country.

The third project, VALTIP3, which this report describes, began just after the Government of Laos had introduced a new Order in 2016, (PMO15) which specified that all types of wood must be turned into finished products, meeting defined standards before they could be exported. The implementation of that Order resulted in a review of all wood processing facilities in Laos and was followed by important regulatory reforms across the sector. VALTIP3 was thus designed to both support the development of new and improved processing capability and focus on Engineered Wood Products (EWPs) produced from small diameter timbers characteristic of much of the extant plantation resource. Specific wood processing skills and knowledge were targeted for the processing of wood for appearance, structural and housing construction purposes and on enhancing termite and decay resistance in the timber products.

The need for further research into the geographic extent, characteristics and socio-economic dynamics of plantations was also recognised in VALTIP2 and so VALTIP3 included more mapping of plantations including teak, eucalyptus and rubber, an inventory of teak in Luang Prabang, more detailed value-chain studies for all the main species, focussed research on the role of men and women in the sector, an investigation of the importance of micro, small and medium sized enterprises, research into farmer decision

making on the adoption of teak as part of their livelihood strategies, and the new and emerging governance settings.

In combination, this sequence of research investments has promulgated a comprehensive set of research outputs, observations recommendations and opportunities spanning plantation-wood value chains in Laos and beyond: from growers to international markets.

As VALTIP3 progressed, several important events occurred, and while some of these interrupted project activities and required some adjustment, much of the work was able to proceed, and some provided unforeseen opportunities:

- In 2019, Prof Barbara Ozarska, who had led the VALTIP projects since they commenced, retired leaving a significant gap in the leadership of project. However, the legacy of her commitment to the projects became evident in the capacity of other team members, especially at NUoL and University of Melbourne (UoM), to step up and take on new roles. Ultimately, Dr Hilary Smith was able to accept the project leadership role in conjunction with an affiliation with UoM.
- The 2019/2020 bushfires in eastern Australia affected several team members, disrupting their work efforts.
- In 2020 and 2021 the COVID-19 pandemic curtailed most in-country research activities and teaching, with shutdowns and travel restriction severely limiting the ability of Lao and Australian researchers to continue their work.

COVID-19 resulted in two project variations, initially extending the project by six months to March 2022, and subsequently to September 2022, with the latter variation providing funding to additional capital investment at NUoL and in targeted research activities including on rubberwood, an emerging plantation resource. . The project end date was further extended from September 2022 to November 2022.

- Despite COVID-19, during 2020 and 2021, the Government of Laos progressed some important strategies and policies to which team members were able to contribute, drawing on work from the earlier ACIAR projects as well as VALTIP3. These were the revision of the Forestry Law, A Decree on Plantation Promotion and Investment, the review of the Forestry Sector Strategy to 2020 and the drafting of a new Forestry Sector Strategy to 2035, the development of a Wood Export Sector Road Map, a Plantation Sector Action Plan, and several important regulations.

The project managed to effectively address its priority research questions and contribute to the considerable momentum that was already building in the plantation and wood processing sector during the period of project operation, as evidenced not only by new public sector policy and governance, but by multi-million dollar investments by the private sector in new plantations and value-added processing.

4 Objectives

The overall aim of the project was to support the development of innovative wood processing industries to enhance markets for planted timber resources within Lao PDR and Australia.

The project had the following objectives:

Objective 1: Identify the key elements of the policy, governance and administrative environment that constrain the development of plantation forests and value chains in Lao PDR, and other constraints to improving plantation value chains, and develop strategies for engaging with the policy, governance and administrative environment and improve plantation value chains.

- **Activity 1.1:** Analysis of the key elements of the policy, governance and administrative environment that constrain the development of plantation forest value chains and value-adding to their products in Lao PDR, and identification of the most important and promising pathways for policy change to address these constraints
- **Activity 1.2:** Analysis of value chains of the Lao PDR smallholder plantation resource
- **Activity 1.3:** Characterising the current plantation resource in Lao PDR, and options for modelling future wood supply.
- **Activity 1.4** Identifying and testing governance mechanisms likely to enhance the Lao plantation wood value chain for domestic processing.

Objective 2: Develop and adapt innovative technologies for the production of adapted engineered wood products, based on veneer and laminated sawn wood from small diameter logs and also composite products based on wood and other materials.

- **Activity 2.1:** Representative characterisation of Lao plantation teak and eucalypt resource potential, relevant to the production of sawn wood and EWPs for domestic and export markets.
- **Activity 2.2:** Characterisation of appropriate techniques for the production of EWPs under prevailing conditions in Lao PDR.
- **Activity 2.3:** Working directly with private sector businesses to pilot enhanced value adding processes for production of new products based on veneer and sawn wood for decorative and structural purposes for local and export markets.
- **Activity 2.4:** Collaborating with selected Australian processors on the development of new durable EWPs from a combination of veneer, sawn wood and other materials.

Objective 3: Improve capacity in value chain analysis and engineered wood products development, and in platforms for industry support and development

- **Activity 3.1:** Enhancement of NUoL research facility and capability for manufacturing and training in EWPs
- **Activity 3.2:** Develop and conduct formal and informal training programs for industry.
- **Activity 3.3:** Student projects
- **Activity 3.4:** Building capacity of women in the Lao education, plantation sector and wood processing industry

5 Methodology

5.1 Project organisation and location

The project was led by the University of Melbourne, in collaboration with Australian partners the Australian National University (ANU), Queensland Department of Agriculture and Fisheries (QDAF) and Responsible Wood, and the international partner Earthworm Foundation.

The principal partners in Lao PDR were the National University of Laos (NUoL) Faculty of Forest Science (FFS) and the Luang Prabang Teak Program (LPTP). Collaborators included the Ministry of Agriculture and Forestry (MAF), Ministry of Industry and Commerce (MOIC), Ministry of Science and Technology, the Laos National Wood Products Association, Lao Furniture Association, Burapha Agroforestry, Mekong Timber Plantations and PML Easbeam.

Australian industry partners included Maton Guitars, Robertson Brothers Sawmill and Jowat Adhesives.

Research was primarily undertaken in Vientiane Capital, Vientiane Province, Luang Prabang Province and Sayaboury Province, with value chain research extending into other provinces.

5.2 Research Methods

The project's overarching methodology was structured following value chain analysis of principal plantation resources through to processing and markets. Methods relevant to the Research Objectives and specific research questions are as described below.

Objective 1: Identify the key elements of the policy, governance and administrative environment that constrain the development of plantation forests and value chains in Lao PDR, and other constraints to improving plantation value chains, and develop strategies for engaging with the policy, governance and administrative environment and improve plantation value chains.

This objective was led by Prof. Peter Kanowski from ANU and included LPTP and researchers affiliated with or contracted through ANU.

Activity 1.1: Analysis of the key elements of the policy, governance and administrative environment that constrain the development of plantation forest value chains and value-adding to their products in Lao PDR, and identification of the most important and promising pathways for policy change to address these constraints.

Building on outputs, networks and initiatives from FST/2010/012, ADP/2014/047, FST/2012/041 and related initiatives ongoing in Lao PDR, this activity adopted the following methods.

- Analysis (policy and document analysis; consultation with key actors and stakeholders) of policy, governance and administrative procedures relevant to plantation growing and plantation wood value chains in Lao PDR.
- Analysis (literature and knowledge review; consultation with key actors and stakeholders; participation in relevant processes and activities) of most promising and relevant pathways for engagement with this environment, and effecting change.
- Facilitation of, and participation in, processes, activities and initiatives (including establishing a plantation value chain reference group; facilitating and participating in relevant fora and workshops) relevant to engaging and improving the policy,

governance and administrative environment for plantations and the plantation wood value chain.

- Consultation with government and industry to describe current value chain(s); document and explore the pathways that have created the current policy, governance and administrative environment for the value chains; identify and describe what an efficient value chain looks like; establish criteria to assess the value chain; propose and test policy mechanisms/processes for effecting change in the value chains.

Activity 1.2: Analysis of value chains of the Lao PDR smallholder plantation resource

Methods (followed Collins et al 2015, ACIAR Monograph 178):

- Identifying, mapping (from inputs to market) and analysing the major value chains for the Lao smallholder plantation resource, complementing and further developing work undertaken by ADP/2014/047 for eucalyptus and teak.
- Analysis of the costs, benefits, risks and constraints along the value chains.
- Characterising ownership categories of plantations and smallholder management intent and strategies with respect to their plantations and wood sales.
- Network mapping and analysis of timber traders and brokers, and their role in the value chains, including regulatory processes and transaction costs.

Activity 1.3: Characterising the current plantation resource in Lao PDR, and options for modelling future wood supply.

- This activity expanded on the characterisation of teak plantation resource (building on those developed under FST/2010/012):
 - GIS mapping of the area and geographical distribution of teak plantations in the landscape in Luang Prabang, and quantifying changes in the plantation area associated with major developments.
 - Estimation of the standing volume of mapped teak plantations through field inventory and biometrics.
 - Evaluation of methods to quantify growth and yield of the teak resource.
 - Mapping the extent and structure of teak plantations, through training of PFS staff, in Xayaboury province using methods developed by FST/2010/012.
 - Testing the utility and reliability of other remote sensing imagery (some acquired under FST/2010/012) for mapping teak in order to scale up into other provinces.
- Capturing base information on corporate owned eucalypt plantations (linking to ADP/2014/047):
 - Negotiated access to corporate eucalypt grower information bases, on terms acceptable to company partners
- Identifying significant plantation resources of potential benefit to future timber supply for domestic processing, through:
 - Exploration and identification of methods for rapid, broad level mapping of the extent of plantation species, in Luang Prabang province, and potential for extrapolation across Laos.
 - Build capacity to map other plantation resources of potential benefit to domestic processing industries, through mapping in Luang Prabang and training of PFS staff in one other province

Activity 1.4 Identifying and testing governance mechanisms likely to enhance the Lao plantation wood value chain for domestic processing.

Methods (informed by Activities 1.1 & 1.2):

- Identify the elements of the Lao plantation wood value chain that are the most critical for domestic processing
- Identify key risks and mitigation measures for actors within the supply chain
- Analysis of the implications and delivery structures of current and emerging certification, timber legality and verification systems for smallholder value chains, including the role and potential of established platforms such as LPTP;
- Identify and test with key actors the governance mechanisms (*sensu* Collins *et al* 2015) that are most likely to improve these critical elements, in the context of applicable certification and legality verification systems.

Objective 2: Develop and adapt innovative technologies for the production of adapted engineered wood products, based on veneer and laminated sawn wood from small diameter logs and also composite products based on wood and other materials.

This objective was led by William Leggate from QDAF, and included researchers from QDAF, UoM and NUoL as well as industry partners.

Activity 2.1: Representative characterisation of Lao plantation teak and eucalypt resource potential, relevant to the production of sawn wood and EWPs for domestic and export markets.

- Log, sawn wood and veneer wood property and grade quality characterisation of plantation teak and eucalypt resources, from representative harvested age classes for each species. Collaboration with activity 1.3 by utilising existing GIS data to stratify log selection.
- Characterisation of sawn wood and green-off-saw, dried and grade recovery volumes, for each species and size class.
- Establishment of best bet sawn/ veneer wood-based products and EWPs on characterised wood property and grade quality volumes.
- Study of the economic cost of production of each product in relation to sawn and peeled recoveries.
- Investigation of the current cost of alternative building materials in Laos (i.e. concrete, steel and bricks) and provide economic comparisons and potential alternatives for using wood based product alternatives.

Activity 2.2: Characterisation of appropriate techniques for the production of EWPs under prevailing conditions in Lao PDR.

- Ensuring that appropriate primary processing best practices recommended from the previous project FST/2010/012 are being implemented at participating companies.
- Laboratory industry scale testing and development of selected EWPs:
 - Performance criteria for each product according to international standards and specifications.
 - Testing a range of adhesives to identify those appropriate for various EWPs, under Laos conditions.
 - Establish basic manufacturing protocols for each selected EWP.
 - Testing performance of the laboratory scale EWPs including adhesive bond durability performances.
- Development and testing of semi-industrial scale EWPs based on the recommended protocols.

Activity 2.3: Working directly with private sector businesses to pilot enhanced value adding processes for production of new products based on veneer and sawn wood for decorative and structural purposes for local and export markets.

- On-site collaborative work with companies to establish optimum manufacturing systems (both processes and equipment) for selected EWPs, encompassing primary processing, machining, adhesion, treatment, joining, sanding, assembly, quality control, packaging and storage.
- Industrial scale performance assessment of factory produced EWPs. This could include glue bond testing, mechanical performance, durability and aesthetics.

Activity 2.4: Collaborating with selected Australian processors on the development of new durable EWPs from a combination of veneer, sawn wood and other materials.

- Consultation with EWPA for consideration of the development of a full range of EWPs, particularly products such as glulam, plywood, LVL, multilaminar products and Agri-fibre products. Targeting novel design and construction strategies for these EWPs including new gluing technologies and combinations of sawn veneer and other materials.
- Investigation into new generation gluing technologies for sawn timber-based EWPs with a focus on Australian hardwoods by researching the manufacturing of sawn timber-based EWPs such as glulam using the newest generation of glues. The new gluing systems could improve product recoveries and manufacturing efficiencies for the Australian and Lao hardwood industry.
- Investigate options for converting wood residues such as Agri-fibres (e.g. sorghum residues, cotton stalks, rice stalks, bamboo and reeds) and out-of-grade veneers into various value added products.
- Investigate economic, market options and feasibility (in a context of growing demand for timber-based buildings) of spindleless lathe operations in Queensland, including various scenarios for production such as small-scale, regionally located peeling mills producing green veneer for centralised drying and processing.

Objective 3: Improve capacity in value chain analysis and engineered wood products development, and in platforms for industry support and development

This objective was led by A/Prof Latsamy Boupha, and included researchers from UoM, DAF and ANU.

Activity 3.1: Enhancement of NUoL research facility and capability for manufacturing and training in EWPs

- Upgrade existing infrastructure to accommodate a range of new equipment for EWP research, development and training i.e. strengthening concrete subfloor, converting to 3-phase power, converting lecture theatre to research laboratory.
- Identifying new equipment for NUoL required for EWPs research. The list of proposed equipment and its justification has been provided in Appendix 1.
- Purchasing, installation and commissioning of selected equipment.
- Investigating the possibility of co-investment in NUoL equipment between GoL and overseas donors.
- Specialist training for NUoL staff in new equipment operation, maintenance and occupational health and safety.

Activity 3.2: Develop and conduct formal and informal training programs for industry.

- Design of training programs on key aspects of the production of EWPs, including:
 - Definition, description, categories and benefits of EWPs;

- Principles of production and manufacture including quality assurance;
- Equipment types and requirements;
- Specialised approaches to adhesion and other elements;
- Wood durability and preservative treatment;
- Performance requirements for EWPs and compliance with standards.
- On-site (factory floor) company training in processing and manufacturing of EWPs. This involves training of workers on relevant techniques to produce novel products.
- Study tour to Vietnam to visit village-based veneer peeling operations and selected companies manufacturing plywood and other veneer based products.
- Presentation to target audiences, including researchers, specialist company technical personnel and relevant government personnel

Activity 3.3: Student projects

- Selection of appropriate small research projects, strongly related to and part of the overall project suitable for students in Laos and Australian universities;
- Execution of projects by students, with mentoring by Australian and Lao project staff.

Activity 3.4: Building capacity of women in the Lao education, plantation sector and wood processing industry

- Collection of relevant literature, and data from companies and relevant authorities;
- Review and analysis;
- Workshop with all relevant stakeholders to develop strategies;
- Preparation and execution of appropriate training and other approaches (eg policies) at universities, colleges, communities, companies, government and industry fora.

6 Achievements against activities and outputs/milestones

Note: Reports are referred to in the table below have been listed in Section xxx

Objective 1: To identify the key elements of the policy, governance and administrative environment that constrain the development of plantation forests and value chains in Lao PDR, and other constraints to improving plantation value chains, and develop strategies for engaging with the policy, governance and administrative environment and improve plantation value chains.

No.	Activity	Outputs/ milestones	Completion date	Comments
1.1	Analysis of the key elements of the policy, governance and administrative environment that constrain the development of plantation forest value chains and value-adding to their products in Lao PDR, and identification of the most important and promising pathways for policy change to address these constraints	a. Report on analysis of relevant policy, governance and administrative environment. (A)	31-08-2022	Completed: Due to the dynamic policy setting, this activity was ongoing through the project Paper published Smith et al. 2021 “Lao Plantation Policy: Prospects for Change”
		b. Report identifying and discussing prospective pathways for influence and change in relevant policy, governance and administrative environment. (A, PC)	31-08-2022	Completed: Report completed.
		c. Facilitation of and participation of activities (consultations, briefings, meetings), and strengthened networks, that inform and foster change in relevant policy, governance and administrative environment.	31-08-2022	Completed: The first meeting of plantation sector stakeholders was conducted (23 March 2018). See: agenda and meeting report. Several meetings and consultations were undertaken or joined: SwedFund, Interlaken Group, Forestry Sector Strategy, WTC Roadmap, National Teak Forum etc. It is anticipated the team will provide comments on the final draft of the Forestry Sector Strategy in August 2022. See: various trip notes

		d. Initiation of appropriate institutional mechanism (e.g., reference group) on plantation policy to support policy, regulatory and administrative development to improve plantation-based value chains (PC)	30-06-2022	Completed. A plantation stakeholder advisory group to support review of Forestry Law and Forest Sector Strategy was active on an <i>ad hoc</i> basis. Three sets of submission were made. Project team members joined meetings for other reforms processes such as FLEGT TWGs.
		e. Annual meetings of 'reference group' (PC) Y1, M6, Y2, M6, Y3 M6, Y4, M6	31-08-2022	Completed: Participation in meetings was completed
		f. Reports and brief on outcomes of workshops and fora.	31-08-2022	Completed Minutes, notes and reports have been consolidated into a report. Policy Brief on the impact of PMO15 on the teak sector provided to DOF and MOIC DOIH.
1.2	Analysis of value chains of the Lao PDR smallholder plantation resource	a. Report and brief on analysis of three value chains (optimal wood supply, actual supply, resource aggregation and supply, and financing).	08-09-2020	Completed Data collection and reports for 4 value chains was completed <ul style="list-style-type: none"> • Teak in Luang Prabang: Smith et al 2018; • Teak in Sayaboury: Ling et al 2019 • Rubber: Smith et al 2020; Smith et al 2022 (Variation 4) • Eucalyptus: Ling et al 2020 5 Info Briefs were completed. Initial assessment of the size and utilisation of the eucalypt resource in NE Thailand and possible impacts for Lao PDR (Field Notes: Midgey 2020)
		b. Report and brief describing the role of timber traders, including costs and regulatory barriers to trade that impact value chain efficiency. (A, PC)	27-04-2021	Completed Based on value chain analysis a focussed assessment of role of and issues facing timber traders was written (Smith 2021) An additional Research Note focussing on Rubberwood was completed under Variation 4.

		c. Reports and briefs describing farmer decision processes and key influencing factors; recommendations for policy, regulatory or administrative reform to improve value chains; costs and benefits of establishing plantation tree crops in the current regulatory and market environment. (A, PC).	July 2021	Completed Mienmany completed her PhD on Rural households' participation and livelihood outcomes associated with teak, banana and cassava crops in Northern Laos (Mienmany 2021 (PhD Thesis). Various activities were undertaken related to reforms aimed at improved plantation registration processes for smallholders. A briefing was provided to DoF plantation Division. LPTP tested and commented on revised regulations for plantation registration.
		d. Report and brief characterizing the ownership and management intent for the current Lao plantation resource (A, PC).	30-03-2022	Completed This activity brought together elements of 1.2a, 1.2c and 1.3g. Smith 2022a report Smith 2022b Info Brief
1.3	Characterising the current plantation resource in Lao PDR, and options for modelling future wood supply.	a. Report on distribution of teak in the landscape and estimate of changes in plantation area and standing volume due to major developments (current and planned) (A, PC)	April 2019	Completed Mapping was undertaken in 2018/2019 using a combination of digital aerial photographs and other freely available data including from Google Earth. Boer (2019) Report Boer et al (2020) Info brief 5. Spatial data was provided to DOF
		b. Inventory design, recruitment and training (A, PC)	October 2017	Completed An inventory method was developed, and training undertaken with staff from LPTP and PAFO in Luang Prabang. Method is reported in Boer 2019a
		c. Inventory field work completed (PC).	April 2019	Completed Field Inventory undertaken in 2018/2019 (Boer (2019a) Report; Boer et al (2020) Info brief 5)
		d. Report on standing volume estimates in smallholder teak in Luang Prabang Province (A, PC).	April 2019	Completed Analysis of standing volume estimates in smallholder teak was undertaken in 2019. (Boer (2019b) Report; Boer et al (2020) Info brief 5)
		e. Report on the utility of existing growth and yield models for teak (A, PC).	January 2022	Completed A desktop review of existing growth and yield models for teak, and other species as available was undertaken. (Report Boer and Smith 2022)

		f. Map the extent of teak plantation resources in Sayaboury province (A, PC).	July 2021	Completed Mapping was completed remotely by Boer and data was provided to DOF and NAFRI. (Boer 2021 Info Brief 13). Due to COVID-19 training of PAFO staff in Sayaboury was not possible. Mapping of Teak and Rubber in Oudomxay province was also completed (Variation 4)
		g. Report on company-owned or –facilitated eucalypt plantation resources in Laos (A., PC).	January 2022	Completed Data from the four main Eucalyptus/Acacia growing companies was acquired and a collaboration agreement entered into with the Centre for Development and Environment (CDE) for access to and analysis of land concession information (Smith 2022a report; Smith 2022b Info Brief)
		h. Report on the methods for broad level mapping of the extent of other plantations (A, PC).	February 2021	Completed This task was changed several times during the project, initially to avoid duplication with other projects already undertaking similar work. On request from DoF the task was replaced with mapping/modelling plantation potential on degraded areas of PFAs in Luang Prabang. However, this was not possible due COVID19. Finally, the task involved mapping of rubber plantations in Luang Prabang and Xayaboury, which contributed to the rubber value chain study.
		Publication of technical Notes and Info-Briefs (A, PC): Y1, M12, Y12, M12, Y3, M12	several	Completed These are reported against each activity above.
1.4	Identifying and testing governance mechanisms likely to enhance the Lao plantation wood value chain for domestic processing.	Report on assessment of the implications of emerging governance regime, current and emerging certification, timber legality and verification systems and on key risks and mitigation measures for smallholder value chains (A, PC).	August 2022	Ongoing. Report on Policy, Governance and Administrative environment, processes, activities and initiatives has been drafted and remains a working paper. A Masters research project was undertaken on current and emerging certification, timber legality and verification systems and on key risks and mitigation measures for smallholder value chains (Ms Cleo Riddy). An Info Brief was completed (Smith, Riddy and Carmichael 2022) Paper submitted (Lu and Smith 2021 under review) “From Booms to Bans: Governing land and forests in Laos”

		Report on innovative governance, financing mechanisms, market access and marketing arrangements that will facilitate smallholder participation in planted forest domestic value chains (A, PC).	August 2022	Ongoing Book chapter on Teak Smallholders submitted
		Report on evaluation, in conjunction with related projects, of options (including various forms of partnership) to improve outcomes for smallholders in the context of the emerging forest and forest products governance regime (A, PC).	August 2022	Completed Following activity 1.2a which made preliminary observations about differentiated roles for men and women in timber value chains a specific labour and gender study was added to this activity. Research was undertaken at two wood processing facilities. Teak: Case Study 1: Ling et al 2021 Eucalyptus: Case Study 2: Ling and Phonetip 2021 Paper published in 2022 “Beyond the ‘Field of Dreams’ model”

PC = partner country, A = Australia

Objective 2: To develop and adapt innovative technologies for the production of adapted engineered wood products, based on veneer and laminated sawn wood from small diameter logs and also composite products based on wood and other materials.

No.	Activity	Outputs/ milestones	Completion date	Comments
2.1	Representative characterisation of Lao plantation teak and eucalypt resource potential, relevant to the production of EWPs for domestic and export markets.	Report characterising plantation teak and eucalypt resource wood properties, grade quality and recoveries for two representative harvested age classes per species with recommendations for the best bet 4 EWPs based on the measured characteristics (A, PC).		Completed.
			December 2019	Peeling trials using plantation teak from Luang Prabang and three different Eucalyptus species from different sites (Mekong Timber Plantations Ltd) have been conducted at NUoL.
			December 2019	Training materials (veneer grading rules, peeling yield data collection spreadsheet) have been distributed and presented at NUoL as part of the Eucalyptus peeling trials.
			December 2019	Paper on eucalypt trials has been published. Info brief on eucalypt peeling trials completed.
			August 2018	Due to industry demand this milestone was extended to include rubberwood peeling trials which have been completed. Report and Info Brief have been completed
			October 2019	Paper on rubberwood trial has been published in a scientific journal
			September 2022	Info Brief on Teak peeling trials completed. A scientific paper on teak peeling and sawing trials is in progress.
			December 2019	Report on Resource Characterisation and Product Recommendations- completed.
		December 2019	Client Study-K7 Resource Characterisation- Burapha	
				Report evaluating the economic cost of production of each recommended product in relation to sawn and peeled recoveries and grade value. The report will also include an assessment of the cost of using alternative building material for construction and interior fit-out in Laos PDR (A, PC).
December 2019	Report on "A Study into the Economic Feasibility of manufacturing Engineered Wood Products in Lao PRD-December 2019" completed.			
December 2019	Info Brief Completed. The report "Value Chain Survey Report Southern Laos Provinces-December 2019" completed.			
2.2	Characterisation of appropriate techniques for the production	Report on the level of adoption of primary and secondary	November 2018	Completed.

No.	Activity	Outputs/ milestones	Completion date	Comments
	of EWPs under prevailing conditions in Lao PDR. (PC)	processing gui practices recommended from the previous project FST/2010/012. This will also assess impediments to adopting the recommendations and possible strategies to address these (A, PC).		The companies involved in FST/2010/012 were visited in November 2017 and February 2018 and questionnaires were filled in the Lao language. The report has been completed.
		Reports on laboratory testing and manufacturing protocols for each selected EWP (4 EWPs). Each report will include results of laboratory tests, recommended adhesives, treatment and recommended manufacturing methods for each EWP (A).		<p>Completed.</p> <p>March 2020 Optimisation and testing of products is complete.</p> <p>March 2020 Report completed on the mechanical property testing of LVL for PML Easbeam.</p> <p>March 2020 Reports completed on the mechanical property testing of LVL and plywood for Burapha.</p> <p>September 2019 Reports completed on Rubberwood and K7 Panel manufacturing</p> <p>September 2019 Info Brief 1 on EWPs completed.</p> <p>January 2021 Journal article published on the mechanical properties of LVL from teak plantations in Laos.</p> <p>November 2020 Report completed on the certification of plywood and LVL products from Laos.</p> <p>June 2022 Trials have been completed on the performance of wood preservative glue-line treatments of K7 Eucalypt plywood from Laos PDR.</p> <p>June 2022 A trial has been completed on the lyctid susceptibility of K7 Eucalypt plywood from Laos PDR.</p> <p>September 2021 A report on manufacturing protocols for particleboard panels made from agricultural residues has been finalised and a comprehensive technical report was produced in September 2021.</p> <p>February 2022 Five technical plywood characteristics property evaluation reports (certification reports) were completed for a range of product thicknesses for Burapha.</p> <p>May 2022 Paper detailing equilibrium wood moisture content for various locations in Lao PDR has been published in a scientific journal</p>

No.	Activity	Outputs/ milestones	Completion date	Comments
			May 2022	A report has been completed on recommended adhesives and manufacturing methods for the fabrication of decorative panelling products using non-structural plywood panel and rattan or bamboo mats as a cover for non-structural constructions. Decorative panelling prototypes manufactured.
			May 2022	A paper on Agri-fibre particle geometry and constituent proportions has been completed and one more publication is under review.
			November 2022	A report has been completed on the bifenthrin glue-line treatment of K7 hybrid plywood and its resistance to subterranean termites.
			November 2022	A report has been completed on the lyctid susceptibility of K7 Hybrid plywood.
		Production of appropriate semi-industrial scale samples, demonstrators and prototypes, with design documentation (PC, A).	December 2020	Completed. Semi-industrial scale samples have been produced such as LVL bed slats, rattan covered plywood and teak bollards etc.
			September 2022	Completed. The product display and catalogue have been updated to include additional rubberwood products.
		Scientific publications on the results from this activity (A, PC) - (publications will be produced throughout the project when data are available)	September 2022	Completed. Twenty-two scientific journal papers and two conference papers have been published or submitted for publication (refer Appendix 2):
2.3	Working directly with private sector businesses to pilot enhanced value-adding processes for production of new products based on veneer and EWPs for decorative and structural purposes for local and export markets. (PC)	Report for each participating company outlining the optimal manufacturing systems, equipment recommendations, guidelines and performance assessment for the selected EWPs, with an indication of a return on investment (A, PC).	June 2019	Milestone removed. At the Mid-Term Review (2019) it was agreed to remove this milestone to accommodate industry requirements.
			January 2019	Completed. A report was completed on the Niphone Furniture manufacturing business kiln optimisation and upgrade June 2019.

No.	Activity	Outputs/ milestones	Completion date	Comments
		Provision of product samples for training, display and promotion purposes (PC) Y2 M6, Y3 M6, Y4 M6.	June 2018, June 2019, December 2020, June 2022	Completed. A suite of demonstration products have been developed as part of training activities.
			September 2022	Completed The product display and catalogue been updated to include additional rubberwood products.
		Construction of a demonstration structure made entirely out of these EWPs to highlight potential of these new products for the Laos industry (PC, A).	September 2022	Completed. This activity was led by the NUoL. Students from the School of Architecture and Engineering from UoM and NUoL FFS were involved in this activity and the Multifunctional Hut is complete.
2.4	Collaborating with selected Australian processors on the development of new durable EWPs from a combination of veneer, sawn wood and agri-fibres. (A)	Report on the consultation with the Australian industry and identification of best bet products. The report will describe the novel design and construction strategies for these EWPs including new gluing technologies and combinations of sawn veneer, agri-fibres and other materials (A).	May 2020	Completed. Report on the consultation with the Australian industry and identification of best bet products has been completed. The project identified four key projects.
			September 2020 November 2020	Completed. Investigations into substitute species for guitar manufacture. A technical report has been completed and 2 scientific papers have been published
			August 2019	Completed. Manufacture of glued composite panels from agricultural waste materials. Two scientific papers have been published. Preliminary results on a study using cotton stalk waste for particleboard manufacture were presented and published, at the 22nd International Conference on Composite Materials August, Melbourne, 2019.
			March 2021	Completed. Work on the assessment of Australian hemp hurd residue for the production of environmentally friendly lightweight biocomposites has been completed and one publication and one presentation have been produced. This work explores, acoustic insulation

No.	Activity	Outputs/ milestones	Completion date	Comments
				properties, and the effects particle geometry of product performance.
			June 2021, July 2021	Completed. An assessment of the SMART THUMPER™ application (low cost and rapid non-destructive wood mechanical property measurement device) has been completed and a technical report written. A paper has been published in a scientific journal.
			May 2020, June 2021	Completed. Research into improved wood adhesion systems for Australian hardwoods and softwoods has been completed. As a result, 2 publications and 2 technical reports have been generated.
		Report on the outcomes of the R&D into new generation glue technologies for sawn timber based EWPs. The report will also include the assessment of the costs of production for each new glue such as bio resins and provide comparisons with conventional glues in the market (A).	September 2019,	Completed. Report on glue technologies completed.
			November 2019, October 2020,	Completed. A report has been completed on trials undertaken on adhesions system development for hardwood engineered wood products.
			June 2020, June 2022	Completed. An International review on the use of bio-adhesives has been completed and has been published in both a scientific journal and technical report.
			May 2019	Completed. A book chapter has been published on a review of existing methods used in investigating the adhesive bond development and penetration in timber products
		Report on options for converting wood residues such as out-of-grade veneers into various products (A).	July 2020	Completed. A technical report has been produced.

No.	Activity	Outputs/ milestones	Completion date	Comments
		Report on the economic feasibility of introducing spindleless lathe technology into the Queensland wood processing industry, including various scenarios for production (A).	March 2020	Completed. This activity has been completed and a technical report produced. A scientific paper has been prepared for journal submission.
Variation 4 –	<p>Rubberwood and capacitation extension -</p> <p>1. Incorporating an additional species, rubber. Initial research already completed (value chain, resource mapping, preliminary peeling trials) suggests rubberwood could unlock significant additional value. Wood processing industries require consistent feedstock in sufficient quantity to achieve economies of scale. Rubber may offer a route to increased competitiveness and expanded Lao processing. Activities undertaken or supported by QDAF include:</p>	An integrated rubberwood trial including key steps of sourcing legal rubberwood, log quality assessment, harvesting and transporting wood, treatment, primary processing, manufacturing engineered and solid wood products, testing and industry assessment, in collaboration with partners Burapha Agroforestry and Mekong Timber Plantations (involving all project partners)	November 2022	Completed This activity has been completed and three technical reports have been produced. This includes a rubberwood literature review, rubberwood preservation report and a rubberwood product development report. A scientific paper has been planned for journal submission.
	2. Further characterisation of the Laos rubber resource requires replacement of failed timber test equipment at NUoL ACIAR-supported Wood Processing Research and Training Centre (The Centre). This is also needed to transition the Centre to a self-supporting, fee-for-service	Development of communication materials for growers, processors and government (administrators and policy makers) (lead by QDAF with NUoL and UoM)	November 2022	Completed. This activity has been completed and three factsheets have been produced including rubberwood utilisation, rubberwood resource recovery and rubberwood product development.
			November 2022	Completed. This activity has been completed and a technical report has been produced. Additionally, seven new standard operating procedures have been developed and translated.

No.	Activity	Outputs/ milestones	Completion date	Comments
	research centre. Training will be undertaken where necessary (jointly by NUoL and QDAF)			
	3. A Roadmap to transition the centre to self-sufficiency will be developed. Once the investments in new/upgraded equipment have been made, the centre will be certified to international standards for product standards testing and for chain of custody against newly introduced regulations in Laos. Standard Operating Procedures developed by QDAF for their facility in Australia will be adapted for use at NUoL and translated into Lao language. NUoL staff will be trained by QDAF to ensure capacitation can be retained.	In collaboration with other organisations and projects, an institutional structure, strategy and a syllabus of courses will be developed so that NUoL can provide support to the priority actions identified under the Lao PDR Wood Processing Sector Roadmap (2021-2025) and Forestry Strategy to 2035 and based on the needs assessment of industry and the relevant government organisation. Key amongst the latter will be supporting MAF's new division of Forest Enterprises, created in October 2021, which has taken on oversight of the wood processing sector, previously with MOIC. QDAF will provide advice on the syllabus and participate in a joint consultation workshop will be undertaken in 2022.	November 2022	Completed. This activity has been completed and a roadmap has been developed.

PC = partner country, A = Australia

Objective 3: To improve capacity in value chain analysis and engineered wood products development, and in platforms for industry support and development

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1	Enhancement of NUoL research facility and capability for manufacturing and training in EWPs (PC)	Report on the enhancement of research facility at NUoL for EWPs including infrastructure, new equipment purchasing, installation and commissioning, and standard operating procedures for the equipment - (A, PC) Interim report Y1 M12, Final report Y3 M6	July 2018 Y3, M6	Complete The new building for a research facility has been completed and equipment purchased and installed. A panel sander has been installed and commissioned, and SOP in Lao language written. A viscometer has been purchased. A glue spreader has been installed and commissioned, and SOP in English written Note – further upgrades are occurring through finding provided through project variation #4.
		Report on specialist training for NUoL staff in new equipment operation, maintenance and occupational health and safety – (A).	March 2021	Completed. This activity occurred in conjunction with the intensive training program provided to Burapha staff
3.2	Develop and conduct formal and informal training programs for industry. (PC)	Development of training manuals and training materials (A, PC) Y1 M12	November 2019	Complete Due to the status of industry development in EWP production, a reduction in activity implementation was previously requested. Training materials have been completed and distributed to the project team members: preservative treatment of timber, veneer recovery study and Standard Operation Procedures for the log peeling equipment. An extensive training manual on veneer processing, adhesives, test methods and performance and agri-fibre panel production has been completed. Training was conducted at Burapha company on saw doctoring to improve sharpening technique and at Phengmounkhoun factory on possible improvements in wood processing methods. A reduction in this activity was approved after Annual report 3.

		On-site (factory floor) company training workshops in the processing and manufacturing of EWP. A report will be written on each training, including the assessment of trainees competencies in the relevant techniques (A, PC) Y1 M12, Y2 M12, Y3 M12, Y4 M12.	October/November 2020 (training workshops) March 2021 (Report)	Completed. Technical training material for Burapha and PML Easbeam on EWPs manufacturing and best practices has been developed and workshops were undertaken in 2021. MOU made with Burapha. Technical training programs covering engineered wood products (EWPs) manufacturing and best practices for Burapha staff and NUoL undergraduate students have been conducted. A report on the technical training sessions has been completed
		Report on the study tour to Vietnam to visit veneer peeling and manufacturing operations, including the assessment of the tour by participants (PC, A).	June 2012	Completed Report completed. Info brief completed
3.3	Student projects (PC, A)	Set of selected small research projects suitable for students in Laos and Australian universities (PC, A) Y1 M2, Y2 M2, Y3 M2, Y4 M2.	2019 2020 2021	Completed. Nine NUoL students selected research projects in 2019-20. The students were supervised by Valtip3 NUoL team and Australian experts. Eleven NUoL students selected research projects in 2020-21. Project-related studies were undertaken by PhD candidate (S Mienmany) and Masters student (V Phengthajaim) at ANU and SCU, respectively. Fifteen NUoL students selected research projects in 2021-22. The students were supervised by Valtip3 NUoL team and Australian experts. Project-related studies were undertaken by Masters student (P Chounlamounty) at QU (ongoing).
		Project reports completed by students with appropriate mentoring – (PC, A) Y1 M12, Y2 M12, Y3 M12, Y4 M9.	various	Completed and ongoing The list of the projects, names of the students and their supervisors is provided in Appendix 2.
		Presentations by students in appropriate fora (e.g., project annual workshops, mid-term or final workshop) – (PC, A) Y1 M12, Y2 M12, Y3 M12, Y4 M9.	September 2018, July 2019, June 2020	Completed Students presented their projects at the FFS final year examination workshops in September 2018, July 2019, June 2020

3.4	Building capacity of women in the Lao education, plantation sector and wood processing industry (PC)	Report on gender issues across the forest industry value chain in Laos, which will include a strategy for enhancing women participation (A, PC).	February 2020 May 2021 December 2021	Completed Gender workshop and report completed. Study on Gender in Teak Wood Processing completed Study on Gender in Eucalypt Wood Processing completed
		Training module/s prepared and presented appropriately. A short report will be written on each training, including the assessment results and comments by the trainees (A, PC) Y2 M3, Y2 M12, Y3 M6, Y3 M12, Y4 M6.	Y2, M3	Complete A report on the workshops, recommendations, training modules and adoption strategies has been completed.
		Report on the adoption of strategies to enhance the role of women within the Lao forest industry across the value chain (A, PC).	September 2022	Completed Two students completed Master theses and a paper is currently under preparation to be submitted to Aust. J. For. by March 2023

PC = partner country, A = Australia

7 Key results and discussion

An overview and a discussion of the key results of the project are provided below for each objective and activity. A list of references and all project outputs and publications is provided in Section 10.

Objective 1: Identify the key elements of the policy, governance and administrative environment that constrain the development of plantation forests and value chains in Lao PDR, and other constraints to improving plantation value chains, and develop strategies for engaging with the policy, governance and administrative environment and improve plantation value chains.

Activity 1.1: Analysis of the key elements of the policy, governance and administrative environment that constrain the development of plantation forest value chains and value-adding to their products in Lao PDR, and identification of the most important and promising pathways for policy change to address these constraints.

In the early stages of the project efforts were made to establish a reference/working on group on plantations. However, as the project progressed, numerous processes and opportunities emerged through and in which team members contributed and participated concerning the governance of forests and plantations, and the wood sector in Laos; and it became evident that a separate working group would not be useful. Central amongst these opportunities was a request from the Department of Forestry (DoF) for team members, together with the GiZ Pro-FEB, to facilitate contributions of stakeholders to the review and formulation of the revised Forestry Law, a Decree on Plantation Promotion, and subsequently the Forestry Strategy 2020. The revised Forestry Law and Decree on Plantation Promotion were both issued in 2019 and the new Forestry Sector Strategy to 2035 was released in 2022.

In 2018 the project co-convened with GiZ the workshop on the Legal Framework for Plantations which was highly effective in bringing together around 30 participants from government, non-government and private sector organisations. Other policy processes that were participated in or observed included the development of a Road Map for Wood processing, the SwedFund Plantation Task Force and the Pro-FEB to support the Lao-EU VPA. A report by Smith and Kanowski (2022) summarises these processes and reflects on their core features to distil the key learnings for policy change. That report draws on the findings from other ACIAR projects, specifically ADP/2016/047 and FST/2019/121 which explored policies for plantations in Laos and Vietnam and SSS/2020/142 which examined research to policy impact in Laos. Bridging between projects was built into the design of VALTIP3, and this was aided by the inclusion of common team members between them. Similarly, the small research and development project, SSS/2020/142, was led by Smith and Kanowski because of the project connections. This enabled the inclusion of forest sector as a focal point of research in that SRA (which was on going at this report was being written).

A cross-project co-authored paper, Lao Plantation Policy: Prospects for Change (Smith et al 2021), draws out the relevant findings from a number of these projects. The core elements of options for improving Lao plantation policy were identified as:

1. Set a clear vision and plan for plantations
2. Undertake strategic land use planning
3. Consider local contexts in the allocation of land use rights
4. Clarify, simplify and improve administrative processes and approvals through “smart regulation”
5. Reduce transaction costs by facilitating value-chain partnerships and knowledge sharing.

Of these, element 1 has been addressed in the 2019 revised Forestry Law and Decree on Plantation Promotion the new Forestry Sector Strategy to 2035, and element 2 in part under PMO9 on The enhancement of governance in the use of concession lands, and subsequent Instructions. Parts of element 5 are also addressed by Instruction No 1758/MAF, which calls for tree growing contracts with farmers to be reviewed, and reconsidered and renegotiated if judged to be inequitable.

Parallel work under SSS/2020/142 identified a number of entry points for policymaking in Laos (best source doc?): through the National and Provincial Assemblies, Provincial Governors, and relevant Ministers, Ministries and agencies, and their staff. This research and our experience in FST and ADP projects, also identified an interest in and openness to timely research results relevant to issues under consideration; this is consistent with expectations in the policy literature (eg Forrester et al 2009; Ramirez and Belcher 2020). The *Transdisciplinary research quality assessment framework* developed by Belcher et al (2016), reproduced from Ramirez and Belcher (2020) below, also informs VALTIP3 outcomes.

L.F. Ramirez and B.M. Belcher

Forest Policy and Economics 114 (2020) 101789

Table 1
Transdisciplinary research quality assessment framework.

Relevance:	Credibility	Legitimacy	Effectiveness
<ul style="list-style-type: none"> ● Clearly defined socio-ecological context ● Socially relevant research problem ● Engagement with problem context ● Explicit theory of change ● Relevant research objectives and design ● Appropriate project implementation ● Effective communication 	<ul style="list-style-type: none"> ● Broad preparation ● Clear research problem definition ● Objectives stated and met ● Feasible research project ● Adequate Competencies ● Research approach fits purpose ● Appropriate methods ● Clearly presented argument ● Transferability/Generalizability of research findings ● Limitations stated ● Ongoing monitoring and reflexivity 	<ul style="list-style-type: none"> ● Disclosure of perspective ● Effective collaboration ● Genuine and explicit inclusion ● Research is ethical 	<ul style="list-style-type: none"> ● Research builds social capacity ● Contribution to knowledge ● Practical application ● Significant outcome

The Framework identifies a suite of factors that confer relevance, credibility and legitimacy on research activities and outputs, and which, in conjunction with other factors, foster the effectiveness of that research in informing policy. In the case of VALTIP3, credibility and legitimacy were fostered through the history of forest sector policy research that the project built from, in VALTIP2 and ADP/2014/040; the wider history and standing of ACIAR research in Laos, over 40 years, and the active engagement of senior diplomatic and ACIAR officers; the standing of Lao project researchers with key actors and institutions nationally; the engagement of Australian project researchers and Lao counterparts with each other, and with Lao institutions and international partner organisations and industry stakeholders, through VALTIP3 and precursor ACIAR projects and other activities; the relationships of mutual awareness and trust built as a result of that engagement; and the responsiveness of the project to partner organisation priorities and requests.

These factors provided the basis for strong project contributions to forest sector policy processes that opened up during the life of the project. They also offer a repertoire of factors to which projects seeking to inform and influence policy should attend.

Activity 1.2: Analysis of value chains of the Lao PDR smallholder plantation resource

Value chain analyses were undertaken for two teak value chains in Luang Prabang (Smith et al. 2018) and Sayaboury (Ling et al. 2019), rubberwood in Northern and Southern Laos (in partnership with Forest Trends, Smith et al. 2020) and for *Eucalyptus* generally (Ling et al. 2020; Redman et al 2019, Midgley and Ruenrith 2020, Midgley, 2019). Info Briefs were produced and disseminated on select topics (Info Briefs 7-11). The research found that:

- value chains for teak are smallholder dominated and diverse with few examples of vertically integrated production. Smallholders remain highly dependent on intermediaries to access markets, increasingly so with PMO15 which banned

round-log exports, and are largely 'price-takers'. Regulatory reforms, such as for plantation registration are yet to benefit them.

- value chains for eucalypts are dominated by four corporate investors (Burapha Agroforestry, Mekong Timber Plantations, SilviCarbon (formally Stora Enso Laos) and Sun Paper (Laos), which all received large concession areas in 2022 to reforest unstocked and degraded areas of state production forests. This decision, while increasing forest cover, investment in value adding and local employment, will nonetheless reduce the reliance on land rental (1+4) and outgrower (2+3) smallholder schemes;
- value chains for rubberwood are nascent. When the research was undertaken there were no rubberwood producers in Laos and there was a low level of awareness of the potential value of the resource. During the course of the project interest rubberwood grew amongst the private sector and the Government. Recommendations from the rubberwood report were taken on by the Lao Rubber Association which is seeking further support to progress these.

Research on teak in highlighted the differences between integrated and dispersed value chains, particularly for female employees. Two additional studies, one on teak processing in Sayaboury Province (Ling et al 2020) and another on eucalypt processing in Vientiane Province (Ling et al 2021), were undertaken further understand the role of women in the wood processing in Laos. Both studies found that women made up the majority of employees at both factories, where they were valued for their attention to detail. The high demand for employment at the mill from local women reflects their desire for regular, off-farm income to meet the needs of a modern lifestyle.

Field work to understand farmer decision-making processes and key influencing factors about teak plantations and other boom crops (ANU PhD candidate Ms Soytavanh Mienmany) was completed in 2021 (Mienmany 2021) and awarded in 2022, and several papers were submitted during and after thesis submission (e.g. Mienmany et al 2020a; 2020b). The key messages from this research are that 'policy-push' and 'peer effect' have both been very important in encouraging farmers to plant teak, but measures to promote good plantation management and enable market access, coupled with more recent regulatory reforms have potentially created a 'stranded asset' which is at risk of being liquidated through conversion to other land uses, without appropriate intervention.

Based on the value chain research, a report on the roles of an issues facing micro, small and medium enterprises (mSMEs) was written (Smith 2022). This highlighted that most mSMEs are informal and that policy changes and incentives are needed to incentivise their formal participation; these need to be fair and scale-appropriate. The role of these actors is not well understood by policy makers and administrators, resulting in negative perceptions and administrative barriers, which need to be identified, acknowledged and addressed. Without action smallholder and mSMEs dominated wood value chains remain at risk of relegation to the informal sector and with this exclusion from legal wood value chains.

Activity 1.3: Characterising the current plantation resource in Lao PDR, and options for modelling future wood supply.

For activity 1.3 the following were completed:

- a. mapping and characterisation of teak, and mapping of rubber plantations in Luang Prabang and Sayaboury province using a range of remote-sensing imagery types and ground truthing. Training of provincial staff in Sayaboury that was scheduled for late 2019/2020 did not occur due to COVID-19 and mapping was undertaken by Australian team members. This found:
 - a. 19,400 ha of teak and 15,800 ha of rubber in Luang Prabang Province Boer and Smith 2022)
 - b. 9,700 ha or teak and 7,600 ha of rubber in Sayaboury Province (Boer 2021)

- b. inventory of standing teak volume in Luang Prabang with training of staff in Luang Prabang on these methods (Boer 2019). This found
 - a. Standing volume of 1,966,000 m³ with merchantable log volume of 573,000 m³ and good quality log volume of 361,000 m³.
 - b. Teak plantations are dominated by trees of small size and of generally poor quality.
 - c. Provincial Forest Service (LPTP) staff were trained in plot measurement, GIS and supervision and completed the inventory to high level of consistency, in time and under budget
- c. An analysis of the changes in the area of teak in Luang Prabang Province due to infrastructure and other conversion activities (Boer 2019), which found the impact of dams and railway construction on teak plantations to be minor. Construction to date has reduced the area of teak by 1.5% with future construction estimated to impact a further 4.5%. Change due to conversion or new plantations is likely to have a greater impact.
- d. Data on corporate *Eucalyptus* plantations was successfully negotiated with the four largest companies and an agreement reached with the Centre for Development and Environment (CDE) for joint analysis against the Land Concession Inventory database (LCI). Results were co-reported (Smith and Boer 2022, Smith 2022).
- e. The task of understanding plantation ownership arrangements which was undertaken through the activity 1.2 was progressed through the collaboration with CDE by way of a small case study in Sayaboury and Luang Prabang.
- f. A review of available literature on growth and yield for teak and other plantation species was undertaken (Boer and Smith 2021). This found that other than for corporate *Eucalyptus* plantations, which develop and utilise their own models, there is a dearth of information on which to reliably predict growth and yield. For teak and rubber plantations, there is a need for further research to develop locally applicable biometrics.

Activity 1.4 Identifying and testing governance mechanisms likely to enhance the Lao plantation wood value chain for domestic processing.

As described for Activity 1.1, the project team monitored and participated in, where possible, Government and development partner programs including the FLEGT VPA process and via the National Plantations Taskforce supported by SwedFund. These processes, which expanded in scope and number during the course of the project, are in themselves a change in governance which has been somewhat effective.

Plantations registration, research on which was initiated during VALTIP2, remained a core focus of the Luang Prabang Teak Program (LPTP) which sustained its efforts working with teak smallholders and supporting the project's other activities. Their involvement in activities such as the workshop on the Legal Framework for plantations in 2018 and by participating in consultation activities on plantation registration and chain of custody organised by others provided an important 'local reality check' on recommendations made. Unfortunately plan to test alternative approaches these were unable to occur due to COVID-19, however later in the project, through variations 4, the LPTP team made an important contribution to exploring the legality of rubber value chains, which in the case of smallholders, experience similar barriers for teak [Note this research was ongoing at the time of writing].

Ms Cleo Riddy completed her Masters thesis at the University Melbourne (jointly with FST/2019/121) and her research explored the implications of timber legality assurance for teak smallholders. Together with relevant finding from other project activities, including the research of Ms Ellie Carmichael during VALTIP2 into certification, these were summarised into an Info Brief (Smith, Riddy and Carmichael 2021) the key messages being that as Lao PDR progresses its policies for increasing regional and international market integration of the wood processing sector through government reforms aimed at improving

timber legality, and larger companies voluntarily pursue market standards for sustainability, the small-scale plantation sector is at risk of being excluded. Micro-, small and some medium enterprises, their employees, and the smallholder tree growers they service, may be relegated to the informal sector.

While some processes, such as the VPA, are intended to be inclusive as they review, clarify and help reform regulations, and voluntary standards-setting organisations have tried to simplify their processes, the small-scale sector is still largely excluded. Representation in consultation is hindered both by the large number of actors involved, their lack of organisation, and government reticence to acknowledge them because they are viewed as illegitimate.

As markets for legal and certified-sustainable wood grow, smallholder plantations risk becoming 'stranded assets', because they remain unable to comply with new regulations. Stranding smallholder assets will have negative impacts on the livelihoods of those who have invested in them, with consequences along the supply chain. If the value of their assets are not realised, this may also discourage future participation in tree growing, as alternative commodity crops become more attractive. These issues have been addressed in a series of papers to which project researcher Stephen Midgley contributed (Flanagan et al, 2022, 2021, 2020, 2019).

Specific policies are needed to encourage group formation, and regulations for plantation and enterprise registration need further improvement so that small-scale sector actors can comply. Incentives, such as waiving fees, are needed with information campaigns to raise awareness. Targeted consultation and testing of regulations with the informal sector is needed to ensure reforms are realistic and can be complied with. Digital solutions must be accessible to all.

The promotion of partnerships between small-scale and larger sector actors must be supported with measures to ensure contracts are fairly negotiated and are mutually-beneficial. Dr Soytavanh Mienmany's PhD thesis, 'Riding the Boom', investigated these issues for teak and two agricultural crops, banana and cassava, in Northern Laos. Contract farming continues to be promoted by GoL as a preferred model for smallholder participation in commercial agricultural crops; experience in these sectors suggests a stronger GoL agency or third-party role, in informing farmers of options and terms, and acting as an honest broker, is necessary to balance the interests of smallholders and investors.

Objective 2: Develop and adapt innovative technologies for the production of adapted engineered wood products, based on veneer and laminated sawn wood from small diameter logs and also composite products based on wood and other materials.

Activity 2.1: Representative characterisation of Lao plantation teak and eucalypt resource potential, relevant to the production of sawn wood and EWPs for domestic and export markets.

Studies on the characterisation of the Laos eucalypt and plantation teak resource potential to produce EWPs were completed. Specific objectives were to: 1) characterise and assess the quality of resource; 2) determine recovery; and 3) determine the influence of species, log position, and diameter on recovery and quality.

Eucalypt recovery study:

Three eucalypt plantations, namely *Eucalyptus pellita*, *Eucalyptus camaldulensis*, and eucalypt hybrid clone K7 (*E. camaldulensis* × *E. deglupta*), located on two different field sites in the Bolikhamxai Province, Laos, were selected for the study. The plantations belong to New Forests Pty Ltd. and were grown as unthinned and unpruned pulpwood stands. A total of 90, 1.2 m long logs totalling 2.5 m³ were processed into veneer sheets at NUoL research facility. The selected species achieved green veneer recoveries that

ranged between 57% and 67% with the eucalypt hybrid clone K7 achieving the highest green recovery. *Eucalyptus pellita* yielded the highest net face grade recovery where eucalypt clone K7 was impacted by end splitting following steaming treatment. End-splitting, tear out, branch-related defects, and growth stress were the most important grade-limiting defects, which restricted veneer sheet quality to a lower grade of most sheets. However, simple timely silvicultural decisions, such as pruning, could significantly help improve the quality of the timber. The obtained results could be used in the formulation of recommendations to adopt better management practices to improve the value of plantation-grown wood.

Teak recovery study:

The objective of this study was to investigate and compare sawn and peeled recovery and grade quality of Luang Prabang teak of harvestable age, for future industry investment and product development and optimisation decisions. Sixty, 3 m long logs were harvested by LPTP staff at Lak Sip village, that included a mix of high and low-grade logs based on LPTP grading rules. Two size classes were also selected: thirty logs with butt diameters of 15-17 cm, making up the majority of the current resource, and thirty larger 23-25 cm diameter logs that are highly sought after by industry for sawlogs. The 3 m logs were cut in half (1.5 m) whereby half of the logs were peeled and the other half sawn. Due to the high level of butt flare (fluting) that naturally occurs in teak, the butt logs were used for sawing trials while the top logs were used for peeling. The VALTIP3 researchers involved nineteen FoF students in the study to allow them to learn about the procedures involved in the trials. Key findings from the teak studies were that teak logs 15-25cm DBH can be peeled into veneer using spindle-less lathes; green veneer recovery was 75% which was 35% greater volume recovery compared to sawing; engineered teak veneer prototypes include multilaminar blocks, sapwood and heartwood teak covered plywood and MDF, turned products and LVL. There is also potential to produce quality round bollards that are resistant to rot and termite attack from small diameter trees by peeling the sapwood and leaving behind naturally durable heartwood.

Rubberwood recovery study:

A study on the peeling recovery and quality of senile plantation-grown rubber trees in Laos has been completed and published in a scientific journal. Fifteen 25-year-old plantation-grown trees were harvested and peeled using spindleless lathe technology. The study demonstrated that rubber trees past the latex-producing prime from unthinned and unpruned stands have qualities and desirable traits to potentially produce certain high-value engineered wood products (EWPs). Green recovery from senile plantation-grown rubber trees varied between 62.1% and 65.4%, depending on the position of the billet in the tree, for an average value of 64.1%. Most of the recovered veneer met low-grade veneer requirements. However, there is a significant opportunity to achieve higher proportions of Grade 1 and Grade 2 face veneer by tackling the manufacturing defects through an optimization of the peeling process.

Senile rubber trees could represent significant additional revenue to growers and a source of raw material to industry which, theoretically, could be converted into high-value products. Further research will explore whether it is possible to get a good proportion of high-quality veneers from rubber trees via peeling parameters optimisation. High-quality face veneer is currently rare in Laos with most *Eucalyptus* and *Acacia* plantations being managed to produce pulp, and wood from Teak plantations is destined for furniture production. Processing high-quality veneers from rubberwood with known mechanical properties and gluability could open access to novel markets. In a booming construction context in Southeast Asia, rubber trees past the prime latex-producing age could represent a significant opportunity for Lao growers to diversify and increase their revenues while providing the wood processing industry a unique resource to expand the production of innovative EWPs. To realise this opportunity, industry development is needed, requiring the right policy signals from Government.

A study was conducted on the financial feasibility of producing some EWPs in Laos. The results showed that production costs of plywood and LVL were between \$340 and \$460 per m³, with profits ranging between \$68 and \$156 per m³ of product. These costs were found to be significantly lower than the production costs in Australia, particularly due to lower labour and capital costs. However, current constructions in Laos mainly utilise materials such as concrete, steel and brick. Despite this, the research found that due to changing preferences towards more sustainable products, in addition to the time and labour cost savings, timber products could provide a more competitive substitute in the future, particularly in largescale residential developments.

A value chain survey report was completed interviewing and assessing 13 forestry industries in Laos highlighting their target markets, production capacity and associated costs, and their value chain. This study highlighted administrative challenges of the Laos timber processing and forestry industries and the underutilisation of stockpiled logs at the time of writing.

A study assessing timber trading and pricing based on a survey of teak buyers has been completed and published in a scientific journal. The research investigated teak trading methods, markets and prices paid for timber types and quality grades. The study found that end buyers of teak timber in Laos are sawmillers and wood manufacturers. Teak timber is supplied from growers to end buyers via three pathways: directly from growers to buyers (49%); from local traders (41.3%); and from local small sawmillers and wood manufacturers (9.7%). Standing trees, round and square logs are the common types of teak timber currently being sold in Laos. Prices for this timber vary depending on factors such as timber size, quality and distance from plantation site to road. The price of a round log size of 26–30 cm diameter of A grade quality is 250 US\$/m³ while the price for the same size of round log without grading is 321 US\$/m³. The findings suggest that there is a need to develop and convey a clear system of teak grading rules to establish a fair pricing system for teak in Laos. Distance from plantation sites to road significantly affect prices of standing trees. The size of square logs has a strong impact on market prices. On average, a square log attracts the higher price than round logs or standing trees (402 US\$/m³, 225 US\$/m³ and 104 US\$/m³, respectively). Therefore, selling square logs should be promoted in Laos.

Activity 2.2: Characterisation of appropriate techniques for the production of EWPs under prevailing conditions in Lao PDR.

Studies conducted on the mechanical properties and performance of LVL and plywood produced from the *Eucalyptus* K7 hybrid plantations in Laos and rubber wood from Luang Namtha have produced promising results, with performance similar to some commercially available veneer-based products. The aim of the activity was also to provide hands-on training on plywood and LVL manufacturing to VALTIP3 team members (4) and 3rd- and 4th- year students from the Faculty of Forestry (FoF) at the National University of Laos (NUoL). Additional samples for bending, water absorption and thickness swelling, and bond integrity were prepared and tested in accordance with the relevant international standards for plywood and LVL.

Non-pressure treatment with alkaline copper quaternary and copper azole wood preservative:

Modern treatment approaches using wood preservatives such as alkaline copper quaternary (ACQ) and copper azole (CuAz) require the use of expensive equipment, outside of the feasible application for poorer countries such as Laos. Hot and Cold timber treatment processes have long been implemented within Australia at low capital costs. The aim of this project was to investigate the feasibility of a hot and cold treatment process for Laos-based producers. A small-scale preliminary study was carried out on a selection of Slash Pine (*pinus eliottii*) blocks using hot and cold dipping processes with ACQ and CuAz. The generalised method consists of the timber material being heated in water and then placed in the moderate temperature treatment solution for a period of time.

The trials returned successful results with a technical report on the tests, methods and analysis as an output, reported in June of 2020. The hot and cold treatment process provides a promising new low cost, simple wood treatment system for ACQ and CuAz preservatives.

Develop and adapt innovative technologies for the production of high-performance engineered wood products (EWPs) and composite products based on wood and other materials – Bamboo and rattan decorative panelling products:

Various adhesives and manufacturing methods have been investigated for the fabrication of decorative panelling products using non-structural plywood panels and rattan or bamboo mats as a cover for non-structural constructions. Three different rattan mat designs and two bamboo mat designs have been selected for testing and prototype fabrication. The selected rattan mats were produced by Danlao, an FSC and CoC certified company located in Vientiane, Lao PDR, supported by WWF. Bamboo mats have been purchased from a local shop in Vientiane. A UV weathering study showed that bamboo and rattans mats are similarly susceptible to UV discolouration but this discolouration tends to differ between the two materials and even within a specific group. The observed differences between the rattan groups can be explained by the fact that rattan, scientific name *Calameae*, is a general name for roughly 600 species of plant-climber from the palm family native to tropical regions especially in Asia. The overall trends in colour change for rattan mats, based on the greatest colour difference changes, were that samples have become darker, redder, and yellow. In the case of bamboo mats, based on the greatest colour difference changes, the samples have become lighter, greener, and bluer compared to unexposed reference samples. Ultimately, the discolouration could be retarded significantly through the appropriate choice of clear coatings. Prototypes were manufactured by laminating sections of mats to one side of selected plywood panels manufactured as part of objective 2 activities (e.g., rubberwood and eucalyptus K7 panel manufacturing, testing trials for PML Easbeam). Three adhesive types were trialled, and the following processing parameters documented: sample machining, adhesive application, glue spread, pressing process. The adhesives were: 1. A liquid one - component polyurethane adhesive typically used for load-bearing structural wood bonding (Jowapur 686.70, long open time: 50-70 min); 2. An emulsion polymer isocyanate (EPI) suitable for bonding hard wood species with high resin content and moisture content up to 15% (Jowacoll 102.49); and 3. A waterborne single component polyvinyl acetate emulsion (PVA) featuring good water resistance and heat resistance (Aquence KL 442.3051). A range of methods were trialled to identify feasible equipment to separate sample sections from respective mats. Equipment trialled included: circular saw, table saw, band saw, and guillotine. Mat overlays were cut as oversized section from the larger originals. A combination of EPI adhesive and guillotine proved appropriate in producing panelling products for appearance applications.

Investigative Study into the Certification of Plywood and LVL Products: Requirements, Processes & Facilities:

Product performance testing is a critical part of the manufacturing cycle. It provides a means of confirming quality, and through regular assessment, monitors consistency. Certification provides a scheme through which this product quality is assessed on a regular basis against the governing standards for design. Due to the product development focused activities presented through objective 2.2, ensuring the Laos-based manufacturers had in place a means of checking for quality consistency was deemed important. Furthermore, for exporting to most countries outside of Laos (Australia/ New Zealand, Americas, Europe) product certification is a requirement.

Therefore, a report of the importance, types of, and coverage of certification was created and aimed at providing information for Laos-based manufacturers to use in developing robust quality management procedures. This report contains reference to international standards and certification bodies who could provide optimal export coverage for Laos-based manufacturers of Plywood and LVL. Further to this, the report details the testing

methods as required for both Plywood and LVL depending on the target country/ region. Finally, the report contains a case study section where Burapha Agro Forestry planned to apply for certification that provided the largest coverage regarding export range. Through consultation with various certification groups, a selection was made and reported on as the most suitable for Burapha's requirements. This report was completed November 2020. Further to the report, through the support of the project team and this certification document, Burapha has obtained certification status for their plywood and has begun exporting to a range of countries.

Engineered Wood Product Testing to Australian/ New Zealand Standards:

Throughout the duration of the project the Salisbury Research Facilities Engineering Laboratory conducted and reported on prototype product performance as provided by Laos-based manufacturers.

Mechanical Property testing of LVL for PML:

As a preliminary trial-based series of experiments, a selection of LVL samples were supplied to DAF by PML for testing to the Australian/ New Zealand standards for LVL product performance (strength, stiffness, bond quality, and moisture content). As a result of the experiments, a report was provided describing the tests conducted and the results and observations witnessed. Testing was conducted in both flatwise (load applied perpendicular to the face) and edgewise (load applied parallel to the face) orientations for the various applications PML was considering. Mechanical performance and bond quality between veneers was reported and recommendations based on noted observations were given to the PML employees. It is understood that production at PML has now been improved and through the efforts of the project team and in conjunction with the certification report provided to industry that PML is planning to pursue certification of their LVL products. The report and testing were completed in March 2020.

Mechanical Property testing of Burapha manufactured EWPs:

During an in-country visit of project staff to the Burapha manufacturing facility, a selection of LVL, LVB (cross banded LVL), and plywood was manufactured to evaluate potential manufacturing procedures and practices for possible product options. A range of construction strategies and adhesive types (including both structural and non-structural) were used in preparation of the samples. The samples were provided to DAF for testing at the Salisbury Research Facilities Engineering Laboratory where product performance (mechanical properties and bond quality) was evaluated against the relevant Australian standards. As a result of this testing, Burapha has refined their production methods and range in order to ensure consistent products are produced. These experiments and the corresponding report was issued in March 2020.

Following the testing and report on Burapha's K7 Eucalypt LVL, LVB and plywood from March 2020, a further series of test samples were provided to DAF for evaluation. Based on the findings of the March 2020 report, refinement of manufacturing procedures was conducted by Burapha and the product type narrowed to plywood. Structural plywood assessment in accordance with the relevant Australian standards was conducted to provide Burapha with a base line performance level against bending stiffness and strength in both parallel and perpendicular directions to the face grain directions. Provisional analysis was conducted on the samples tested to detail expected stress grades based on the various product designs. The experiments and the corresponding report was issued in June 2021.

Through the various product development activities undertaken with Laos-based producers in conjunction with the instructions and procedural stages outlined in the EWP certification report, product quality and consistency has improved. Through the stages of product evaluation conducted with Burapha, a final programme of work involved assisting them and their certification body through the product testing for their K7 Eucalypt species plywood. Five thicknesses were evaluated (9, 17, 19, 21, and 25 mm) against the

Australian testing and design standards for plywood. The testing involved visual grading, mechanical performance, bond quality, and formaldehyde emissions. The outcomes of these experiments and related reports on product performance resulted in Burapha obtaining certification for their products and manufacturing processes enabling them to ship products to a large majority of countries for sale. The testing and reporting was completed February 2022.

Equilibrium moisture content map of Lao districts:

An equilibrium wood moisture content map for all the districts in Laos has been developed and published in a scientific journal (. The tool developed by the Laos-Australian team will allow the avoidance of major problems due to dimensional changes in wooden products. This study evaluated the average equilibrium moisture content values in Laos for twelve months from 1981 to 2020. A model was used to generate the equilibrium moisture content values based on temperature and relative humidity data obtained for 18 provinces (148 districts). This data was then validated onsite. The lowest equilibrium moisture content (12% to 13%) values were found in Vientiane Capital City, Vientiane province, Louangprabang, Bokeo, Attapeu, Louang Namtha, Oudomxay, Houaphan, Sayaburi, Savannakhet, Salavan, and Champasak province. The rest of the districts, which had an equilibrium moisture content ranging from 13% to 16%, were mostly found on the eastern part of Laos and a small part of Northern Laos. The monthly swinging average value of the equilibrium moisture content ranged from 10% to 18% across the country.

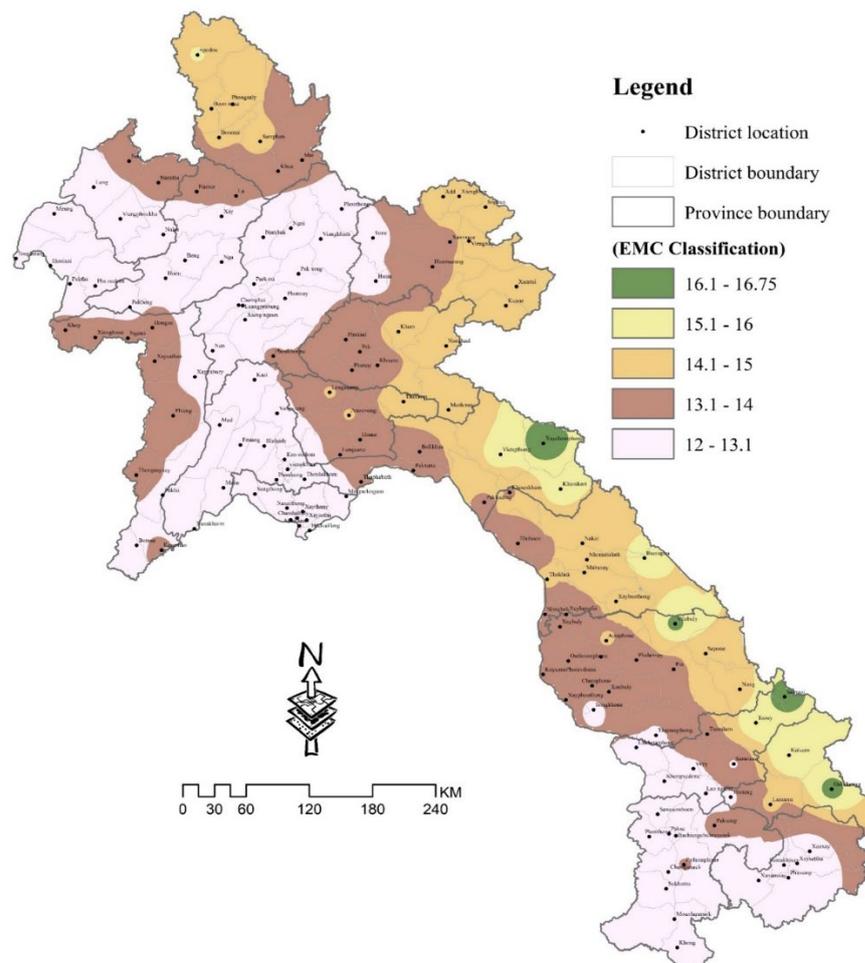


Figure 1: Equilibrium moisture content map of Lao districts

Recommended average moisture contents for interior use wood products in different parts of Laos based on NASA (2021) with EMC correction (Phonetip et al. 2022).

Particle board manufacturing:

The manual covering recommended adhesives, treatment, and recommended manufacturing methods for particleboard manufacturing has been prepared. The document is divided into three sections. The first section provides definitions and classifications used in Australia and around the world and presents the various constituents of particleboard. The second section discusses the variables influencing particle properties. The third and final section presents recommended processing steps, from an R&D perspective, for alternative raw material assessment at the laboratory scale.

Powder Post beetle (Lyctid sp.) susceptibility of K7 hybrid solid wood

Powder-post beetles (*Lyctus sp.*) are so named because their larvae can reduce susceptible timber to a fine flour-like powder and can be a significant issue causing structural damage to a range timbers around the world. Test blocks of Laos grown plantation K7 hybrid sapwood and blocks of lyctus susceptible sapwood of blackbean (nominally the control) were placed at various locations within the timber storage shed at SRF (known exposure site) in a paired comparison exposure test. The trial was established on the 30th of June 2020 and ran until July 2022 however minimal activity of beetle activity was reported as the trial relied on a “wild population”. Further work is required as there is currently no information on the lyctine susceptibility of the K7 hybrid (*E. camaldulensis* x *E. deglupta*) which is grown in plantations in Lao PDR.

Glueline treatment of K7 hybrid plywood

Termites cause considerable damage to wooden structures in Laos, Australia and many other countries around the world each year. There is increasing use of Engineered Wood Products (EWPs), e.g., plywood, in termite-prone areas, and this often requires pre-treatment of the product prior to use. Traditional vacuum pressure treatments can be problematic with EWPs, especially with large plywood panels. One solution is introducing an effective termiticide into the adhesive before plywood production. One-hundred veneer sheets of two thickness’ were supplied by Burapha Agroforestry in Laos PDR. Two adhesives being MUF and PF were used and eight different combinations of plywood were manufactured, resulting in four in-line glue treatments and four untreated controls. There were ten replicates of each configuration with a total of 80 test samples. The addition of glueline treatment (bifenthrin (Permatek 100 encaps)) to the glueline (MUF or PF) has been successful in protecting the K7 hybrid plywood blocks from anything more than moderate attack when exposed to feeding by *C. acinaciformis* in a field trial under H2 simulated conditions. Damage was only to a face and/or back veneer, and there was no damage to the core veneers. When compared to the untreated controls, mass losses were up to 40% in a number of blocks with a subsequent visual termite damage rating in the range 6 (severe attack) to 4 (very severe attack). There was also damage to some of the core veneers with > 5mm penetration. The substantial attack on the hoop pine feeder blocks (some more than 60% mass loss) showed the test blocks were exposed to strong termite activity during the trial. Moreover, there was more attack to the plywood blocks with the PF adhesive than with the MUF adhesive, and this was more evident in the control blocks than in the treated blocks. The reason for this at this time is unclear and will require further investigation.

Activity 2.3: Working directly with private sector businesses to pilot enhanced value adding processes for production of new products based on veneer and sawn wood for decorative and structural purposes for local and export markets.

Work was completed with The Niphone Factory in Ban Kok Ngui, Luang Prabang. The primary objective was to improve the drying time and function of the existing kiln as well as provide best practice drying advice to reduce the kiln drying time and reduce the quantity of energy (wood waste) required to run a kiln charge. The airflow in the kiln was improved by constructing baffles using metal sheeting and structural steel. The baffles were put in place and were hinged so that they can accommodate different timber pack sizes. Vast improvements were made in the airflow where very little airflow was recorded

through the stack originally compared with at least a tripling of the airflow after baffling. This modification to the kiln has improved the quality of dried timber and decreased the drying time by 50% which will provide significant savings and faster production times.

Additional activities relevant to this activity mainly included considerable work assisting Burapha and PML to establish optimum production processes for converting Laos forest resources into high value EWPs suitable for sale in local and export markets. This included training and capacitation as well as product and process development.

Activity 2.4: Collaborating with selected Australian processors on the development of new durable EWPs from a combination of veneer, sawn wood and other materials.

Considerable work has been undertaken in the field of wood adhesion which is critical to the production of EWPs. This work has included a state-of-the-art review of bio-based adhesives, comparison of test methods for the determination of delamination in glued laminated timber, evaluation of a promising new surface incision method to improve bond performance, and more than a dozen research trials on hardwood glulam. A range of products have been produced from veneers for prototype development and testing. The results will be used by industry partners to make decisions on marketable products. This work is highly transferable and has added value in Activity 2.2. A detailed study has highlighted opportunities for using veneer and veneer-based product wastes from manufacturing facilities in Laos. Suggested opportunities for the re-use and recycling of this waste in Laos can comprise three broad categories viz. use in its current form e.g. bark as landscaping mulch; use as a fuel e.g. chipped peeler cores into a burner/boiler and as a reformed fibre e.g. incorporation into engineered wood products. This work also contributes to Activity 2.2.

Smart Thumper Evaluation:

The recently released iPhone application SmartThumper™ has been comprehensively tested for measuring stiffness in timber elements using acoustic technology. The application was shown to be able to successfully measure stiffness non-destructively when compared with the alternative, expensive traditional methods of testing. The application is particularly useful for developing countries as it costs approximately \$10 AUD. In comparison, destructive mechanical testing equipment costs approximately \$150,000 AUD. This work also contributes to Activity 2.2.

Emerging hemp panels:

The legalization of hemp seeds for human consumption has revitalized the cultivation of hemp in Australia. With a strong focus on seed varieties, opportunities arise for the valorisation of the stem's xylemic core (hemp hurd). Hemp hurd has low specific gravity and resemblance to low-density timber species, which makes it a prospective constituent for lightweight composite panels increasingly used in the ready-to-assemble furniture industry. This study investigated the effect of hemp hurd particle size and constituent proportions on internal bond strengths (IB) of single-layer, low-density hemp hurd particleboards (LHPBs) with densities between 219 to 304 kg/m³. Particle size distributions (PSD) and granulometry assessments were conducted on three particle size classes (fine, medium, coarse) based on digital image analysis. Subsequently, four particle size mixes were considered for the LHPB manufacture with bio-epoxy, phenol resorcinol formaldehyde (PRF) and emulsifiable methylene diphenyl diisocyanate (MDI) adhesives, respectively. IB testing followed the methods of testing for reconstituted wood-based panels (AS/NZS 4266.1). The data was analysed for potential differences of group means using the Analysis of Variance test (ANOVA) and all IB results were evaluated against the specifications for particleboards stipulated in AS/NZS 1859.1. The granulometry assessment showed the smallest mean elongation amongst the particles in the coarse PSD. IB performance increased in most LHPBs comprising coarse particles and declined with the addition of smaller particle sizes. Particle and adhesive loadings affected the LHPBs differently and varied significantly per adhesive type. All LHPBs manufactured with high particle loading and high MDI loading surpassed the IB

specification limit of AS/NZS 1859.1. The results confirmed a strong interdependence of particle size and constituent proportions on IB performance and indicated that various LHPBs can surpass the minimum IB strength requirements stipulated in the Australian particleboard standard. Identifying optimal processing parameters and key performances are crucial in the development and advancement of novel LHPBs from underutilised hemp hurd and other agricultural by-products.

Cottonstalk particleboard panels:

In Australia, cotton (*Gossypium hirsutum L.*) is cultivated in Queensland and New South Wales where one hectare of cotton generates roughly three tons of dry stalks. It indicates that about 1,160,000 tons of cotton stalks are produced in Australia annually. Research to develop sustainable particleboards from cotton stalk agricultural waste is very advanced. To date, characterisation of cotton stalk morphology and investigations of the influence of particle sizes and cotton ball load on performance properties of homogenous manufacture particleboard have been completed. Results indicate that a particle size of 8 mm and removing residue cotton balls produced panels with the best mechanical properties within thresholds set by the Australian standards. Studies have also been completed on investigations into other manufacturing parameters for particleboards made from cotton stalks as well as investigations into the influence of particle size and particle load on cotton stalk Polyhydroxyalkanoate (PHA) composites.

Economic benefit analysis:

An economic analysis was performed focusing on LVL manufacture and the potential of distributed production models. This report highlighted that strong economies of scale were present with EWP production in the analysis. Encouragingly for forest growers and wood processors, the optimal strategy for an EWP manufacturing facility processing a log volume of 30,000m³/y required 42.6% of log volume to be small logs. The model revealed that one-stage LVL manufacture was profitable at larger scales of production; however, the superior investment alternative was the production of two-stage LVL. While processing logs and converting them into EWPs within one facility proximate to the forest will always be most profitable, the analysis highlighted that distributed production operations, where a facility close to the forest produces and transports dry veneer to an EWP manufacturing plant located far away from the resource, can allow the manufacturing plant to profitably increase its levels of production. The advantages of distributed production models are extended if the entire operation is owned by a single vertically-integrated business. The model framework was demonstrated with an application to subtropical eastern Australia; however, the methodological framework and parameter levels are likely to be suitable for forestry decision-making environments outside Australia.

Acoustic and anatomical evaluation of Australian Native Hardwood Species for Guitar Fretboard Production:

Premium guitar manufacture has long used the species Indian Rosewood (*IRW – dalbergia latifolia*) for fretboard production. In 2017, the Convention of International Trade of Endangered Species of Flora and Fauna (CITES) announced new limitations for the use of some tropical hardwoods (including rosewood). In order to find alternative species with comparable characteristics to that of IRW, this study investigated 14 native Australian hardwoods. Characteristics such as bending stiffness and strength, hardness, acoustical performance, anatomical descriptors, and appearance were evaluated for the 14 species against the IRW benchmark. The outputs of this study in collaboration with the industry partner (Maton Guitars) recommended 4 select Australian hardwoods for further trialling by the industry partner. The industry partner is currently trialling the select species in prototype guitars to undergo further inhouse experimental trials.

Variation 4 – Capacitation extension

A variation in 2022 extended the VALTIP 3 program and included additional work to further characterise the Lao rubber resource and replace failed timber test equipment at

NUoL's ACIAR-supported Wood Processing Research and Training Centre. This work was focused on transitioning NUoL to a self-supporting, fee-for-service research centre.

Rubber characterisation

Building on the rubberwood characterisation work of Belleville et.al, research was completed to better understand the potential of rubberwood grown in Laos. Two small studies were completed exploring a sawing and peeling via spindleless lathe technology on plantation rubberwood from a Southern province in Laos. Results suggested that rubberwood sourced from the Bolikhamsai province provided reasonable overall performance for merchandising, peeling/veneer production, sawing, recovery, adhesion and mechanical properties for the manufactured demonstration prototypes. A literature review was also completed highlighting the global utilisation of rubberwood and its potential for high value products including engineered wood products and furniture with examples available of a strong rubberwood sector in China, Malaysia and Brazil. Despite desirable processing qualities and appearance, rubberwood is highly susceptible to attack by borers, mould, stain, termites and decay organisms. This is because of the relatively high carbohydrate (sugar and starch) reserves deposited in the parenchyma and the absence of phenolic compounds in rubberwood. The high moisture content in freshly felled trees in combination with warm temperatures makes rubberwood grown in Laos particularly susceptible to stain and decay. This degradation can take hold within 24 hours in some areas with a maximum of 2-3 days before processing is required. This is a significant logistical challenge for Laos and further research and development is required. There is also strong concern that rubber growers are unaware of the value their plantations hold and may not replant due to competing pressures. To realise this opportunity and ensure a consistent rubberwood supply, industry development is needed, requiring the right policy signals from Government.

NUoL Laboratory Capacitation

Building upon work completed in VALTIP1, VALTIP2, this work focussed on further increasing the capacity, equipment, and skills of NUoL's ACIAR-supported Wood Processing Research and Training Centre and establish a fee-for-service business model. Self-sufficiency is expected to attract and retain staff and provide an option for mechanical property testing and research for timber products within Laos. Timber and engineered wood products (EWPs) intended for structural use and export are required to meet the strict specifications outlined in the country of interests' construction codes and product standards. For example, structural plywood products to be exported from Lao and marketed in Australia need to conform to the Australian design standards for plywood (AS/NZS 2269.0 (2012) Plywood – Structural, Part 0: Specifications) as well as meet the mechanical performance, bond integrity, and formaldehyde emission cut-offs for the expected application. Currently there exists no capacity in Lao for providing these testing services, resulting in local producers seeking external providers to support their requirements. This leads to higher costs in terms of logistics, minimal bargaining opportunities given lack of services in region, and opportunities for local industry to re-invest in Lao-based services missed. Information regarding operational procedures, laboratory management, costing strategies, certification, and maintenance costs were investigated and a range of standard operating procedures were developed. Based on costs, location and scope of accreditation the Accreditation Office for Standards Conformity Assessment Capacity (AOSC) was determined to be the most appropriate and attractive for NUoL. This work also contributed to a roadmap however work is still required to reach self-sufficiency.

Objective 3: Improve capacity in value chain analysis and engineered wood products development, and in platforms for industry support and development

Activity 3.1: Enhancement of NUoL research facility and capability for manufacturing and training in EWP

A number of investments to the FFS facility were made including extension to the building, upgrading of the roof, and the purchase of new equipment including a universal testing machine. Standard Operating Procedures (in English) have been prepared. Several research structures were completed including a multi-function hut constructed or and showcasing various EWPs manufactured during the course of the project and a solar kiln, that latter of which is being used by NUoL and the private sector for ongoing research.

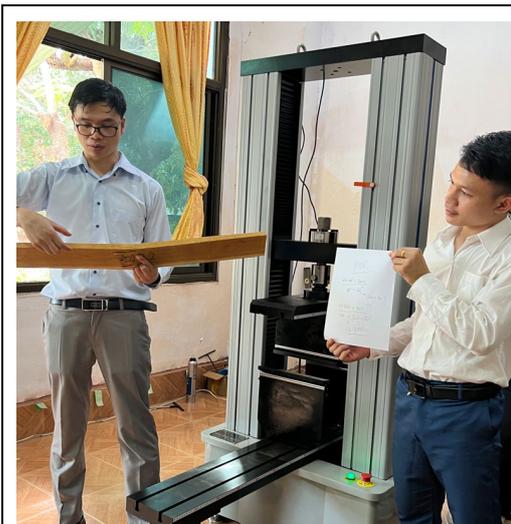


Figure 2: Universal Testing Machine



Figure 3: Multi-function Hut

Training was provided on a range of project topics GIS mapping, inventory, value chain assessments, social-survey methods and wood products manufacturing. Details are provided in Appendix 1 and below.

The project has developed a Roadmap for the future of the NUoL FFS (ongoing to Sept 2022). Initial consultations were held with other organisations and interested parties to explore partnerships and funding models. As part of this, team members from NUoL participated in and observed training conducted by the European Forest Institute and the Food and Agriculture Organisation of the United Nations (FAO) on chain of custody for wood processors in Attapeu province. A draft framework concept for the Roadmap has been prepared, which will be supported through additional capital investments in the Wood Technology Training Centre and collaboration with the GiZ/FAO funded Woodworks project.

Activity 3.2: Develop and conduct formal and informal training programs for industry.

Based on project research, three companies, Burapha Agro-Forestry, PML Easbeam and Mekong Timber Plantations increased their processing investment in Laos; Burapha is producing plywood (with export markets in Australia), Mekong Timber Plantations has completed an integrated saw log, veneer and chipping mill and PML Easbeam will produce LVL. Two companies are employing graduate students from FFS as skilled workers because of their advanced knowledge of veneer technology. Intensive training programs which took place in October and November 2020 provided Burapha staff, VALTIP3 team members, and NUoL undergraduate students with technical knowledge and skills on key aspects of the production EWPs and LVL. The training modules included presentations and hands-on practical sessions covering the principles of production and manufacture of

EWPs, OH&S, and quality control associated with EWPs production. The first session, conducted by VALTIP3 researchers, was aimed at NUoL graduated FFS students moving into Burapha supervisory positions. The second session was targeted at new factory staff and current undergraduate NUoL FFS students and was conducted by the supervisors trained during the first session providing the new Burapha supervisory staff to gain confidence in training prior to entering the factory where they will be required to train subordinate staff. Post-training competency assessments to measure the effectiveness of the training sessions and material have also been completed. The training was conducted at the FFS research facility at NUoL, with 19 people (4 females) attending the first training and 50 attending the second session.

A technical manual. In Lao and English, focused on veneer-based products and adapted specifically for the industry was also prepared and distributed as part of the training to the participants. This has since been added to the teaching curriculum at FFS.

Feedback from the participants from the training was collected. The results are presented in report “*Technical training: Engineered Wood Products (EWPs) - Manufacturing and Best Practices*”¹. In summary, benefits of the training and experience included:

- Developing a skilled workforce for the wider Lao wood processing sector;
- Educating and training future experts in the plantation wood value chain under the new veneer processing subject which is being taught by former and current VALTIP research team members;
- Facilitating capacity building for the Burapha staff to run the training for current NUoL students;
- Establishing cohesion between the University and Lao wood processing industry under the ACIAR banner.

Activity 3.3: Student projects

Between 2017 and 2021 28 students (16 male and 12 female) at NUoL FFS undertook research projects related to VALTIP3 project. These are summarised below in Table 1 and a report summarising the projects was compiled. A further 15 student elected projects in 2021-2022 these were still being undertaken at the time of writing.

Table 1: Summary of Bachelor students’ thesis

Thesis themes	No. of students	Male	Female
Wood drying process	4	3	1
Bamboo /rice husk product	4	4	
Wood processing	4	3	1
Physical and mechanical property testing of wood	4	3	1
Wood anatomy/taxonomy	4		4
Comparison of physical properties of plywood, veneer using different type of glues	3	3	
Investigating wood grade and shrinkage	1		1
Log management and transportation	1		1

¹ There is also a version in Lao language (Phonetip et al., 2021) entitled “The Contribution to Wood processing sectors of the Wood Science and Wood Products Research Center (WS-WPRC)- training facility supported by ACIAR-VALTIP3.”

Manufacturing and physical properties assessment of Roof Board	1	1	
The wage of female workers of Burapha Agro-Forestry Company	1	1	
Natural durability and preservative treatment against feeding by termites	1	1	
Total	28	16	12



Figure 4: Online meeting between NUoL FoF students and supervisors in March 2022 to present and discuss the project aims, objectives and methodologies.

Postgraduate studies were undertaken by NUoL students as follows:

- Mr. Vansy Phengthajaim completed a Master by coursework at SCU
- Mr. Phouluang Chounlamounty started a Master by research at QU in June 2022 on engineered wood products manufacturing.
- Mr. Pongki Phommachan completed a Master by research at NUoL on wood anatomy.
- Mr. Phonxiong Wanneng completed his PhD at UoM in 2019 on “*The impact of wood characteristics and properties on the market price of plantation grown teak logs (Tectona grandis Linn.F) in Lao PDR*”.
- Mr. Douangta Bouaphavong started his PhD at Kasetsart University on physical and manufacturing properties of teak for building applications.
- Mr. Louxiong Siakhor completed his Master by coursework at Kasetsart University in 2020.

Activity 3.4: Building capacity of women in the Lao education, plantation sector and wood processing industry

The gender-oriented research in the project was both exploratory and targeted. The project initially undertook an exploration of Gender in Forestry in Laos (Kikon and Miletic 2018). They ran three workshops, the aims of which were:

- sharing of information and experience in relation to gender and forestry in Lao PDR;
- to create an environment where experiences could be shared amongst participants and project partners in a grounded, exploratory approach;

- to generate insights and knowledge about gender and the forestry in Lao PDR that can enhance the project and related activities in the future;
- to develop recommendations for strategies to enhance the integration of gender in this sector and across project components in the coming phase of the project and beyond.

That work recommended:

1. Supporting the development of a Masters degree- level course on gender and extractive industries (forestry)
2. Increased contextually grounded knowledge on gender and forestry in Laos through participatory or grounded methods to explore gender and forestry research that deepens and develops knowledge and practice in relation to gender equity in Laos
3. Development of guidelines or policy frameworks for gender equity and inclusion in relation to timber factories.
4. Continue to encourage and acknowledge leadership for and by women in the sector

Subsequent research, primarily related to, and derived from observations in the value chain analysis and a small project funded by ACIAR through the Australian Research Support Facility II followed up on these findings. Conducting more focussed research in relation to:

- rural employment and gender in teak Wood Processing (Ling et al 2021),
- gender and employment in a eucalypt plywood mill (Ling and Phonetip 2021)
- impact assessment of COVID-19 and PMO15 on labour in the plantation-wood processing sector (Phonetip and Smith 2022).

Through the project capacity was built for female participation in research and in the wood processing sector:

- Soytavanh Mienmany, completed a PhD at ANU, her thesis explored farmer decision making about crop choices, and this included consideration of the respective roles of women and men.
- Two female Masters students at NUoL undertook research on gender-related issues.
- 12 females undertook undergraduate research projects in wood processing related topics

Also as noted above, FFS signed an agreement with the Burapha Agroforestry Company (BAFCO) in April 2020 that included research and training activities. This culminated in May 2021, when BAFCO recruited six female graduates to be supervisors (out of a total of 14) for the start-up of its new plywood factory in Hin Heup district. Since then the company report around 60% of its factory employees are women, undertaking a wide range of tasks.

8 Impacts

8.1 Scientific impacts – now and in 5 years

Key scientific impacts include knowledge as the basis for better-informed decision-making such as through:

1. enhanced information base for plantation tree crops in Laos, strengthening the basis for resource planning, management and modelling. This information has already been used by other projects (ITTO Teak; UNREDD/RECOFTC; The impact of this knowledge is likely to increase over the next 5 years given the investment in domestic processing in Laos;
2. richer knowledge of farmer decision-making in relation to tree crops, and to (non)participation in regulatory systems. This knowledge is relevant to GoL ambitions to increase the adoption of contract farming in the agricultural and forest sectors, on terms that are fair and attractive to farmers;
3. detailed knowledge of MSME-dominated farmer-grown wood value chains and their interactions with regulatory mechanisms. This knowledge can inform decisions that strengthen the role of MSME actors in wood value chains, noting the gap that currently exists between policy ambitions and outcomes for these actors;
4. the first formal study of gender in the Lao wood processing sector, which establishes a baseline for future studies, and policy and business responses. The impact of this work will grow with the Lao plantation wood processing sector. Studies on the characterisation of teak, eucalypt and rubber wood indicated that taxa, log geometry, and other log traits influence recovery and veneer sheet quality, and that these could be improved with appropriate silvicultural and management decisions. The results will help improve silvicultural management for more effective use of plantations in Laos and ultimately improve the livelihood of small landowners and foresters.

The research on rubberwood value chains and peeling recovery and quality of plantation-grown rubber trees were the first of their kind in the country. Recommendations from the value chain analysis have been taken up by the Lao Rubber Association and peeling recovery activities were observed by NAFRI, with product examples shown to growers, industry and government. One company has since expressed interest in using project information to help them source and integrate rubberwood into their processing. The peeling study demonstrated that senile smallholder grown rubber trees have qualities and desirable traits to potentially produce high-value EWPs and could represent a significant source of raw material to industry and additional revenue to growers.

Further research is required to explore whether it is possible to get a good proportion of high-quality material from rubber trees to establish a viable rubberwood industry in Laos.

Studies on sawn and peeled recovery, and grade quality of plantation teak found that trees 15-25cm DBH (the dominant size class) can be peeled using spindle-less lathes with good recovery. This could become a significant opportunity for smallholder teak growers, with the right industry investment.

Low-cost technology trialled and tested by the project will be beneficial to industry:

- Testing of the iPhone SmartThumper™ application measuring stiffness in timber using acoustic technology found it to be able to successfully measure stiffness non-destructively when compared with the alternative, expensive traditional methods of testing. The application costs approximately \$10 AUD, in comparison to destructive mechanical testing equipment which costs approximately \$150,000 AUD.
- A promising new low cost, simple wood treatment system has been developed which uses hot and cold processes with ACQ or Copper Azole wood preservatives.
- A prototype small solar kiln was designed and constructed and its application for plantation grown wood is currently tested.

Studies on mechanical properties and performance of LVL and plywood produced from Eucalyptus K7 hybrid and rubber produced promising results, with performance similar to some commercially available veneer-based products. VALTIP3 team members and students also received hands-on training on plywood and LVL manufacturing.

A study on the financial feasibility of producing EWPs in Laos revealed production costs were significantly lower than equivalent costs in Australia, particularly due to lower labour and capital costs. While current construction in Laos utilises concrete, steel and brick, research found that due to changing consumer preferences and the time and labour cost savings, timber products could be competitive in the future, particularly in large scale residential developments.

A detailed study has highlighted opportunities for using veneer and veneer-based product wastes from manufacturing facilities in Laos. Suggested opportunities for the re-use and recycling of this waste in Laos can comprise three broad categories viz. use in its current form e.g. bark as landscaping mulch; use as a fuel e.g. chipped peeler cores into a burner/boiler and as a reformed fibre e.g. incorporation into engineered wood products. This offers the potential to not only increase value recovery but also address environmental and social issues arising from waste management.

The research undertaken on the use of crop residues in Australia will add-value to existing industries through potential use in EWPs.

- In Australia, cotton (*Gossypium hirsutum* L.) cultivation produces around 1.16 M tons of cotton stalk residue annually. The research highlighted the potential to develop particleboard from cotton stalk agricultural waste. The project also established manufacturing parameters for particleboards made from cotton stalks'
- Australia's emerging hemp industry focusses exclusively on grain production which renders the remaining stem of the plant a by-product with opportunities for further value adding. The project has demonstrated the potential of Australian hemp hurd residue for the production of environmentally friendly lightweight bio-composites.

Considerable impact has also been generated in the field of wood adhesion which is critical to the production of EWPs. This has included new knowledge generated through a state-of-the-art review of bio-based adhesives, comparison of test methods for the determination of delamination in glued laminated timber, evaluation of a promising new surface incision method to improve bond performance, and more than a dozen research trials on hardwood glulam. A range of products have been produced from the project for prototype development and mechanical property performance testing. The results will be used by industry partners to make decisions on marketable products and demonstrations of these products are available at NUoL or in the 'product catalogue'.

8.2 Capacity impacts – now and in 5 years

There are current and future capacity impacts in each arena of project activity:

- Lao PhD, Masters and Bachelor graduates associated with the project have the capacity to conduct research in a range of policy, social science and wood technology topic areas. The majority of these graduates have been working professionally in Laos since graduation, complementing their academic skills and further developing their professional capabilities;
- the capacity of Lao project researchers and collaborators to engage in applied research has been strengthened through project participation. These impacts were realised in relation to a range of forest inventory skills for Luang Prabang Provincial Forest Service staff in 2018; this capacity has already been applied in other projects (Governance, Forest Landscapes and Livelihoods; Village Forest Mapping); in relation to policy engagement for LPTP and NUoL staff, and in relation to value chain and gender research for NUoL staff;

The enhanced teaching, research and training capacity of the NUoL will provide direct benefits to Laos by educating and training future experts in the plantation wood value chain. The wide range of research studies undertaken within the three objectives of the project has significantly strengthened the skills and expertise of the Laos team members.

The installation of a log peeling and plywood production research facility at NUoL has allowed the university to undertake research on EWPs development for Lao PDR companies interested in investing in this technology. The facility is now being used to characterise the quality and potential of different plantation wood species for veneer production and veneer-based product development. Veneer processing has already been added to the university curriculum involving hands-on practice and training. Through training provided within VALTIP2 and VALTIP3 projects, NUoL researchers can now run the machinery autonomously and can use SOPs and user manuals as training tools for students and the industry.

A major impact from the project has been that several companies in Lao PDR have established/or are in the process of setting up veneer and veneer-based engineered wood-product facilities.

- Burapha has constructed a state-of-the-art plywood manufacturing plant. The company has employed approximately 300 employees and they have employed numerous NUoL graduates to work in the factory. To date, the VALTIP3 project has conducted a suite of veneer peeling and EWP manufacturing activities for Burapha. The company has recently used the facility to peel logs to send veneer to a potential customer for assessment. This is a good impact and highlights how the facility is becoming a stand-alone research and industry utilisation/training centre. The project team has provided considerable advice, training, research and development input to Burapha which has been critical to the progress the company has made towards plywood production from Laos forest resources. Burapha has already established a formal MOU with NUoL to engage the facility for R&D purposes.
- Another company (PML Easbeam) is also in the process of negotiating an MOU with NUoL along similar lines. PML Easbeam will soon commence larger scale production targeting plywood and LVL products, employing up to 70 workers with 60-70% being graduates from NUoL.
- Mekong Timber Plantations (MTP) have also announced the installation of integrated processing facilities which will draw upon the expertise developed, and research undertaken through VALTIP3.
- The wood product mechanical properties evaluation assistance provided by DAF to the Laos-based industry has greatly facilitated its growth and expansion of production capacity and material outputs. The R&D activities including product testing has enabled the industry to learn the correct manufacturing processes for different EWPs as detailed in the many reported outputs. Furthermore, due to the progressive development in Laos, major companies such as Burapha and PML have grown their staff numbers and increased their level of production significantly.

Material prepared for various technical training sessions has been added to the NUoL curriculum as part of the Bachelor of Forestry under the new veneer processing subject which is being taught by former and current VALTIP research team members under the supervision of the Australian team. This level of direct skills development will have significant impacts through developing a skilled workforce for the wider Lao wood processing sector. Characterisation activities also provided opportunities encouraging students to address real world problems through innovative technology and problem-based approaches to learning. This contribution is and will be having a significant impact on national capacity in Laos on utilising plantation timber resources for economic development and employment.

As a result of the capacity building approach selected, the experience gained by the Laos researchers under the supervision of the Australian team has prepared them for future work, which is likely to continue after the projects' completion. Over the duration of the project, three members from the Laos team have been successful with their applications for scholarships to pursue an MSc or PhD in Australia.

8.3 Community impacts – now and in 5 years

The project has generated community impacts that will further manifest over the coming 5 years.

At the national policy level, the project has contributed to the development of the 2019 revised Forestry Law and Decree on Plantation Promotion the 2021 Forestry Sector Strategy to 2035, and to subsidiary mechanisms. These policy instruments will shape the contribution of the forestry sector to the Lao economy and to communities engaged in forest sector activities, from growing to processing, with each of economic, social and environmental impacts.

8.3.1 Economic impacts

The project has contributed to a number of current and future economic impacts:

1. The project has informed the development of regulatory instruments for timber legality and sustainability, and for MSMEs in plantation wood value chains, although not yet as favourably for small-scale actors as hoped. The impacts of this work on farmer and MSME participation in the plantation sector over the next 5 years (and subsequently) will depend on the extent to which policy and regulatory development draw on project findings;
2. plantation resource data generated by the project is being used by project partners in the planning and development of new processing facilities;

Through the product development, testing and evaluation conducted with Laos-based manufacturers, the project has assisted the industry to produce consistent quality LVL and plywood with the aim of exporting products to the international community. The commercial use of the K7 eucalypt plantation resource in Laos is a testament to the product development and refinement process conducted through this project. The characterisation studies of the Lao plantation resources for EWPs production (plywood, LVL), will improve significantly the livelihood of Laos smallholders and wood processors by raising awareness about value-adding to a resource currently being sold for woodchip or firewood (i.e. poor financial return) due to better recoveries and efficient use of resources.

The establishment of new facilities and an increase in manufacturing of EWPs in Laos will have a positive economic impact along the value chains.

Assessment of commodity and production costs of EWPs versus steel, concrete, bricks and other construction products used by building and joinery industries has identified opportunities for using plantation timber as a viable alternative construction material.

8.3.2 Social impacts

The project has contributed to a number of current and future social impacts:

1. project work on farmer decision-making and on women's participation in plantation value chains and processing contributes to the knowledge base for decisions that assist smallholder tree growers and enhance the participation of women in plantation-based industries;
2. The ability of FFS to provide meaningful and well-paid work for graduates of forest science, including women, has increased the desire of school leavers to pursue a forestry career in the private sector instead of government. The demands of the private sector has meant that FFS is now reviewing its curriculum to provide

greater expertise to its graduates in the areas of wood sales and marketing, logistics and English;

3. The apparently greater role that women play in wood processing in Laos raises the question of why similar mills in Australia employ so few women (17.3% according to the latest WGEA figures) and also suffer from low retention rates. According to the Business Council of Australia, (2013), the main incentives that help drive employee retention are workplace flexibility, breastfeeding facilities, return to work programs and parental and carers leave provisions. The issue of flexibility is interesting, because Australian workers are predominantly from nuclear, rather than extended, families – the role of extended families in being able to provide the flexibility and childcare that women need to participate in the workforce appears to be an important factor in the high proportion of women in the Lao wood processing industry compared to Australia. The socio-economic differences that enable women in Lao to have a greater role in wood processing than in Australia is an area worthy of further research.

8.3.3 Environmental impacts

The project contributed to the following environmental impacts:

1. fostering understanding of how the environmental impacts of smallholder tree growing might best be governed by each of public and private regulation;
2. contributing to efforts that will motivate investment in plantations and value-adding to plantation grown teak, eucalypts and rubber wood, providing an alternative and, eventually preferential wood supply to native tropical timbers. It is hoped that this will relieve pressure on the diminished native forest resources.
3. supporting initiatives through which degraded forestland will be reforested through a combination of commercial plantations and natural forest restoration – providing an important source of wood, enhancing forest cover and providing other environmental benefits such as carbon sequestration and watershed protection. Project partner Burpaha Agroforestry is participating in this program and has had their feasibility study certified by the Department of Forestry.
4. Demonstrating through proof of concept ‘green option’ for woods processing such as the use of a solar kiln at NUoL which was shown to be beneficial in demonstrating to the community and industry on low cost, environmentally friendly technologies for drying wood products.

8.4 Communication and dissemination activities

The project sought to communicate information about activities through publications, technical reports, meetings, workshops, a project website and social media. The information tools used during the project are summarised below.

8.4.1 Publications

In total over 100 publications were produced during the project period. Different types of publication were used for different audiences including:

- Technical reports targeted to companies or public sector organisations.
- Policy Briefs, for example to MAF and MOIC on the impact or a recommendation about PMO15 on the plantation sector.
- 16 information (Info) Briefs summarising key research topics and findings
- Conference and seminar presentations and posters.
- Story Maps to communicate using more visual and social media compatible formats
- Journal papers to communicate with academic audiences.
- 18 3-minute video-interviews with students, researchers and industry

The list of publications is provided in Section 10.2 of this report.

8.4.2 Project meetings and management workshops

A project inception meeting was held on 30th May 2017 at which the project aims and objectives were presented to and discussed by project stakeholders and partners. On 31st May a second meeting was convened (In the morning) with the industry and government partners to discuss the opportunities for development of the Engineered Wood Products in Laos and a project management meeting occurred in the afternoon. A key activity of this management meeting was the drafting of a communication plan. Annual Workshops were held in Laos in October 2018 and September 2019, with various Objective specific ad hoc meetings occurring as well, most often associated with in-country research activities. Opportunities were taken to meet with key public and private sector partners, for example in April 2019 project team members met with the Department of Forestry to share research progress, discuss key issues and identify areas for collaboration with other projects.

In person annual meetings in 2020 and 2021 were not possible due to COVID-19 travel restrictions and during this time, with planning for two project variations, Zoom meetings were used to discuss project progress and options. These did not include the range of stakeholders that would normally participate in Annual meetings.

A closing workshop was held on 25th November, both in person and online, followed by a small study tour visiting Luang Namtha, Luang Prabang and Vientiane involving staff and students from NUoL, government representatives and members of the project team from Laos and Australia to view and meet with the Laos forest products industry.

Basecamp, which is an online project management tool was set up early in the project for communication and information management purposes. It proved useful for monitoring and evaluation purposes (which was undertaken annually), but less effective for communication within the project team, for which phone, virtual tools (Zoom, Teams etc), and emails remained more effective.

The project established a website <https://laoplantation.org/> through which reports and other outputs were distributed (following email notifications to stakeholders). A Facebook page (<https://www.facebook.com/laoplantation>) was also used to communicate activities, short stories and Info briefs.

8.4.3 Workshops and meetings

Throughout the project team members organised, facilitated and participated in various meetings and workshops organised by the project, collaboratively or by invitation. A list of all meetings and workshops is provided in Appendix 2.

8.4.4 Field Trips and demonstrations

Various field trips, study tours and demonstration activities were undertaken which contributed to the research findings and their dissemination.

A study tour was undertaken to Vietnam in 2018 to expose Lao PDR ministerial policy makers, wood-processing managers and National University of Laos researchers to veneer-based peeling and product-manufacture operations at the village and industrial-scale levels (Redman 2018).

A study tour was undertaken to Thailand to undertake initial assessment of the size and utilisation of the eucalypt resource in NE Thailand and possible impacts for Lao PDR (Midgley & Ruenrith 2020). This further informed value chain research and policy recommendations.

Numerous demonstrations were held at NUoL for students, industry and government. In 2019 and 2022, for example, NUoL undertook rubberwood peeling trails, attended by representatives from NAFRI's rubber research institute.

Various field trips were conducted to undertake research and to communicate findings amongst the project team, when associated with annual meetings. In 2018, for example after the Annual Meeting the project team visited Luang Prabang and surrounding areas and made site visits related to the teak inventory and mapping and the ongoing development of the now completed Lao-China railway, which was expected to both impact the extent of the teak resource (through clearing activities) and provide market access for wood products.

Team members visited partner companies throughout the project.

8.4.5 Training courses

Numerous training courses were organised by the project, and team members also participated in training organised by others. A list is provided in Appendix 11. Key activities were:

Objective 1

Plantation Inventory training for Luang Prabang Provincial Forest Service staff in 2018. Four staff were trained in plot and tree measurement, navigation, GIS and supervision. All achieved competency in required skills and put them into practice in the field inventory of teak in Luang Prabang Province.

Objective 2 & 3

A series of product manufacturing related training courses were delivered specific to adhesive use and application. The training focused on the application methods and specific techniques required when working with adhesives at the environmental conditions experienced in Laos PDR. Further to this, training on the principles of mechanical property analysis, product testing standards and equipment training was delivered to the NUoL FoF team and students. This included mechanical properties such as bending stiffness and strength as well as glue bond integrity and bond quality evaluation testing.

A study tour conducted in year 3 of the project saw the PML Easbeam workers travel to Australia for training in product testing techniques, bond quality analysis and evaluation of some products brought over from Laos.

An additional study tour conducted in 2022 was completed in Australia visiting Eco-cottages, Big Rivers, Austral Plywoods, and Robertson Brothers sawmill following attendance at the International Society of Wood Science and Technology conference.



Figure 5: Female worker at Burapha's plywood mill

9 Conclusions and recommendations

The following section presents the main project conclusions followed by recommendations for further research and development.

9.1 Conclusions

Project activities and impacts demonstrate pathways for effective forest sector policy engagement in Lao PDR, and exemplify how the relevance, credibility and legitimacy of research can lead to effective outcomes. Relationships established by project team members through previous projects, those with other key Lao and international actors, and the enabling contexts of ACIAR and official Australian – Lao relations, underpinned these pathways. The timing of the project in relation to the strategic planning cycle and other policy processes of the Government of Lao PDR, and to commercial investments by forest sector businesses, was fortuitous and important. These learnings are informative for other policy research projects in Lao PDR and elsewhere.

As elsewhere, regulatory structures and markets continue to favour larger enterprises in Lao plantation-based value chains, rather than mSMEs. Project research identified both the importance of and barriers to the greater participation of smallholder tree growers, small-scale traders, and mSME processors in these value chains. Realising the policy ambition to strengthen these enterprises, and their roles in improving rural livelihoods and those of women, will require further policy and regulatory development; and the provision of enabling services such as those provided by LPTP. The current regulatory burden on smallholder tree growers and mSMEs is overwhelming rather than facilitating vibrant smallholder/mSME dimensions to the forest sector.

The resource characterisation work undertaken by the project demonstrated the value of such information to the forest sector. It also revealed the extent of the potential rubberwood resource available for processing. The data will be useful in broader contexts through which the Government, with partners, is developing approaches for better land use planning including in forestlands, assessment of forest cover and change, and as competition for land for other production systems grows with better regional market connections, including for wood and wood products. Research highlighted the limitations of the existing information for long-term planning for the wood sector.

Project research confirmed, for various case studies, established understanding of farmer decision-making, particularly in the context of the dynamic crop booms and land use changes that now characterise much of Lao PDR. Farming households and communities are challenged to ride these booms; while longer-term tree crops can be a valuable household asset, they are being displaced for many households by crops with shorter return cycles. Addressing the regulatory disincentives to tree growing and wood marketing, compared to those of other crops, will help farmers decide in favour of trees.

Wood products research and testing undertaken in both Laos and Australia, has generated multiple outputs that have greatly assisted stakeholders in both countries' to achieve optimal utilisation of forest resources through the production of EWPs. The impact this research has had in Laos has enabled three medium-large wood product manufacturers to progress to a status where they can now sell various high-quality EWPs made from Laos forest resources into local and international markets. The considerable new knowledge and capacitation specific to product development, manufacture and quality control is expected to result in considerable long-term beneficial impact across plantation-forest industry value chains.

Trials of new and innovative products using plantation-grown wood in combination with non-wood products, such as hemp-hurd and bamboo, show promise, as does early testing of the production of plywood from peeled senescent rubberwood. Indications are that the

project inspired investment in the first rubberwood plywood-mill in Laos which will utilise mainly smallholder grown tree, thus adding value this crop.

The installation of the new veneer peeling and plywood production facility at NUoL FFS has been a major success, allowing the project team to undertake research and scale-out training on plantation wood characterisation and EWP development. The new investments by several companies in veneer and veneer-based wood-product facilities, the MOUs they have entered into with NUoL FFS and the interest of the Government and other stakeholders in establishing the facility as a training hub for the sector as a whole, suggests a bright future for the facility.

Perhaps one of the biggest achievements of the project has been the high demand by plantation-wood processing companies to recruit NUoL FFS graduates into their operations, and by the Government and other stakeholders looking to VALTIP3 team members for their contributions to significant policy changes. Significant opportunities have emerged for female NUoL graduates for employment in the sector, and for other women, who, as the project has shown, are particularly valued for their attention to detail in finishing tasks. In mills where there is a high level of mechanisation and a commitment to training and gender equality, women also play an important role in management. The project found a correlation between the satisfaction of women and permanent contracts which provide specific benefits such as maternity leave and social insurance. These conditions were also found to have benefitted women during COVID-19, with them able to stay in employment. There is an identified need to encourage other enterprises in the sector to offer contracts with such benefits.

9.2 Recommendations

ACIAR's investment in this project and those that preceded it has fostered a high level of forest sector policy engagement, understanding and influence. It would be desirable to maintain and capitalise on this platform as the Lao planted forest sector continues to develop rapidly, through continuing support for some forest policy presence in ACIAR activities. Fostering the policy and operating environment for smallholder growers and mSMEs in wood value chains will be necessary to realise national ambitions for encouraging and benefitting these actors. ACIAR could have an ongoing role in this work, in partnership with Lao and other international actors, including forestry businesses. Similarly, further investment in opportunities and strategies to capitalise on the project's contributions to better understanding the gender dimensions of plantation wood value chains could strengthen the benefits to women from the forest sector.

Whilst the project has significantly increased the capacity for NuOL to operate as a stand-alone organisation offering R&D, training and wood product testing services for Laos, it is likely that further follow-up capacitation and expert guidance will be required from members of the project team.

In order to fully exploit the substantial, valuable outputs from this project a follow-on project particularly focusing on technology transfer, adoption and uptake would also be recommended.

New wood products research would also be beneficial to further advance the manufacturing of EWPs in Laos. Forest resources and markets are constantly changing and for Laos to adapt and capitalise on new opportunities it must keep up to date with the latest forest product innovations.

The apparently greater role that women play in wood processing in Laos raises the question of why similar mills in Australia employ so few women and suffer from low retention rates. The socio-economic differences that enable women in Lao to have a greater role in wood processing than in Australia is an area worthy of further research.

Rubberwood remains an underutilised resource and further work to characterise the resource and develop products suitable for Laos and for exports markets would add value ahead of the predicted 'boom' of senile trees in 2030-2035. Significant challenges in logistics, treatment, grower awareness, and product development still exist and further research is required.

10 References

10.1 References cited in report

- Collins, R.C., Dent, B., Bonney, L.B., 2015. A Guide to Value-Chain Analysis and Development for Overseas Development Assistance Projects. ACIAR Monograph 178.
- Belcher, B.M., Rasmussen, K.E., Kemshaw, M.R., Zornes, D.A., 2016. Defining and assessing research quality in a transdisciplinary context. *Research Evaluation* 25, 1–17.
- Flanagan, A.C., Midgley, S.J., Stevens, P.R. (2022). Unfinished Business: Rethinking Certification for Smallholders in SE Asia. Chapter 14 in: Janette Bulkan, Mary Hobley, Anne Larson and John Palmer (eds) (2022). *Routledge Handbook of Community Forestry* (in press).
- Flanagan, A.C., Midgley, S.J., Stevens, P.R. (2020). Smallholder tree-farmers and forest certification in Southeast Asia: alternative approaches to deliver more benefits to growers. *Australian Forestry*. <https://doi.org/10.1080/00049158.2020.1762150>
- Flanagan A. C., Stevens P. R., Midgley S. J. (2019) Cui bono - Who Stands to Gain? Certification for Smallholder Tree-Farmers in Southeast Asia. Chapter 33 (p 621 – 638) in: Schmidt M., Giovannucci D., Palekhov D., Hansmann B. (Eds.). *Sustainable Global Value Chains. Natural Resource Management in Transition*, Vol. 2. Springer-Verlag, Berlin Heidelberg. 727 p.
- Flanagan, A.C., Midgley, S.J., Stevens, P.R., McWhirter, L. (2019). Smallholder tree-farmers and forest certification in Southeast Asia: productivity, risks and policies. *Australian Forestry*. <https://doi.org/10.1080/00049158.2018.1560569>
- Midgley, S. J., Stevens, P. R. and Arnold R. J. (2017). Hidden Assets: Asia's Smallholder Wood Resources, and their Contribution to Supply Chains of Commercial Wood. *Australian Forestry* 80 (1). Pp 10-25. <http://dx.doi.org/10.1080/00049158.2017.1280750>
- Forrester, J., Nilsson, M., Lee, C., Moora, H., Persson, L., Persson, A., Peterson, K., Simon, J., Tuhkanen, H., 2009. *Getting to Policy Impact: Lessons from 20 Years of Bridging Science and Policy with Sustainability Knowledge*, Stockholm Environment Institute.
- Ramirez, L.F., Belcher, B.M., 2020. Crossing the science-policy interface: Lessons from a research project on Brazil nut management in Peru. *Forest Policy Econ* 114, 101789.

10.2 List of publications produced by project

Project Reports

Objective 1

Smith, H. Legal Plantation wood: A new Approach to demonstrating source of origin in Lao PDR (Briefing Note Objective 1.1)

Boer, K. (2019a) Luang Prabang Province Teak Inventory, Technical Report (Objective 1.3.1)

Boer, K. (2019b) Luang Prabang Province Teak Inventory, District summary. Technical Report (Objective 1.3.1)

Smith, H., Ling, S., Barney, K. and Kanowski, P. (2018) Value Chain Assessment: Interim Summary Report - Teak plantations in Northern Laos, Technical Report (Objective 1.2)

Smith, H., Lu, J., To, P.X., Mienmany, S. and Soukphaxay, K. (2020). Rubber Plantation Value Chains in Laos: Opportunities and Constraints in Policy, Legality and Wood Processing, Technical Report (Objective 1.2)

Ling, S., Smith, H. F., Midgley, S., Barney, K. and P. Kanowski (2020) Value Chain Assessment: Interim Summary Report – Eucalypt plantations in Laos from a smallholder perspective, Technical Report (Objective 1.2)

Midgley, S. and Ruenrith, P. (2020) An initial assessment of the size and utilisation of the eucalypt resource in NE Thailand and possible impacts for Lao PDR, Technical Report (Objective 1.2)

Midgley, S. J. (2020). Patterns of Trade in Teak Logs and Lumber, China – Lao PDR 2010 – 2020. Report to ACIAR Project *Advancing enhanced wood manufacturing industries in Laos and Australia* (VALTIP3). 9 pp.

Smith, H. (2019) Plantation Grown Teak and PMO15 (un published Policy Brief, Objective 1.1)

Ling, S. Phonetip, K. and Soukphaxay, K. (2021) Livelihood impacts for women due to employment in a teak wood processing factory, Paklay District, Sayaboury Province, Lao PDR, Technical Report (Objective 1.4)

Boer, K. and Smith, H. (2022) Evaluation of Growth and Yield Information for Plantations in Laos, Technical Report (Objective 1.3)

Smith, H. F. (2021) Rethinking the role of traders, micro, small and medium enterprises in efficient plantation-wood markets: Insights from Laos, Technical Report (Objective 1.2)

Smith, H.F. (2022) Analysis of corporate and smallholder plantations in Lao PDR, Technical Report (Objective 1.2)

Khamtan Phonetip, Stuart Ling, Latsamy Bouphe, Sayavong Thoraty, Oudone Sichaleuen, Khambon Bonphalack, Latsanida Ontavong and Somxay Khambuddaphan (2021) The contribution of the Wood Science and Wood Products Research Center (WS-WPRC)- training facility supported by ACIAR-VALTIP3, report produced for ACIAR project FST/2016/151 - Advancing enhanced wood manufacturing industries in Laos and Australia.

Objective 2

Redman, A. (2018) Client Peeling Study 1

Redman, A. (2019) Client Study 2: K7 Burapha Peeling Study

Redman, A. (2019) Client Study 3: K7 Burapha Peeling Study

Redman, A. (2018) Resource characterisation and product recommendations, Technical Report

Redman, A., Antony, G., Soukphaxay, K., Xetern, L. (2018) Value Chain Assessment: Interim Summary Report - Southern Provinces, Technical Report

Redman, A., Antony, G., Soukphaxay, K., Xetern, L. (2019) Value chain survey report for Southern Lao provinces, Technical Report

Redman, A., Sayavong, O. (2019) Optimisation of wood drying kiln in Luang Prabang, Technical Report

Belleville, B., Redman, A., Ferhmann, J. (2018) Technical report for Maton Guitars, Technical Report

Davies, T., Redman, A., Dakin, T., Faircloth, A. (2018) Assessment of a low cost acoustic grading method, Technical Report

Belleville, B. (2019) Internal report for Jowat Vietnam, Technical Report

Kumar, C. (2020) An overview of adhesives for engineered wood products: a focus on bio-based adhesives, Technical Report

- Faircloth, A., Dakin, T. (2020) Mechanical Property Testing of Laminated Veneer Lumber (LVL) for PML Easbeam, Technical Report
- Dorries, J. (2019) A study into the economic feasibility of manufacturing engineered wood products in Lao PDR, Technical Report
- Kumar, C. (2020) Assessment of the SMART THUMPER™ application as a low-cost and portable device for stiffness measurement of timber product, Technical Report
- Faircloth, A., Dakin, T. (2020) Mechanical Property Testing of Laminated Veneer Lumber (LVL) and Plywood for Burapha Ltd. Technical Report
- Dorries, J., Venn, T., McGavin, R., Leggate, W. (2020) Effect of facility location on the financial feasibility of LVL manufacturing and the potential of distributed production models in subtropical eastern Australia. Technical Report
- Belleville, B. (2019) Rubberwood and Eucalyptus K7 Panel Manufacturing. Technical Report
- Redman, A., Sayavong, O. (2019) Niphone Kiln Upgrade. Technical Report
- Dakin T. (2020) Australian industry consultation and identification of best bet products and key research needs. Technical report
- Norton J. (2020) Non-pressure treatment with alkaline copper quaternary and copper azole wood preservatives. Technical report
- Fitzgerald C. (2020) Options for the reuse and recycling of wood waste from veneer-based manufacture. Technical Report
- Faircloth, A. (2020) Investigative Study into the Certification of Plywood and LVL Products: Requirements, Processes & Facilities. Technical report
- Outhwaite, A., McGavin, R. and Leggate, W (2020) Adhesion System Development for Spotted Gum Solid Timber Engineered Wood Products. Technical report (Objective 2.4.2)
- Faircloth, A. and Dakin T. (2020) Mechanical property testing of K7 laminated veneer lumber (LVL) for Burapha Pty. Ltd. Technical report (Objective 2.2.2)
- Faircloth A. (2020) Investigative study into the certification of plywood and LVL products: requirements, processes & facilities. Technical report (Objective 2.2.2)
- Faircloth, A., Dakin, T. (2021) K7 Eucalypt plywood evaluation for Burapha Ltd to AS/NZS 2269.1 and AS1720.1. Technical report (Objective 2.2.2)
- Phonetip, K., Bouppha, L., Bouppha, S., Khambouddaphan, S. (2021) Designing and building a solar kiln suitable for Vientiane's geography and climate, Laos
- Belleville, B., Fehrmann, J. and Phonetip, K. (2022). Development of EWPs- Rattan and bamboo mats as a cover for non-structural constructions.
- Faircloth, A. (2021). Burapha 9 mm Plywood certification.
- Faircloth, A. (2021). Burapha 17 mm Plywood certification.
- Faircloth, A. (2021). Burapha 19 mm Plywood certification.
- Faircloth, A. (2021). Burapha 21 mm Plywood certification.
- Faircloth, A. (2021). Burapha 25 mm Plywood certification.
- Faircloth, A. (2021). Burapha Plywood certification.
- Fitzgerald, C, (2022), Glueline Treatment of K7 Hybrid Plywood, Technical report
- Fitzgerald, C, (2022) Lyctid susceptibility of K7 Hybrid, Technical Report
- Robinson, R, (2022) Global Utilisation of Rubberwood, Technical Report

Norton J, Robinson R, (2022) Best Management practice for Rubberwood Presentation, Technical Report

Faircloth, A, (2022) Rubberwood product development, Technical Report

Faircloth, A, (2022) NUoL Lab Capacitation, Technical Report

Faircloth, A, (2022) Standard operating procedures (7), (Operations Manual, Characterisation of Structural Timber, Plywood, LVL, Bond Quality, Moisture Content, Formaldehyde Emissions)

Objective 3

Redman, A. (2018) NUoL research facility upgrade - interim report, Technical Report

Norton, J., Redman, A., (2019) Durability Workshop Reports

Redman, A. (2019) Burapha Study Tour. Working paper

Redman, A. (2019) PML Easbeam Study Tour. Working paper

Kikon, D., Miletic, T. (2019) A report of workshop activities, outcomes and project recommendations for the ACIAR project, Laos PDR, Technical Report

Phonetip, K., Souxphaxay, K., Belleville, B.(2019) Summary Report: Student projects. Working paper.

Journal Publications, Conference Papers and Posters

Midgley, S. J. (2022). Plantation forest potential for Green Growth: Regional Experience. Presentation to Forest Investment Program (FIP) Stakeholder Dialogue: Enabling Commercial Plantation Forest Investment in Lao PDR. Ministry of Agriculture and Forestry, Lao PDR. 24 March 2022.

Midgley, S. J., Arnold, R. J., Stevens, P. R., Phimmavong, S., Kien, N. D., Chen, S. X. (2021). Eucalypts and Acacias: smallholders' friends in Asia. Presentation to IFA/AFG National Conference "Your Forests, Our Future", Launceston, Tasmania 11 – 13 October, 2021.

Mienmany, S. Kanowski, P. Robins, L and Smith, H. (2020a) Household participation and livelihood outcomes associated with export banana farming in Northern Laos. *J Land Use Science*. under review.

Mienmany, S. Kanowski, P. Robins, L. Smith, H. and Barney, K. (2020b) Livelihood outcomes of rural households' participation in the Northern Lao cassava boom. In preparation.

Smith, H.F., Kanowski, P., Keenan, R. J. and S. Phimmavong. (2021). "Lao Plantation Policy: Prospects for Change." *Forests* 12: 1132 (<https://doi.org/10.3390/f12081132>).

Mienmany, S. Kanowski, P. Robins, L and Smith, H. (2020) Household participation and livelihood outcomes associated with export banana farming in Northern Laos. Paper to: 25 years of Living Under Contract Farming workshop, Wageningen, May 2020.

Mienmany, S, Smith, H and Kanowski, P. Green gold or fool's gold? The dynamics of smallholder teak growing in Northern Lao PDR. In: D Race (ed). *Raising Trees and Livelihoods*. ACIAR, in preparation.

Belleville B, Chounlamounty P, Soukphaxay K, Phengthajam V, Saetern L, Smith H, Ozarska B (2020) An investigation on peeling recovery and quality of senile plantation-grown rubber trees in Laos

Vella, R., Heitzmann, M. T., Redman, A., (2019) Improving the Adhesion of High-Density Softwoods with Isocyanate Based Adhesives through Surface Incision

- Vella, R., Heitzmann, M. T., Redman, A., Bailleres, H. (2019) Comparison of Test Methods for the Determination of Delamination in Glue Laminated Timber
- Belleville, B., Redman, A., Chounlamounty, P., Phengthajam, V., Xiong, S., Bouphe (2018) Potential of Veneer Peeled from Young Eucalypts in Laos
- Phonetip K, Brodie G, Ozarska B, Belleville B (2018) Drying timber in a solar kiln using an intermittent drying schedule of conventional laboratory kiln
- Phonetip K, Ozarska B, Harris G, Belleville B, Brodie G. (2018) Quality assessment of the drying process for *Eucalyptus delegatensis* timber using greenhouse solar drying technology
- Midgley, S. J. (2018). Hidden Assets: The importance of small holders to wood supply in South-East Asia and possible lessons for Borneo. Invited presentation to the Borneo Forestry Cooperative Plantations seminar. 07 December 2018. Sabah, Malaysia.
- Midgley, S. J. (2018). Global Markets for Plantation Teak + The Promise and Reality of Certification: Help or Hindrance to Smallholders? + What can we learn? Presentation to ACIAR-supported Workshop Developing DNA-based Chain of Custody Systems for legally-sourced Teak. Luang Prabang, 25-26 September, 2018.
- Phonetip K, Ozarska B, Belleville B, Brodie G (2018) Comparing two intermittent drying schedules for timber drying quality
- Phonetip K, Brodie G, Ozarska B, Belleville B (2018) Simulating Solar Kiln Conditions using a Conventional Kiln
- Phonetip K, Ozarska B, Brodie G, Belleville B, Bouphe L (2018) Applying a GIS-based Fuzzy Method to Identify Suitable Locations for Solar Kilns
- Fehrmann J, Belleville B, Ozarska B. (2020) Assessing the potential of hemp hurd (*Cannabis sativa* L.) for the production of environmentally friendly lightweight panels. Conference Paper
- Nguyen T , Heitzmann M T, Vandi L, Bailleres H, Redman A (2019) The Influences of Particle Sizes on Performance of Biodegradable Wood Plastic Composites Manufactured from Ligno-cellulosic Agricultural Waste. Conference Paper
- Shirmohammadi M, Faircloth A and Redman A. (2020) Determining acoustic and mechanical properties of Australian native hardwood species -for guitar fretboard production
- Nguyen T , Bailleres H, Redman A, Leggate W, Vandi L, Heitzmann M. (2020) Homogenous particleboard made from whole cotton (*Gossypium hirsutum* L.) stalk agricultural waste: optimisation of particle size and influence of cotton residue on performance
- Soukphaxay, K, Phonetip, K, Bouphe, L., Khammanivong, K. and Yu, F, (2021) Mechanical Properties Assessment of Laminated Veneer Lumber from Teak Plantation in Laos
- Khamtan PHONETIP, Latsamy BOUPHA, Bounyu PHANOUVONG, Oudone SICHALUENE, Khanxay KHAMMANIVONG, Douangta BOUAPHAVONG (2021) Dry a standing teak tree using a solar kiln drying method
- Phonetip, K., Brodie, G. I., Bouaphavong, D., Bouphe, L., and Khambouddaphan, S. (2020) Drying *Tectona grandis* boards using the simulating solar kiln conditions technique
- Fehrmann, J., Belleville, B., Ozarska, B., Wilson, D. (2020) Assessing the potential of hemp hurd (*Cannabis sativa* L.) to produce environmentally friendly lightweight panels. Conference paper
- Shirmohammadi M, Faircloth A and Redman A (2020) Assessment of sound quality: Australian native hardwood species for guitar fretboard production

Shirmohammadi, M and Leggate, W (2021) Review of existing methods for evaluating adhesive bonds in timber products (Book Chapter)

Nguyen T , Redman A, Leggate W, Vandi L, Bailleres H and Heitzmann M. (2021) Processing parameters optimisation of cotton stalk (*Gossypium hirsutum* L.) particleboards with emulsifiable polymeric isocyanate adhesives

Kumar, C, Redman, A., Leggate, W., McGavin, R. and Dakin, T (2021) Assessment of the application of a SMART THUMPER as a low-cost and portable device used for stiffness estimation of timber products

Wanneng, P., Ozarska, B., Phimmavong, S., Belleville, B., Davidson, B. (2021) Timber Trading and Pricing of Plantation Grown Teak (*Tectona grandis* Linn.F) in Laos

Fehrmann, J., Belleville, B., and Ozarska, B. (2022) Effects of particle geometry and constituent proportions on the performance of low-density hemp hurd particleboards (Under Review)

Kumar, C., and Leggate, W. (2022). An overview of bio-adhesives for engineered wood products.

Midgley S.J. (2016). The promise and reality of certification: help or hindrance to smallholders? Teak Agroforestry and Smallholder Workshop 14-17 November 2016 Luang Prabang, Lao PDR. Australian Centre for International Agricultural Research (ACIAR) Canberra. Available from: http://aciar.gov.au/files/node/14946/tr081_enhancing_livelihoods_in_lao_pdr_through_en_37142.pdf

Midgley, S. J. (2016). Certification and Legality: Help or Hindrance to Smallholders? Invited keynote address, Session1: Pathways to prosperity - Future trade and markets. Small Forest Enterprises: Barriers and Opportunities in Participating in the Responsible Wood Products Trade. Asia-Pacific Forestry Week, Clark Freeport Zone, Pampanga, Philippines, 22-26 February 2016.

Student Theses and Reports

Carmichael, E. (2020) Improving policy and regulation for smallholder tree plantations in Lao PDR. Unpublished Master's thesis, Australian National University.

Mienmany, S. (2021) Riding the boom: Rural households' participation and livelihood outcomes associated with teak, banana and cassava crops in Northern Laos. Unpublished PhD thesis, Australian National University.

Riddy, C. (2020) Plantations, Policy and Participation: Smallholders and the timber legality assurance system in Lao PDR. Unpublished Master's thesis University of Melbourne.

Thammavong, S. (2019) Wage of Female Workers of Burapha Agro-Forestry Company in Sanoudom Village, Xaythany District, Vientiane Capital. Master's Thesis, FFS, NUoL.

Sittivong, K (2021). Gender Role in Teak Plantation at Paklay District Sayaboury Province, Master's Thesis, FFS, NUoL.

Chaysy, S. (2021). Gender in a wood processing factory in Sayaboury, Master's Thesis, FFS, NUoL.

Sittivong, K., Phonetip, K., Ling, S. and Boupaha, L. (2022) Gender Role in Teak Plantation at Paklay District Sayaboury Province, published in NUoL journal (forthcoming)

Info Briefs

No. 1. Fitzgerald, C. and Smith H. (2020) Overview of Engineered Wood Products and Their Applications

No. 2. Dorries, J., Leggate, W. (2020) Are Engineered Wood Products Economically Feasible in Laos

No. 3. Belleville, B., Redman, A., Chounlamounty, P., Phengthajam, V., Xiong, A., Boupfa, L., Ozarska, B. (2020) The Potential of Veneer Peeled from Young Eucalypts in Laos

No. 4. Redman, A. (2020) What are the Opportunities for Spindle-less lathe technologies in Lao PDR?

No. 5. Boer, K., Lattanavongkot, B., Phonphakdy, S., Phengchanh, P., Seneanachak, H. Petlamphan, T. (2020) How much Teak is there in Luang Prabang Province?

No. 6. Leggate, W., Belleville, B., Boer, K., Smith, H. (2020) Quality of Veneer from Smallholder Grown Teak Trees in Laos

No. 7. Smith, H., Ling, S. (2020) Gender Roles in Teak Plantation Wood processing in Laos

No. 8. Smith, H., Lu, J. and To, P. (2020) Prospects for a Sustainable Rubberwood Industry in Laos

No. 9. Smith, H., Lu, J. and To, P. (2020) Land for Rubber Plantations in Laos

No. 10. Smith, H., Lu, J. and To, P. (2020) Labour in the Rubber Sector in Laos

No.11. Smith, H., Lu, J. and To, P. (2020) Natural Rubber Production in Laos

No. 12. Belleville, B. and Chounlamounty, P. (2020) Can Lao Smallholder-grown Rubber trees produce high-grade veneer?

No. 13. Boer, K. (2021) Teak and Rubber Plantations in Sayaboury Province

Midgley, S., Redman, A., Antony, G., Soukphaxay, K., Xetern, L. (2020) Prospects for a Rubberwood Industry in Laos

Smith, H. F. (2022) A Snapshot of plantations in Lao PDR (with CDE)

Robinson, R, (2022) Rubberwood utilisation

Faircloth, A (2022) Rubberwood product development

Belleville, B (2022) Rubberwood recovery

Training Manuals

Belleville, B. (2021) Technical training: Engineered Wood Products (EWPs) - Manufacturing and Best Practices

Belleville, B., Saetern, L., Phengthajam, V. (2019) Standard Operating Procedure - Bourke Sanding Machine

Belleville, B. (2020) Rotary Veneer Products Manufacturing and Best Practices Part I - Veneer Processing & Grading

Belleville, B. (2020) Rotary Veneer Products Manufacturing and Best Practices Part II - Adhesives, Production & Troubleshooting

Redman, A. (2018) Engineered Wood Product Production Training Manual

Fehrmann, J, Belleville, B (2021), Best practice manual for the manufacture of Agri-fibre particleboard

Other Publications

Smith, H.F (2019) Trip Report – Vientiane, 22 April-2 May 2019

Smith, H.F (2019) Trip Report – Vientiane, 4-9 November 2019

11 Appendixes

11.1 Appendix 1: Training

Project start-June 2018

Activity 1.2 - One PhD student (Ms Soytavanh Mienmany, ANU), one Graduate student (Ms Sangkhan Bounthaphan NUoL FoF) and two LPTP staff (Mr Bouthan Souksavath, Mr Sichanh Chandiphit) were trained in value chain field work techniques. Ms Mienmany, Mr Souksavath and Mr Chandiphit participated in three weeks of field work for value chain assessment of the Luang Prabang teak value chain and Ms Bounthaphan and Mr Chandiphit participated in 2 weeks of field work for value chain assessment of the Xayaboury teak value chain.



Figure 6: Mr Stuart Ling, Mr Bounthan Souksavath, Ms Soytavanh Mienmany and Mr Sichanh Chandiphit doing value chain training in Luang Prabang Province.

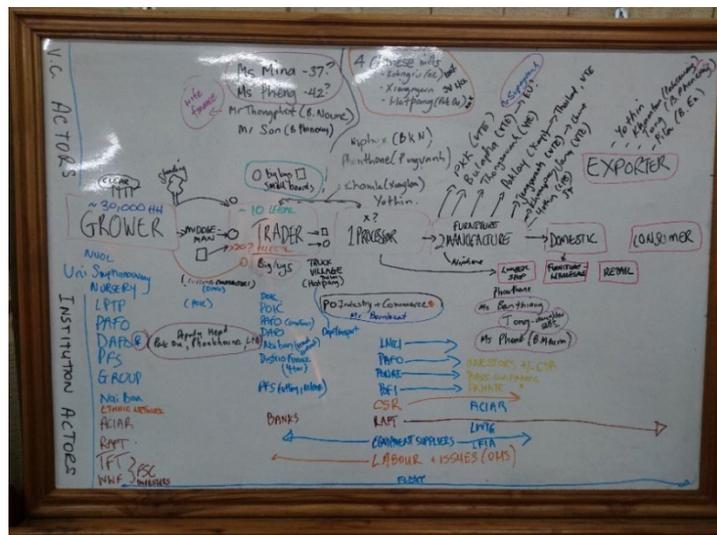


Figure 7: Value Chain Mapping for Luang Prabang Teak

Activity 1.3 - Four LPTP staff were trained in field inventory techniques, two staff were trained in inventory supervision including map production, data checking and entry, and problem solving. One LPTP staff member (Mr Hongkham Seananachak) has been further trained in plantation mapping and GIS analysis techniques.



Figure 8: Inventory training in Luang Prabang

Researchers and students from Faculty of Forestry, NUoL, were trained in peeled veneer grading and quality characterisation as part of eucalypt and teak veneer recovery studies (Figure 12 and 13). Ten FoF students were involved in the eucalypt recovery study and nineteen in the teak study which allowed them to learn about the procedures involved in the trials.

Dr Adam Redman provided training in log grading for quality at the Burapha company (Vientiane) to the industry staff and NUoL students (Figure 14).



Figure 9: National University of Laos students attend the training in peeled veneer grading and quality characterisation as part of a study for New Forests company.



Figure 10: Teak recovery study involving NUoL students



Figure 11: Dr Adam Redman (second from right) providing industry staff and student training in log grading for quality at the Burapha company (Vientiane).

Mr Jack Norton (wood durability consultant) and Dr Adam Redman undertook a termite and fungal durability workshop with participation from Laos Government policy makers, company managers, university researchers and students. An intensive training for VALTIP3 researchers and FFS students was also undertaken on establishing long term termite and fungal durability trials at the National University of Laos (Figure 15). The training attracted thirty-six trainees.



Figure 15: FFS students and researchers participate in establishing long term termite and fungal durability trials

Mr Outhit Sayavong (Tony) of NUoL held a training workshop for 13 final year FFS students who had low scores of their study. The training included the following topics:

- Log grading before sawing.
- Kiln drying of timber; kiln operation and maintenance.
- Production stages after timber is dried.
- How to repair various woodworking machines.
- Safety requirements in using woodworking machines.

Mr Outhit Sayavong provided support to 16 final year FFS students in completing their projects.

Training and technical advice to Burapha company.

Burapha has manufactured and is now using concrete weights as rack tops to minimise distortion of the upper layers of their eucalypt material. The company is also in the process of constructing baffles (made from wood offcuts) in all of their kilns. These are impacts from VALTIP2 project as these recommendations to the company were made during this project.

Adam Redman provided training and technical advice to the Burapha company on how to improve product quality and develop new products which may open new markets.

Advice was provided on solar pre-heating water prior to entering the boiler as a means to save energy.

Technical support to Niphone wood processing enterprise in Luang Prabang

A kiln was built as part of a joint Japanese NGO project but it was not properly designed. Adam Redman and Outhit Sayavong improved the airflow in the kiln by constructing baffles using metal sheeting and structural steel. The baffles were put in place and were hinged so that they can accommodate different timber pack sizes (Figure 16). Vast improvements were made in the airflow where very little airflow was recorded through the stack originally compared with at least a tripling of the airflow after baffling. This modification to the kiln has already improved the quality of dried timber and decreased the drying time by 50% which will provide significant savings and faster production times. Mr Niphone, the owner of the company was extremely grateful for the support provided.



Figure 16: Installation of baffling in Mr Niphone’s kiln in Luang Prabang (left: before baffles were installed, right: timber stack with baffles installed)

July 2018 – June 2019

Intensive training was provided to the Lao project team and students from Faculty of Forestry, NUoL during Year 2 of the project term. The list of training activities has been provided in Table 2.

Training at NUoL EWP’s facilities focused on peeled veneer grading, quality characterisation and product development for plantation eucalypt, teak and rubberwood.

Mr. Khonethong Soukphaxay from the FFS at NuoL participated in value chain assessment of rubberwood in Northern Laos.

Table 2: Record of training provided within VALTIP3 Project (2nd Year, July 2018 – July 2019)

Name of Training	Dates	Names of trainers	No. trainees	Where they were from	No. women	Location of the training
Field work to collect farmers’ information for Ms S Mienmany’s PhD thesis	5-10/7/18	Dr Hilary Smith	2		1	At Ban Tad Kacham, Xieng Nguen District
Field work to collect farmers’ information for Ms S Mienmany’s PhD thesis	2-7/8/18	Dr Hilary Smith	2		1	At Ban Houeyphang, Ngoi District
South East Asia-National Governing Bodies - collaboration workshop organised by PEFC	1 st Oct.2018	South East Asia PEFC team		South East Asia PEFC		Faculty of Forestry Science, Vientiane
Training on ASEAN consultative on standards and quality working group2: Forestry certification capacity building for future cooperation	2 nd Oct.2018	South East Asia PEFC team		South East Asia PEFC		Faculty of Forestry Science, Vientiane
Engineered Wood Product Development Training – funded by The Crawford Fund	2-12/9/2018	DAF team	3	Mr. Outhit Sayavong, Dr. Oudone Sichaleune and Mr. Saysamone Phengmounkhoun		DAF, Brisbane

ACIAR workshop on developing DNA-based chain of custody systems for legally-sourced teak	25 – 26/9/2018			NAFRI		Luang Prabang
Plywood and Composite Products Workshop	15 - 19/10/2018	Valtip3 and Australian Team	27	Students and staff of the Faculty of Forestry Science	10	Faculty of Forestry Science, Vientiane
Veneer products and adhesive applying Workshop	25 – 30/11/2018	Mr. Rod Vella, Dr Adam Redman & Dr Benoit Belleville	27	Students and staff of the Faculty of Forestry Science	9	Faculty of Forestry Science, Vientiane
Veneer production and Grading Workshop	29/4 - 8/5/2019	Dr. Benoit Belleville	21	Students and staff Faculty of Forestry Science	3	Faculty of Forestry Science, Vientiane
Lecture for FOF, NUoL students about timber as a sustainable and renewable material for the construction sector.	10/05/2019	Dr. Benoit Belleville		Bachelor students at the Faculty of Forestry Science	70	Faculty of Forestry Science, Vientiane

July 2019 – June 2020

Intensive training was provided to the Lao project team and students from Faculty of Forestry, NUoL during Year 3 of the project term. The list of training activities has been provided in Table 1.

Table 3: Record of training provided within VALTIP3 Project (July 2019 – June 2020)

Name of Training	Names of trainers	No. trainees	Where they were from	No. women	Location of the training
Plywood production training – Burapha and PML Easbeam	Adam Redman & Simon Dorries	18	Burapha & PML Easbeam	2	Faculty of Forestry Science, Vientiane
EWP manufacturing & performance testing & study tour of Australian industry – PML Easbeam	DAF Team, University of Melbourne, Simon Dorries, Jack Norton	4	PML Easbeam	0	DAF, Brisbane, University of Melbourne, Industry sites in Australia
Study tour of Australian industry – Burapha	DAF Team, Austral Plywoods, Kevin Lyngcoln, EWPA	1	Burapha	0	DAF, Brisbane, Industry sites in Australia
EWP Mechanical Property Testing	Benoit Belleville	4	FFS, NUoL and 2 VALTIP3 project staff	0	Faculty of Forestry Science, Vientiane

The mechanical testing of Eucalyptus K7 and rubber wood plywood and LVL panels at NUoL laboratory included a training component provided by Dr Benoit Belleville on mechanical testing of EWPs for final year FFS students .

Training on glue bond and mechanical testing and plywood production was undertaken at Queensland Department of Agriculture and Fisheries as part of PML Easbeam study tour in Australia.

Plywood production training for Burapha and PML Easbeam was undertaken at NUoL, with 18 participants (two were female). It was attended by foresters, machinery operators, sales managers, plywood project manager, HR, sawmillers and the company CEO .

During the period June 2020 –July 2021

Soy Mienmany completed her PhD at ANU.

Dr Khamtan Phonetip and Mr Khonethong Soukphaxay undertook training with PEFC on forest certification.

Eleven student projects were planned and commenced in relation to the multifunctional hut. Only 4 projects were able to progress due to COVID-19:

1. Design and produce bamboo lamps.
2. LVL properties assessment.
3. Investigate wood legality (chain of custody) within the teak value chain in Sayaboury (bringing teak to Vientiane), including testing of the Woodpecker app.
4. Drying performance of a solar kiln.

One Master student commenced research on LVL & Plywood value adding.

Two intensive technical training sessions have been completed in 2020 at NUoL. The first one in October was essentially for Burapha supervisory staff, made up of predominantly NUoL graduated FFS students, and the second one in November was for the new factory staff and current undergraduate NUoL FFS students. The teachers for the first session were mostly Valtip 3 research team members and Burapha personnel. The second training was presented by the supervisors trained during the previous session. This allowed Burapha supervisory staff to gain some confidence in training prior to entering the factory where they will be required to train subordinate staff. The training sessions, designed specifically for Burapha and PML Easbeam staff and focusing on plywood and LVL production, covered topics such as veneer processing, veneer drying, and veneer grading, adhesives, and veneered products production and testing methods and requirements. The training included OHS and best practices and hands-on practical sessions (e.g. peeling, grading, making panels). Ancillary documents associated with Burapha's specific production and needs have also been prepared and included. The training also included NUoL students and Valtip 3 team members interested in the training and topics.

The venue for the technical training sessions was the FFS research facility at NUoL. A total of 19 persons (4 females) attended the first training: Fourteen from Burapha (12 supervisors and managers, 2 trainers) and five from FFS (3 Students, 2 VALTIP3 team members). A total of 50 persons attended the second training session.

Table 4 – Record of training provided within VALTIP3 Project (2022)

Name of Training	Names of trainers	No. trainees	Where they were from	No. women	Location of the training
Study Tour, Aus	Robbie McGavin	2	FFS, NUoL	0	Australian Industry in QLD and NSW
Equipment training	Adam Faircloth	9	FFS, NUoL	2	Faculty of Forestry Science, Vientiane
Equipment training	Adam Faircloth	10	FFS, NUoL	2	Faculty of Forestry

					Science, Vientiane
Equipment training and Study Tour (Laos)	William Leggate and Adam Faircloth	13	DOF, MOIC, NUoL FFS,	3	Luang Namtha, Luang Prabang, Vientiane
Agri-fibre particle board best practice training	Hannes Fehrmann, Benoit Belleville	20	FFS, NUoL	4	Faculty of Forestry Science, Vientiane

Travel was made available again to Australian project participants in mid-2022 following COVID-19 travel restrictions. Four independent trips were completed in June, July, September/October and November focused on capacity building, training/extension, and 'hands on' product development at NUoL.

Adam Faircloth and Benoit Belleville in June travelled to the Bolikamsai province to source rubberwood logs with NUoL students. This training focused on sourcing legal rubberwood material, felling, transport, safe handling, merchandising, drying and storage in preparation for product development. A total of 9 students participated in the log merchandising with 2 women involved in the training.

Khamtan Phonetip and Khonethong Soukphaxay travelled to Australia to participate in the International Society of Wood Science and Technology conference in Kingscliff, NSW, Australia. The conference was followed by a study tour to some Australian Industry, including Big Rivers (NSW), Austral Plywoods (QLD), Eco Cottages (QLD) and Robertson Brothers sawmill (QLD) to gain an insight into the practices of companies in Australia.

Adam Faircloth in September/October worked directly with staff and students and at NUoL to build on previous rubberwood product development work as well as equipment training and developing operating procedures to help transition NUoL to self-sufficiency. A range of standard operating procedures for equipment was developed in collaboration with NUoL staff and students and this has been translated. Practical 'hands on' training was provided by using non-destructive testing software Smart Thumper™ to evaluate MOE of harvested rubberwood boards.

Hannes Fehrmann and Benoit Belleville travelled to NUoL and delivered detailed training on agri-fibre particle board manufacturing. The training attracted 20 students with 4 female participants. The training involved both theory and practical components.

Adam Faircloth and William Leggate travelled to Laos in November for final training on newly installed machinery and to implement the standard operating procedures. A number of students were involved in the machinery and equipment training. A study tour was completed involving representatives from a range of organisations and the tour visited industry in Luang Namtha, Luang Prabang, and Vientiane.

11.2 Appendix 2: Meeting and Workshops attended

VALTIP3 team members participated numerous non-government activities and processes through which project results were presented to the government, other donor partners and their projects and the private sector. These are summarised below in chronological order:

2017

B. Lattanavongkot of LPTP participated in a High Government Exchange Visit to Quang Tri and Da Nang Province, Vietnam on "Improving Sustainable Plantation Management and Supply Chain Control" on 18 - 23 July 2017. The aims of the trip were: to visit and learn from the experiences related to contracted individual tree plantation on state lands,

particularly those related to contract conditions and government supporting policies; supply chain and value chain of planted timber in processing factories with COC and FSC certification; policy and regulations related to the processing and management of planted timber.

LPTP team and Teak Farmer Group from Kokgnui, Ban Xienglom attended a workshop on plantation and processing of teak wood in Luang Prabang on 24-25 August 2017. The purpose of this workshop was to report on the conditions and experiences related to the development of the plantation industry, especially teak wood of Lao PDR; to discuss and analyse the potential opportunities, problems, constraints and challenges of developing the teak industry sector in order to identify policies, strategies, measures and approaches.

B. Lattanavongkot attended a meeting “Strategy on Teak Plantation Managements to ensure that teak resources are sustainable and meet to the Government forest strategy and international standard” organised by WWF and Department of Industry and Commerce. He made a presentation on LPTP roles on sustainable teak resource including teak mapping activities which aim to collect information and data for future teak resource strategy in Luang Prabang.

B. Lattanavongkot attended a workshop organised by the Mekong Region Land Governance, and he presented a paper “How can forest certification improve the land tenure security of smallholder farmers?”. The objective of the workshop was to discuss how to improve land tenure for Lao farmers.

2018

H. Smith and Dr Phimmavong attended the FLEGT expert group workshop on plantations on 13 February 2018 which aimed to define legal plantation timber. It should be pointed out that VALTIP2 work on plantation legality, policy and environmental management was used by FLEGT team as a guideline for making definitions of legal plantation timber and clarify areas of uncertainty. The VALTIP2 work on Smallholder Policy Legality in Lao PDR assisted specifically with respect to smallholders. The ACIAR policy brief on Agroforestry and woodlots also influenced the two new notices on plantation registration and harvesting/transport and the new draft Forestry Law, in particular that there is no longer a requirement to have DAFO undertake pre-harvest inventory of plantations nor issue transport permits.

H. Smith attended the plantation policy forum on 21 June 2018 in Vientiane, organised by ACIAR project ADP/2014/047 “Improving policies for forest plantations to balance smallholder, industry and environmental needs in Lao PDR and Vietnam”. The forum has been a good platform for learning and information sharing between ACIAR projects

A meeting of 30 key plantation sector stakeholders was organised on 23 March 2018, organised in partnership with ACIAR project ADP/2014/017 (H. Smith)

An Annual Workshop was held on 11 October 2018 at the FoF, NUoL, to provide an update on the project and the official launch of the new Research Centre at FoF by the Australian Ambassador. The Workshop was followed by VALTIP3 Policy Reference Group meeting and VALTIP3 Technical Reference Group meeting.

H. Smith co-convened a technical workshop on the Legal Framework for Tree Plantations in Vientiane from 3-4 October 2018. The workshop was organized by DoF and DOFI, with the support of GIZ and ACIAR.

B. Lattanavongkot attended the workshop entitled IT Solutions for Sustainable Forest Management in South East Asia in Singapore on the 29th Nov 2018.

2019

In January 2019, H. Smith presented at a National meeting on the Wildlife Law in Laos. Hilary presented results of a project to develop a “Wildlife Legality Compendium” which builds on the method developed for legal mapping during VALTIP2.

In April 2019 H. Smith and S. Mienmany attended the National Conference celebrating the 20th Anniversary of NAFRI. Hilary presented on Policy research for plantations in Lao PDR and Vietnam: Results and recommendations (a joint presentation for VALTIP3 and the ACIAR LVPPP).

On 22 April 2019 H. Smith, K. Phonetip and S. Phimmavong met with Department of Forestry to present research results from Objective 1 and discuss future research activities.

On 23 April 2019 H. Smith attended a meeting of plantation projects to discuss the development of applications for plantation supply chains. The meeting was convened by PEFC.

On 24-25th April 2019 H. Smith attended a meeting with Ministry of Industry and Commerce (Department of Industry and Handicrafts), convened by GiZ to workshop the Ministerial Decision on Chain of Custody for wood processing.

On 26th April 2019, S. Ling and H. Smith attended a Plantation Registration Consultation Workshop to discuss the draft guidelines on plantation registration issued by the Division of Forest Plantation Promotion and Rehabilitation within the DoF.

On May 2 Hilary Smith attended a workshop of the Pro-FLEGT technical working group for Plantations to review the timber legality definition for plantations in preparation for the Lao-EU VPA negotiations in May 2019.

From 17-21 June 2019 B. Lattanavongkot attended the Asia Pacific Forestry Week in Incheon, Republic of Korea.

During a project visit from 22 April to 3 May 2019, H. Smith organised and participated in a number of meetings with industry, government and development partners, as summarised in Table 1.

B. Lattanavongkot attended launch of IT COC Woodpecker app for chain of Custody in Laos, 16th October 2019

S. Midgley attended the lenders forum for Burapha Agroforestry Company. 29th October, 2019.

B. Lattanavongkot attended NAFRI 20th Anniversary workshop of JIRCAS-NAFRI-NUOL collaborative project 2016-2021 “Technical achievements of the projects and their application” Vientiane 30th October 2019

H. Smith attended meetings with GIZ and the Ministry of Industry and Commerce to discuss the development of a regulation on timber chain of custody, 4th November 2019.

S. Ling, H. Smith and S. Midgley participated in a meeting on Multi-Stakeholder Consultation on Facilitating High-Quality Forest Plantation Investments in Lao PDR. Facilitated by the Interlaken Group 5th November 2019. H. Smith gave a presentation on ACIAR plantation and wood industry research projects: Past research, new legislative frameworks, opportunities and challenges.

From 17-21 June 2019 Mr Bounchanh attended the Asia Pacific Forestry Week in Incheon, Republic of Korea.

Table 5: List of policy-oriented meetings

Date	Organisations	Team members	Purpose
2019			
22 April	Department of Forestry	Smith; Boer	Update on project activities (objective 1). Discussion about ongoing and future activities. Discussion about data availability for plantation mapping.
23 April	IFC, PEFC, VALTIP3, LATARP, Trimble, Innova	Smith	Meeting on projects developing applications for plantations and plantation grown wood.
23 April	Stora Enso Laos	Smith; Boer	Requesting access to company plantation data for Obj 1.3
23 April	Burapha	Smith; Boer	Requesting access to company plantation data for Obj 1.3
24 April	MOIC	Smith	Workshop with MOIC on Chain of Custody Decision
24 April	CDE	Smith; Boer	Access to land concession data and other sources of relevant information
25 April	MOIC	Smith	Workshop with MOIC on Chain of Custody Decision
25 April	FERN	Smith	Contract farming law, CSO activities and research on contracts and dispute resolution processes.
26 April	NAFRI	Smith	Presentation on plantation policy research at NAFRI Seminar
29 th April	World Bank	Smith	World Bank and ACIAR project synergies
29 th April	SUFORD	Smith	SUFORD method for mapping for plantations on degraded PFA. Advice on accessing GIS data from FIPD General discussion about current policy changes for plantations especially for plantations in PFAs
29 th April	Mekong Timbers	Smith; Boer	Requesting access to company plantation data for Obj 1.3
29 th April	VFI	Smith	Rubber value chain research
30 th April	NAFRI	Smith; Boer	Data for plantation mapping Rubberwood value chain research
2 nd May	FLEGT Office	Smith	Plantation Legal Framework road map meeting

An important event for VALTIP3 was a visit to the Engineered Wood Products Research Facility in the NUoL by Delegation officials from ACIAR and the Australian Ambassador to Laos Mr Jean Bernard Carrasco, in March 2019 (Figure 3). Dr Adam Redman and NUoL researchers demonstrated the facility's log peeling, veneer grading, drying and panel production capabilities. Dr Redman also presented results from the forest resource-value characterisation studies, and the innovative wood product development trials, undertaken by the research team for industry investors. While in Laos, the delegation also visited a small-enterprise sawmills owned by Mr. Niphone and Mr. Khamla, in the northern province of Luang Prabang. Work by the project team on-site to improve sawmill layout and modify the drying kiln has increased profitability of this small business by 30 percent.

H. Smith and S. Midgely participated in a Study Tour on Promoting Industrial tree Plantations in Degraded Production Forest Areas organised by the FAO and Burapha, 6th-8th November 2019

B. Lattanavongkot attended Global Forest Industry Forum Sustainable Wood for a Sustainable World, FAO — CNFPPIA – ASEAN Expo, Nanning China, 23rd – 25th November 2019

K. Barney represented VALTIP 3 at the Forest Sub-Sector Working Group meeting, 13th December 2019, Vientiane. A poster presenting a summary of the project was displayed.

B. Lattanavongkot attended IFC and DOF training of trainer curriculum workshop on plantation registration and planted tree certification, Vangvieng Laos. 19th-13th December 2019

S. Midgley attended the multi-stakeholder consultation. Wood processing strategic roadmap supported by the International Trade Centre (ITC) and Ministry of Industry and Commerce with funding through the EU. 18th December. 2019.

2020

B. Lattanavongkot attended International Collaboration through Tree Planting and Forest Education in Asia-What we are aiming for a sustainable environment, IGES-JISE, Tokyo Japan 12th January 2020

B. Lattanavongkot attended The 2nd ITTO Project Steering Committee Meeting in LAO PDR “Enhancing Conservation and Sustainable Management of Teak Forests and Legal and Sustainable Wood Supply Chains in the Greater Mekong Sub-region” (ITTO PP-A/54-331)” 18th February 2020

S. Midgley and B. Lattanavongkot helped organise, participated in, and B. Lattanavongkot presented at The National Teak Forum in Lao PDR: “Sustainable Teak Value Chains for Sustainable Local Development”. NAFRI + ITTO Teak in Mekong Initiative 19th-20th February 2020, Vientiane and Luang

S. Midgley attended Technical Consultation Workshop on Plantation Investment in Production Forest Area (PFA). 13th March 2020.

S. Mienmany presented project results in a Journal of Peasant Studies (virtual) Writeshop, 25-30 July 2020

H. Smith met with FAO and GiZ to discuss project collaboration and policy support activities, 25 August 2020

H. Smith attended the Consultation Meeting on Market Analysis, Part II: Process & Product quality, organised by GiZ, 17 December 2020

2021

H. Smith attended meeting on ASEAN Guidelines for Promoting Responsible Investment in Food, Agriculture and Forestry (ASEAN RAI), 15th January 2021

H. Smith attended meeting with GiZ on collaborations on wood processing, Chain of Custody and opportunities for NUoL 19th February 2021

H. Smith met with EFI on SME support in Laos and MOIC training – NUoL Roadmap, 25th February 2021

S. Ling attended a webinar on Migration and Women’s Land Tenure Security in the Greater Mekong Sub-region, 19th May, 2021.

S. Ling and H. Smith attended the Mekong Regional Land Forum organised by MRLG on 26-27th May, 2021

H. Smith attended “How community forests boosted pandemic and disaster resilience in Asia” organised by RECOFTC 15th June 2021

H. Smith participated in consultation on the Forestry Strategy 2030 from 29-30 June 2021

S. Ling attended the National Food Systems Summit Dialogue for Lao PDR organised by FAO on 2nd June, 2021

S. Mienmany presented a public seminar on her PhD research at the ANU Fenner School of Environment and Society, on 8 July 2021.

K. Phonetip and L. Siakor participated in the ARISE Plus Quality Champion program, see <https://www.intracen.org/arise-plus-laos/past-events/>

K. Phonetip participated in the Circular Economy Project, December 2020-March 2021.

B. Belleville and K. Phonetip met with WWF Laos to discuss collaborating with the Sustainable rattan and bamboo production and harvesting project and works also with the private sectors (rattan SMEs) in sourcing rattan from FSC certified area to fabricate prototypes as part of activity 2.2.

2022

S. Khonethong, K. Phonetip, A. Faircloth and W. Leggate attended the International Society of Wood Science and Technology, in Kingscliff, NSW, Australia (June 10-15) focussed on “ A global perspective of the present and future utilisation of renewable materials”.