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project

Enhancing key elements of the value chains for plantation-grown wood in Lao PDR

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1 Acknowledgments

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Acronyms

AGM	Annual general meeting
ANU	Australian National University
ASEAN	Association of Southeast Asian Nations
COC	Chain of Custody
DAF	Department of Agriculture and Fisheries (from February 2015)
DAFF	Department of Agriculture, Fisheries and Forestry
DGCIS	Indian Directorate General of Commercial Intelligence and Statistics
DOF	Department of Forestry
EDC	Enterprise and Development Company Ltd
EFI	European Forest Institute
EU-FLEGT	European Union Forest Law Enforcement Governance and Trade
FAO	Food and Agriculture Organization of the United Nations
FGE	Farmer Group Enterprise
FOA	Faculty of Architecture
FOF	Faculty of Forestry
FSC	Forest Stewardship Council
GOL	Government of Lao PDR
GOS	Green-off-saw
GTA	Global Trade Atlas
IUFRO	International Union of Forest Research Organizations
Lao PDR	Lao People’s Democratic Republic
LDC	Less Developed Country
LFA	Lao Furniture Association
LFTP	Lao Forest and Trade Platform
LPTP	Luang Prabang Teak Program
MAF	Ministry of Agriculture and Forestry
MOIC	Ministry of Industry and Commerce
MONRE	Ministry of Natural Resources and Environment

NUoL	National University of Laos
OHS	Occupational Health and Safety
PAFO	Provincial Agriculture and Forestry Office
PARDI	Pacific Agribusiness Research for Development Initiative
PEFC	The Programme for the Endorsement of Forest Certification
PFS	Provincial Forestry Section
PVA	Polyvinyl acetate
RMIT	Royal Melbourne Institute of Technology
SEALPA	South East Asia Lumber Producers Association
SME	Small and medium-sized enterprises
UoM	The University of Melbourne
VAFS	Vietnamese Academy of Forest Sciences
VALTIP	“Value-adding to Lao plantation timber products” (ACIAR project FST/2005/100)
VALTIP2	Researchers involved in the current ACIAR project

2 Executive summary

Laos has an emerging forest plantation industry, based on both smallholder and corporate growers. The Lao People's Democratic Republic (PDR) Forestry Strategy to 2020 envisages a substantial forest plantation estate, with a target of a total of 500,000 ha of tree plantations. Plantations and planted trees have the capacity to provide significant financial benefits to Lao PDR, and to smallholder growers. However, there are many challenges, constraints and opportunities that need to be addressed in order to maximise returns to smallholders and support the development of competitive value-added wood industries.

The aim of the project was to improve livelihoods for farmers and processing workers and the international competitiveness of Lao PDR wood industries through improved efficiency of key elements of the planted wood value chain.

The project has built upon the achievements of a previous project, FST/2005/100 "Value-adding to Lao plantation timber products" (VALTIP), which focused on building capacity and enhancing the range, quality and value of manufactured wood products in Lao PDR.

The principal research findings in relation to these objectives are:

- The study on the legal barriers to smallholder plantation owners and the associated timber value chain project have identified impediments to greater adoption of plantation registration, including lack of information, ease of circumventing legal requirements in the timber market, lack of enforcement, and insufficient benefits to offset the cost of plantation registration. The methodology has been adopted in the Lao European Union Forest Law Enforcement Governance and Trade (EU-FLEGT) Forest Legality Compendium project and Wildlife Law in Lao PDR.
- Research found that streamlining and simplifying regulations and reducing transaction costs would likely increase smallholder returns and improve the competitiveness of plantation enterprises through increased value chain efficiency. The research has identified a broad range of opportunities for legally minimising the impact of plantation transaction costs.
- A review of existing approaches to forest certification found that these are largely inappropriate and cost prohibitive in the context of smallholder plantations, and add little value for growers.
- Community-based enterprises that could undertake harvesting, processing of local teak were unsustainable since growers sell as needed, often in response to household shocks, rather than on a collective basis with other farmers.
- The project team worked with the Industry Cluster companies on improving wood recovery during log sawing and furniture production, improving drying methods, machining, gluing and finishing processes, increasing production efficiency, and waste management. A strong focus was placed on improving OHS procedures. Standards for log and sawn timber grading have been developed for implementation by the government and industry. Best practice manuals have been produced, which provide industry with the information required to improve their primary processing and manufacturing operations in the short- to mid-term.
- Opportunities for new value-added technologies based on veneer have been identified, which will increase the value recovery from small dimension logs, including the development of novel appearance and structural wood products for which there is a strong demand in Laos and international markets.
- The project made significant achievements in enhancing local capacity in wood processing, manufacturing and furniture design practices, mainly through collaborative research and the development of strong network linkages between partner organisations representing education, research, training and the industry.

3 Background

The Government of Lao PDR (GOL) has policies that are clearly directed towards economic growth and poverty alleviation, and has recognised the plantation sector as one of the highest priorities leading towards economic growth and increased revenues in rural areas (MAF 2010). The Lao PDR Forestry Strategy to 2020 seeks to expand plantation forest area to 500,000 ha (MAF 2005).

Understanding and improving the efficiency of the whole value chain of plantation-grown wood production is an important element of achieving these national goals. Under Program 4 (forestry development) of the Agricultural Master Plan (2011–2015), the GOL proposed the following priority measure: "Promote a balance between wood processing industries and annually approved wood harvest volumes; strongly promote domestic processing of wood, promote sustainable trade in wood products by certification (e.g. the requirements of Chain of Custody (COC)."

Under the 7th National Socio-economic Development Plan (2011–2015), the GOL was implementing policies for small and medium processing industries using domestic raw materials, in order to increase value-adding and competitiveness of exports in international markets. In 2008, the GOL moved responsibility for harvesting and processing forest resources from the Ministry of Agriculture and Forestry (MAF) to the Ministry of Industry and Commerce (MOIC). Accordingly, the MOIC has established the following priorities:

a) Raise factory productivity and value addition to raw materials with emphasis on wood.

b) Upgrade technologies and skills of the wood processors in Lao PDR.

c) Minimise production waste and utilise by-products.

d) Sustainable use of natural resources and the protection of the environment.

e) Develop Lao standards of wood processing to conform to regional and international standards (including certification of forest products).

f) Promote growth and strengthening of the private sector and the creation of wood processing association.

g) Trade promotion for finished products in domestic, regional and international markets.

In 2010, the GOL released its National Export Strategy for the Period 2011–2015 (NES). The NES recognised that, while some processing industries for the domestic and export market (including furniture) have been developing gradually, they are still in their infancy, with the export of finished products accounting for only a minor proportion of overall exports as compared with the export of raw materials. One of the nine export strategies, The Wood Products Export Strategy, had a clear focus on ensuring that “Lao furniture will reach international standard and have a national brand in order to sell to government and private offices locally as well as to export to the overseas market”.

The project was built on the “Value-adding to Lao plantation timber products” (VALTIP) ACIAR project, FST/2005/100, which was completed in January 2011. This project made significant achievements in enhancing local capacity in timber testing and processing and facilitated improvements in the range and value of wood products in nine wood manufacturing enterprises. The review of project (Walker 2010) recommended that “ACIAR consider the development of a new project to support the development of export markets for furniture and wood products derived from sustainably managed plantations in Laos”. It recommended a focus on developing an export-oriented quality assurance program; identifying technologies required to produce export quality furniture and wood products; developing an export marketing strategy for Lao furniture and wood products; and facilitating the development of required educational/training capabilities. It was

recognised that there was an opportunity to exploit the networks developed under the previous project and use its achievements to provide significant support to the Lao PDR in the development of the Wood Product Export Strategy and the Strategy on Export Quality Management under the NES.

Apart from using recommendations from the project final review, the project was also largely based on the findings of the ACIAR Scoping Study (C2010/101) on the background and potential research needed for Payments for Environmental Services and Planted Log Value Chains in Lao PDR. The Scoping Study report (Midgley *et al* 2011) identified major constraints and opportunities for R&D across the value chain for plantation-grown wood in Lao PDR. The key elements of the value chain that required intervention to increase returns to smallholders, wood processors and manufacturers were identified and these were used as the foundations for developing the FST/2010/012 project proposal.

The key issues identified for investigation were:

- improving knowledge of the extent of planted teak (*Tectona grandis*) and the measures needed to enhance log quality
- enhancing the role of grower groups in addressing value chain inefficiencies
- improving response to increased global demand for legal wood products through development of forest certification and COC systems for forest products. Lack of legality of the resources limits market opportunities due to restrictions in Europe (EU-FLEGT), Australia and North America (the Lacey Act)
- adding transparency to the formal regulations and procedures for plantation logs and timber, and improving farmers' understanding of log pricing
- improving efficiency of harvesting and transport systems
- improving value-adding for plantation-grown wood through technical improvements in wood processing and manufacturing
- improving product design and manufacture
- enhancing the skills of the people working in the Lao wood industries.

The project addressed the above priorities through its activities and tasks developed for the key links of the value chain, which connect tree growers in rural Lao PDR with processors and furniture producers, and distributors to both the domestic and overseas markets.

The project was aligned with Australian industry priorities (Duff 2010). The local processing industry lacked information on processing options for and the performance of plantation-sourced teak and eucalypt (*Eucalyptus camaldulensis.*) value-added wood products. The project enabled Australian researchers to work with more advanced plantation material than is currently available from plantations in Australia, to better answer these questions.

4 Objectives

The overall aim of the project was to improve livelihoods for farmers and processing workers and the international competitiveness of Lao PDR wood industries through improved efficiency of the planted wood value chain.

The underpinning objectives and associated activities were as follows:

1 To address constraints and inefficiencies in the value chain, from harvest to processor stages, that limit returns to smallholder growers.

Activities:

1.1 Characterise smallholder planted tree resource in Luang Prabang region.

1.2 Identify and test how barriers to legal registration of smallholder planted trees can be addressed, and how transaction costs in their sale and delivery can be diminished.

1.2A Identify and test how barriers to legal registration of smallholder planted trees can be addressed.

1.2B Identify and test how transaction costs in the sale and delivery of smallholder planted trees can be diminished.

1.3 Identify and test what forms of grower organisation and group certification are feasible and sustainable, and will improve returns to smallholders, and how these can be fostered.

1.3A Enhance the role and reach of grower groups.

1.3B Establish certification processes feasible for smallholders.

2 To increase returns to processors and smallholders through improved efficiencies of the primary wood processing sector.

Activities:

2.1 Identify and characterise current production practices and processing efficiency in Lao companies.

2.2 Improve or implement log grading / segregation activities at the mill prior to processing.

2.3 Conduct studies to optimise and improve sawing operations and recovery.

2.4 Develop and/or improve drying operations to reduce degrade and costs.

2.5 Develop and/or improve product grading and implement the rules in the Industry Cluster companies.

2.6 Provide impartial and independent advice and demonstration of appropriate primary processing equipment suited to Lao industry.

3 To improve the value and quality of wood products for domestic and export markets.

Activities:

3.1 Determine typical current recovery and productivity levels in Lao manufacturing facilities and identify and recommend improved efficiencies in-company and through cooperative cluster scenarios.

3.2 Determine the most appropriate practices and equipment for furniture and joinery machining, bonding and finishing.

3.3 Improve quality of wood products and product design.

4 To enhance the competitiveness and capacity of wood processing industries.

Activities:

4.1 Develop an industry-led value-added timber market strategy.

4.2 Develop short-term and long-term training programs.

4.3 Enhance educational and research capabilities.

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) and Queensland Department of Agriculture and Fisheries (QDAF) and several Australian consultants who contributed to Objective 1 through ANU.

The principal partners in Lao PDR were as follows: National University of Laos, Souphanouvong University, Pakpasack Technical College, Lao Furniture Industry Association, Ministry of Industry and Commerce (MOIC), National Wood Industry Association, Luang Prabang Teak Program (LPTP), and Lao Forest and Trade Platform. The Northern Agricultural and Forestry Research Institute, Department of Forestry and Department of Forest Inspection were also important partners, but with limited roles.

The focal points of the project were in Luang Prabang and Vientiane. Local contact "offices" were established at LPTP in Luang Prabang and at the National University of Laos in Vientiane to assist the project partners with operation of "field" research activities, implementation of research outcomes, and dissemination and communication with the project partners and stakeholders.

5.2 Research methods

The methodology used in this project was based on the value chain analysis and as such the focus was placed on identifying ways to identify the systemic factors and conditions under which a value chain of plantation-grown wood and its major players (the chain links) can achieve higher levels of performance. The analysis focused on identifying ways to contribute to (i) improving the competitiveness of value chains with large numbers of small firms (smallholder growers and small and medium-sized enterprises (SMEs), and ii) expanding the depth and breadth of currently generated benefits.

The key methodologies for each major component of the project are summarised below.

Objective 1: To address inefficiencies in the value chain (harvest to sawmill stages) that limit returns to smallholder growers

The Objective 1 projects involved close cooperation between researchers from ANU, NUoL and the key supporters from The Forest Trust and the LPTP, which provided joint coordination and support for the Objective 1 projects.

Members of Objective 1 team were as follows:

- Mr Alf Said – Objective leader
- Mr Ken Boer – leader of Activity 1.1
- Dr Hilary Smith – leader of Activity 1.2A
- Mr Alf Said – leader of Activity 1.2B
- Mr Stuart Ling – leader of Activity 1.3A
- Mr Richard Laity – leader of Activity 1.3B
- Aidan Flanagan – team member for Objective 1
- Mr Bounchanh Lattanavongkot – Lao coordinator for Objective 1
- Ms Katia Massia-Bröcker – TFT Program Manager.

The above were also supported by key Lao PDR research and government officials and field assistants.

Objective 1 encompassed a set of five projects grouped under three activities. These projects addressed complex and challenging subjects covering resource mapping, plantation legality, plantation transaction costs, grower organisations and certifications. A collaborative approach was developed across the activities and also with related ACIAR projects. The project research partners, particularly the LPTP and The Forest Trust, provided valuable assistance in surveys and provision of training activities related to these projects.

Activity 1.1 Characterise smallholder planted tree resource in Luang Prabang region

1.1.1 Establish partnership arrangements and negotiate access to remotely-sensed imagery

This activity included establishment of contacts with key project partners, investigation of appropriate imagery, GIS platforms and other technical parameters, gaining approvals for access to satellite imagery and for housing project personnel and equipment at the Provincial Forestry Office complex in Luang Prabang. Options for GIS platforms were investigated, including more cost-effective options for ESRI ArcGIS (not-for-profit licenses) and QGIS, a non-proprietary software.

1.1.2 Develop methodologies and ground-truth for sample of imagery

The ACIAR project was designed on the basis of the use of satellite imagery for forest mapping and made a number of assumptions about the availability and utility of satellite imagery. The primary assumption was that SPOT[1] satellite imagery that had been acquired by the Department of Forestry (DOF) would be available and suitable for the purposes of the project. Further investigation found that this was not the case. The imagery was not freely available and was too old (2005).

The suitability and availability of other remote sensing imagery was subsequently reviewed. The essential requirement of suitable imagery was that it be of a resolution that enabled consistent identification and quantification of teak crowns and canopy to provide for accurate boundary definition and delineation of stand age or size. The most suitable and cost-effective option was found to be 3-band colour digital aerial imagery, with a resolution of 0.5m pixel size, captured in 2013–2014 by the National Geographic Department (NGD) of Lao PDR. Therefore, the imagery for the Luang Prabang province was acquired.

Milestones 1.1.3–1.1.5:

1.1.3 Delineate, map and communicate extent of Luang Prabang teak resource

1.1.4 Map and communicate age class distribution of resource

1.1.5 Establish and communicate protocols for ongoing monitoring and reporting

The methodology for the three milestones above was combined to present a single report.

The mapping had two aims:

- identification and delineation of teak plantations
- delineation and estimation of plantation size class.

[1] From French: *Satellite Pour l'Observation de la Terre (SPOT)*

ESRI ARCGIS 10.1 software was used for the mapping. The images were mosaicked together in map-sheet blocks for use in the GIS. Multivariate image classification methods were tested with the imagery but were found to be unsuitable due to:

- variable colour balance
- variable appearance of the teak plantations. Presence/absence of leaves, understorey conditions, small size of plantations, tree density and tree size were the main contributors to the variation.

Manual interpretation combined with field-checking was found to be the most accurate in identifying teak and also enabled estimation of size classes. Manual interpretation combined flexible pattern recognition with knowledge of landscape and land use to improve identification of teak. Consistency was provided by regular field-checking and cross-checking between mappers. Field-checking efficiency was gained by the use of a GPS enabled digital camera; ground photos could be uploaded and viewed in the GIS for direct reference to the mapping. The sharing of these photos then enabled remote collaboration review between Lao mappers and Australian project team members as well as ongoing desktop review and monitoring.

A sample area was mapped first to determine an appropriate and achievable mapping classification. The minimum polygon size was initially set at 0.5 ha as an achievable resolution for the project timeframe and budget. After the training and initial mapping it was determined that a smaller minimum polygon size was achievable within the project constraints. This was set at 0.35 ha. A subset area was also mapped down to a polygon size of 0.16 ha (1 *rai*) to use for estimation of smaller areas of plantation of 0.16–0.35 ha.

Reliably mapping the age class, which is typically done on the basis of tree size and crown size/features, was found to be difficult due to significant variation between plantations in their tree size at the same age. Size class was determined to be a more reliable and appropriate measure of the structure of plantations, and more relevant to industry, and as result this was used as the classification for the mapping (Figure 1).

Mapping classes were subsequently designed to:

- cover the range of plantation size and structure
- be consistently identified and mapped
- provide for stratification for future volume inventory.

Mapped areas of teak were analysed with landscape variables.

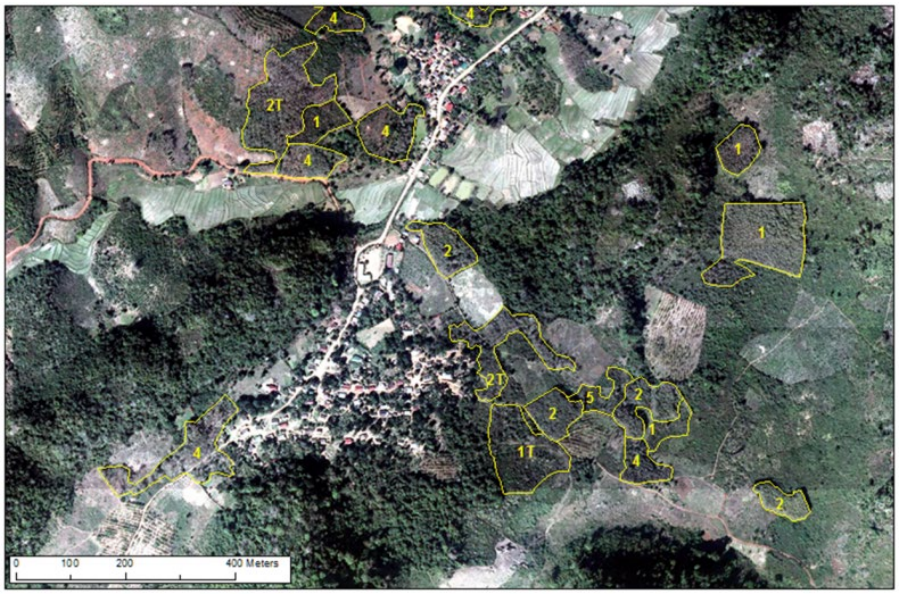


Figure 1: Example of teak area mapping.

Activity 1.2 Identify and test how barriers to legal registration of smallholder planted trees can be addressed and transaction costs in their sale and delivery can be diminished

1.2A Identify and test how barriers to legal registration of smallholder planted trees can be addressed

1.2A.1 Establish partnership arrangements with responsible agencies and related projects at national and provincial levels

Responsible agencies for forest law and plantations were identified and a network of key officials and academics involved in forest and plantation law was established and expanded over the course of the project.

1.2A.2 Publish and communicate a report outlining current and potential improved processes for legal registration of planted trees

The following approaches have been used in this study:

- A description of the governance structure and legal framework was made to establish the overarching rules operating in the value chain.
- A review of laws and legal instruments in place and operating for the main processes and products in the value chain has been undertaken. Lao and English versions of legal texts, strategies and policies were collated from a number of sources and wherever possible official English translations were used. However, the vast majority of the documents accessed were only available in Lao or as unofficial translations; where necessary additional translations were made from Lao into English.
- Maps of the legal value chain were made to:
  - visualise networks to gain an understanding of connections between actors and regulatory processes
  - demonstrate the interdependencies between actors and processes
  - identify regulatory constraints and possible solutions at different levels in the value chain. These are depicted in the value systems diagrams provided in this report.
- A literature review of research papers, technical reports and data on smallholder plantations in Lao PDR and other countries was undertaken.
- A review of the concept and drivers of legality assurance was made to verify if wood products conform to national laws.

1.2A.3 Identify acceptable improved processes and trial implementation with grower groups; adapt approach as necessary

Interviews with 227 smallholders were conducted to understand farmers' attitudes to plantation registration; 68 interviews were undertaken directly by VALTIP2 researchers, a further 159 households were surveyed in conjunction with interviews undertaken by ACIAR project FST.2012/041 on Teak Agroforestry.

1.2A.4 Publish and communicate a report outlining experience of improved approach(es) and expand scope of implementation through relevant agencies

Building on the legal mapping undertaken in Milestone 2, this study explored the policy basis for plantation registration, the incentives that have been used to encourage registration and the attitudes of plantation owners to plantation registration. In undertaking this research a central question, largely overlooked in project design, was revealed – that of plantation ownership. This is fundamental to the motivations of plantation owners with respect to plantation ownership, registration and participation in the timber value chain.

Finally, the study considered whether plantation registration in its current form is needed to meet market-based requirements for legality and explores some alternatives that are focused on the project objective of addressing constraints and inefficiencies in the value chain that limit returns to smallholder growers.

The methods utilised included:

- review of the policy and regulatory basis for plantation registration and changes in the use of plantation registration over time
- deconstruction of the regulatory process for plantation registration, drawing on the legal systems mapping reported in Smith 2014, to fully understand why plantation registration has become a bottleneck in the time value chain
- analysis of what influences farmers' compliance with plantation registration regulations.

The analysis resulted in consideration of a number of options as alternatives to plantation registration and the benefits, costs, risks and risk mitigation measures for smallholders, the government and industry. Proposals for alternative institutional arrangements for the formalisation of timber from teak plantations were developed and presented to the Department of Forestry. There is ongoing consideration of these options as DOF works to review the Decree on Plantation Registration and Promotion (Decree No 96/PM 2003) and revise associated regulations. Project team members continue to participate in this review process.

Contacts have been established with several key stakeholders including consumer countries.

1.2B Identify and test how transaction costs in the sale and delivery of smallholder planted trees can be diminished

1.2B.5 Map supply chain from forest to processer, and survey transaction and component costs at each stage

This study was focused on conducting an institutional and regulatory analysis, a mapping of the supply chain from tree to processor, and a survey of transaction and component costs along this chain.

A literature review on forestry transaction costs regimes in similar economies was undertaken. Meetings were held with growers and processors and this allowed the compilation of a first draft mapping of transaction costs and characterisation of plantation transaction costs in terms of points of incidence and magnitude. Results from the initial stage of Activity 1.2A (legality) also provided an important basis for comparing policy against actual operation and incidence of transaction costs in the field. Additional data were gathered from growers and processors as well as from relevant government agencies to improve the understanding of the transaction costs regime.

These data provided the basis for the identification of policy and regulatory constraints, the development of proposals for more efficient approaches and the discussion of these approaches with relevant authorities and with participants in the supply chain.

1.2B.6 Publish and communicate a report contextualising the issues and summarising results of this study, for discussion with government agencies and businesses comprising the supply chain

The results of the transaction costs mapping, further supplemented with case study data, were the basis of the interim project report produced at this stage. The report also included initial thoughts on mitigating the impact of plantation transaction costs, as a basis for discussion with industry and other researchers.

The report was also circulated at annual meetings and workshops and input widely sought from research colleagues and other Objective and Activity leaders.

1.2B.7 Publish and communicate a report outlining proposals for reducing transaction costs

The results of the initial research and feedback gained from the previous report, circulated as a Discussion Paper, formed a basis for preparation of the report at this stage. The methodology here involved:

- Further literature review particularly around two important themes in feedback from the initial research results – the impact of non-monetary transaction costs, including grower opportunity transaction costs, and the social / cultural context around "unofficial" transaction costs, or "facilitation payments";
- A review of previous studies on plantation transaction cost regimes in Lao PDR and similar economies. The previous review by Savathvong (2010) was a key source here;
- Obtaining translations of key government decrees concerning the imposition of official transaction costs;
- Further discussion with industry and growers to better appreciate the operation of the transaction costs regime;
- Reviewing of further case study data; and
- Further discussion with project partner organisations – the Luang Prabang Teak Program and The Forests Trust.

The report prepared at this stage included an expanded set of recommendations for legally mitigating the impact of plantation transaction costs in Lao PDR – from nine recommendations at the initial report stage, to over thirty five recommendations, addressing both monetary and non-monetary transaction costs.

1.2B.8 Trial implementation of proposal(s) in conjunction with grower group(s) and other supply chain participants

The research approach here was to field test the transaction cost mitigation recommendations developed at the previous stage. Two key research techniques were involved:

- In conjunction with Activity 1.3A (Grower Groups) to test the feasibility of the recommendations with growers. This was implemented through discussions with growers through the final Activity 1.3A action research interview round, and
- Development and administration of questionnaires with industry and growers, seeking feedback on the cost mitigation recommendations. The questionnaires were administered and feedback collated by TFT support staff.

The feedback obtained at this stage was incorporated in developing the final set of recommendations set out in the final research paper for the activity, which incorporates the results of all research stages.

Activity 1.3 Identify and test what forms of grower organisation and group certification are feasible and sustainable, and will improve returns to smallholders; and how these can be fostered

1.3A Identify and test what forms of grower organisation are feasible and sustainable, and will improve returns to smallholders, and how these can be fostered

1.3A.1 Establish partnership arrangements with responsible agencies at national, provincial and district levels, and with related projects and community-based organisations

The Action Research Team was established which included the following partner organisations: ACIAR, NUoL, LPTP and Souphanouvong University. Four communities were selected to participate in the action research, three of whom were FSC certified teak grower groups, and one which was an established rubber co-operative in Luang Namtha.

As its name suggests, action research combines action with research. Fisher (2006), describes it as:

> *A process in which a group of people with a shared issue of concern collaboratively, systematically and deliberately plan, implement and evaluate actions. Action research combines action and investigation. The investigation informs action and the researchers learn from the critical reflection on the action.*

All action research starts with identifying the problems with clients (in this case grower groups), and then proceeds to design interventions with the group aimed at resolving these problems. The effects of these interventions are evaluated to determine the extent to which the problem has been resolved, and also to learn from the results obtained before moving to the next action research cycle.

1.3A.2 Publish and communicate a report outlining rationale for, and feasible approaches to, development of grower groups; and recommending pathways for development of these groups

This report was prepared in April, 2014, based on an extensive literature review, the first two rounds of action research, and opportunities to attend meetings and workshops, interview government officials and participate in other LPTP activities. The key recommendation in the report was to encourage the grower groups, which relied on the sale of unprocessed wood, to transform themselves into groups enterprises that were capable of value adding at village level.

1.3A.3 Implement recommended approaches adaptively in trial locations

Four more cycles of action research were undertaken within the four target villages to monitor the development of the enterprises and assess their contribution to the income of teak growers. Again the learning through the research cycles was supplemented by opportunities to attend meetings and workshops, interview government officials and participate in other LPTP activities.

1.3A.4 Publish and communicate a report summarising experiences, and progressively implement successful approaches with more grower communities

The final report was prepared in accordance with the milestone. Of significance was the inclusion of new findings from studies on other grower groups within Asia, and particularly how certification had influenced the success or otherwise of these groups.

Activity 1.3B Identify and test what forms of group certification are feasible and sustainable, and will improve returns to smallholders, and how these can be fostered

1.3B.1 Establish partnership arrangements with responsible agencies at national, provincial and district levels, with LFTP and LPTP and any related initiatives / parties, and with NUoL

This milestone included planning meetings with Objective 1 team members at the NUoL Forestry faculty; action towards the engagement of research officers who will provide primary field assistance to the certification and grower group formation projects (Sub-projects 1.3A and B) and assistance on other sub-projects as required; and contact with certification bodies, FSC, private sector, auditors and government.

A structure was developed for the analysis of options for approaches to certification appropriate to the circumstances of smallholder growers in Lao PDR. Key support was also provided to the LPTP, which supports the extension of certification and plantation registration to Luang Prabang province.

1.3B.2 Publish and communicate report identifying options and pathways for cost-effective certification of teak smallholders

The report is based on the following studies:

- A review of voluntary verification and involuntary regulatory compliance systems that influence market promotion and access.
- Mechanisms that operate internationally and those that operate, or could operate, within Lao PDR.
- The feasibility of the above mechanisms in regards to the value chain for smallholder plantation growers. Feasibility was defined under three broad criteria: appropriateness, practicality, and cost effectiveness.

The overall methodology used in this study was based on a risk-based value chain analysis that allocated an assessment score from 1 (very positive) to 10 (very negative) against each of the criterion. Each of the three criteria contained sub-elements (second tier criteria) that were used to provide a guide to the appropriateness when applied to small growers in Lao PDR. This approach has allowed the authors to identify those systems that provide the potential to deliver a cost-effective verification and/or compliance system for small plantation growers in Lao PDR.

1.3B.3 Trial implementation of preferred option(s) with one or more grower groups, in conjunction with LFTP, LPTP, certifiers and any other relevant parties

ACIAR research findings have extended beyond Laos. ACIAR and LPTP hosted the project manager from Hue University of Vietnam, responsible for a PEFC Group Certification Pilot project, and the Team Leader of Natural Resources Development Foundation of the Solomon Islands, who have a FSC community group. Also, the ACIAR team with PEFC South East Asia were active in sharing the findings with stakeholders from Thailand, India, the Philippines and Vietnam who are embarking on group certification of smallholders.

During the final year of the project, through the findings of the certification project, there were multiple verification initiatives implemented in preparation for group certification including producer-based initiatives, LPTP legality verification and 3rd party non-accredited sustainability certification. ACIAR-supported research officers have been implementing the streamlined LPTP group certification approach.

The Objective 1.3B research findings have also assisted in discussions elsewhere in the Asia Pacific region on more practical and feasible verification processes for smallholders.

Objective 2: To increase returns to smallholders and processors through improved efficiencies of the wood processing sector (primary processing)

The team for Objective 2 activities was led by Dr.Henri Bailleres (DAF) and included researchers from DAF and NUoL (Faculty of Forestry [FOF] and Faculty of Architecture [FOA]), and members of the Industry Cluster.

Activity 2.1 Identify and characterise current production practices and processing efficiency in Lao companies

2.1.1 Formation of sawmilling and drying operation Industry Clusters

In conjunction with Objective 3 researchers, a network of Industry Cluster companies was established with which researchers could work on implementation of improved processing and drying operations and research. Representative enterprises from Vientiane and Luang Prabang were approached to determine if they were interested and suitable for forming part of the Industry Cluster. To be eligible, the enterprises had to meet the

selection criteria developed by the project management. A total of 11 wood processing companies were selected, consisting of seven companies within the Vientiane province and four in the Luang Prabang province (Table 1).

Table 1: Objective 2 and 3 stakeholder companies.

Previous project				
No	**Company name**	**Location**	**Objective 2 (wood processing : sawing and/or drying)**	**Objective 3 (wood products manufacturing)**
1	Khamphai Sana Wood Furniture Company	Vientiane Capital	✓	✓
2	Viengniyom Wood Furniture Company	Vientiane Capital	✓	✓
3	PKK Wood Furniture Company	Vientiane Capital		✓
4	TNK Furniture Processing Product Co Ltd	Luang Prabang	✓	✓
5	Sone Sawmill	Luang Prabang	✓	
6	Burapha Agroforestry Co., Ltd	Vientiane Capital	✓	✓
Current project				
No	**Company name**	**Location**	**Objective 2 (wood processing : sawing and/or drying)**	**Objective 3 (wood products manufacturing)**
1	Lao Furniture Industry Company (Km 21)	Vientiane Capital	✓	✓
2	Kongsa Furniture	Vientiane Capital		✓
3	Phonebouly Furniture	Vientiane Capital		✓
4	Somsakid Furniture	Vientiane Capital	✓	✓
5	Phetsamone Factory	Vientiane Capital	✓	✓
6	Pheangmoungkoun Furniture	Vientiane Capital	✓	✓
7	Phouthone Factory	Luang Prabang	✓	✓
8	Changpheng Factory	Luang Prabang	✓	✓

2.1.2–2.1.3 Detailed analysis of current production and processing practices in Lao companies

A survey questionnaire was developed. The questionnaire in conjunction with industry site, production and processing line tours enabled a detailed analysis of current practices. The analysis included information on each company's profile, infrastructure, log and timber data, green sawmilling, drying, expertise, training, safety, grading, storage and recommendations for research and improvements.

2.1.4 Workshop to present activity outputs

A workshop presenting the company survey outputs and recommendations for research was presented to industry representatives, ACIAR and the project team at the project annual general meeting (AGM) in October 2013.

Activity 2.2 Improve or implement log grading / segregation activities at the mill prior to processing

2.2.1–2.2.2 "User-friendly" manual and recommendations on log grading and segregation rules used in sawmilling applicable to SMEs in Laos to meet optimal performance

A comprehensive literature review was prepared, relating to grading systems for small logs, with an emphasis on plantation teak. Grading rules from the United States, Australia, Burma, Sri Lanka, the South East Asia Lumber Producers Association (SEALPA), Indonesia, Malaysia and the Philippines were collated and analysed. An assessment of current native forest and company in-house grading rules were also analysed. Based on the literature review, round and square plantation log grading rules were proposed.

2.2.3 Implementation of grading rules by members of Industry Clusters and possibly other companies

Log grading rules were trialled at three Industry Cluster companies. Two workshops on log grading, one at NUoL in Vientiane and the other in Luang Prabang, were conducted for industry company representatives. During monitoring and evaluation surveys, companies were asked if they were implementing the proposed grading rules.

Activity 2.3 Conduct studies to optimise and improve sawing operations and recovery

2.3.1 "Use-friendly" manual on best practice sawing operations and recovery improvements used in sawing applicable to SMEs in Laos

The best practice sawing operations manual was developed based on surveys and research into the sawing efficiency across a range of Lao PDR processing facilities using plantation teak logs. Experts from DAF and NUoL recorded their observations in five different sawmills during recovery studies. The manual covers OHS laws, the log yard, blade handling, sawing equipment, housekeeping, maintenance, sawing methods and mensuration for quality control.

2.3.2 Documented realisation of sawing operations and recovery improvements and proposed potential hardware modifications

This activity determined green-off-saw (GOS) recoveries in five sawmills in Lao PDR, as a benchmark study, providing recommendations to improve sawn efficiency and worker safety. Recovery studies were conducted in three Luang Prabang sawmills and two Vientiane sawmills. Equipment varied from circular bench saws to both vertical and horizontal bandsaws. All trials were conducted using plantation-grown teak ranging in age from 10 to 20 years old. The trials included classical recovery of sawn boards from natural round logs as well as recovery rates for squares (square billets) from round logs and sawn board recovery from square billets. The inclusion of square billets in these data collections was important due to the prominence of mills who purchase square billets in the Lao teak sector. Recovery studies included measurements of log dimensions, bend factor, ovality ratio and taper.

A sawing jig was trialled at Phouthone sawmill in Luang Prabang to test its potential to reduce sawn thickness variation and improve recovery for bandsawing small plantation logs. The sliding jig cradles the logs in a rigid manner for the initial cut on the bandsaw blade (Figure 2).

Figure 2: Sawing jig being tested at Phouthone sawmill.

2.3.3 Implementation of sawing operations by members of Industry Clusters and possible other companies

The best practice sawing operations manual developed in Activity 2.3.2 listed, for each company, a number of recommendations to improve sawing efficiency and OHS. During subsequent monitoring and evaluation surveys, companies were asked if they were implementing the recommended sawing practices.

Activity 2.4 Develop and/or improve drying operations to reduce degrade and costs

2.4.1–2.4.3 Documented drying improvements and advice to Industry Cluster companies on how to improve drying best practices including cost-effective upgrades to current drying equipment

These activities were achieved through a series of kiln drying auditing trials at four selected sawmills; two located in Luang Prabang and two in Vientiane province. Equipment varied from large commercial-scale conventional style kilns with air, temperature and humidity control to converted “container style” wood-fired kilns with little to no control of drying conditions. The trials included, where possible, measurements of the kiln conditions during drying trials (temperature, humidity and airflow) (Figure 3a) and dried quality after drying. Dried quality was determined by quantifying the distribution of final average moisture content, moisture content gradient, board distortion, end-splitting, surface cracking and residual drying stress (Figure 3b). For one sawmill, staff were trained in the correct loading of kilns to maximise drying efficiency and quality. For each company a number of recommended improvements were reported and disseminated. Follow-up drying studies were conducted to quantify any improvements compared with the benchmark drying studies.

(a) (b)

Figure 3: NUoL researchers measuring (a) kiln airflow and (b) board distortion as part of company drying trials.

For some companies, physical adjustments and additions to equipment were made and for all companies cost-effective methods to improve drying operations were proposed.

2.4.4 "User-friendly" manual on best practice drying operations used in drying facilities in Laos

A drying best practice manual was prepared based on research into drying efficiency across a range of Lao PDR drying facilities using plantation teak and eucalypt resource. The user manual covers topics such as physics of wood and water, science of the drying process, drying during harvesting in the log yard and green milling, racking, air drying, kiln drying, quality assessment and moisture content monitoring.

Activity 2.5 Develop and/or improve product grading and implement the rules in the Industry Cluster companies

2.5.1 "User-friendly" manual on product grading rules applicable to SMEs in Laos

To develop proposed dried product grading rules for Lao PDR a review of international standard and non-standard rules was conducted. As the Australian and New Zealand Standard (AS/NZS 2769.3:1999) was already being used by some companies in Lao PDR, it formed the basis for the proposed grading rules. A few adjustments were made to take into account the short component lengths used in Lao PDR. The rules were written in the Lao language and disseminated to the Industry Cluster companies.

2.5.2 Documented recommended standardised grading, product and product waste segregation systems

The recommended standardised product grading component of this activity was moved into the best practice manual of Activity 2.5.1.

For the sawmilling waste component of this activity, a review of the different types of sawmills and primary processing waste by-products were reviewed and identified. The types of waste utilisation were categorised into three main areas: current form, fuel and reformed fibre. Within each category the different uses for primary processing sawmill waste were identified. A sawmill waste management strategy was proposed.

2.5.3 Implementation of grading rules by members of Industry Clusters and possibly other companies

The product grading sawmilling waste utilisation recommendations were sent to the Industry Cluster companies (the reports were translated to the Lao language). A workshop was held at NUoL to allow a practical hands-on introduction to product grading using the proposed standard. During subsequent monitoring and evaluation surveys, companies were asked if they were implementing the recommended product grading and waste utilisation practices.

Activity 2.6 Provide impartial and independent advice and demonstration of appropriate primary processing equipment suited to Lao industry

2.6.1 Report on findings for optimal processing equipment and potential product streams gathered from LIGNA exhibition, Germany 2013

Through the activity team's knowledge of processing small plantation logs in SE Asia and Pacific countries, and identification of potential product streams from the LIGNA exhibition, processing equipment appropriate to Lao industry was identified. This led to the recommendation to build a semi-industrial scale veneer peeling system at NUoL and review portable and relocatable sawmills.

2.6.2 Report on findings for optimal processing equipment and potential product streams gathered from woodworking machinery and furniture manufacturing exhibition, China 2014

Attendance to this exhibition was cancelled under a revised strategy to purchase, install equipment and run peeling trials at NUoL – see Activity 2.7. During the lathe purchase in China in September 2014, a visit to the wood processing equipment company Raute was conducted. Raute is newly established in China and is internationally recognised as a producer of high-quality equipment.

Note: Activities 2.6.3–2.6.5 were reduced to relocate project resources to focus on installation, commissioning and conducting research trials and training using the veneer lathe installed at NUoL – Activity 2.7.

2.6.3 Documented review of successful small log sawmilling and veneering operations in developed countries and their applicability to the Lao industry

A literature review of portable and relocatable sawmills, including recommendations for Lao PDR, was conducted.

2.6.4 Demonstration of optimally identified process and product solutions to Lao delegates in Vietnam

Two NUoL delegates attended the ACIAR FST/2008/039 project final review workshop in Hanoi in June 2016. The title of the project was "Enhancement of production of acacia and eucalypt peeled and sliced veneer products in Vietnam and Australia".

2.6.5 Laos workshop detailing range of recommended processing equipment and layout options

Selected NUoL staff and industry delegates were trained in veneer processing, sawing, drying, adhesion, project management and lean manufacturing techniques at the Salisbury Research Facility in Brisbane, Australia February 2015 and at three workshops held at NUoL in 2015 and 2016.

2.6.6 Final manual on wood processing methods recommended for Lao timber industry

The log grading, sawmilling, drying, product grading and waste utilisation manuals were combined to form a final manual that was translated into the Lao language and disseminated to industry.

Activity 2.7 Introduction of veneer peeling technology to Laos

2.7.1 Procurement of lathe to undertake research at NUoL

NUoL and DAF staff visited the BSY Plywood and Woodworking Machinery company in China (after a company shortlist process) to inspect the veneer processing equipment factory and select the appropriate equipment for the veneer processing facility within the given budget.

2.7.2 Install and commission lathe

The veneer processing infrastructure was improved to accommodate the machinery. This included cleaning the site, laying down an extra 15 cm of reinforced concrete and supplying 3-phase power and associated safety switches. The equipment installation and commissioning was completed by BSY technical staff.

2.7.3 Perform initial trials and train staff

From 1 to 11 November 2015 DAF staff conducted veneer peeling training for NUoL researchers, Laos industry representatives and Vietnamese Academy of Forestry Sciences researchers.

2.7.4 Perform trials to investigate the recovery, grade quality and potential utilisation of peeled plantation eucalypt and teak

Three plantation species were chosen for the peeling trials based on the availability of material: teak (*Tectona grandis*), K7 hybrid (*Eucalyptus camaldulensis* × *Eucalyptus deglupta*) and brown salwood (*Acacia mangium*). Details of each species including average log diameter, number of logs peeled, resulting number of veneer sheets and analysis type (green recovery and grade quality) are provided in Table 2. Green recovery was determined for each species. Veneer grade quality was analysed for plantation teak material only. The age of teak logs was 15 years; the ages of the other species was unknown.

Table 2: Trial feedstock details.

Species	Average diameter (cm)	Number of logs	Number of veneer sheets	Green recovery	Veneer grade quality
Teak	15.8	15	119	☑	☑
K7 hybrid	14.2	5	41	☑	☒
Brown salwood	14.7	9	84	☑	☒

For each log the small and large end diameter was measured and log volume calculated.

To soften the logs prior to peeling, all logs of each species were pre-treated using saturated steam at 70°C for at least 24 hours using the NUoL wood drying kiln.

Billets were de-barked and rounded using the rounding machine and the diameter of the peeler log was measured. Billets were peeled to produce veneers with a target green thickness of 2.8 mm until a core diameter of approximately 40 mm was attained (Figure 4a). During peeling a guillotine was used to clip 130 cm × 65 cm (width) veneer sheets (Figure 4b). Sometimes the initial sheet was discarded due to severe thickness variation and internal sheets were discarded due to peeling stoppages. The length of each sheet was measured in order to calculate recovery figures.

(a) **(b)**

Figure 4: (a) Peeling rounded billet and (b) resulting veneer on the conveyer to the clipper.

The thickness of veneers was measured at three discrete locations and the green off-saw recovery was calculated. Veneers were dried outdoors positioned vertically in racks, until the moisture content of the sheets was 16%. Teak veneer was graded using the Vietnamese Standard TCVN 10316:2014. The standard includes five face veneer grades, 1 to 5, where 1 is the highest quality and 5 the lowest. Two core veneers are included, where 1 is the highest and 2 the lowest. The standard grade criteria include sound knots, unsound knots, holes, splits, bark/gum pockets, insect attack, discoloration, grain tearout, pin knots, scratches, knife marks and decay.

Objective 3: To improve the value and quality of wood products for domestic and export markets (secondary processing)

The team for Objective 3 activities was led by Prof. Barbara Ozarska (UoM) and included researchers from UoM and NUoL (FOF and FOA), teachers from Pakpasak Technical College and members of the Industry Cluster.

Activity 3.1 Determine typical current recovery and productivity levels in Lao manufacturing facilities and identify and recommend improved efficiencies in-company and through cooperative cluster scenarios

3.1.1 Formation of cooperative clusters of manufacturing companies willing to improve the value and quality of their products

The first task within Objective 3 was the establishment of a network of Industry Cluster companies with which researchers could work on implementation of improved production methods and the project research findings. This task was combined with Task 2.1.1 from Objective 2. The most important requirement for potential members of the Industry Cluster was that they were required to use plantation timber or confirm their intention to reduce reliance on native species by substituting with plantation-grown timber in the future.

Two Industry Clusters (consisting of 13 manufacturing companies) were formed (see Table 3, Activity 2.1.1):

- Cluster 1 consisted of five companies involved in the previous ACIAR project FST/2005/100.
- Cluster 2 consisted of eight “new” companies producing furniture and flooring.

3.1.2 Detailed analysis of the current wood recovery rate in the production of high-value wood products

3.1.3 Detailed analysis of the current productivity levels in Lao manufacturing facilities

A template in the form of a questionnaire for the assessment of manufacturing capabilities was developed by the members of the team prior to the assessment visits. The

questionnaire identified and listed important data and information to be collected during the visits.

Each company in the Industry Cluster was visited by Lao and Australian team members. The observations and notes made during the visits were used as the basis for writing a detailed report on each individual company that was assessed. Twelve reports were written by Lao researchers in English and then revised by the team leader. The reports were translated into the Lao language and submitted to the companies.

3.1.4 Recommendations for improving efficiencies in-company and through cooperative cluster scenarios

3.1.5 Workshop to present the activity outputs

The company assessments were used as the basis for preparing a summary report and recommendations for improving overall industry capability. The report was widely circulated to industry and government and presented at a workshop held at the Annual meeting in 2013. The workshop involved the members of the Industry Cluster, all participants of the project and relevant government and industry representatives.

3.1.6 Yearly review of progress made by the companies on improving production efficiency and recovery rate

The Objective 3 team worked closely with the Industry Cluster companies during the four years of the project term to ensure that improvements in their processing and manufacturing processes were made and the research outcomes implemented according to each company's capabilities.

Each company was considered on an individual basis according to its needs, current capabilities, financial constraints and future strategic plans. It was recognised that a critical factor in achieving successful outcomes of the implementation was building a relationship with each company based on trust, openness and confidence.

Frequent follow-up visits to each company involved in the Industry Cluster were made by the VALTIP2 teams (Figure 5). During the visits researchers checked whether any of the recommended improvements had been implemented by the company, discussing any problems and obstacles which prevented the implementation, providing advice and in-house training on various aspects of production, machinery, and OHS. Advice on further improvements was also provided.

Figure 5: Implementation visits to furniture companies by Objective 3 team.

Activity 3.2 Determine the most appropriate practices and equipment for furniture and joinery machining, bonding and finishing

3.2.1 Laboratory testing of glue-bond strength for plantation species

3.2.2 Laboratory testing to assess the performance of various types of glues and joints in various conditions

A comparative study was performed to assess the shear strength mechanical property in compression loading of glued joints made with 15- to 20-year-old plantation-grown teak and eucalypt (*E. camaldulensis*) at NUoL Wood Technology Laboratory (Figure 6). Four different types of nonstructural adhesives commonly used in high-value appearance wood in indoor applications were assessed: cross-linking polyvinyl acetate (PVA) emulsion, PVA emulsion, polyurethane and epoxy. Joints were conditioned to different exposure conditions in accordance with ASTM D5751. Additional factors such as wood properties, timber preparation and adhesive application were considered.

Results were then compiled and evaluated against shear strength and wood failure requirements for laminated joints of teak and eucalypt determined according to a method defined in ASTM standard D5751. The shear strength of the test specimens was expressed as a percentage of the average shear strength of the wood species at 12% moisture content.

Figure 6: Glue application on wood specimens and sample preparation.

3.2.3 Guidance on optimal gluing methods and types of adhesives for various products and service conditions for Lao plantation timbers

The results of the above studies were used as the basis for developing guidance on optimal gluing methods and types of adhesives for Lao plantation timbers. Recommendations were incorporated into the “Manual of furniture manufacturing processes for Lao industry”.

3.2.4–3.2.6 Specifications were developed, based on the compilation of technical literature on:

- optimal machining parameters, tools and machining methods
- joining methods for various types of components and products to maximise wood recovery and strength of products
- most appropriate finishing methods and finishes for various products and service conditions.

The specifications were included in research reports and incorporated as chapters in the “Manual of furniture manufacturing processes for Lao industry”.

3.2.7 Detailed plan for wood waste reduction and waste utilisation

Wood recovery studies in manufacturing processes were carried out at nine companies. They provided data on wood recovery rates, the amount of waste and recommendations for waste reduction and utilisation. Four individual reports translated into the Lao language

have been handed to Industry Cluster companies in June 2016 as part of the wood recovery activity.

The recovery rate (%) was determined by collecting data on input and output (volume or weight) on each machining operation from the original dry sawn timber to the final wood component as it is going into the dimensional change. Each and every machine or station within the manufacturing process was assessed and provided its own specific recovery rate. The data was analysed and an action plan containing recommendations was provided to each company. After implementation of the recommendations, recovery was re-assessed and compared with previous results to measure improvement.

3.2.8 Recommendations for GOL, industry associations and stakeholders on major improvements and investment required to implement value-added manufacturing processes

Based on the outcomes of the industry assessment (Activity 3.1) the recommendations were developed and distributed to the relevant stakeholders.

3.2.9 Presentation of the activity outputs to project partners and stakeholders at the workshop

Based on the study results, recommendations were developed for the GOL, industry associations and stakeholders on major improvements and investment required to implement value-added manufacturing processes, such as investment in equipment and new technologies, production management and training and skills development.

Outputs of the activities were presented during an Annual Project Meeting. Training on wood gluing, finishing. machining and wood recovery were conducted for VALTIP2 researchers and industry members.

Activity 3.3 Improve quality of wood products and product design

This activity is closely related to Activities 2.1–2.6 and 3.1–3.2 as the final quality of a wood product is dependent on the quality control at each stage of processing and manufacturing.

3.3.1 "User-friendly" manual on quality control methods used in wood processing and manufacturing applicable to SMEs in Laos

Simple "user-friendly" quality control procedures for various stages of wood manufacturing were developed to assist industry with quality control in manufacturing.

3.3.2 Guidance on quality requirements for various types of wood products for various markets

The review of international standards and specifications related to furniture and furniture production at SMEs was completed and the results presented in a report. The aim of the report was to collate international standards, methods and specifications related to furniture production methods, quality control and requirements for furniture materials, components and final products.

3.3.3 Proposal for national testing facilities for assessment of product quality and performance, incorporating testing methods and testing equipment

A proposal to the MOIC was written with recommendations to establish The Furniture Testing Laboratory in Laos. The laboratory would help companies to assess the quality of their products and understand what improvements need to be made to meet international quality criteria and requirements for various products.

3.3.4 Recommendation on strategies for improving product design to meet market requirements in the medium and long term

3.3.5 Implementation of designs by members of Industry Clusters

A Furniture Design Competition was initiated with the aim of encouraging Lao designers to develop innovative furniture designs that could provide opportunities for Lao wood manufacturers to better compete in international furniture markets. The competition included two categories of designers: professional designers and students.

One of the criteria for the competition entry was that the design should reflect the Lao style (design style, culture, tradition) and the main material used should be one of the plantation timbers included in the ACIAR project: teak or eucalypt (*E. camaldulensis*). The jury consisted of experts from NUoL (FOA and FOF), Lao Furniture Association, UoM and Pakpasak Technical College). Three winners from each category were selected and provided with certificates and financial awards. The first-place winners of each category were awarded an intensive furniture design training course in Australia. The details are provided in Section 7 “Key results and discussion”.

3.3.6 Development of the “Manual on wood manufacturing methods recommended for Lao wood manufacturing industry”

3.3.7 Publishing the final manual which will combine wood processing and wood manufacturing methods recommended for Lao industry

The “Manual on wood manufacturing methods recommended for Lao wood manufacturing industry” was completed. The manual consists of 195 pages and is to be published by De Gruyter Publisher, Germany.

The manual on wood processing was completed by the Objective 2 team.

Objective 4: To enhance the competitiveness and capacity of wood processing industries

As the main aim of this objective was capacity building, it involved all project team members from the partner organisations. Activity 4.1. was led by Dr Benoit Belleville (UoM) and Activities 4.2 and 4.3 by Assoc. Prof. Latsamy Boupha (NUoL).

Activity 4.1. Develop an industry-led value-added timber market strategy

4.1.1 Report on market analysis that will comprise market information on selected wood products

A comprehensive market research report was completed with the aim of providing information required for the development of an industry-led value-added timber market strategy to enhance the competitiveness and capacity of wood processing industries in Lao PDR. This document was developed by compiling numerous market studies and reports realised by international and governmental agencies. A comprehensive analysis of international markets was undertaken to provide an overview of markets and market trends for selected wood products such as furniture, flooring and veneered products.

4.1.2 Report on market trends including consumption, production and trade of the selected products

Much of the material used for this report derived from another ACIAR technical report which was done as part of the Pacific Agribusiness Research for Development Initiative (PARDI) funded by ACIAR.

The study relied upon a review of available published and “grey” literature such as market analyses through subscription, project reports from producing and importing countries and unpublished data. Trade data was extracted from several sources: the databases of the Global Trade Atlas (GTA), the Indian Directorate General of Commercial Intelligence and Statistics (DGCIS), the Customs Departments of China, Vietnam and Thailand and the Department of Import and Export within the Ministry of Finance of the Lao PDR.

4.1.3 Workshop involving stakeholders and government representatives to brainstorm the findings and gather views on strategic directions

A workshop involving stakeholders and government representatives was held in Vientiane on 20 May 2014, with the aim of presenting and discussing the findings of the report on the market analysis.

4.1.4 Formation of industry-led small groups to develop market strategy

A group led by the Dept. of Industry and Handicraft has been formed in May 2015.

4.1.5–4.1.7 Development of market strategy for Lao value-added timber industry

Development of government and industry-led marketing plan for Lao plantation timber products was a high priority for the MOIC at the time of project establishment and through the first half of the project. However, MOIC withdrew its interest in developing a market strategy for Lao industry although the Research Program Manager (RPM) and project team made significant efforts to activate this task without success. Therefore, a decision was made by RPM and the project management during the mid-term review to discontinue this activity.

Activity 4.2 Develop short-term and long-term training programs

4.2.1 Assessment of current training programs for smallholder groups and timber industry, and identifying gaps according to the industry strategic directions

The NUoL team collected and summarised data and information on training programs for timber industry and smallholder groups. A detailed report was written in the Lao language while an executive summary was prepared in English for the Australian partners.

Current training program assessment was conducted through questionnaires, interviews and discussions with internal and external partners, Industry Clusters, teak farmers, training facilitators, industry associations, the Lao National Chamber of Commerce and the Industry and Pakpasak Technical College.

4.2.2 Workshop to discuss the findings and possible solutions

A workshop was held as part of the 2013 Annual Project Meeting. A subsequent workshop involving relevant Lao Ministries and educational institutions was held in 2016.

4.2.3 Development of training modules and training materials

Training material was developed for different training modules, mainly in the Lao language.

4.2.4 Workshop with key stakeholders and government to discuss the implementation plan

The workshop was held on 26 September 2013 at the FOF, NUoL to discuss the implementation plan. The workshop was attended by 16 people representing the Department of Industry and Commerce, National Chamber of Commerce and Industry, Lao Furniture Association, Lao Wood Industry Processing Association, Pakpasak Technical College, SUFORD, WWF, GFTN, Department of Wood Technology and Forest Economics (NUoL) and VALTIP2 team.

4.2.5 Implementation of project training programs

In total 83 training courses and workshops were conducted for smallholders, timber industry and NUoL researchers.

Activity 4.3 Enhance educational and research capabilities

4.3.1 Assessment of current teaching programs with gaps and needs for changes and improvements identified

A review of teaching programs at the FOF, NUoL was undertaken under the leadership of Assoc. Prof. Latsamy Boupha.

4.3.2 Review of current research facilities

A review of the current research facilities at NUoL was undertaken to identify what equipment was required for conducting research activities within VALTIP2 and future projects.

4.3.3 Strategy for enhancing teaching and research capabilities for Laos wood value chain

A workshop was held in February 2016 at FOF to discuss strategies for enhancing teaching and research capabilities. The workshop involved the Academics Committee and included heads and deputies from four departments and nine divisions. The meeting allowed for discussion of the implementation plan of education and training programs.

4.3.4 Workshop with project partners and stakeholders

The NUoL and other stakeholders Education Planning Committee met in July 2016 to discuss the NUoL teaching program and training for industry.

6 Achievements against activities and outputs/milestones

Note: Reports are referred to in the table below (Table 3) have been listed in Section 10.2

Objective 1: To address inefficiencies in the value chain (harvest to sawmill stages) that limit returns to smallholder growers

	Activity	Outputs/ milestones	Completion date	Comments
1.1	Characterise smallholder planted tree resource in Luang Prabang region	1. Establish partnership arrangements and negotiate access to remotely-sensed imagery.	31-12-12	Suitable current imagery has been identified through NGD and a request has been made through NUoL for free access as GOL in-kind contribution. A reduced price was negotiated.
		2. Develop methodologies and ground-truth for sample of imagery.	31-12-13	A Lao GIS assistant has been recruited and training completed, allowing finalisation of project methodologies, including ground-truthing.
		3. Delineate, map and communicate extent of Luang Prabang teak resource.	30-06-16	Results for the Milestones 3–5 have been presented in the final report: Report 1.
		4. Map and communicate age class distribution of resource.	30-09-16	
		5. Establish and communicate protocols for ongoing monitoring and reporting.	30-03-16	

1.2	A. Identify and test how barriers to legal registration of smallholder planted trees can be addressed	A. 1. Establish partnership arrangements with responsible agencies and related projects at national and provincial levels.	31-12-12	Early research into the legal framework identified numerous responsible agencies and appropriate counterparts.
		2. Publish and communicate a report outlining current and potential improved processes for legal registration of planted trees.	30-09-14	Comprehensive overview of the legal framework for plantations and timber processing was issued and a summary presented at a meeting of the Project Contact Group (Report 2). A policy brief summarising key findings has been provided in English and Lao (Report 3).
		3. Identify acceptable improved processes and trial implementation with grower groups; adapt approach as necessary.	30-06-16	A review of plantation regulations within DOF was conducted. 68 households were interviewed about plantation registration.
		4. Publish and communicate a report outlining experience of improved approach(es), and expand scope of implementation through relevant agencies.	30-09-16	Final report on analysis of interviews and options written (Report 6). Policy brief and notification on alternatives to plantation registration written and provided to DOF (Reports 4 & 5).
	B. Identify and test how transaction costs in the sale and delivery of smallholder planted trees can be diminished?	B 5. Map supply chain from forest to processor, and survey transaction and component costs at each stage.	30-06-13	An initial mapping was issued for discussion in May 2013 and a revised draft issued in late 2013, presenting transaction costs and points of incidence along the value chain.
		6. Publish and communicate a report contextualising the issues and summarising results of this study, for discussion with government agencies and businesses comprising the supply chain	31-12-13	Results have been incorporated in the Report 7. However limited discussion with industry and government restricted to interactions with participants at project meetings and government/industry forum in Oct 13.
		7. Publish and communicate report outlining proposals for reducing transaction costs.	31-12-14	Report 7 – which includes almost 40 possible actions/recommendations for growers, industry, government and others for legally mitigating impacts of transaction costs. Summary paper in English and Lao was written (Report 8). Report findings presented and discussed at Annual Meeting 2015.
		8. Trial implementation of proposal(s) in conjunction with grower group(s) and other supply chain participants.	31-08-16	Implementation of recommendations trialled through grower and industry interviews. Recommendations in Final report (Report 9) incorporate feedback from those trials.

1.3	Identify and test what forms of: (A) grower organisation and (B) group certification are feasible and sustainable, and will improve returns to smallholders; and explore how can they be fostered	A. 1. Establish partnership arrangements with responsible agencies at national, provincial and district levels, and with related projects and CBOs.	31-12-12	Partners undertaking the action research are National University of Laos (Vientiane), Souphauvong University (Luang Prabang), and LPTP. Visits made to potential partner companies (e.g. Burapha, Oji Paper).
		2. Publish and communicate a report outlining rationale for, and feasible approaches to, development of growers groups; and recommending pathways for development of these groups.	31-12-13	Report was completed in both English and Lao language (Report 12). The findings were presented at the "Consultancy Workshop for the future planning of LPTP" on 20 December 2014 in Vientiane.
		3. Implement recommended approaches adaptively in trial locations.	30-09-14	Four farmer group enterprises (FGEs) were established and trained of which two (Kok Ngiu and Xienglom) have invested in processing equipment. Six rounds of action research for Growers groups were conducted (Reports 10, 11, 13–16).
		4. Publish and communicate a report summarising experiences, and progressively implement successful approaches with more grower communities.	30-9-16	A report summarising experiences of the entire action research process has been completed (Report 17), and a paper was presented at the Teak Agroforestry Workshop in Luang Prabang in November 2016 (FST/2012/041).
		B. 5. Establish partnership arrangements with responsible agencies at national, provincial and district levels, with LFTP and LPTP and any related initiatives / parties, and with NUoL.	31-12-12	Partners actively undertaking the action research were NUoL, LFTP, Burapha, Luang Prabang Sawmill Cluster and LPTP. 2 ACIAR funded research assistants were appointed to LPTP. FSC Group COC Handbook for consultation of sawmills was prepared by the team (Report 19).
		6. Publish and communicate report identifying options and pathways for cost-effective certification of teak smallholders.	31-12-14	An initial report (Report 18) was disseminated in Dec 2014, updated in 2015 (Report 20) incorporating results of further stakeholder input and other agreed activities. Report on verification mechanisms for smallholder plantations in Vietnam was written (Report 21).
		7. Trial implementation of preferred option(s) with one or more growers groups, in conjunction with LFTP, LPTP, certifiers and any other relevant parties.	30-09-14	Trials were conducted and changes implemented within project time and resource constraints.

		8. Publish and communicate report summarising experiences, and progressively implement successful approaches with more grower communities. 9. Work with DOF, NUoL, LPTP and other relevant parties to develop and communicate proposed Code of Forest Practice appropriate to smallholder teak.	30-10-16 31-12-14	Final report completed (Report 22). As flagged at the September 2014 mid-term review meeting, there has been little progress in advancing CoFP development by responsible agencies in Laos. Discussions indicated in-principle interest remains in government and industry towards development of a national standard, although leadership remains an issue.

Objective 2: To increase returns to smallholders and processors through improved efficiencies of the wood processing sector (primary processing)

.	Activity	Outputs/ milestones	Completion date	Comments
2.1	Identify and characterise current production practices and processing efficiency in Lao companies	1. Formation of sawmilling and drying operation clusters.	30-07-12	Ten companies were selected for the Industry Cluster according to the Selection Criteria developed within this project (Report 23).
		2. Detailed analysis of current production practices in Lao companies.	30-01-13	Milestones 2 & 3: All companies were visited and their production practices & processing efficiencies were assessed and English report written. Lao PDR report completed (Reports 24 & 25).
		3. Detailed analysis of current processing efficiencies in Lao companies.	30-01-13	
		4. Workshop to present activity outputs.	30-03-13	Combined workshops for Obj. 2 & Obj. 3 were held in conjunction with the Annual Meeting in October 2013
2.2	Improve or implement log grading / segregation activities at the mill prior to processing	1. "User-friendly" manual on log grading and segregation rules used in sawmilling applicable to SMEs in Laos.	30-06-14	Literature review and in-mill log grading data gathering completed May 2014, English report completed and submitted with the annual report. Revised final version includes diagrams and updated criteria based on testing the rules and ministerial workshop (Report 26). Lao translation completed May 2015.
		2. Recommendation on strategies for improving log grading and segregation to meet optimal performance.	30-06-14	Included in the User Manual (Report 33a).
		3. Implementation of grading rules by members of Industry Clusters and possibly other companies.	31-12-15	A one-page rule sheet in Lao language has been developed and sent to Industry Clusters. NUoL staff has conducted in-mill training and adoption of the testing phase of the grading rules at selected companies.
2.3	Conduct studies to optimise and improve sawing operations and recovery	1. "User-friendly" manual on best practice sawing operations used in sawmilling applicable to SMEs in Laos.	28-8-15	Manual was developed (Report 28).
		2. Documented realisation of sawing operations and recovery improvements and proposed potential hardware modifications.	30-07-15	Six companies used for this analysis. (Report 29).
		3. Implementation of sawing operations by members of Industry Clusters and possibly other companies.	28-08-15	NUoL staff has conducted implementation of improved sawing operations at two factories and the results were provided in Report 29.

2.4	Develop and/or improve drying operations to reduce degrade and costs	1. Documented advice to Cluster companies on how to improve drying best practices.	20-02-16	Four companies used for this analysis (Report 30a).
		2. Documented improvements to drying operations and drying schedules for plantation species to improve dried quality and reduce costs.	20-02-16	Recommended improvements to drying operations provided in Report 30a.
		3. Documented advice on cost-effective upgrades to current drying equipment.	320-02-16	Advice provided in Report 30a. Lao language translation completed.
		4. "User-friendly" manual on best practice drying operations used in drying facilities in Laos.	30-08-16	Manual completed (Reports 30b and 33a).
2.5	Develop and/or improve product grading rules systems and implement the rules in the Industry Cluster companies	1. "User-friendly" manual on product grading rules applicable to SMEs in Laos.	30-09-15	A set of grading rules in the form of a manual has been developed (Report 31). Lao language translation completed.
		2. Documented recommended standardised grading, product and product waste segregation systems.	20-03-16	Recommended standardised product grading provided in the Report 31. A separate sawmill waste utilisation manual has been completed (Report 32). Lao language translation completed.
		3. Implementation of grading rules by members of Industry Clusters and possibly other companies.	30-09-16	Training for industry provided. Impact assessment survey completed to assess implementation.

2.6	Provide impartial and independent advice and demonstration of appropriate primary processing equipment suited to Lao industry	1. Report on findings for optimal processing equipment and potential product streams gathered from LIGNA exhibition, Germany 2013.	30-10-14	Through the activity team's knowledge of processing small plantation logs in SE Asia and Pacific countries, and by identifying potential product streams from the LIGNA exhibition; veneer processing and easily relocatable sawmills were identified as potential new processing streams relevant to the current Lao PDR wood processing climate. Review on portable sawmilling options available globally including recommendations for Laos completed (Report 27) and translated into Lao language.
		2. Report on findings for optimal processing equipment and potential product streams gathered from woodworking machinery and furniture manufacturing exhibition, China 2014.	30-10-14	Attendance to this exhibition was cancelled under a revised strategy to purchase, install equipment and run peeling trials at NUoL – see new Activity 2.7. During lathe purchase in China in September 2014, a visit to the wood processing equipment company Raute was conducted. Raute are newly established in China and are internationally recognised as a producer of high-quality equipment.
		3. Documented review of successful small log sawmilling and veneering operations in developed countries and their applicability to the Lao industry.	30-06-15	Review of portable sawmilling options completed and translated into Lao language (Report 27).
		4. Demonstration of optimally identified process and product solutions to Lao delegates in Vietnam.	30-10-15	Activities 2.6 has been partly used to focus on installation, commissioning and conducting preliminary research trials and training using the veneer lathe installed at NUoL. Selected NUoL staff and industry delegates were trained in veneer processing, sawing drying, adhesion, project management and lean manufacturing techniques at the Salisbury Research Facility in Brisbane, Australia in February 2015.
		5. Laos workshop detailing range of recommended processing equipment and layout options.	30-10-16	
		6. Final "Manual on wood processing methods recommended for Lao timber industry".	30-12-16	Final manual has been completed (Report 33a).

2.7	Introduction of veneer peeling technology to Laos	1. Procurement of lathe to undertake research at NUoL.	30-02-15	BSY company lathe, purchased and delivered.
		2. Install and commission lathe.	30-05-15	
		3. Perform initial trials and train staff.	30-05-15	Veneer processing theory training completed in Brisbane between 16-27 February 2015 and during lathe commissioning at NUoL between 25–29 May 2015. From 1–11 November 2015 DAF staff conducted veneer peeling training for NUoL researchers, Lao industry representatives and Vietnamese Academy of Forestry Sciences researchers. Lao team members can now run trials on theirown. Peeling trials using planation eucalypt, acacia and teak have been conducted. Recovery and quality data has been collected and reported in Report 33b.
		4. Perform trials to investigate the recovery, grade quality and potential utilisation of peeled plantation eucalypt and teak.	30-09-16	Report 33b. *Remark:* Part of the allocated time devoted to procure, install and perform relevant peeling trials was taken from other activities in Objective 2.

Objective 3: To improve the value and quality of wood products for domestic and export markets (secondary processing)

3.1	Determine typical current recovery and productivity levels in Lao manufacturing facilities and identify and recommend improved efficiencies in-company and through cooperative cluster scenarios	1. Formation of two Manufacturing Clusters.	30-07-12	Two Manufacturing Clusters were formed: Cluster 1 – four companies involved in the previous project, Cluster 2 – eight "new" companies.
		2. Detailed analysis of the current wood recovery rate in production of high-value wood products. a) Cluster 1 b) Cluster 2	30-01-13 30-06-13	*Milestones 2 & 3:* All companies were visited and their current recovery and productivity levels were assessed. A report on each company visited was written and discussed with company's managers. (Reports 34 & 35).
		3. Detailed analysis of the current productivity levels in Lao manufacturing facilities. a) Cluster 1 b) Cluster 2	30-01-13 30-06-13	
		4. Recommendations for improving efficiencies in-company and through cooperative cluster scenarios.	30-07-13	Report 36: a summary on the assessment of the Lao PDR furniture companies with recommendations for improvements.
		5. Workshop to present the activity outputs.	30-07-13	Results were presented at the Annual Workshop in October 2013 and Advisory Committee Meeting jointly with the Objective 2 results.
		6. Yearly review of progress made by the companies on improving production efficiency and recovery rate.	30-05-2014,2015, 2016	Implementation and assessment visits to the Cluster companies were conducted (approximately on 3-monthly basis). A template for the assessment/implementation visits was developed for Lao PDR researchers (Report 57). Four individual reports translated in Lao language have been handed to Industry Cluster companies in June 2016 as part of the wood recovery activity.

3.2	Determine the most appropriate practices and equipment for furniture and joinery machining, bonding and finishing: 1. Laminating and finger jointing technologies 2. Improving quality of wood products through introducing optimal machining, joining and coating methods 3. Investigating various uses of wood waste and off-cuts	1. Laboratory testing of glue-bond strength for plantation species (report). 2. Laboratory testing to assess the performance of various types of glues and joints in various conditions (report). 3. Guidance on optimal gluing methods and types of adhesives for various products and service conditions for Lao plantation timbers. 4. Specification on optimal machining parameters, tools and machining methods. 5. Specification on joining methods for various types of components and products to maximise wood recovery and strength of products. 6. Specification on most appropriate finishing methods and finishes for various products and service conditions. 7. Detailed plan for wood waste reduction and waste utilisation. 8. Recommendations for GOL, industry associations and stakeholders on major improvements and investment required to implement value-added manufacturing processes. 9. Presentation of the activity outputs to project partners and stakeholders at the workshop. 10. Training of Lao researchers and training instructors on the sub-activities 1–7.	30-04-15 30-06-16 30-12-13 30-12-14 30-12-13 31-12-15 30-03-14 30-06-15 30-09-15	Laboratory testing of four types of glues for teak and eucalypt for combined Milestones 1 & 2 has been completed and documented (Reports 40, 41 & 52). Executive Summary was translated into Lao language. Results of gluing testing have been presented at two international conferences: the 2015 ISCHP in Canada; and the 2016 World Wood Day Symposium, Kathmandu, Nepal. Training for industry was conducted in June 2016. The guidance on gluing and joining methods was written and included as chapters in the “Manual on furniture manufacturing” (Report 58). Report 38 and training on wood machining. Reports 37 & 54 on joining methods and a chapter in the “Manual on furniture manufacturing” (Report 58). Report 39 and a chapter of the manual (Report 58). Wood recovery studies were carried out in nine companies and reports written: Report 43: methodology for wood recovery studies. Reports 42 & 51: recommendations on recovery reduction and waste utilisation were written. Workshop on wood recovery study conducted. Based on the outcomes of the industry assessment the recommendations have been developed and distributed to stakeholders (Reports 53, 56 & 36). Workshop on wood recovery study was held in the last week of June 2015 and on gluing in July 2015. Training on gluing, machining and finishing was provided to Lao researchers and industry members.

3.3	Improving quality of wood products and product design	1. "User-friendly" manual on quality control methods used in wood processing and manufacturing applicable to SMEs in Laos.	30-10-14	Seven simple "checklists" were developed for Obj. 3 quality control methods (Reports 44–50).
		2. Guidance on quality requirements for various types of wood products for various markets.	30-10-14	Report written which compiles international standards and specifications for various materials and final products (Report 53).
		3. Proposal for national testing facilities for assessment of products quality and performance, incorporating testing methods and testing equipment.	30-10-14	Report 56. The proposal was submitted to Lao MOIC.
		4. Recommendation on strategies for improving product design to meet market requirements in the medium and long term.	30-11-15	Three training courses on furniture design were provided by Fac. of Architecture, NUoL, to researchers and industry members. Design Competition was developed & completed in October 2015. Training on green design was arranged for the winners at RMIT, School of Design, Melbourne, on 16–20 November 2015.
		5. Implementation of designs by members of Industry Clusters.	30-12-15	Prototypes of the best designs were made by furniture companies for implementation.
		6. Development of the "Manual on wood manufacturing methods recommended for Lao wood manufacturing industry".	30-06-16	Manual has been completed and will be published (Report 58).
		7. Publishing the final manual which will combine wood processing and wood manufacturing methods recommended for Lao industry.	30-11-16	Manuals on wood processing and manufacturing methods have been completed (Reports 33a & 58).

Objective 4: To enhance the competitiveness and capacity of wood processing industries

	Activity	Outputs/ milestones	Completion date	Comments
4.1	Developing an industry-led value-added timber market strategy	1. Report on market analysis which will comprise market information on selected wood products.	30-01-14	Milestones 1 & 2: comprehensive report has been written and distributed to stakeholders and government representatives (Report 61). In addition, report on global markets for plantation teak was written (Report 63).
		2. Report on market trends including consumption, production and trade of the selected products.	30-01-14	
		3. Workshop involving stakeholders and government representatives to brainstorm the findings and gather views on strategic directions.	20-05-14	Workshop was conducted in Vientiane on 20 May 2014.
		4. Formation of industry-led small groups to develop market strategy.	30-09-14	A group led by the Dept. of Industry and Handicraft has been formed in May 2015.
		5. Analysis of Lao market situation and product research.	30-06-15	Milestone 5–7: The milestones did not continue as MOIC finally withdrew its interest in developing market strategy for Lao industry. Decision was made by ACIAR RPM and the project management during the mid-term review to discontinue this activity.
		6. Identification of target markets for Lao timber industry based on the results of “3Cs” analysis.	30-10-15	
		7. Activity report or book “market strategy for Lao value-added timber industry”. Presentation to the project stakeholders at the workshop.	30-03-16	

4.2	Developing short-term and long-term training programs	1. Assessment of current training programs for smallholder groups and timber industry, and identifying gaps according to the industry strategic directions. 2. Workshop to discuss the findings and possible solutions. 3. Development of training modules and training materials. 4. Workshop with key stakeholders and government to discuss the implementation plan. 5. Implementation of training programs.	31-12-12 30-10-13 30-12-2016 20-02-16 30-06-16	Report 59 (written by FOF team). Results were presented at Annual Workshop in Oct. 2013. Training materials were developed for each training course conducted. Workshop was conducted in Vientiane in February 2016. In total 83 training courses and workshops were conducted for smallholders, timber industry and NUoL researchers.
4.3	Enhancing educational and research capabilities	1. Assessment of current teaching programs with gaps and needs for changes and improvements identified. 2. Review of current research facilities. 3. Strategy for enhancing teaching and research capabilities for Lao wood value chain. 4. Workshop with project partners and stakeholders.	Sub-activities 1-3: 31-12-14 31-12-14	Milestones 1–3: Assessment of current teaching programs at NUoL was undertaken. Gaps and needs for changes and improvements were identified. Report 60. NUoL and other stakeholders planning committee met in July 2016 to discuss the NUoL teaching program and training for industry.

7 Key results and discussion

An overview and a discussion of the key results of the project are provided below and the summary of results/outputs for each objective and activity is presented in Table 8.

Objective 1: To address inefficiencies in the value chain (harvest to sawmill stages) that limit returns to smallholder growers

Activity 1.1 Characterise smallholder planted tree resource in Luang Prabang region

The mapping of smallholder planted tree resources in Luang Prabang region provided a more accurate estimate of the extent and stand structure of smallholder teak. The total area of teak plantation mapped in Luang Prabang province, with polygons larger than 0.35 ha in size, was 15,342 ha (Figure 7). Earlier estimates ranged as high as 50,000 ha. The work also highlighted the complexity of defining and identifying small plantings within the patchwork of a diverse rural landscape.

In summary:

- A total of 11,699 polygons were mapped.
- The median polygon size was 0.92 ha. Median polygon size is driven largely by splitting teak plantations into size classes.
- Median plantation/patch size was 0.98 ha. A plantation unit or patch is informative of the geographical size of contiguous plantation areas.
- The maximum plantation unit size was 157.5 ha.
- The total number of plantation units was 7,418.

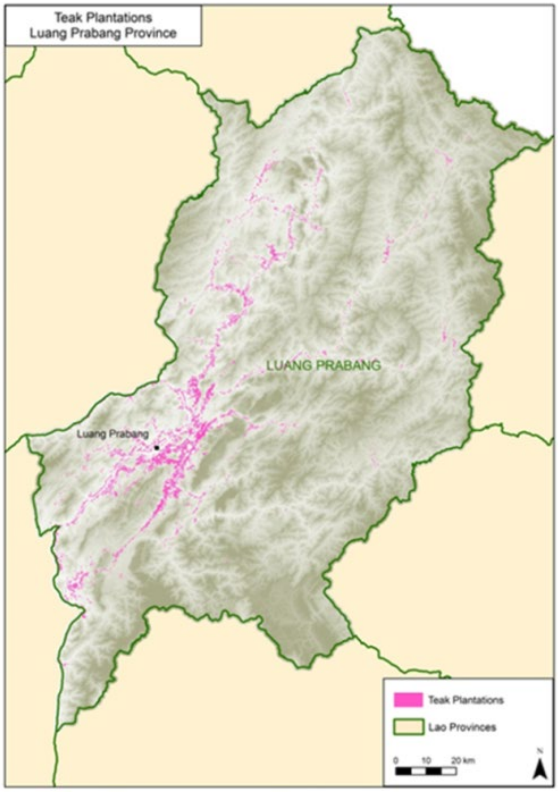
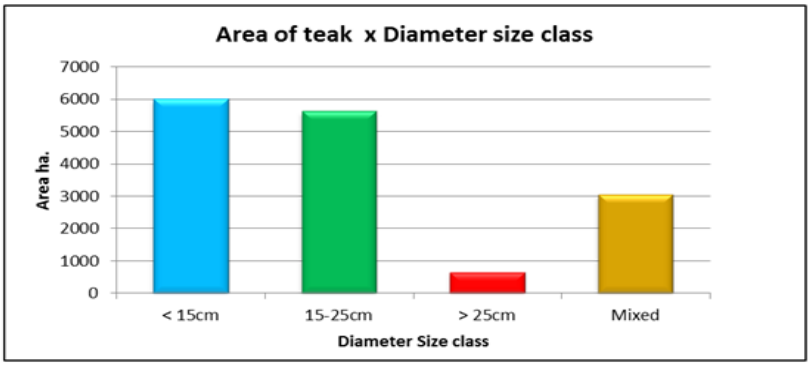


Figure 7: Teak plantations in Luang Prabang province.

The plantations were found to be predominantly of small tree size; 39% of the area was dominated by trees <15 cm dbh (diameter at breast height) in classes 1 and 1T; and more than 75% <25 cm dbh (Classes 1, 1T, 2, 2T and Part 4, 5, 6). Only around 4% was found to be >25 cm dbh (Classes 3 and 3T) (Table 4 and Figure 8).

Table 4 and Figure 8 (below): Diameter size classes for teak in Luang Prabang region.

Teak Map Class	DBH Size Class	Description	Area (ha)	Area %
1	< 15cm	Small, fully stocked	4881	32%
1T	< 15cm	Small, partially stocked	1123	7%
2	15-25cm	Intermediate, fully stocked	4377	29%
2T	15-25cm	Intermediate, partially stocked	1255	8%
3	> 25cm	Large, fully stocked	372	2%
3T	> 25cm	Large, partially stocked	275	2%
4	Mixed	Mixed size	1555	10%
5	Mixed	Partial plantation	1184	8%
6	Mixed	Possible plantation	320	2%
Total			**15342**	**100%**



The distribution of teak clearly follows the road network and proximity to roads is also a measure of accessibility and indicative of harvest and haulage cost. The analysis showed that 83% of the mapped plantation area was less than 1 km from a road, and that accessibility of most plantations is good (Figure 9).

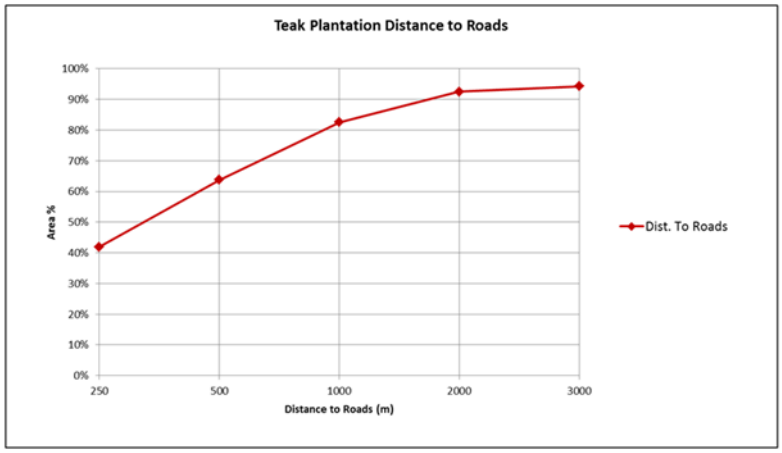


Figure 9: Proximity of teak to roads.

Proximity of teak plantations to rivers and major streams was also included in the assessment because these have previously provided a means of access for plantation establishment and the transportation of logs after harvesting. The results showed that 80% are within 2 km of a river or major stream, and that 90% are within 3 km (Figure 10).

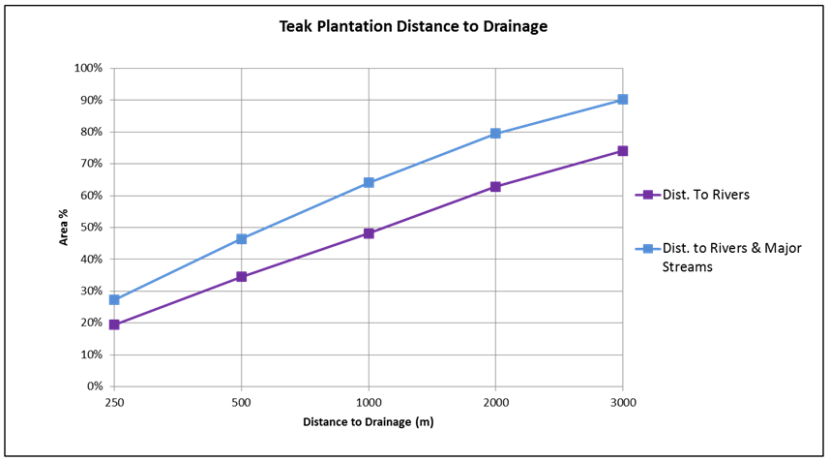


Figure 10: Proximity of teak to drainage.

Activity 1.2 Identify and test how barriers to legal registration of smallholder planted trees can be addressed and transaction costs in their sale and delivery can be diminished

1.2A Identify and test how barriers to legal registration of smallholder planted trees can be addressed

The regulatory environment for the plantation value chain is extensive and complex, with many steps and costs to produce, transport, process and export legal timber. This reduces returns to smallholders and industry, and also reduces the incentive to grow and process plantation wood. Many of the rules that apply to the plantation value chain have been transferred from laws designed to reduce unsustainable or illegal harvesting of natural forests. They are therefore more restrictive than rules need to be for plantations and plantation-grown wood.

The key findings of this study are summarised below:

- Farmer-owned and community-based plantation enterprises, capable of harvesting and processing local plantation-grown wood such as teak, have the potential to contribute to national policy objectives by generating rural employment, boosting farm income and suppling timber to the processing sector. However, they are currently uncompetitive due to policy barriers associated with perceived risk around processing of timber illegally harvested from natural forests, unnecessarily complex regulatory procedures and high transaction costs.
- Plantation registration was hypothesised to be a barrier to smallholder participation in the legal value chain for plantation-grown wood. Analysis found that processes for plantation registration have been complicated by multiple perceptions of the purpose of registration; for some, plantation registration has become a substitute land titling process, for others it is needed merely to demonstrate source of origin for legal wood sales. For the former, a consequence is that the cost and administrative procedures for registration have become prohibitive for farmers. For the latter, procedures to register plantations may be seen as not strictly legal. Recommendations for policy review and clarification of the purpose of plantation registration were made.
- Systems mapping of the regulations along the entire teak value chain and analysis of the transaction costs revealed a complex operating environment. Research found that streamlining and simplifying regulations and reducing transaction costs would likely increase smallholder returns and improve the competitiveness of plantation enterprises through increased value chain efficiency. These procedures also need to address national and provincial regulatory and revenue requirements.

- Research into farmer attitudes to plantation registration and into the effectiveness of grower groups revealed that there is diversity in plantation ownership arrangements that were not recognised in FST/2010/012. As a result, the supply of this wood to industry is unpredictable. Better understanding of the ownership arrangements and the management intent of owners could facilitate resource availability and a consistent flow of wood to processors.
- The role and legal status of timber traders and brokers ("middlemen"), who play an important role in consolidating consignments of wood and connecting growers with markets, was not included within the project and are not well understood.
- With some capacity building, local level institutions such as village forestry units, may be able to more effectively undertake the regulatory approvals needed to enable a more simple and cost-effective means for farmers to legally harvest and sell their timber.

1.2B Identify and test how transaction costs in the sale and delivery of smallholder planted trees can be diminished

Thirty-five recommendations for legally mitigating the impacts of plantation transaction costs were developed. The recommendations are grouped around the key participants – growers, industry and government and others, chiefly certification bodies. The recommendations are also organised into four key themes:

1. Addressing existing inefficiencies and complexity within the smallholder plantation transaction cost regime in Lao PDR.
2. Accessing existing opportunities for transaction cost reduction.
3. Opportunities for cost reduction through better awareness and coordination
4. Cost reduction opportunities through improved arrangements between growers and industry.

The recommendations cover both monetary and non-monetary transaction costs.

Some key recommendations include:

- Addressing regulatory complexity and unwarranted inconsistency in application of regulations pertaining to transaction costs.
- Addressing administrative overlaps and inefficiencies.
- Simplified regulatory processes for smallholder plantations, perhaps including a measure of accredited self-performance.
- Enhanced implementation of anti-corruption laws to address the demand for illegal facilitation payments.
- Accessing cost relief already allowed under existing regulations, and seeking additional relief in accordance with provisions in current laws.
- Accessing land tax relief through plantation registration.
- Education, training and facilitation (perhaps through enhancement and extension of the LPTP model) to improve knowledge of and consistency in the application of regulations pertaining to transaction costs.
- Formation of cooperative and integrated structures along the value chain to reduce the number of interfaces at which transaction costs arise, while being aware of the efficiency limits of integration.
- Potential efficiencies through new technologies, especially to assist in market discovery.

- Introducing a level of self-performance of administrative functions associated with timber harvest and sale;
- Introducing simpler pathways for smallholder timber plantations;
- Pursuance of group certification.
- Development of certification standards that are realistically achievable within the capabilities of smallholder growers and unsophisticated industry.

Importantly, all participants along the value chain should explicitly recognise and budget for the impact of transaction costs, while government should consider the transaction cost implications of new policy settings.

Activity 1.3 Identify and test what forms of grower organisation and group certification are feasible and sustainable, and will improve returns to smallholders; and how these can be fostered

1.3A Identify and test what forms of grower organisation are feasible and sustainable, and will improve returns to smallholders, and how these can be fostered

The research found that there were differing expectations between growers and the Luang Prabang Teak Program (LPTP) about forming groups. LPTP wanted growers to collectively market their timber as FSC certified on a regular basis, while growers joined the group to gain a plantation certificate which provided them with legal recognition and land tax exemption. Compared to agricultural crops, teak is unsuited to group formation since growers sell as needed, often in response to household shocks, rather than on a seasonal basis with other farmers. Certification did not provide a sufficient price premium, particularly for small logs, to motivate risk adverse smallholders to sell their timber regularly. Therefore there was no incentive for growers to remain active in the group once their plantation certificate had been received, and they continued to sell on an individual basis. Under these circumstances, this form of grower group is neither feasible nor sustainable.

In response, the action research team recommended the introduction of an enterprise (or value-adding) unit under the umbrella of the existing group, to take on the role of buying, harvesting and processing timber within the value chain and improve returns to growers (Figure 11). Several members from two of the groups decided to invest their own funds to set up such enterprises, and since their establishment in 2014, both enterprises had confidently invested in factory site improvement and new machinery. Government support has been strong. However, there is insufficient evidence at this stage to suggest that ordinary group members have improved their returns as a result of the local enterprises, since the majority have chosen not to become shareholders: the cost of entry is high and it is difficult for the enterprise to provide financial transparency. Improved returns will likely occur in time as a result of local enterprises paying higher prices for timber, rather than through active group membership. This is because that there is clearly a viable niche market for legal (as distinct from certified) quality teak furniture produced by local enterprises in Luang Prabang, which provides social and economic benefits.

Figure 11: Members of Ban Kok Ngiu grower group during the action research.

Activity 1.3B Identify and test what forms of group certification are feasible and sustainable, and will improve returns to smallholders, and how these can be fostered

Voluntary certification systems have failed to deliver cost-effective market benefits to smallholders. They are complex and do not add value.

Current certification systems apply a similar risk profile and compliance cost structure to smallholder plantation growers and large, industrial growers. Few smaller, private growers are able to adopt these systems, and those that do so in Laos generally receive no improved market access or price premium.

External support has been provided for certification; however, low take up by small, farmer-scale plantations indicates that verification or compliance requirements are too complex and costly to adopt. Where certification has been adopted, the expected increases in returns to plantation owners have not occurred. Where certification has been implemented it has been reliant on external funding from international donors. These funding arrangements need to be put on a more sustainable basis.

Complex and inflexible measures are used by multiple, different certification systems to assess sustainability. Certification systems must simplify their requirements and demonstrate value to smallholders if they are to increase the involvement of small-scale growers in markets for sustainably managed timber.

Recommendations for certification bodies:

- Undertake a broad risk assessment of small, individually owned plantations.
- Review requirements for smallholder plantation growers to better reflect the risks for these growers.
- Allow for flexible approaches to verification that are appropriate to farmer-owned plantations. Options include self-assessment of pre-harvest, harvest and post-harvest activities by farmers, Village Forestry Units or grower groups.
- Consider partnerships whereby companies can include smallholders in their certification or supply chains.
- Clearly communicate the process and costs of certification and provide realistic information about the likely benefits.
- Develop more efficient and cost-effective approaches to timber plantation certification for smallholders.

- Assess the potential benefits of a national certification scheme, or other national systems and approaches to legality; ensuring consistency with the ASEAN Consultative Committee on Standards and Quality.

Objective 2: To increase returns to smallholders and processors through improved efficiencies of the wood processing sector (primary processing)

Activity 2.1 Identify and characterise current production practices and processing efficiency in Lao companies

Stakeholder companies were selected from the Vientiane and Luang Prabang areas of Laos so the survey results could provide an overview of the sawmilling and furniture manufacturing industry in the country. The selected companies specialise in sawmilling, solid wood processing, the production of furniture or a combination of these. A list of company stakeholders that covers both Objectives 1 and 2, indicating companies that were involved in the previous ACIAR Laos project and new companies taking part in this project, has been provided in Table 1, Section 5.

The results of the company surveys related to primary processing operations provided the following recommendations to improve current standards and profitability:

- Improve infrastructure, particularly where live electrical wiring and termite damage exists.
- Segregate wood species in the log yard.
- Round and square logs should be graded to suit the desired end product.
- Methods to minimise log end-splitting should be investigated.
- Sawing recovery should be investigated to quantify a current baseline.
- Investigate better sawmill layout.
- Drying operation and recovery studies should be conducted to provide a current baseline.
- Drying needs to be improved at all sites carrying out drying operations. Particularly, kiln drying best practice, kiln control and moisture content monitoring.
- Training is required in processing, machinery operation, drying, grading, OHS and waste management.
- Machine maintenance schedules should be implemented.
- Dried product should be graded before secondary processing and product manufacture.

Activity 2.2 Improve or implement log grading / segregation activities at the mill prior to processing

Round and square plantation log grading rules, specific to Lao PDR, were developed after a review of the literature and assessment of current practices and log qualities during factory visits in Lao PDR. The rules build on a current system used by Burapha company, by adding quality parameters relevant to the target end products (furniture, door and window joinery, flooring and decking). The grading criteria and rules, although heavily influenced by current grading rules used by Burapha company, include some additions from the Lao PDR government grading rules.

The grading rules document includes the measurement techniques required for each grade criteria for both round and square logs. The grade criterion consists of the following assessments: heartwood proportion, bend, pipe, knots and knot holes, end splits, end

checks, decay, insect attack, want and presence of metal objects. A two-page document summarising the grading rules was produced for both round and square logs. This provides a useful training tool for industry. One page contains the grade criteria limits and the other diagrams of how to measure each criterion (Figure 12).

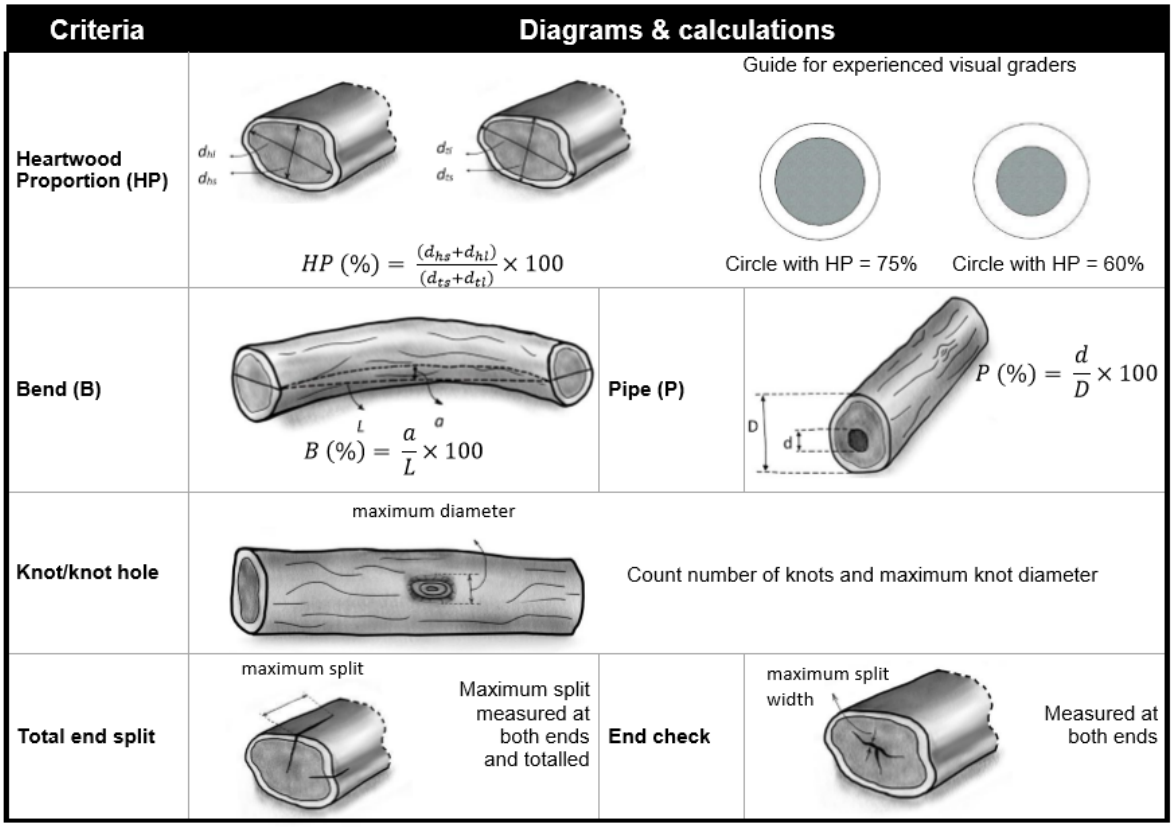


Figure 12: Example of grade measurement summary age for round logs.

Activity 2.3 Conduct studies to optimise and improve sawing operations and recovery

The Green Off Saw recovery results for each sawmill are provided in Table 5. The saw type, log type and log age are also provided. The lowest recovery was 26% correlating with the smallest logs (Changpheng, mean diameter 177 mm). Sone Sawmill produced a higher recovery of 35% which is typical for small hardwood logs. This sawmill is not experienced in producing sawn boards because they normally only produce square section billets.

Table 5: Green-off-saw recovery results.

Facility	Saw type	Input type	Age (years)	GOS recovery (%)
Changpheng Factory	circular	round	15	**26**
Sone Sawmill	circular	round	15	**35**
Phouthone/Pongwan (1)	bandsaw	round	20	**44**
Phouthone/Pongwan (2)	bandsaw plus jig	round	20	**46**
Kongsa	tablesaw	square	unknown	**68**
PKK	bandsaw	square	unknown	**75**

The two trials undertaken at Phouthone/Pongwan sawmill produced the highest proportions of recovered sawn boards for the round log trials and the 46% achieved by using the sliding log jig was an excellent result for small log processing. The logs used in the Phouthone/Pongwan trials were from plantations that were five years older than the material sawn in Changpheng and Sone trials, which may account for the higher

recoveries. This facility also utilised a thinner kerf sawing system (bandsaw) compared with the other two round log processors (circular bench saws). Thinner kerf (width of saw cut) generally equals higher recovery of sawn wood volume, assuming that the bandsaw cuts straight with no deviation. This theory is confirmed by the results of the square billet processing, where the horizontal bandsaw resulted in a recovery of 75%, compared with a result of 68% for a circular bench saw.

The recoveries achieved from the square section billets were obviously higher due to the geometrical difference of sawing rectangular boards from a rectangular prism compared with cylinders. The difference in GOS recovery results for the two populations was attributed to the significantly higher sawing deviation present in the Kongsa squares compared with PKK squares, which resulted in corresponding high levels of cross-sectional variation.

It should also be noted that between the Phouthone trials 1 and 2, the mean thickness variation of boards was reduced by approximately 40% (4.7 to 8.0%). This can be directly attributed to the use of the sawing jig which, by producing a straighter primary cut, results in lower variation in the thickness of sawn boards.

Activity 2.4 Develop and/or improve drying operations to reduce degrade and costs

The main improvements to drying operations resulting from company drying studies are listed below:

- Baseline data of current drying capacity and quality of three companies was achieved.
- Major losses in energy, time and cost were identified by not controlling airflow through timber racks using baffling. Baffling curtains force air to flow through racks making drying more efficient. Burapha company halved their drying time by using baffle curtains inside their kiln (Figure 13).
- Recommendations to kiln dry branches left after harvesting logs, intended for the Maldive resort market, has solved Burapha company's problems with degrade in this product due to insect attack.
- Phenmoungkhoune factory has improved kiln drying time from 12 to 10 days as a result of the project drying training.
- Documented advice given to companies on how to improve drying practices.
- Advice on cost-effective upgrades to current equipment was provided.

Figure 13: Kiln baffles installed at Burapha company.

Activity 2.5 Develop and/or improve product grading and implement the rules in the Industry Cluster companies

Sawn timber grading rules, specific to Lao PDR, were developed after a review of international standards. The grading rules are based on the Australian/New Zealand grading standard AS/NZS 2796.3:1999. Adjustment to the standard allows for distortion grading of short (down to 300 mm) furniture components – a necessity for the Lao PDR furniture industry. The grade criteria includes the following assessments: knots, knot holes, other holes, gum pockets and veins, injury overgrowth, splits, want and wane, decay, stain, insect attack and distortion.

The grading rules for feature and distortion are provided in a format that is intended to be printed back to back as a training tool, or singularly to hang as a poster in a sawmill grading area for reference (see example Table 6).

Table 6: Example of product grading rules for feature.

Criteria	Select	Medium Feature	High Feature
Tight knots	≤ 15 mm wide, ≤ 1/4 board width	≤ 40 mm wide, ≤ 1/3 board width	≤ 50mm wide, ≤ 1/2 board width
Loose knots and knot holes	Not permitted		Same for holes
Knot checks	Not permitted	≤ 2 mm wide	≤ 3 mm wide
Holes – borer, termites etc.	≤ 2 mm wide maximum 6 in 100 x 100 mm area maximum 12 in 300 x 300 mm area	≤ 3 mm wide maximum 20 in 100 x 100 mm area maximum 30 in 300 x 300 mm area	≤ 3 mm wide maximum 20 in 100 x 100 mm area maximum 30 in 300 x 300 mm area ≤ 10 mm wide 3 per 1m length > 10 mm not permitted
Tight gum vein	≤ 2 mm wide, ≤ 250 mm long ≤ ½ total board length (added)	≤ 60 mm wide, ≤ 1 m long ≤ 2 mm deep	≤ 2 mm deep
Loose gum vein	Not permitted	Not one surface to another ≤ 3 mm wide ≤ 1/5 total board length (added)	
Gum pocket and Over growth injury	Not permitted	Not one surface to another ≤ 10 mm wide, ≤ 50 mm long ≤ 2 mm deep	Not one surface to another ≤ 15 mm wide, ≤ 75 mm long ≤ 2 mm deep
Checks - external	≤ 1 mm wide, ≤ 250mm long (each)	≤ 2 mm wide, ≤ 250mm long (each)	≤ 2 mm wide, length unlimited
Stain - natural	Slight (up to consumer)	Unlimited	
Stain – other including sticker mark	Not permitted		
Want and wane	Exposed surface = not permitted Concealed surface ≤ 1/3 of surface width, ≤ 300 mm long		
End split, decay, termite galleries	Not permitted – splits can be removed		
Lyctus susceptible sapwood	Not permitted		

Activity 2.6 Provide impartial and independent advice and demonstration of appropriate primary processing equipment suited to Lao industry

The main result from this activity was the identification of veneer and engineered wood products and their production equipment as “best-bet” options for future processing of small plantations material in Lao PDR. This led to reallocation of human resources and securing of funds to install veneer processing equipment at NUoL to perform subsequent peeling trials.

Additionally, as requested by the project partners, a review of current portable and relocatable sawmilling technology was conducted and disseminated to industry stakeholders. The report recommended portable circular blade sawmills (rather than bandsaws) for the Lao industry as they provide advantages in ease of setting and sharpening, longer blade life, superior quality of cut and higher productivity in hardwood processing. Circular blade sawmills are capable of cutting more boards per day than a chainsaw or band sawmill taking into account log size, species and products being cut. All circular blade models appear to have good portability with either custom-built trailers or the ability to be easily loaded onto a utility or truck. Portability is a significant issue in relation to the accessibility of the teak resource.

Best practice components of Activities 2.2–2.6 resulted in a combined best practice primary processing manual including the following topics: log grading, sawmilling, drying, dried timber grading, and sawmill waste classification and uses. This document, along with a similar secondary processing best practice manual produced from Objective 3, forms a processing and production best practice compendium applicable to small plantation logs in Lao PDR.

Activity 2.7 Introduction of veneer peeling technology to Laos

A significant achievement of Objective 2 has been the purchase, installation and commissioning of a veneer peeling lathe and ancillary equipment. The state of the art veneer production equipment consists of a log rounding machine, veneer peeler and conveyer, veneer clipper and a knife sharpening machine (Figure 14). The official opening of the Veneer Processing and Production Center at NUoL was held on 11 November 2015. Australian Ambassador to Laos, H. E. John Williams, gave a speech to mark the occasion.

Figure 14: Veneer peeling facilities at NUoL.

Green peeled veneer recovery figures for teak, K7 hybrid and brown salwood are provided in Table 7. The results were similar for each species; around 80%. The green sawn recovery of sawn 15-year-old teak from the Changpheng Factory and Sone Sawmill were 26% and 35%, respectively (from Activity 2.3). The results indicate that green peeled recovery can be up to three times the recovery of sawn wood from trees of the same diameter.

Table 7: Green peeled veneer recovery results.

Species	Average diameter (cm)	Recovery (%)
Teak	15.8	**78**
K7 hybrid	14.2	**81**
Brown salwood	14.7	**83**

Grade quality of teak veneers resulted in 57% of the veneers meeting lower quality grades 4 and 5, with the remaining 43% attaining the higher quality 1 to 3 grades. Veneer quality downgrade was mainly caused by the resource features such as unsound knots, holes and sound knots, and controllable processing defects such as grain tearout and splits.

Objective 3: To improve the value and quality of wood products for domestic and export markets (secondary processing)

Activity 3.1 Determine typical current recovery and productivity levels in Lao manufacturing facilities and identify and recommend improved efficiencies in-company and through cooperative cluster scenarios

A detailed assessment of current processing and manufacturing methods, production efficiency and production infrastructure of the Industry Cluster companies was undertaken according to the methodology described in Section 5. The aim of this activity was to develop a comprehensive understanding of the current processing and manufacturing capabilities of the Lao furniture industry.

Ten general comments and recommendations were made to improve current standards and profitability, based on the weaknesses and gaps identified during the assessment:

1. It is critical to educate the industry to understand that product design is a very complex process which must take into account timber properties and processing characteristics, as well as the whole production process with its various parameters and various jointing techniques. Products must be designed for long-term performance in various environmental conditions that may occur in service.
2. It is evident that the majority of companies urgently need capital to improve their machinery. Advice is also required on the types of machines needed for various operations and on proper set up machining parameters and efficient use of the machinery.
3. Material flows through the production process should be clearly planned to minimise double handling or excessive changeover times (moving components from one work station to the next station in the sequence).
4. The companies should identify their levels of waste and work to eliminate or reduce it.
5. Gluing is one of the most important wood product manufacturing processes. The selection of adhesives for various products and applications must be well understood by the companies.
6. No safety precautions are undertaken during sanding operations in many companies. Sanding is usually done by workers sitting on the floor without using safety masks. Based on observations, the quality of sanded surfaces is rather poor and needs to be improved.
7. It is important that training is provided to the Industry Cluster companies on the performance requirements for various surface finishes, which will assist them in determining the appropriate selection of finishes for various applications.
8. Quality control procedures – generally the product development procedures do not follow any standards or specifications regarding product design, quality and performance.
9. Occupational, health and safety conditions in the majority of factories are very poor. There is very little guarding of machinery and work practices are very dangerous. The OHS measures should be coordinated with the training and management component, as well as technology aspects.

10. Companies urgently need training, in particular in the following areas:
    - timber preparation
    - product development
    - standards and specifications for products
    - furniture manufacturing techniques (machining, gluing, joining of timber, finishing techniques)
    - production management
    - occupational health and safety procedures.

The level of adoption of recommended improvements and changes varied between the various companies in Industry Cluster No. 1 and Industry Cluster No. 2. Some companies only made small improvements while others made considerable improvements across various stages of the value chain including wood processing, production efficiency, waste management and product quality. It was observed that the Industry Cluster companies that had been involved in both VALTIP projects (VALTIP1 and VALTIP2) have made better improvements in their production methods and product quality than the companies involved only in the VALTIP2 project.

The project team recognised that implementing recommendations and changes in processing and manufacturing methods is a difficult process because, in the majority of cases, capital investment is required in order to put the recommendations into practice (e.g. drying). However, it is evident from the above analysis that 69% of the companies involved in the project have already implemented some project outputs that have provided benefits or will do it in the future.

Activity 3.2 Determine the most appropriate practices and equipment for furniture and joinery machining, bonding and finishing

3.2.1 Laminating and finger jointing technologies

A comprehensive glue testing program on adhesives used for high-value appearance wood products was completed. The testing was carried out with the aim of gaining an understanding of the relationship between wood property, wood preparation, and adhesive application factors on the shear strength of glue joints of teak and river red gum eucalypt (*E. camaldulensis*).

The shear strength mechanical property in compression loading of joints made from both species was assessed using four types of nonstructural adhesive used in high-value appearance wood products such as furniture and flooring used in indoor applications: cross-linking PVA emulsion, PVA emulsion, polyurethane and epoxy. Both species performed reasonably well. Cross-linking PVA laminated river red gum provided the best shear strength results compared with all the other combinations of adhesives and species. However, PVA adhesive was the only tested adhesive to meet all the requirements for all of the exposure conditions for dry-use applications as recommended for indoor furniture. At this stage, the produced joints were not able to meet the requirements for wet-use applications (e.g. outdoor furniture).

The comparative analysis also showed that a high slope of grain in a sawn board affects the shear strength mechanical property of glued joints. Such an observation suggests that secondary processing industries aiming to produce high-quality wood products should be careful when selecting or dressing sawn boards prior to gluing. Optimisation through improved efficiencies of the primary wood processing sector could help in limiting the impact of this factor by preventing the production of boards with high slope of grain.

The number of knife marks when planing prior to gluing was also found to have a significant effect on the glued joint shear strength. The best finish surface is produced with

12 to 25 knife marks per 25.4 mm and the height of the marks, also known as chip thickness, should never be higher than 2 mm for a finished surface. The results and recommendations for optimal gluing conditions as well as surface preparation parameters and methods have been documented in a research report. A conference paper was also written which was presented at International Scientific Conference on Hardwood Processing in Quebec City, in September 2015 and the 2016 World Wood Day Symposium, Kathmandu, Nepal.

3.2.2 Improving quality of wood products through introducing optimal machining, joining and coating methods

Technical specifications were developed on optimal machining, joining and coating methods for appearance products used in indoor conditions.

Specifications on optimal machining parameters, tools and machining methods highlighted that several factors enter into any complete appraisal of the machining properties of a given wood or wood-based panel. The quality of the finished surface is recommended as the basis for evaluating machining properties. Rate of dulling of cutting tools and power consumed in cutting are also important considerations.

Guidance was developed on joining methods for various types of components and products to maximise wood recovery and strength of joints. Important factors which need to be taken into account while designing and making wooden products were discussed. Four critical factors were identified as determining the success of any given joint:

1. The stress system involved or what the joint is being asked to do mechanically.
5. The grain direction of the joined parts.
6. Dimensional change in response to moisture.
7. The surface condition of the joining parts.

Specification on wood finishing provided recommendations on coating systems and methods applicable to appearance wood products. High-quality finish is one of the major elements of the selection criteria for high-quality wood products and, as such, it increases the product marketability and eliminates the risk of complaints from the end consumers. Achieving a good quality finish on wood involves a combination of three major factors:

1. The selection of coating system.
8. The wood surface condition.
9. The finishing treatment applied to wood.

All the three factors have an equally important role in obtaining a high-quality finish and they must be considered in the overall manufacturing process.

3.2.3 Investigating various uses of wood waste and off-cuts

Wood recovery studies in manufacturing processes carried out at the Industry Cluster furniture companies have provided data on wood recovery rates, the amount of waste, and recommendations for waste reduction and utilisation. The study identified practices and value-added manufacturing technologies to increase the value recovery of small dimension, inferior quality plantation wood and facilitate early improvements from dry feed stock to marketable products. Such a study with secondary processing companies has never been done before and helped to understand productivity in Lao manufacturing facilities and assess the efficiency of every manufacturing step to rank priorities and elements requiring immediate intervention to improve capacity.

One area of interest in regard to this activity is that it allowed measuring, with a high level of precision and accuracy, how much wood was actually recovered or wasted for each individual processing step and for each assessed company. Validating this information allowed the targeting of areas requiring immediate intervention and, following

implementation of recommendations, the ability to measure precisely its impact on wood recovery. The wood recovery studies also demonstrated that the manufacturing process in many companies is under control.

Such findings suggest that significant economic and environmental benefits can be gained, notably by reducing the planing allowance and stopping the use of oversized material, which would substantially increase wood recovery and profits by doing more with less. Using less raw material will also help to reduce the number of off-cuts produced, resulting in saved storage space and time by not having to segregate and store those off-cuts for future use. Following a workshop conducted in June 2015, multiple assessment visits were conducted by the VALTIP2 team (Figure 15). The company owners, quality controllers, and workers are now aware of the impact of processing elements such as product design, production planning, quality control and equipment maintenance on wood recovery and productivity.

Figure 15: VALTIP2 researchers conducting a wood recovery study.

Activity 3.3 Improve quality of wood products and product design

3.3.1 Quality control procedures

Simple “user-friendly” quality control procedures for various stages of wood manufacturing were developed. In total, seven quality control “checklists” were developed: wood gluing, finishing (for operators and quality controllers), machining (for operators and quality controllers) and OHS machining (for machine operators and supervisors). The checklists were translated by NUoL researchers into the Lao language for distribution to the industry.

3.3.2 Improving product design skills available for Lao furniture companies

As described in Section 5, a furniture design competition was held at NUoL involving students and professional designers. In total 25 submissions were received. Training was provided to the winners from Laos and two winners of a similar competition held in Vietnam within the ACIAR project FST/2008/039 “Improving veneer products from plantations in Vietnam and Australia”. The training was supported by the Crawford Fund and the two ACIAR projects’ funds.

The following is a list of the participants who attended the furniture design training course in Melbourne:

- Souliya Saysongphet (Laos: student at National University of Laos)
- Phoutthasone Keophuvong (Laos: professional designer)
- Dang Truong Vu (Vietnam: student recently graduated in furniture design major)
- Tran Le Duy Khanh (Vietnam: professional furniture designer).

The training allowed the participants to learn about the principles of “green design” and provided them with a general knowledge in the creative design methodologies associated with the modern furniture manufacturing industry. They experimented with solid wood,

veneer and wood composites such as particleboard, medium density fibreboard and plywood (Figure 16).

Figure 16: Designers learning about the use of different materials.

Prototypes of the best designs were made by furniture companies for implementation (Figure 17).

Figure 17: Winning designs of the Furniture Design Competition.

3.3.3 Manual on furniture Manufacturing

A “Manual on furniture manufacturing” was written as the compilation of research conducted within Objective 3 of the project, with the aim of improving the value and quality of appearance wood products. The manual comprises nine chapters, which combines the knowledge of Australian and Lao wood scientists working closely with furniture companies in Laos (involved in the project as “The Industry Cluster” companies).

The manual addresses the following topics:

- Requirements for timber used in high-value appearance wood products.
- Specification on optimal machining parameters, tools and machining methods.
- Guidance on optimal gluing methods and types of adhesives for various products and service conditions for Lao plantation timbers.

- Specification on joining methods for various types of components and products to maximise wood recovery and strength of products.
- Guidance on optimal finishing methods and types of finishes for various products and service conditions for Lao plantation timbers.
- Wood waste reduction and waste utilisation.
- Quality control in wood processing and manufacturing.
- OHS requirements for furniture factories.

The manual provides, to manufacturers producing high-value wood products, "user-friendly" guidelines on product requirements, proper manufacturing procedures and methods of improving processing efficiency, product quality and worker safety.

Objective 4: To enhance the competitiveness and capacity of wood processing industries

Activity 4.1 Develop an industry-led value-added timber market strategy

A comprehensive market research report was completed, which provides market information on selected wood products such as furniture, joinery, flooring, and architectural wood products; and market trends including consumption, production and trade. The report identified that the development of plantations can be combined with opportunities to exploit technologies that have evolved for wood products to improve the performance of fast-growing species. Examples include lamination, finger jointing, heat treatment (particularly of plantation teak and rubberwood [*Hevea brasiliensis*]), the production of composite panels from wood residues and other natural fibres, new paint treatments (e.g. for acacia [*Acacia* sp.]), and reconstituted veneer products (e.g. Alpi's Alpilignum).

Opportunities associated with marketing teak products have been identified, e.g. increasing focus on quality standards, creative design, and increased awareness of energy-efficiency measures that create opportunities in the doors and windows sector.

Activity 4.2 Develop short-term and long-term training programs

The results of the assessment of current training programs for smallholder groups and the timber industry have been complied in a report that consists of the following sections:

- current training program for smallholder groups and the timber industry
- training gaps identified according to the industry strategic directions
- results of the survey from training facilitators' perspectives and Industry Clusters
- results of the survey of teak growers, which aimed to find out what new courses should be added to the current training programs
- current training program as part of short- and long-term training programs.

The assessment provided the basis for the development of training programs for growers and timber companies.

As stated in the previous sections, in total 83 training courses and workshops were conducted for smallholders, the timber industry and NUoL researchers (see the list of training courses in Appendix 1).

Activity 4.3 Enhance educational and research capabilities

This activity has resulted in significant achievements in the following areas:

- Improving scientific knowledge and technical skills of VALTIP2 researchers involved in the project through lectures, workshops, conferences and training. The training was provided both in Laos and in Australia (Brisbane and Melbourne).
- Enhancing research capabilities at NUoL through the establishment of the Veneer Processing and Production Center.
- Developing new curricula for the FOF, NUol, which includes subjects in wood processing, wood manufacturing and wood products.

Table 8: Major achievements and outputs.

Objective 1: To address inefficiencies in the value chain (harvest to sawmill stages) that limit returns to smallholder growers

No	Activity	Main achievements	Main outputs
1.1	Characterise smallholder planted tree resource in Luang Prabang region	1. Appropriate imagery was sourced and a method developed to reliably map and characterise the planted teak. 2. Provincial Forestry Section (PFS) staff trained in GIS and mapping using aerial imagery and in on-the-ground validation of mapped data. 3. Mapping of teak in Luang Prabang province was completed. Over 15,000 ha of teak plantation was mapped and characterised.	1. GIS data files of the mapped extent and characteristics of teak plantation resource. 2. Mapped extent analysed and reported.
1.2 A	Identify and test how barriers to legal registration of smallholder planted trees can be addressed	1. Laws and regulations relevant to the plantation value chain were collated and reviewed. 2. System mapping method developed and used to describe and analyse the legal and governance framework for the smallholder plantation value chain. Legal systems mapping method adopted for the mapping of timber from all sources (by Lao Pro-FLEGT). 3. 68 Farmers households interviewed about attitude to plantation registration. Data was also collected from 159 other households via ACIAR project FST/2012/041. 4. Alternative approaches to plantation registration reviewed and discussed with government.	1. Report and policy brief on legal framework. 2. Report, policy brief and draft notification made. 3. Publication on famer compliance with plantation registration written and submitted. 4. Policy brief on Objective 1.

1.2 B	Identify and test how transaction costs in the sale and delivery of smallholder planted trees can be diminished?	1. The theoretical and policy background for plantation transaction costs was reviewed, including thorough examination of the relevant literature. 2. The plantation value chain was described and the points of incidence and scale of transaction costs were indicated, with reference to primary data collected through interviews with growers, agents and the processing industry, case study data and also through a review of the scheduled fees and charges. 3. The nature of plantation transaction costs was discussed, including observations regarding "unofficial" or "facilitation" costs, including discussion of customary attitudes towards these costs. 4. An initial list of legal potential cost mitigation measures was proposed. These proposed measures that could be adopted by the principal participants in the value chain – growers themselves, industry and government. 5. The proposed cost mitigation measures were presented to a wide audience – principally through discussion at the 2015 Annual Workshop, through grower group meetings in conjunction with Project 1.3A, and through grower and industry surveys administered through The Forest Trust (TFT) on behalf of this project.	A final report that consolidates all of the stages of this objective. The final report includes 35 recommendations for legally mitigating plantation transaction costs in Lao PDR, grouped according to "actors" – growers, industry and government and others (principally certification bodies). These recommended actions are further grouped around four major themes: • Addressing legal and administrative inefficiencies and complexities; • Accessing existing opportunities for transaction cost reduction; • Opportunities for transaction cost reduction through education, training and industry facilitation; and • Opportunities through improved grower and industry arrangements. A summary paper was also produced, in Lao and English, in September 2015, setting out the project interim findings.
1.3 A	Identify and test what forms of: (A) grower organisation are feasible and sustainable, and will improve returns to smallholders; and explore how can they be fostered	1. Twenty-two grower groups established and trained in silvicultural management by ACIAR's partner, Luang Prabang Teak Program (LPTP). 2. Two grower group enterprises established and processing teak furniture for domestic markets, including the installation of a $10m^3$ kiln. 3. Six rounds of action research completed which analysed the factors leading to the feasibility and sustainability of grower groups. 4. Learning facilitated with numerous farmer to farmer exchange visits, farmer market research trips, multi-stakeholder workshops and an international visit to Vietnam.	Plantation registration certificates. Official enterprise registration certificates. Interim report with recommendations. Final report summarising experiences. Meeting minutes, trip reports.

1.3 B	Identify and test what forms of: group certification are feasible and sustainable, and will improve returns to smallholders; and explore how can they be fostered	1. Finalised analysis of global market access and voluntary verification systems with emphasis of applicability within a Lao PDR mall holder plantation context. 2. Promotion of findings and engagement with project partners to progress recommendations designed to simplify current approaches. 3. Regional dissemination of findings through incorporation and expansion within ACIAR project FST/2008/039 in Vietnam, PEFC smallholder development committee, ASEAN, FLEGT and FAO and other International events. 4. Provided technical advice to key partners and other projects to review and modify processes and approaches based on smallholder needs. 5. Activities included the preparation of concept notes; and new initiatives (inc. FAO.FLEGT) with partners in Lao and the region based on the report's findings. 6. Fostered changes in approaches by LPTP to verification, and directly supported wood sales and a study tour to Vietnam for key staff.	1. Report 20: on verification systems for smallholders in Lao PDR. 2. Poster based on the key findings. 3. Presentation and attendance at Asia-Pacific Forestry Week (APFW) and IUFRO conferences. 4. Report 22: Final report with progress to date based on the recommendations.

Objective 2: To increase returns to smallholders and processors through improved efficiencies of the wood processing sector (primary processing)

No.	Activity	Main achievements	Main outputs
2.1	Identify and characterise current production practices and processing efficiency in Lao companies	1. Sawmilling and drying operation Industry Cluster companies formed. 2. Processing efficiencies of production companies surveyed and analysed. 3. Processing efficiencies of processing companies surveyed and analysed. 4. Workshop of survey outcomes presented at the project AGM in October 2013.	Report 23. Report 24. Report 25. Survey workshop presentations.
2.2	Improve or implement log grading / segregation activities at the mill prior to processing	1. Log grading and segregation rules applicable to plantation hardwood in Lao PDR developed and disseminated. 2. Development of a log grading strategy and recommendations to meet optimal performance. 3. Industry Cluster companies received translated copy of log grading rules and at least one company using the rules.	Report 26. Report 33a.
2.3	Conduct studies to optimise and improve sawing operations and recovery	1. Development and dissemination of best practice sawing manual applicable to SMEs in Lao PDR. 2. Sawmill recovery study completed and reported, and recovery improvements realised.	Report 28. Report 29. Report 33a.
2.4	Develop and/or improve drying operations to reduce degrade and costs	1. Best practice drying manual developed specifically for Lao PDR SMEs. 2. Documented advice given to companies on how to improve drying practices. 3. Improvements to drying operations and recommended drying schedules to improve dried quality and reduce costs documented. 4. Advice on cost-effective upgrades to current equipment provided.	Report 30a. Report 30b. Report 33a.
2.5	Develop and/or improve product grading rules systems and implement the rules in the Industry Cluster companies	1. Manual on product grading rules applicable to SMEs in Lao PDR developed. 2. Recommended product grading rules provided. 3. Sawmill waste management, identification and segregation information provided to SMEs.	Report 31. Report 32. Report 33a.

2.6	Provide impartial and independent advice and demonstration of appropriate primary processing equipment suited to Lao industry	1. Review on portable sawmill options including recommendations for Lao PDR wood processors completed. 2. Veneer and engineered wood products and their production equipment identified as “best-bet” options for future processing of small plantations material in Lao PDR.	Report 27. Lathe installation. Industry consultation.
2.7	Introduction of veneer peeling technology to Laos	1. Veneer peeling lathe and ancillary equipment purchased, installed and commissioned. 2. Preliminary peeling trials conducted and staff trained. 3. Small-scale veneer recovery trials completed.	Installation and opening of veneer processing facility at NUoL. Spindleless lathe technology introduced to Laos. Training. Report 33b.

Objective 3: To improve the value and quality of wood products for domestic and export markets (secondary processing)

No.	Activity	Main achievements	Main outputs
3.1	Determine typical current recovery and productivity levels in Lao manufacturing facilities and identify and recommend improved efficiencies in-company and through cooperative cluster scenarios	1. Two Manufacturing Clusters were formed: Cluster 1 – four companies involved in the previous project, Cluster 2 – eight "new" companies. Detailed analysis of the current production methods and wood recovery rate was undertaken and documented. 2. A summary on the assessment of the Lao PDR furniture companies with recommendations for improvements of the industry capabilities has been written and distributed to all project partners, relevant government departments and industry associations. The report was completed jointly by the Lao PDR and Australian team members. 3. Implementation visits to the Cluster companies were conducted on approximately 3-monthly basis by the Lao PDR researchers. This allowed the researchers to develop skills in assessing various stages of wood manufacturing processes and product quality and provide advice to the companies on the required changes and improvements. A template for the assessment/implementation visits was developed for Lao PDR researchers' future activities.	1. Report 34 & 35: reports on individual companies assessment. 2. Report 36: a summary on the assessment of the Lao PDR furniture companies with recommendations for improvements. 3. Training provided to Lao PDR researchers on the assessment of furniture companies. Report 57: template for implementation visits.

3.2	Determine the most appropriate practices and equipment for furniture and joinery machining, bonding and finishing: 1. Laminating and finger jointing technologies 2. Improving quality of wood products through introducing optimal machining, joining and coating methods 3. Investigating various uses of wood waste and off-cuts	1. Laboratory testing of four types of glues for teak and eucalypt was conducted at NUoL laboratory. Guidance on optimal gluing methods and types of adhesives for various products and service conditions was developed for Lao PDR plantation timbers. 2. Specification developed on optimal machining parameters, tools and machining methods. 3. Specification on joining methods for various types of components and products was developed with guidance on how to maximise wood recovery and strength of products. 4. Specification on most appropriate finishing methods and finishes for high-value wood products was developed with the focus on appearance products used in indoor conditions. 5. Detailed studies on wood waste reduction and waste utilisation have been conducted and reported. Wood recovery studies in manufacturing processes were carried out in nine companies which provided data on wood recovery rates, the amount of waste and recommendations for waste reduction and utilisation. Four individual reports translated in Lao language have been handed to Industry Cluster companies in June 2016 as part of the wood recovery activity. 6. Recommendations on major improvements and investment required to implement value-added manufacturing processes were summarised and distributed to GOL, industry associations and stakeholders.	1. Reports 40, 41 & 52. Results of gluing testing have been presented at two international conferences: the 2015 ISCHP in Canada; and the 2016 World Wood Day Symposium, Kathmandu, Nepal. Training for industry on gluing. 2. Report 38 on wood machining. Training on wood machining. 3. Report 37 & 54 on joining methods. 4. Report 39 on wood finishing. 5. Report 43: methodology for wood recovery studies. Reports 42 & 51: recommendations on recovery reduction and waste utilisation were written. Workshop on wood recovery study conducted. 6. Reports 53, 56 & 36.
3.3	Improving quality of wood products and product design	1. Seven quality control “checklists” for assessing the quality of major furniture manufacturing processes were developed for the industry use. 2. International standards and specifications for various materials and final products were compiled which provides a guidance on quality requirements for various types of wood products for various markets. 3. Proposal for national testing facilities for assessment of products quality and performance, incorporating testing methods and testing equipment was developed and submitted to Lao PDR MOIC. 4. Furniture Design Competition was developed & completed. Training on green design was arranged for the winners at RMIT, School of Design, Melbourne, on 16–20 November 2015. 5. The “Manual on wood manufacturing methods recommended for Lao wood manufacturing industry” was completed. The manual is being edited for publishing by De Gruyter Publisher, Germany.	1. Reports 44–50. 2. Report 53. 3. Report 56. 4. Three training courses on furniture design for researchers and industry members. Training for the competition winners at RMIT, School of Design, Melbourne. Prototypes of the best designs were made by furniture companies for implementation. 5. Manual, 195 pages (Report 58).

Objective 4: To enhance the competitiveness and capacity of wood processing industries

No.	Activity	Main achievements	Main outputs
4.1	Developing an industry-led value-added timber market strategy	1. A comprehensive analysis of international markets was undertaken to provide an overview of markets and market trends for selected wood products such as furniture, flooring and veneered products, including consumption, production and trade of the selected products. 2. The analysis of global markets for plantation teak with implications for growers in Lao PDR was conducted. The study provides answers to important questions such as “How much teak is traded and where?”, “What are the characteristics of these markets?”, “What prices can be expected for small and large logs?” and “What makes some sources of teak commercially attractive and others struggle?” Reports were distributed to stakeholders and government representatives.	Report 61. Report 63.
4.2	Developing short-term and long-term training programs	1. Assessment of current training programs for smallholder groups and timber industry was undertaken by FOF team. 2. In total 83 training courses and workshops were conducted for smallholders, timber industry and NUoL researchers. See the list of training courses (Appendix 2).	1. Report 59. 2. Training courses conducted within VALTIP2: • Training material and certificates. • Linkages with Vietnamese researchers and kiln manufacturer. • Exposing Lao PDR sawmillers to veneer peeling. • Linkages with Australian furniture designers.

4.3	Enhancing educational and research capabilities	1. Assessment of current teaching programs at NUoL was undertaken. Gaps and needs for changes and improvements were identified. 2. Investigating various uses of wood waste and off-cuts. 3. Wood recovery studies in manufacturing processes have provided data on wood recovery rates, the amount of waste and recommendations for waste reduction and utilisation. The study identified practices and value-added manufacturing technologies to increase the value recovery of small dimension, inferior quality plantation wood and facilitate early improvements from dry feed stock to marketable products. Such study in secondary processing companies has never been done before and will help to understand productivity in Lao manufacturing facilities and assess the efficiency of every manufacturing step to rank priorities and elements requiring immediate intervention to improve capacity. One area of interest in regard to this activity is that it allowed measuring how much wood was actually recovered or wasted for each individual processing step and for each assessed company. Validating this information allowed targeting areas requiring immediate intervention and, following implementation of recommendations, being able to measure precisely its impact on wood recovery. Following a workshop conducted in June 2015 and multiple assessment visits over the last year, the company owners, quality controllers and workers are now aware of the impact of processing elements such as product design, production planning, quality control and equipment maintenance on wood recovery and productivity. 4. Training was provided to NUoL researchers on many research and industry topics, including: • wood processing and manufacturing methods and quality control, • use of laboratory equipment, drying kiln and woodworking machinery. 5. Lectures on wood drying fundamentals were provided by DAF researcher for NUoL students. 6. A half-day training course on plantation log grading, using newly developed Lao log grading rules, for NUoL students at Burapha company was conducted by DAF. 7. Training on furniture manufacturing for four researchers from NUoL was held in Melbourne, at the University of Melbourne and Furnishing Industry Training Centre, Holmesglen Institute of TAFE (2015). 8. A three-day workshop on veneer peeling was run by DAF at NUoL 9. A two-day workshop (2016) led by NUoL researchers in Luang Prabang on project developed square and round log grading rules. 10. A one-week Crawford Fund training (2016) was held by DAF researchers in Brisbane for NUoL researchers on the development of innovative engineered wood products from forest plantations and agri-fibre residues.	Report 60. Additions to NUoL curriculum. Ability to use audit industry kilns and use the lab equipment. Crawford Fund (2015 & 2016) training manuals. Visits to Australian furniture companies. Exposure to new innovative types of engineered wood products using agri-fibres and veneer. ACIAR blog on 2016 Crawford Fund training.

8 Impacts

8.1 Scientific impacts – now and in 5 years

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

Objective 1 – Inefficiencies in the value chain that limit returns to smallholder growers

- A method for mapping and characterising smallholder plantation teak was developed and implemented. As a result, the distribution and structure of the teak plantation resource in Luang Prabang province have been characterised. The study provides valuable data on area and stratification for inventory of standing volume and yield forecasting.
- Capability in forest mapping and analysis has been built in the Provincial Forest Service.
- An innovative method for mapping of the forestry laws in Lao PDR was developed. The methodology has been adopted in the EU-FLEGT Forest Legality Compendium project and Wildlife Law in Lao PDR. The project has identified a range of disincentives and impediments to greater adoption of plantation registration, including lack of information, ease of circumventing legal requirements in the timber market, lack of enforcement, and insufficient benefits to offset the cost of registration.
- A comprehensive study was completed that assessed the legal barriers to smallholder plantation owners and the associated timber value chain by describing, deconstructing and mapping the institutional and regulatory environment of the value chain for smallholder timber plantations and wood processing. Recommendations with respect to improving the efficiency and effectiveness of the regulatory process and for removing barriers to participation were made. The study examined the nature and evolution of international and transnational timber legality policies and their impacts on both the legal framework in Lao PDR and the consequences for smallholder plantation owners and the timber value chain. In particular, the implications of regimes for timber legality assurance were examined.
- A series of economic criteria for gauging the appropriateness of transaction cost regimes was also proposed, contributing to the general discussion on economic development in LDCs.
- A comprehensive research report was produced that draws together all of the project milestones. The report adds to the literature on the economics of smallholder plantations in Less Developed Countries (LDCs) and proposes economic criteria for assessing the operation of transaction cost regimes. While the primary focus was on smallholder timber plantations, the observations will also have relevance for commercial plantations and also to other sectors in LDCs.
- The science impacts of the transaction costs project arise primarily in the social sciences, by assisting in understanding the prevalence, motivations and behaviours that underpin certain kinds of informal costs that appear to be widely associated with the plantation value chain in Lao PDR. Although this question is not central to the terms of reference or the project, a number of important observations were made that will assist further research, particularly where the interest is in the factors that give rise to and perpetuate corrupt practices. The project will contribute to the body of research by providing a more recent view on the questions and perspectives particular to the plantation forestry sector.

- Through their participation in the action research process, partners from the NuOL and Souphanouvong Universities have developed research skills that will be useful in their future work. The outcomes of the action research have been incorporated into the community forestry curriculum at NUoL. Further, it is expected that the linking of family socio-economic data (Teak Agroforestry Project) and data on the participation in group activities (VALTIP2) will boost understanding by researchers and field practitioners of the motivating factors that enable teak farmers to participate in group activities.
- A value chain, risk-based, methodology for reviewing, comparing and analysing voluntary certification and involuntary regulatory compliance systems was undertaken to determine what verifiable systems are feasible for private, smallholder plantations in Lao PDR. Seven options have been suggested that would enhance the involvement of smallholders in certified supply chains in a way that delivers net benefits.
- Outputs from all Objective 1 activities were used as inputs to the ACIAR project "Improving policies for forest plantations to balance smallholder, industry and environmental needs in Lao PDR and Vietnam", which is expected to directly contribute to and influence plantation policy in both countries.

Objective 2 – improving efficiencies of the wood processing sector

- As a result of the development and testing of round and square log grading systems combined with in-mill trials, the VALTIP2 team has developed a good understanding of the log grading requirements for the Lao PDR plantation teak and eucalypt industry. Negotiations are underway with the relevant government departments to standardise these grading systems.
- Sawn timber grading rules specific to Lao PDR were developed after a review of international standards which should improve the consistency of timber quality within wood processing factories.
- The review of portable sawmilling equipment provides recommendations for optimal processing of plantation teak logs through improved technologies currently not widely used in Lao PDR.
- Scientific advice on the drying schedule for Lao species and literature provided to sawmills have assisted in growth and expansion of the companies.
- Sawn recovery studies conducted at six sawmills provides valuable baseline data for Lao companies on sawn recoveries, for square and round logs, using different equipment. A specialised "jig" was designed and produced by DAF and the NUoL team to improve the accuracy of the first flitch cut, with the intention of improving overall sawing accuracy and sawn recovery. Significant economic impacts are expected due to improved wood recovery.
- Optimal lathe settings and pre-treatment conditions for peeling plantation-grown eucalypt and acacia species and teak were developed through a series of veneer peeling trials and during commissioning of the NUoL lathe.
- NUoL staff have received training in novel techniques to produce panels from agri-fibre products, in particular sorghum residues.

- A series of wood processing best practice manuals were produced, which provides industry with the information required to improve their primary processing operations in the short- to mid-term. These manuals were combined into the final manual on wood processing, which includes the following topics: log grading, sawmilling, drying, dried timber grading, and sawmill waste classification and uses. This document, along with a similar secondary processing best practice manual produced from Objective 3, forms a processing and production best practice compendium, applicable to small plantation logs in Lao PDR.

Objective 3 – improving the value and the quality of wood products

- Research studies on glue-bond strength on various types of adhesives for appearance wood products using plantation species provide a significant scientific contribution to wood technology research. To date, limited data is available on this subject, in particular in relation to teak and eucalypt (*E. camaldulensis*). The results of the study were presented at the International Scientific Conference on Hardwood Processing in Quebec City, and at the 2016 World Wood Day Symposium, Kathmandu, Nepal.
- The analysis of wood recovery in furniture manufacturing conducted at the Lao companies provides a noteworthy contribution to science. The literature review revealed that only a limited number of studies on wood recovery in the manufacturing process have been undertaken.
- Manuals on “Wood processing” and “Furniture manufacturing” provide valuable information to scientific communities and to the timber industry, not only in Laos but also in other countries around the world. Limited published manuals or books are currently available on wood processing and manufacturing, in particular for young plantation timbers.

Objective 4 – enhancing competitiveness and capacity of wood processing industries

- More than 10 young researchers have been trained on various aspects of wood processing and secondary processing. Through research and training activities the researchers have acquired knowledge that makes them the country’s leaders in these areas. Their knowledge has already been disseminated through teaching activities at the FOF, NUoL. All researchers have been assigned to teach various subjects on wood science to undergraduate students.
- Two lecturers/researchers at NUoL were each awarded a prestigious John Allwright Scholarship to undertake PhD study at the University of Melbourne.

8.2 Capacity impacts – now and in 5 years

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

Training and experience in computer-based GIS mapping, and the imagery acquired, will enable LPTP and PAFO to undertake mapping for other forest management and land use planning requirements.

Staff within DOF have acquired skills in regulatory analysis and legal system mapping, which will aid in the ongoing review of efficiencies, barriers and complexities in the legislative environment for plantations in Lao PDR.

The legal systems mapping method has been adopted for all timber value chains in Lao PDR through Pro-FLEGT and the development of the Forestry Legality Compendium. This

compendium is being used by DOFI and is being provided to all Provincial Offices of the Forest Inspection Departments.

Three Lao scientists were actively participating in evidence-based research and will be able to use new skills in their future research activities.

Research findings on the certification of smallholders assisted in discussions elsewhere in the Asia Pacific region on more practical and feasible verification processes for smallholders.

Workshops and training courses in primary and secondary processing for Lao PDR industry personnel and NUoL researchers has resulted in increased knowledge, and implementation of knowledge, throughout the Industry Cluster. The training has included both theoretical sessions and in-mill/in-factory practical training. As a result of this training, the Khampai Sana company is now using lean manufacturing techniques to create a tidy work environment, sort stock, improve their drying practice and use stored waste off-cuts for small furniture components. It was reported by the company manager that staff now take more pride in a culture of better cleanliness, order and safety. Phenmounkhoun company has also started to implement lean manufacturing techniques as a result of the project training.

Effective methods were used to improve the efficiency of the production, product quality and safety of the factory workers. Working with each company on an individual basis allowed the development an open relationship between the company managers/owners/workers and the VALTIP2 team members, which will hopefully continue after the project completion. Experience which the companies, gained during the implementation program, allowed the companies to self-audit quality control procedures on a continual basis to underpin the development of efficient and high-quality production processes.

The installation of a veneer peeling plant at NUoL has allowed the university to undertake veneer processing research for Lao PDR companies (such as Oji) interested in investing in this technology. The plant can be 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 DAF training, NUoL researchers can now run the machinery autonomously and have created their own user manuals to be used as training tools.

Two successful applications for the Crawford Fund have provided excellent opportunities for researchers to be trained in Australia:

- Two researchers from Vietnam and Laos were involved in training held at DAF's Salisbury Research Centre in Brisbane. They gained the knowledge necessary to make engineered products from agri-fibre residues within their respective countries as well as multilaminar panels for furniture production. They benefited from the program in Australia as neither country currently has the skills or equipment to produce these products.
- Four young furniture designers from two ACIAR projects, who won the Furniture Design Competitions held in Laos and Vietnam, attended a training course "Furniture design with the focus on solid and veneered furniture products" held at the Royal Melbourne Institute of Technology (RMIT), School of Architecture and Design, Melbourne. The friendship and the networks created as a result of the training will strengthen and enrich future collaboration between the Australian institutions organising and providing the training, the trainees, and the institutions that they represent.

A very important example of capacity impact can be seen through a continual improvement of the capacity of the FOF at NUoL:

- New capacity in making wood-based fibre and particle panel materials following the acquisition of a 75-ton laboratory press and Instron internal bond and tensile strength fixtures.
- New capacity in conducting scientific research trials based on international standards and providing recommendations on optimal processing and pressing conditions following the provision of a 2-day workshop to eight researchers of the VALTIP2 team in July 2016, which will enable the participants to continue R&D projects in the future.

More than 10 young researchers have been trained on various elements related to wood processing and production management such as drying, primary and secondary processing, machining, gluing and finishing. Through research and research training activities the researchers have acquired knowledge that makes them the country's leaders in these areas. Their knowledge has already been disseminated through teaching activities at the FOF, NUoL. All researchers have been assigned to teach eight subjects on wood science and technology to undergraduate students. An intensive teaching of various subjects is a good example of the project capacity impacts. The knowledge and expertise gained by the project researchers are already being transferred to hundreds of students who will be the future experts in wood science, wood processing and wood product manufacturing, working in industry, government, research or training institutions. The researchers will also be able to pass on that knowledge via consultancy to the Lao wood processing industry.

Mr Khamtan Phonetip and Mr Phongxiong Wanneng, lecturers at NUoL and active members of VALTIP1 and VALTIP2 teams, were each awarded a prestigious John Allwright Scholarship to undertake PhD study at the University of Melbourne. The skills they will acquire during their PhD studies will be of great value not only to NUoL but also to the whole Lao forestry and timber sectors.

8.3 Community impacts – now and in 5 years

Community impacts are split between the following topics: economic, social and environmental impacts.

8.3.1 Economic impacts

The teak mapping will assist in understanding timber supply and constraints to industry development.

The recommendations from this project should assist in improving the efficiency of the smallholder plantation sector in Lao PDR and therefore improve the settings for smallholder participation. The project addressed the question of transaction costs at all key levels, from smallholder growers to government, and addressed the question of how transaction costs can be made more efficient, effective and equitable, and current disincentives to participation in the sector diminished.

Grower groups alone have little economic impact. However, grower enterprises can add value locally and increase returns to their local communities.

Significant economic benefits for sawmills are expected due to improvements in wood drying techniques. For example, introducing a kiln baffling system, and more efficient stacking of boards into Burapha company kilns has halved their cost per 20 m^3 load from US$800 to US$400 due to reduced electricity costs.

Recommendations to kiln dry branches from harvesting logs, intended for the Maldive resort market, has solved Burapha company's problems with degrade in this product due to insect attack, and resulted in a saleable product.

Khampai Sana factory management reported improved drying rates and quality from improved air flow and baffling as a result of the drying studies and training.

As a result of waste management training, the Khampai Sana factory is now utilising their large stockpile of waste off-cuts to re-saw into components for finger jointing and making blockboard furniture. This previously unutilised resource is now value added into the production stream to improve profitability.

Phengmoungkhoune factory has reduced kiln drying time from 12 to 10 days as a result of the project training.

Initial studies using a specialised sawing jig at Phouthone factory resulted in a 40% reduction in thickness variation and a 2% improvement in recovery. It is expected that, with more practice, recovery figures will be further improved.

Recommendations to Lao Furniture Company to conduct a regular maintenance and sharpening schedule enabled a reduction in thickness and width variation within and between pieces of more than 60%. Such improvement allows the company to reduce the planing allowance, which results in increased wood recovery and also improves the overall product quality by reducing potential delamination of glued products due to high dimension variation between components to be glued together.

Following a recommendation regarding the improvement of material pre-selection, Viengniyom Furniture Company has been able to increase its overall wood recovery by almost 24% over the past 12 months. In addition, the company is now using less raw material and they have also reduced off-cuts.

Various options for improvements of wood processing and manufacturing methods and quality of final products have been disseminated to the industry through training and implementation visits. Improving production efficiency, producing fewer defects and reducing waste will provide economic benefits, but it is a long process until these benefits can be measured.

8.3.2 Social impacts

It is envisaged that there will be significant social and community benefits arising from the project activities. In particular, studies of transaction costs and legality across the supply chain will offer increased transparency and market information to growers and processors. In due course, this will influence harvesting and sales intentions and negotiations about price.

The legal information collated by Objective 1.2A has been included in the Forest Legality Compendium (FLEGT-VPA). All of this information is freely available online, thus providing access to legal information for all stakeholders and increasing transparency in the legal process.

Clarification and streamlining of the process for land use rights and plantation registration may enhance security of tenure for smallholder farmers and encourage more farmers to establish plantations. A more efficient and transparent regime for transaction costs may distribute the impact of these costs amongst value chain participants in line with their capacity to pay. The development of growers' groups will improve collaboration of farmers growing teak and will enhance community cohesion.

Since the start of the project, Khampai Sana sawmill has improved their workforce gender ratio from 80 : 20 men : women to 50 : 50. Management reports better quality output and improved productivity by improving gender balance. Female employees are reportedly more reliable and have more attention to detail.

During the assessments of sawmills and furniture companies, the research teams noted a lack of workplace health and safety culture. Recommendations for increasing awareness of risk in the workplace were incorporated into Objective 2 and 3 reports to foster a safety culture.

Social advantages of training and development of skills undertaken within the project are obvious: there are many benefits in having a skilled and dedicated workforce.

8.3.3 Environmental impacts

As a general point, the Objective 1 projects, in assisting the attainment of the GOL's objective of fostering smallholder plantation development, also contribute to the GOL's social and environmental objectives of promoting more settled patterns of land use, income diversification opportunities and reduced environmental impacts through reduced shifting agriculture and, in the longer term, fostering the development of a plantation resource which should reduce pressures on native forests.

The project is introducing more efficient wood processing and manufacturing methods, decreasing wood drying degrade, and increasing utilisation of small dimension timbers and wood off-cuts for various components and products. These value-added methods will result in more efficient use of timber, which will provide both environmental and economic benefits. Examples are provided below:

- The correct use of log and dried product grading rules minimises waste through better segregation and allocation of resources to the most suitable product. For example, higher value wood is used for high-value products and lower quality wood is used in low-value components or products.
- As a result of the project waste management training, Khampai Sana factory is now using stockpiled off-cuts to reprocess into finger jointed block board furniture. This redirection of waste products into usable products reduces the impact on the environment.
- Eliminating insect attack in branch products for Burapha company has decreased environmental waste.
- Improved sawn recovery and recovery in the furniture manufacturing process minimises waste of sawn logs and potentially reduces the demand on raw material.
- The introduction of peeled veneer processing into Laos has the potential to increase wood recovery from small plantation logs, reducing the amount of sawn waste residues.

The project has proven that the opportunity exists for value-adding industries to utilise plantation timber resources, further reducing the industry's dependency on native old-growth hardwoods. This should encourage further plantation development within Lao PDR.

8.4 Communication and dissemination activities

The project sought to communicate information about activities through publications, technical reports, coordination meetings, workshops, competitions, and through media outlets such as TV and internet. The information tools used during the project are summarised below.

Publications

In total 74 publications were produced during the project period ranging from technical reports, manuals, journal papers, conference papers and posters. The list of publications is provided in Section 10.2 of this report.

Coordination meetings

Various coordination meetings were conducted throughout the project. They are listed in detail in the project annual reports but in summary include the following:

1. Frequent communication by email, telephone, skype and face-to-face meetings:
   - between the Project Leader and the Country Coordinator, objective team leaders and team members on the project progress, planning and reporting

- between team leaders and team members of each objective and sub-objective, regarding the work program for activities and sub-activities for each team (action plan, timetable, research progress, budget, publications)
- NUoL VALTIP2 team regular meetings (3 times per month) to review the progress of various project activities and assignments
- between researchers within partner organisations
- between Lao researchers and the Industry Clusters companies.

2. Project Country Coordinator meetings with stakeholders.
3. In country management meetings between Australian and Lao partners.
4. Interstate management meetings between DAF and UoM.

Management workshops

The project inception meetings were held on 19 June 2012, in Vientiane, and on 22 June 2012, in Luang Prabang, with the aim of presenting and discussing the project objectives, methodology and expected outcomes. The meetings were well attended by the organisations participating in the project.

Annual workshops were held over the course of the project, aimed at providing industry, management and policy makers with key project outcomes and/or hands-on demonstrations. The project mid-term review was held in Luang Prabang on 16 September 2014. The event provided an opportunity for project members and stakeholders to gather and discuss the challenges and opportunities for the project and review its progress. The final review was held between 31 October and 4 November 2016 in Vientiane to review the project's achievements against objectives and activities, and to assess its scientific, economic, social, environmental and capacity-building impacts.

Workshops and training courses

As stated in the previous sections, a total of 83 training courses and workshops were conducted for smallholders, timber industry and NUoL researchers (see the list of training courses in Section 11). Extensive training materials were developed and given to the course participants. Some of the training materials are being used for teaching at NUoL.

Successful Crawford Fund applications allowed Lao researchers to be trained in primary wood processing at DAF, Brisbane; in furniture manufacturing at UoM and Holmesglen Furnishing Industry Training Centre, Melbourne; and in furniture design at RMIT, Melbourne.

The project name and logo

The project was named "VALTIP2" to recognise its link to a previous project, FST/2005/100 "Value-adding to Lao plantation timber products", which was known under an abbreviated name "VALTIP". The project logo (Figure 18) was developed to enable easy identification of the project publications, activities and announcements and to enable a group identity to be established.

Figure 18: The VALTIP2 project logo.

Website

The project website “laoplantation” was developed and can be located on the following URL: http://www.laoplantation.org/. The website was designed to provide information on the project objectives, partner organisations, project teams, project documents and reports, photo albums related to research activities, media releases, news, and policies related to the project.

By 15 February 2017 the website had a total of 217,212 individual hits.

Newsletters

A total of four newsletters were produced during the course of the project and were submitted to the project members, stakeholders and industry as well as uploaded onto the project website.

Project Dropbox

A Dropbox folder called VALTIP_2 was created as a way for the project team to download research reports and publications related to the project in a secure and structured way. Dropbox allowed everyone on the team to have access to the same information at the same time.

Field trips

Regular visits to plantation sites, tree growers, timber companies and other relevant companies and organisations have been undertaken by research teams according to the project needs.

Visits to the Industry Cluster companies were undertaken by team members of Objectives 2 and 3 to implement recommended improvements in their wood processing and manufacturing processes.

Media

Following the inception meeting in 2012, annual workshops in 2013 and mid-term review in 2014, short articles about the project activities were published in the *Vientiane Times* and *Lao Economic Daily*.

On 13 November 2015, the *Vientiane Times* and the *Lao Economic Daily* newspapers ran articles on the opening of the “Veneer Processing and Production Center” at the NUoL. The article has also been uploaded on the *Vientiane Times* website. The opening ceremony was attended by Vice President of the NUoL Assoc. Prof. Dr Saykhone Saynasine, Australia’s ambassador to Laos, Tony Bartlett from ACIAR and other officials.

In January 2016, the Crawford Fund E-Newsletter, published a story “Green Furniture Design” on training on sustainable furniture design for four designers from Laos and Vietnam at RMIT’s School of Architecture and Design. The participants were actively involved in the training activities, and stated that they were privileged to have an opportunity to gain new experience and knowledge from Australian experts in furniture design.

Tony Bartlett wrote a blog on the ACIAR website “ACIAR project providing opportunities for Lao and Australian wood manufacturers”, which can be found online at: http://aciarblog.blogspot.com.au/2016/03/aciar-project-providing-opportunities.html

On 3 June 2016, the ACIAR blog (http://aciarblog.blogspot.com.au/) published an article on the Crawford Fund training in Brisbane on engineered wood products.

9 Conclusions and recommendations

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

9.1 Conclusions

The key learnings from the project are as follows:

Approximately 15,000 ha of plantation teak were mapped in Luang Prabang province. The plantations were characterised as predominantly immature, with more than 75% in size classes of less than 25 cm tree diameter. This has implications for investment in domestic wood processing technology. Plantations are in thousands of small parcels, which are geographically dispersed across the province. Proximity to roads, infrastructure and processing facilities has implications for wood flow and costs for owners and industry which are not fully understood. The mapping and resource classification methods developed within the project could be applied to other provinces and plantation species.

Farmer-owned and community-based plantation enterprises, capable of harvesting and processing local plantation-grown wood such as teak, have great potential to contribute to national policy objectives by generating rural employment, boosting farm income and supplying timber to the processing sector. However, they are currently uncompetitive due to policy barriers associated with perceived risk around processing of timber illegally harvested from natural forests, unnecessarily complex regulatory procedures and high transaction costs.

Plantation registration was hypothesised to be a barrier to smallholder participation in the legal value chain for plantation-grown wood. Analysis found that processes for plantation registration have been complicated by multiple perceptions of the purpose of registration; for some, plantation registration has become a substitute land titling process, for others it is needed merely to demonstrate source of origin for legal wood sales. For the former, a consequence is that the cost and administrative procedures for registration have become prohibitive for farmers. For the latter, procedures to register plantations may be seen as not strictly legal. Recommendations for policy review and clarification of the purpose of plantation registration were made.

Systems mapping of the regulations along the entire teak value chain and analysis of the transaction costs revealed a complex operating environment. Research found that streamlining and simplifying regulations and reducing transaction costs would likely increase smallholder returns and improve the competitiveness of plantation enterprises through increased value chain efficiency. These procedures also need to address national and provincial regulatory and revenue requirements.

Research into farmer attitudes to plantation registration and into the effectiveness of grower groups revealed that there is diversity in plantation ownership. As a result, the supply of wood to industry is unpredictable. Better understanding of the ownership arrangements and the management intent of owners could facilitate resource availability and a consistent flow of wood to processors.

Improved linkages between growers, traders and processors can enhance the value chain, and innovative collaborative investment and funding approaches are needed to facilitate the supply of plantation-grown teak to the market in a way that meets the needs and addresses the constraints of the plantation owners.

Market requirements for legal or certified wood could be met through simplified procedures that recognise the low-risk nature of farmer-owned plantations when compared with other sources of timber.

The project findings on the utilisation of plantation timbers covered critical aspects of the key stages of wood processing and manufacturing of the final wood products: sawmilling, log and sawn timber grading rules, drying, machining, gluing, joining, finishing, as well as developing methods for wood recovery assessment and wood waste utilisation. To date, a very limited number of international research studies have been undertaken that address the entire value-adding production process for young plantation timbers. As such, this project's research findings provide a valuable contribution to scientific communities around the world, research communities and the wood processing industry in Laos and other countries focusing on growing and utilisation of plantation timbers.

The project identified that opportunities exist in developing technologies for production of engineering wood products for the rapidly growing construction, furnishing and joinery activities in Laos, neighbouring countries and Australia. "State of the art" veneer production equipment was purchased and installed at NUoL and extensive training on the use of the veneer machinery was provided to the Industry Cluster companies and NUoL researchers. The new veneer processing centre provides great opportunities for Lao industry and a firm foundation for future research at NUoL.

9.2 Recommendations

The project team has recognised that, similar to Vietnam and other countries, opportunity exists to introduce new value-adding technologies based on veneer for developing novel appearance and structural wood products, for which there is a strong demand in Laos and international markets.

The establishment of the veneer processing facilities at NUoL has created interest within timber companies and provided opportunities for new research on the utilisation of plantation timbers for the production of veneers and veneer-based products. For the new products and related industries to be internationally competitive, the plantation wood resource and its availability and accessibility needs to be known and the enabling policy environment and value chain needs to be well understood and efficient. Therefore, a detailed value chain analysis and competitiveness mapping are required to assess opportunities for using plantation timber as a viable alternative to steel, concrete, bricks and other materials currently used in building, joinery and furniture industries. Specific skills and knowledge for wood processing and improved durability are lacking in the timber industry in Laos, resulting in the use of concrete and steel for construction. Therefore, the project team has identified the need for a second stage of research with a focus on smallholder decision making, timber resource characterisation, and developing novel appearance and structural wood products based on veneer, sawn wood and composite products (combining wood and other materials) that would provide new markets for the existing plantation resources. The focus will be on addressing problems and impediments of the wood value chain, and on identifying ways to contribute to improving sustainability and competitiveness of the plantation-grown wood value chain.

The concept note for the new project has been developed and approved by ACIAR, followed by the development of the preliminary and then the final proposal for the VALTIP3 project, with the aim of supporting the development of innovative wood processing industries to enhance markets for planted timber resources within Lao PDR and Australia. The proposed research program will maintain continuity of the previous research effort and partnerships.

The new project directly aligns with a recent Prime Minister Order (No. 15/PMO/2016), which specifies that all types of wood must be turned into finished products that meet defined standards before they can be exported. The implementation of this order will require strong support to wood processing enterprises through capacity building, training and product development, which will be provided through the research program of the VALTIP3 project.

10 References

10.1 References cited in report

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Midgley, S. *et al* 2011. *Scoping study: Payments for environmental services and planted log value chains in Lao PDR. Part 3: Opportunities for R&D across the value chain for plantation-grown wood in Lao PDR*. Report for ACIAR. pp 53–90.

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Standards Vietnam. 2014. TCVN 10316:2014: Rotary veneer grading.

Walker, S. 2010. *Review Report: FST/2005/100 Value adding to Lao plantation timber products*. 84 pp.

10.2 List of publications produced by project

A. REPORTS

Objective 1

Objective 1.1

1. Boer, K. and H. Seneanachack (2016). Mapping and characterisation of plantation teak in Luang Prabang province, Lao PDR. Final report. 22 pp.

Objective 1.2A

2. Smith H.F. (2014). Smallholder teak plantation legality in Lao PDR: A study to assess the legal barriers to smallholder teak plantations and the associated timber value chain. ACIAR Project FST/2012/012, VALTIP2. 149 pp.
3. Smith, H. and K. Phengsopha (2014). Policy brief on legal barriers and legality issues for smallholder plantation owners and their wood. 9 pp. The document is written in Lao and English versions.

4. Smith, H.F., Boupha, L., Boer, K.B., Midgley, S., Ling, S., Laity, R., Flanagan, A., Said, A. and P. Kanowski (2016) Policy changes are needed to unlock the potential of the smallholder plantation resource in Lao PDR. 9 pp. Policy Brief. The document is written in Lao and English versions.
5. Smith, H.F. (2016) Demonstrating legal source of origin for smallholder grown plantation wood: An alternative to plantation registration, 3 pp.
6. Smith, H.F. (2016) Making smallholder plantation owned wood legal: Alternatives to plantation registration: Final report objective 1.2 a, 45 pp.

Objective 1.2B

7. Said, A.M. (2015). Transaction costs associated with growing and selling smallholder plantation grown wood in Lao PDR – incidence and mitigations. 28 pp.
8. Said, A.M. (2015). Transaction costs associated with growing and selling smallholder plantation grown wood in Lao PDR – incidence and mitigations. Summary paper in Lao and English. 5 pp.
9. Said A.M. (2016). Discussion paper – Transaction costs associated with growing and selling smallholder plantation grown wood in Lao PDR. Incidence and mitigations. Final report. 100 pp.

Objective 1.3A

10. Ling, S. (2013). Fieldwork Notes. Action Research Round 1. Report with an input from the Action Research Team: Dr Lamphoune (NUoL), Mr Chaly Lor (Souphanouvong University) and Mr Sichan (Upland Research Centre).
11. Ling, S. (2013). Fieldwork Notes. Action Research Round 2. Report with an input from the Action Research Team: Dr Lamphoune (NUoL), Mr Chaly Lor (Souphanouvong University) and Mr Sichan (Upland Research Centre). 31 pp.
12. Ling, S., Xayavongsa, L., Chandiphit, S. and C. Laoyongxy (2014). The rationale for, and feasible approaches to, the development of grower's groups. A report produced for the ACIAR Project FST/2010/012, VALTIP2. (English and Lao versions). 46 pp.
13. Ling, S., Xayavongsa, L., Chandiphit, S. and S. Phonechaluen (2014). Fieldwork Notes. Action Research Round 3. ACIAR project report. 14 pp.
14. Ling, S., Xayavongsa, L., Chandiphit, S. and S. Phonechaluen (2015). Fieldwork Notes. Action Research Round 4. ACIAR project report. 27 pp
15. Ling, S., Xayavongsa, L., Chandiphit, S. and S. Phonechaluen (2015). Field trip notes: Action Research Round 5 (Grower groups). 53 pp.
16. Ling, S., Xayavongsa, L., Chandiphit, S. and S. Phonechaluen (2016). Field trip notes: Action Research Round 6 (Grower groups). 16 pp.
17. Ling, S., Xayavongsa, L., Chandiphit, S. and S. Phonechaluen (2016). The evolution of teak grower groups in Luang Prabang, Lao PDR: An action research approach. Final report for the Grower Group subcomponent (Objective 1.3A). A report produced for the ACIAR Project FST/2010/012, VALTIP2.

Objective 1.3B

18. Flanagan, A. (2013). Certification or legality? A discussion paper for developing an appropriate approach under ACIAR Project FST/2010/012. 10 pp.
19. Draft FSC Group COC Handbook for the consultation of sawmills – by Richard Laity, Katia Masias Bröcker, Bounchanh Lattanavongkot and other members of Team 1.3B.

20. Flanagan, A. and R. Laity (2015). Over regulated and under marketed: Challenges in supporting feasible verification processes in Lao PDR. ACIAR project report. 133 pp.
21. Laity, R., Flanagan, A., Ho Ha, Nga Ha and Ho Van Cu (2015). Leveraging sustainability with profitability: verification mechanisms for smallholder plantations in Vietnam. 134 pp.
22. Flanagan, A. and R. Laity (2016). Final implementation report for component 1.3 (b) of ACIAR Project FST/2012/012. 52 pp.

Objective 2

23. Redman, A., Hopewell, G. and D. Bouaphavong (2014). Current production practices and processing efficiency. Industry survey results. Final reports on 10 Industry Cluster companies, in English, currently being translated into Lao language. 72 pp.
24. Redman, A., Hopewell, G. and D. Bouaphavong (2014). Current production practices and processing efficiency. Industry survey results. Separate reports on 10 Industry Cluster companies, in Laos, completed and sent to the relevant companies.
25. Redman, A., Hopewell, G. and D. Bouaphavong (2014). Current production practices and processing efficiency. Summary report. 8 pp.
26. Hopewell, G., Redman, A and C. Fitzgerald (2015). Log grading. Report was updated after testing in industry and feedback from Government workshop. Final version in English and Laos completed April 2015.
27. Fitzgerald, C. and H. Bailleres (2014). Optimal processing equipment for small-scale sawmilling – portable sawmills. English and Laos versions completed and sent to industry.
28. Hopewell, G. (2015). Sawmilling: A best practice manual for small log processing in Lao PDR. 32 pp.
29. Hopewell, G. and A. Redman (2015). Sawmilling in Lao PDR: Benchmark recovery study and recommendations for improved efficiency and safety. 16 pp.
30. (a) Redman, A. (2016). Drying in Lao PDR: Drying operations and dried quality study, and recommendations for improved drying efficiency. 54 pp.
30. (b) Redman, A. (2016). Drying sawn timber: A best practice manual for wood drying in Lao PDR. 69 pp.
31. Redman, A. (2016). Sawn timber grading in Lao PDR: Product grading manual – rules and recommendations. 18 pp.
32. Redman, A. and C. Fitzgerald (2016). Sawmill waste grading in Lao PDR: Sawmill waste grading and potential uses. 22 pp.
33. (a) Redman, A., Hopewell, G. and C. Fitzgerald (2016). Manual on primary processing of plantation timber. 117 pp.
33. (b) Redman, A. (2016). Veneer peeling: Plantation log peeling trials in Lao PDR. 15 pp.

Objective 3

34. Ozarska, B., Boupha, L., Siakor, L., Xaypha, S., Bouaphavong, D. and Si Xiong (2013). Assessment visits to the Manufacturing Cluster companies. Part 1: Manufacturing Cluster No 1. Final report on the Industry Cluster 1 companies in English and translated into Lao language. ACIAR Project FST/2012/012. 62 pp.
35. Ozarska, B., Boupha, L., Siakor, L., Xaypha, S., Bouaphavong, D. and Si Xiong (2013). Assessment visits to the Manufacturing Cluster companies. Part 2:

Manufacturing Cluster No 2. Nine separate final reports on the Industry Cluster 2 companies in English and translated into Lao language. ACIAR Project FST/2012/012.
36. Ozarska, B., Boupha, L., Siakor, L., Bpuaphavong, D., Xaypha, S., Si Xiong and G. Hopewell (2014). Assessment visits to the Manufacturing Industry Cluster companies. Summary and recommendations. Report for ACIAR Project FST/2012/012.
37. Rasera, S. (2013). Utilization of small dimension and low quality plantation timber for the manufacture of wood products. Exchange student research project, UoM and University of Sao Paulo. ACIAR Project FST/2012/012.
38. Belleville, B. (2014). Specification on optimal machining parameters, tools and machining method. Report for ACIAR Project FST/2012/012. 39 pp.
39. Ozarska, B. (2014). Specification on finishes and finishing methods for various products and service conditions. Report for ACIAR Project FST/2012/012. 44 pp.
40. Belleville, B. (2014). Laboratory testing of glue-bond strength of various types of glues in various climatic conditions for plantation timber species. ACIAR Project FST/2012/012. Testing program document.
41. Belleville, B. (2014). Wood material and surface quality assessment. Part of laboratory testing of performance of various types of glue in various climatic conditions. 14 pp.
42. Belleville, B. (2014). Detailed analysis of wood recovery rate in production of high value wood products. Report for ACIAR Project FST/2012/012.
43. Belleville, B. (2014). Improving value and quality of wood products for domestic and export markets. Methodology for wood recovery analysis. ACIAR project report. 13 pp.
44. Belleville, B. (2014). Machining with planing machine. Checklist for operator. Quality control checklist. 2 pp.
45. Belleville, B. (2014). Machining quality control checklist for quality controller. Quality control checklist. 17 pp.
46. Belleville, B. (2014). OHS machining checklist for machine operator. Quality control checklist. 2 pp.
47. Belleville, B. (2014). OHS machining checklist for supervisor. Quality control checklist. 4 pp.
48. Belleville, B. (2014). Gluing checklist for operator. Quality control checklist. 4 pp.
49. Ozarska, B. (2014). Quality control checklist for finishing workers. Quality control checklist. 5 pp.
50. Ozarska, B. (2014). Checklist for quality controller of finishing process. Quality control checklist. 11 pp.
51. Belleville, B. (2015). Wood waste reduction and waste utilization: An investigation on the various uses of wood waste and off-cuts for the Lao wood processing and manufacturing industry. ACIAR project report. 37 pp. Executive summary translated into Lao language.
52. Belleville, B., Ozarska, B., Siakor, L. and L. Boupha (2015). Improving the value and quality of wood products for domestic and export markets – Laboratory testing of performance of various types of adhesives in different conditions. ACIAR project report. 41 pp. Executive summary translated into Lao language.
53. Ozarska, B. (2015). International standards and specifications for furniture materials, production methods and performance requirements for furniture product. ACIAR project report. 47 pp.
54. Belleville, B. (2015). Improving quality of wood products – Specification on joining methods for various types of components and products to maximize wood recovery and strength of products. 20 pp.
55. Belleville, B. (2015) ACIAR Project Newsletter #4. 9 pp.

56. Ozarska, B. (2015). Recommendations for the establishment of furniture testing facilities in Lao PDR. 12 pp.
57. Ozarska, B. (2016). Template for implementation visits to industry cluster companies. 9 pp.
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Objective 4

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61. Belleville, B and J. Fideles (2014). International markets overview and market trends for the development of an industry-led value-added timber market strategy in Lao PDR. Objective 4.1 Report for ACIAR Project FST/2010/012. 88 pp.
62. Siakor, L. and S. Boupha (2014). Report on international training course on biomass energy utilization and technology for Southeast Asia from 15–29 July 2014. 8 pp.
63. Midgley, S., Mounlamai, K., Flanagan, A. and K. Phengsopha (2015). Global markets for plantation teak: Implications for growers in Lao PDR. ACIAR report. 74 pp.

B. JOURNAL PUBLICATIONS, CONFERENCE PAPERS AND POSTERS

65. Bouaphavong, D. (2013). Hardwood plantations processing industry in Lao PDR. Poster for the 4th International Scientific Conference on Hardwood Processing 7–9 October 2013, Florence Italy (ISCHP 13).
66. Smith, H. (2014). Legal issues and legality barriers for smallholder plantation owners in Lao, PDR. The Chatham House (Royal Institute of International Affairs) 24th Illegal Logging Update and Stakeholder Consultation meeting in London on 16–17 June 2014.
67. Smith, H. (2014). Timber legality: what it means for smallholder plantation owners in Lao PDR. Paper presented at the Australian Forester Abroad Conference November 2014.
68. Bailleres, H., Ozarska, B. and L. Boupha (2015). Enhancing key elements of the value chains for plantation-grown teak wood in Lao PDR. Overview and initial results. Paper presented by H. Bailleres as the keynote at the 3rd World Teak Conference, 11–15 May 2015, Guayaquil, Ecuador.
69. Belleville B., Ozarska B., Siakor L. and L. Boupha (2015) Enhancing key elements of the value chains for plantation-grown wood in Lao PDR. Pages 28–35 in Proceedings of the 2015 International Scientific Conference on Hardwood Processing, Quebec City, 14–17 September 2015.
70. Flanagan, A. and R. Laity (2016). Overregulated and under marketed: Challenges in supporting feasible regulation services in Lao PDR. Poster for the Asia Pacific Forestry Week.
71. Siakor L. and B. Belleville (2016). Laboratory testing of glue-bond strength of various types of glue in various conditions for plantation timber species. 2016 World Wood Day Symposium, Kathmandu, Nepal, 21–23 March 2016.
72. Bouaphavong, D., Jarusombuti, S. and T. Veenin. (2016). Teak log grading for teak plantation in Lao PDR. Thai Journal of Forestry, 35 (3): 160-169.
73. Phonetip, K., Ozarska, B. and G.I. Brodie (2017). Comparing two internal check measurement methods for wood drying quality assessment. European Journal of Wood and Wood Products. 75 (1): pp 139–142.
74. Phonetip K., Ozarska B., Harris G., Belleville B. and G.I. Brodie (2017). Quality assessment of *Eucalyptus delegatensis* dried in the solar kiln. A paper submitted to IUFRO Division 5 (Forest Products) Conference, Vancouver, British Columbia, 12-16 June 2017 (accepted).
75. Smith, H., Ling, S. and K. Boer (2016). Teak plantation smallholders in Lao PDR: What influences compliance with plantation regulations? (submitted to *Australian Forestry* [under review]).

Conference and workshop attendance

24 September 2015: Workshop involving MOIC and FOF, NUoL, to establish a committee to oversee the marketing strategy development process.

Bounchanh Lattanavongkot from the Lao Department of Forestry (LPTP) attended the IUFRO Working Group 3.08 Smallholder and Community Forestry conference, together with pre- and post-conference tours, on the Sunshine Coast, Queensland, in October 2015. Attendance was funded 100% by ACIAR (50% from VALTIP 2, Objective 1, funds).

1–3 & 19–21 October 2015: Market Analysis & Business Planning Development Workshop.

Hilary Smith attended and presented at The Chatham House (Royal Institute of International Affairs) 24th Illegal Logging Update and Stakeholder Consultation meeting, in London on 16–17 June 2014.

Hilary Smith attended and presented at a national workshop on the Forestry Legality Compendium in Vientiane in November 2015.

Representatives of Objective 1 team (Stephen Midgley, Bounchanh Lattanavongkot and Richard Laity) made presentations at the Asia Pacific Forestry Week held in Pampanga, Philippines, 22–26 February 2016. The presentations incorporated the experiences of VALTIP2 1.3A, by mentioning many of the challenges to establishing and maintaining smallholder groups and the considerable resources this requires.

Richard Laity presented a Certification Poster, and contributed to two events at the Asia Pacific Forestry Week in the Philippines (February 2016) and the Chinese Forest Certification Council's event at the International Union of Forest Institute event in China (November 2016)

Richard Laity participated in the Pan-ASEAN Timber Certification Working Group meeting in Thailand (June 2016) where he was able to share experiences and learnings from the VALTIP 2 projects.

Barbara Ozarska, Latsamy Boupha, Hilary Smith and Aidan Flanagan attended mid-term review of ACIAR project FST/2012/041 "Teak-based agroforestry systems to enhance and diversify smallholder livelihoods in Luang Prabang province of Lao PDR", 22 February 2016.

Mr Thongsavanh attended The Chatham House (Royal Institute of International Affairs) 26th Illegal Logging Update and Stakeholder Consultation meeting, in London representing Laos on behalf of the Lao Wood Processors Association with a presentation entitled "Private sector perspective of the VPA process and the development of a national COC system for Lao wood processing companies and traders".

Mr Bounchanh Lattanavongkot, LPTP, attended the 15th Meeting of the Working Group on a Pan ASEAN Timber Certification Initiative (15th WG-PATCI) on 2–3 June 2016, Lampang province, Thailand. He was supported by FAO and had a chance to talk to Mr. Bruno Cammaert of the FAO EU-FLEGT Program about needs to obtain a support from FLEGT for small growers in Laos.

Representatives of Objective 1 team (Stephen Midgley, Bounchanh Lattanavongkot, Hilary Smith, Stuart Ling,) made presentations at the ACIAR teak Smallholder Workshop in Luang Prabang 14–18 November 2016.

Hilary Smith attended the project initiation workshop for the ACIAR project ADP/2014/047 on Improving policies for forest plantations to balance smallholder, industry and environmental needs in Lao PDR and Vietnam, in Vientiane in November 2016.

Midgley, S. J. (2016). Certification and Legality: Help or Hindrance to Smallholders? Invited keynote address, Session 1: 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.

Midgley, S. J. (2016). Wood production systems of the future: private sector investment in in communities and smallholders. Invited Keynote address to PEFC Side-event: Positive impacts from private sector investment in communities and smallholders: The forest production systems of the future. Asia-Pacific Forestry Week, Clark Freeport Zone, Pampanga, Philippines, 22-26 February 2016.

Midgley, S. J. (2016). Global Markets for Plantation Teak: Implications for Lao PDR. Paper to ACIAR Teak Agroforestry and Smallholder Workshop, 14-17 November, 2016.

Midgley, S. J. (2016). Hidden assets: Asia's smallholder wood resources. Paper to ACIAR Teak Agroforestry and Smallholder Workshop, 14-17 November, 2016

11 Appendix 1: Project training activities

Year 1

Training for researchers and students at the Faculty of Forestry, NUoL

1. 1–20 October 2012. An intensive training course on wood drying that covered theoretical aspects of wood drying and practical use of the laboratory mini-kiln at NUoL.

2. 8–21 February 2013: Training on how to assess drying defects and to advance the knowledge of young researchers on wood drying and on the use of the laboratory mini-kiln.

3. Training was held at NUoL on the use of laboratory equipment available at the Wood Technology Laboratory (drying oven, conditioning chamber and Instron testing machine). The training was provided by Khamtan Phonetip, NUoL researcher, under supervision of Dr Latsamy. The course was organised for VALTIP2 researchers to ensure that they can operate the equipment and conduct experiments after the departure of Khamtan to undertake PhD studies at UoM.

4. Intensive training was provided by Dr Benoit Belleville, UoM, on 2–3 May 2013 for NUoL researchers on testing methods to assess the performance of various types of glues used for high-value wood products (nonstructural applications) at standard moisture conditions, after an aging cycle with variable relative humidity, and other exposure conditions. The training covered the preparation of samples for testing, testing procedures and assessment of the results.

Training in Luang Prabang

5. FSC training for village teak growers (20–21 May 2013) and for government (23–24 May 2013): Project members Stuart Ling and Richard Laity made presentations at the training. Several team members attended the training.

6. Training for new research assistants appointed to LPTP during the week starting 27 May 2013.

Year 2

7. The Lao GIS Forest Mapper was trained in methods for mapping teak smallholder plantations using the FINNMAP high resolution digital aerial photography. Field visits were made to assess the accuracy of the mapping and to investigate methods for differentiating the age class of plantations. Methods for using geo-located (GPS referenced) photographs to assist in ground-truthing the mapping were trialled and a method developed. Additional training was provided to LPTP to assist in GIS processing of GPS data collection during plantation registration.

8. NUoL researchers involved in Objective 2 were trained in methods for conducting sawmilling studies including experimental design, data collection, importance of accurate measurements and presentation of results in a report. This will allow local staff to continue with recovery studies for the full suite of Industry Cluster companies before and after implemented improvements.

9. NUoL Objective 2 staff were provided with and trained in the use of kiln assessment tools including an anemometer, humidity sensors, thermocouples and data loggers.
10. Furniture coating training at Lao Furniture Association at Km 5, held on 6 May 2014. Attended by Louxiong Siakor, NUoL.
11. Wood machinery application and maintenance training at Pakpasak Technical College for VALTIP2 researchers, 23 April – 1 May 2014.
12. Furniture design training, 6–8 May 2014 at the FOA, NUoL. The training was attended by 20 trainees: 6 NUoL researchers, 6 industry members, 10 FOF students and 4 lecturers from the FOA. The training focused on the development of the concept of design.
13. Training on wood recovery study in furniture manufacturing was provided to VALTIP2 researchers on 21 May 2014. The training was done before the recovery studies were undertaken in selected furniture companies to ensure that the researchers understand the procedure of collecting input and output data for wood machined during various stages of the production process. Templates for the recovery studies were developed.
14. Training on gluing testing methodology was provided to VALTIP2 researchers in April 2013, September 2013, January 2014 and May 2014.
15. Training was provided for three final year undergraduate students from FOF on wood recovery studies in sawmilling and furniture manufacturing.

Year 3

16. Training in enterprise development and business planning for representatives of 4 FGEs, Luang Prabang, 17–19 June 2014 (19 participants, including 3 women).
17. Study tour for 4 FGEs to wood processors in Vientiane, January 2015, involving a total of 19 participants (15 farmers and 4 staff) on the processing study tour to Vientiane, which took place on 3–6 January 2015.
18. Objective 1 partner organisations the LPTP and The Forest Trust (TFT), which are funded partly by ACIAR project FST/2010/012 delivered the following training and coordination activities (Table 9):

Table 9: Training and coordination activities delivered by LPTP and TFT (26 training courses, workshops and study tours in total).

Activity date	Village	Description	Participants	
			Total	Women
5/11/2014	Ban Sop Jaeck	Handout teak farmer plantation certificates	27	3
17/11/2014	Kokwan	Handout teak farmer plantation certificate	19	2
19–21/11/2014	Ban Nambor	Assessment for plantation certificate and preparation of Forest Management Plan	4	0
19–21/11/2014	Kokwan	Assessment for plantation certificate and preparation of Forest Management Plan	4	0
26/11/2014	Ban Natan	Thinning and pruning training	15	5
26/11/2014	Ban Dansavang	Thinning and pruning training	12	1
4/12/2014	Ban Heuymart	Handout teak farmer plantation certificate	24	1

8/12/2014	Ban Xieng Lom	Meeting with Indian trader to discuss future wood sale	4	0
22/12/2014		Meeting with trader – plantation survey and discuss future wood sale possible PEFC certification	6	0
6–9/1/2015		LPTP-Teak Farmers Group (TFG) study tour: Vientiane wood processing factories	16	0
20/1/2015	Kokwan	Hand teak farmer plantation certificate and clarified purpose and the benefit of LPTP	25	5
21/1/2015	Ban Nambor	Hand teak farmer plantation certificate and clarified purpose and the benefit of LPTP	23	3
26/1/2015	Ban Hart Ya	Meeting with villagers/teak farmers regarding LPTP activities	32	10
28/1/2015	Ban Somsanouk	Meeting with villagers/teak farmers regarding LPTP activities	39	18
19/2/2/2015	Ban Natan	Harvesting and wood sale training	24	0
20/2/2015	Ban Napho	Harvesting and wood sale training	15	2
26/2/2015	Ban Thinsom	Harvesting and wood sale training	16	1
27/2/2015	Ban Kok Ngiew	Review previous year activities, planning for year ahead and discuss Tree Farmer Group structure	30	13
3/04/2015	Ban Xieng Lom	Review previous year activities, planning for year ahead and discuss Tree Farmer Group structure	17	2
17/3/2015	Ban Laksip	Review previous year activities, planning for year ahead and discuss Tree Farmer Group structure	18	5
3/12/2015	Ban En	Review previous year activities, planning for year ahead and discuss Tree Farmer Group structure	16	2
18/3/2105	Ban Dansavang	Harvesting and wood sale training	18	4
18/3/2015	Ban Kokwan	Building teak farmer group	24	8
27/3/2015	LPTP office	To present LPTP plan and activities to Japan International Cooperation Agency (JICA) team to continue LPTP funding support	7	0
4/01/2015	Ban Sopjaeck	Building teak farmer group	21	3
4/02/2015	Ban Sopjaeck	Thinning, pruning, measurement, harvesting and wood sale training, including TFG managers from Ban Napho and Pakkeng	22	3

19. A two-week ACIAR funded training course was held at the DAF Salisbury Research Facility, Brisbane from 16 to 27 February 2015. Five NUoL staff attended the training along with 3 Vietnamese Academy of Forest Sciences (VAFS) researchers involved in ACIAR project FST/2008/039. Training included the following topics: veneer processing, veneer grading and property measurement, mechanical property testing of wood-based products, adhesives and plywood production, log grading, small log processing, dried product grading, wood anatomy and ID, biological degrade in timber, wood drying, project management, report writing, data analysis and formatting, and lean manufacturing concepts.

20. A two-day training workshop on wood drying fundamentals, technology, processes, quality assurance and best practice was held on 7–8 May 2015 provided by Adam Redman. There were 42 attendees including: 12 company personnel (from the Industry Cluster), 4 LPTP personnel, 11 NUoL staff members, and 15 NUoL students. Professor Cac from CAXE Engineering, HCM Vietnam was invited to the workshop as a special guest to present on innovations in solar drying.

21. A half-day lecture on fundamentals of wood drying was presented to Year 5 NUoL students on 10 November 2014.
22. A half-day training course on log grading was provided for NUoL students at Burapha company on 5 February 2015.
23. NUoL researchers were provided with and trained in the use of kiln assessment tools including an anemometer, humidity sensors, thermocouples and data loggers. This equipment has been used for data gathering for kiln drying study activities.
24. NUoL and DAF staff were trained on the use of the veneer processing equipment installed at NUoL on 25–29 May 2015.
25. Training on furniture manufacturing for four researchers from NUoL was held on 7–15 March 2015, in Melbourne, at the University of Melbourne and Furnishing Industry Training Centre, Holmesglen Institute of TAFE. The trainees also had the opportunity to visit a few furniture companies in Melbourne which allowed them to observe the Australian methods of furniture manufacturing, furniture design style and quality control procedures used in the production. Project partner, Salwood Asia Pacific Pty Ltd, hosted two of the trainees for a further one-week visit to Canberra the New South Wales South Coast and Sydney to inspect natural eucalypt forests and high-market wood furniture outlets.
26. Two furniture design training courses were arranged for the Industry Cluster members, VALTIP2 researchers, NUoL students and Pakpasak students. Training No 1 was held on 5–6 May 2014 and Training No 2 on 4–5 December 2014. The participants enjoyed the training as they had an opportunity to learn about the design process and work in groups to design their own products.
27. Louxiong Siakor attended Finishing Training at the Lao Furniture Training Center, May 2014, in Vientiane, organised by Lao Furniture Association and Thai Do No Gen Gen Co., Ltd.
28. Louxiong Siakor and Sithatha Boupha attended training on Biomass Energy and Technology in Kunming Science and Technology University, China, on 14–30 July 2014.
29. Training on wood recovery study and gluing testing was provided to VALTIP2 researchers in May 2014, September 2014 and January 2015.
30. Market Research Workshop was held on 20 May 2014, in Vientiane. The workshop allowed discussing the findings of the market research study conducted by VALTIP2 team and give ownership of the activity to the MOIC.
31. Adam Redman attended a one-day workshop in Vientiane on 12 December 2014 organised by German Development Agency (GIZ) and Laos PDR MOIC. The workshop outlined the early stages of FLEGT implementation in Lao PDR and MOIC draft of Agreement 415; a wood product dimension standard.
32. A half-day workshop on log grading was held on 10 February 2015. The workshop was attended by 12 government department representatives, 13 NUoL staff and 1 German aid (GIZ) representative. The government departments included: Division of Forestry (DOF harvesting and standards sectors), Dept. Of Industry and Handicraft, Dept. Of Forest Inspection, Dept. of Measurement and Standards, Dept. of Import and

Export, Dept. of Forest Economy and Wood Technology, Dept. of Forest Management and Forest Resource, Dept. of Watershed and Land Use, Dept. of Ecotourism.

33. A two-day workshop on wood drying fundamentals, technology, processes, quality assurance and best practice was held on 7–8 May 2015. There were 42 attendees including: 12 company personnel (from the Industry Cluster), 4 LPTP personnel, 11 NUoL staff members, and 15 NUoL students.

Year 4

34. Study visit to cooperatives in Xieng Khouang, 5–8 August 2015, for LPTP district staff and farmer group leaders. Total 36 participants including 2 women.
35. LPTP Farmer Group Exchange visit to Kok Ngiu, 28 August 2015, 25 participants including 2 women.
36. Study visit to Vietnam to study acacia plantations, farmer groups and certification, legality and other sustainability issues, 12–16 January 2016, 9 participants including 1 woman.
37. Partner organisations LPTP and TFT participated in the following training (either as participants or trainers) (Table 10).

Table 10: LPTP – TFT activities from July 2015 to June 2016 (11 training courses and study tours in total).

Activity date	District	Village	Activity title
8,28 and 30/7/2015	Phonxay, Pak Ou and Luang Prabang	Nam Bor, Thapho, Huay No, Huay Mat Somsanouk, Hat Ya and Sing	Training on sustainable forest management and timber supply.
5–8/8/2015	Xiengkuang	PAFO, vegetable cooperative, NTFP association and rice association	Study tour on establishment of farmer group associations and cooperatives.
18–23/8/2015	LPB, Phonxay, Pakxieng, Pak Ou and Xieng Ngurn	20 villages	Study tour of small sawmills to promote smallholder teak enterprises and value-adding.
28/8/2015	Luang Prabang with five districts attending	Ban Kok Ngiew	Workshop for farmer group leaders (18 groups, 22 farmer group leaders) to exchange experience on groups and establishment of enterprises.
3–4/9/2015, and 7–8/9/2015	Luang Prabang and Xieng Ngurn	Kok Ngiew, Ensavan, Lak Sip and Xieng Lom	Support election of new farmer group leader (4 FSC certified groups).
21–29/9/2015	LPB, Phonxay, Pakxieng, Pak Ou and Xieng Ngurn	20 villages	5-yearly review of teak forest management land implementation.
1–3 and 20–21/10/2015	Forestry Faculty of NUoL		Training on marketing analysis and business planning.
14–28/11/2015 And 25–30/11/2015	LPB, Phonxay, Pakxieng, Pak Ou and Xieng Ngurn	18 villages	Field training on teak plantation model including pruning, thinning and other plantation silviculture.
11–17/12/2015	Pak Ou	Hat Kham and Hat Ya	Teak plantation inventory prior to plantation registration, including preparation of plantation management plan and plantation register.
17–23/12/2015	Pak Xieng	Hat Huay	Teak plantation inventory prior to plantation registration, including preparation of plantation management plan and plantation register.
May 2016 – ongoing	Luang Prabang	5 districts	Training to build capacity of farmers on teak silviculture, sustainable forest management including 5-year plantation management planning, legal timber supply and plantation register.

38. A three-day workshop on veneer peeling was run by DAF staff at NUoL from 4–6 November 2015. The training was attended by Industry Cluster company managers and staff, NUoL researchers and students, and 2 researchers from the VAFS. The following Lao companies attended the training: Burapha, Khampai Sana, KM21, Saisamone, Pakpasak and Oji.

39. A two-day workshop on log grading, sawmilling best practice, dried product grading, sawmill waste utilisation, veneer grading and lean manufacturing was held on 4–5 December 2015 at NUoL. There were 31 attendees including: 14 company personnel

(from the Industry Cluster), 1 LPTP personnel, 5 government department personnel and 11 NUoL staff members.

40. Last year NUoL researchers were trained in the square and round log grading rules in Vientiane. As a result, they autonomously held a workshop on square and round log grading in Luang Prabang for sawmillers, the LPTP group and forest growers from 7–8 April 2016.

41. A training program, supported by the Crawford Fund, on the development of innovative products from forest plantations and agri-fibre residues, was held at DAF's Salisbury Research Facility. The training was attended by research scientist, Mr Tien Manh Ha from the VAFS, Hanoi, and teacher Mr Phouluang Chounlamounty from the National University of Laos (NUoL). The purpose of the training was to share knowledge of methods to produce composite veneer products, specifically for multilaminar veneer production and alternative composites using agri-fibre residues.

42. Training Workshop on Wood Recovery in Manufacturing was held in Vientiane, 24–25 June 2015, at Pakpasak Technical College. Practical demonstrations and exercises allowed participants to make links between the theory and the realities of manufacturing. Total 19 participants including 2 women: Changpheng factory (2), Pakpasak Technical College (4), Somesakit factory (1), PKK factory (1), and VALTIP2 team (11).

43. Training on Market Analysis and Business Planning Development in October 2015 held at NUoL was attended by 30 people. It was run by Mr. Thone Boungvathana from Enterprise and Development Company Ltd (EDC). The training focused on business planning development for wood processing companies to strengthen business and management capacities. It was held in 2 stages; 3 days for each stage with 2-week break for homework. Topics included: how to write a wood processing business plan (technical writing, components to be included), the importance of the wood business plan, how to find new markets and production planning, profits and losses calculation, product management, production layout.

44. Gluing and Finishing Training Workshop: the aim of the two-day workshop was to explain theory and demonstrate appropriate methods and practices behind gluing and finishing for the production of high-quality wood products meeting international standards. Activity date: 3–4 June 2016. Location: FOF and Khampai Sana company. The training was provided by Prof. Somgklod Jarusombuti from Kasetsart University, Thailand and qualified teams from Unicorp Co Ltd (Gluing) and Thai Washin Co. Ltd (Finishing). The practical training was organised at Khampai Sana company which provided an opportunity for participants to apply what they learned the previous day. A total of 54 participants including 17 women attended the workshop, including 22 from ACIAR project (Industry Clusters and FOF) and students from FOF (Years 3 and 4).

45. Five members of Lao VALTIP2 team attended a training workshop on "Research methodology and writing journal papers for international publications" at Thalath, Thoulakhom District, Vientiane province, from 29 May – 5 June 2016. The event was organised by World Bank and supported by ACIAR project funds.

46. VALTIP2 researchers participated in English language training at NUoL taught by the Australian volunteer, James Cornwell.