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 - SMP Enterprises.
 - PKK Lao Furniture Company Ltd
 - Kawi Wood Products Co
 - Viengniyom Furniture
 - Siththisone
 - SOM Somsack
 - Sone Sawmill.
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List of abbreviations used in the Report

DED	German Development Service
DTP	Downstream Timber Processing Industry
FOF	Faculty of Forestry
FSC	Forest Stewardship Council
GoL	Government of Laos
GOPA	German development consulting firm
GTZ	German Technical Cooperation
LFIA	Lao Furniture Industry Association
LFTP	The Lao Forest and Trade Platform
NES	National Export Strategy
NUOL	National University of Laos
SUFORD	Extension of the Sustainable Forestry for Rural Development
SIDA	Swedish International Development Cooperation Agency
SEQUA Asia-Invest	German worldwide development organisation
TFT	Tropical Forest Trust
UNIDO	United Nations Industrial Development Organisation
UoM	The University of Melbourne
WoodTech	Wood Technology
WWF	World Wide Fund
VALTIP	The research team of the ACIAR project" Value adding to Lao PDR plantation timber products"
MOE	Modulus of Elasticity
MOR	Modulus of Rupture
MC	Moisture content
EMC	Equilibrium moisture content
LaoDCGE	Lao Dynamic Computable General Equilibrium model
GoLFP2020	The Government of Laos' forest policy 2020
LaoHMS	Lao Household Microsimulation model

2 Executive summary

Over the last decade, the wood and wood products sector in Lao PDR has undergone significant reforms in response to the depletion of the country's forest resources, increased demand for timber, low-value exports of timber and the illegal trade in raw logs. The reforms begun in 2001, when the Government of Lao legislated a ban on the export of raw logs, followed by a policy imposing a reduction on the export of sawn wood. In 2006, the government launched a policy for promoting downstream processing and exporting finished or semi-finished wood products. However, the performance of the industry has been constrained by weaknesses in production and product quality skills, process and technology deficiencies and low wood recovery rates.

ACIAR recognised the need for research to support the development of value-added secondary wood products in Lao PDR. As a result, the project "Value-adding to Lao plantation timber products" was developed with the aim to *"enhance the range, quality and value of products produced from plantation grown timber in Laos, in particular from plantation eucalypts and teak, and to raise local capacity in timber processing and related R&D"*

The ACIAR project has played an important role in assisting the Government of Laos in the implementation of the policy on the development of a downstream wood processing industry. Significant accomplishments were achieved in capacity building (research, education and training) which will provide long-term benefits for the downstream wood processing industry.

An important achievement of the project was the establishment of the "State of the Art" Wood Technology (WoodTech) Laboratory and an extensive library which includes reference materials on all aspects of timber processing and manufacturing at the Faculty of Forestry, National University of Laos (NUOL). The laboratory is already used for research purposes, teaching undergraduate and postgraduate students in wood utilisation courses and for providing training and advisory services to the wood-related industry.

Assessment of properties and processing characteristics of young plantation teak (*Tectona grandis*) and *Eucalyptus camaldulensis* grown in Laos was undertaken which provided valuable scientific data and information required for the design and production of high quality wood products made from plantation timbers. The results showed that physical and mechanical properties of teak plantation wood were not significantly different between different age groups: 10, 15, 20, and 25 years old. This finding made a significant contribution to the Lao timber industry sector by allowing timber from younger plantations to be used in the production of furniture for domestic and export markets.

A network of companies "The Industry Cluster" was established consisting of 9 furniture companies and 1 sawmill which actively participated in the project activities. An in depth assessment of the current capabilities of these companies was conducted which resulted in the development of recommendations on improved processing, drying and manufacturing processes, as well as the identification of relevant strengths, weaknesses, opportunities and threats for the timber and furniture industry in Laos. The companies were provided with extensive technical support on the reduction of waste in furniture manufacturing by introducing more efficient wood production methods, decreasing wood drying degrades, utilisation of small dimension timbers and wood off-cuts for various components, and implementing quality control procedures. These value-

added methods has resulted in more efficient use of timber, which will enable to the production of "more from less".

The project placed a strong emphasis on improvements in the health and safety aspects of workers involved in the timber processing and manufacturing industry. The practices in many wood processing factories were unsafe and were causing serious injuries to factory workers. The project implemented safe production procedures in the Industry Cluster factories and it is anticipated that the companies have already developed a culture of a safe working environment which will be maintained on an on-going basis.

A series of product designs utilising small dimension components were developed during the project which were made available to the members of the Industry Cluster with encouragement for the development of prototypes. Linkages between the designers and the Industry Cluster members were established.

Wood bending technology, new to the Lao furniture industry, was selected as an appropriate technology to be introduced to the Lao furniture industry. Steam bending equipment was built at Pakpasak Technical College which will be used to train the industry in wood bending techniques. The adoption of wood bending in the production of furniture will result in increased recovery of timber and lower production costs when compared to machine shaping, and will open opportunities for new product designs.

A further outcome of the project was the enhancement of training in wood value-adding which provided a sound groundwork for developing efficient training programs for the industry, especially for SMEs which are predominant in Laos. Intensive training on various wood value-adding topics was provided to Lao researchers, training instructors and industry personnel (in Australia and in Laos). Training "in-house" was introduced through the researchers' implementation visits to the Industry Cluster companies. Improving knowledge and technical skills will stimulate the Lao companies to produce higher quality products which could compete on international markets. It will also assist the workers and academics in this sector to have equivalent knowledge and skills to those working in neighbouring countries such Vietnam, Thailand and China.

The adoption of the Industry Cluster model in the project made the companies involved in the Cluster the primary beneficiaries of the project outcomes. These companies were provided with extensive advisory services on how to improve their production efficiency, change old-fashionable machining and joining methods into cost effective less labour intensive methods, advance waste reduction and utilization, and ultimately on improving the quality of the final products. It is envisaged that the project findings will be spread to the other companies in Laos by the 'chain reaction' principle.

Although a major expansion of the whole industry may take longer time, there is no doubt that adoption of the project findings by the Industry Cluster companies and the project participating organisations will deliver economic impacts within five years of completion of the project.

The project has proved that the opportunity exists for the Lao value adding industry to expand into the use of increasing plantation timber resources, further reducing the dependency of the industry on native old growth hardwoods. The achievements of the project will stimulate the industry to produce higher quality products to meet international market requirements.

3 Background

Wood and processed wood products play a significant role in the economy of the Lao PDR. In the 1990s, wood and wood products accounted for 40 percent of export earnings, almost half of which was from the export of logs, and employing about 22,000 people (UNIDO 2002). During this period, the forestry sector grew faster than the rest of the economy, with an increase in log extraction from 300,000 m³ in 1990 to 734,000 m³ in 1998.

Although the Lao timber industry has grown rapidly over the past three decades, the export value of finished wood products has been very low compared to that of processed timber. The country earned 7.6 billion kip (US\$800,000) from exporting finished wood products in 2005, which was more than doubled to 16 billion kip (US\$1.7 million) in 2006, but the total value of processed timber exports climbed from 584 billion kip (US\$61 million) in 2002 to 919 billion kip (US\$96 million) in 2006 (UNIDO 2002).

The low export figure for wood products in 2002-2006 was due to the fact that most sawmills focused on selling logs and processed timber rather than refining the wood into finished goods such as furniture, which is more difficult to produce.

Due to concerns about the low value of exports of logs and the depletion of the country's precious forest resources, the Government of Laos PDR (GoL) legislated a ban on the export of logs in 2001. As of 2004, the GoL ordered a reduction of the export of sawn wood, which reduced the annual harvest to approximately 150,000 m³ in 2004/05, and subsequently increased it to 370,000 m³ in 2005/06.

It became clear that Lao PDR must continue to reduce the export of low-value wood products and work towards adding value to its domestic wood processing sector. Therefore, in 2006, the government launched a policy for promoting downstream processing and export of finished or semi-finished wood products. This strategy specifically identified the need to improve performance of the wood industry by aligning the processing capacity with the sustainable timber supply, the need for improving efficiency in wood processing and further promoting export of finished and semi-finished products. Priorities included:

- To raise the productivity and added value production of wood products;
- To upgrade technologies and skills of workers and managers in the wood industries;
- To reduce excess waste throughout the wood production chain, and utilize waste in an environmentally sustainable manner;
- To develop technical standards for wood industries and standards for wood products, and introduce forest certification;
- To promote and strengthen the private sector;
- To promote a finished products trade for domestic, regional and overseas markets.

Laos has an emerging forest plantation industry. In 2005, the country's total area of plantations was 157,556 ha. More than 20,000 hectares of teak have been planted, in particular around Luang Prabang and in some southern districts. Some of this is now being harvested. Significant areas of *Eucalyptus camaldulensis* have been established in central and southern Laos.

The Lao PDR Forestry Strategy to 2020 envisages a substantial forest plantation estate, forming the backbone of a vibrant forestry sector that includes 'an installed processing

capacity commensurate with sustainable levels of production from natural forests and tree plantations, with the use of efficient high performance machinery and equipment and well-trained personnel producing high-quality, competitively priced products designed according to national and international tastes and well positioned in international markets'. Lao PDR has some competitive advantages that could allow the country to become a much larger participant in the production of sustainable wood products for export markets based on plantation timber resources. The development of a successful, competitive secondary wood industry would provide substantial export income for Laos, employment for large numbers of people in both urban and rural areas, and a ready market for smallholders growing trees.

In 2006, during this ACIAR Project development phase, the primary wood industry was functioning as a stand-alone log export oriented sector, which was characterised generally by little or no new investment and low utilization of raw material. A low level of production engineering resulted in an unsafe working environment and contributed to low productivity. The number of operators incorporating further downstream processing like drying, grading and machining with the target of manufacturing high value added products was limited. The sawn wood was not graded according to international standards, which was further limiting market access. The waste created during processing was very high due to low efficiency of the production processes and low labour skill.

The secondary processing industry consisted mainly of cottage-based businesses, which did not have sufficient individual production capacity and were not sufficiently organised collectively to participate in export oriented production of wood products. The sawn timber supply for the furniture cottage based industry was limited and dried wood, the basis for any high value added production, was rarely available. Therefore the majority of wood products were not suitable for international markets due to poor quality, low performance and low durability in changing conditions of environment. The product designs were old-fashioned and required a high consumption of raw materials which made the products very expensive for local consumption. Other problems were related to the lack of market access especially for Small and Medium Enterprises (SMEs) in rural areas. In 2006, there were 2,096 wood processing factories operating in Laos, of which 174 were considered as primary processors producing lumber for the domestic market, including raw material for the secondary wood processing industry. A number of 402 companies were considered as secondary processors producing joinery, plywood and veneers, particleboard and pulp and paper; and the remaining 1,520 were considered tertiary processors producing furniture, handicrafts and household articles (GoL unpublished report, 2010).

ACIAR recognised that the Lao timber industry is in a position to develop into an important player for value-added secondary wood products, in particular due to the country's agroforestry plantation policy which aims to provide a sustainable source of raw material for the sector in the future. Additionally, traditional skills available in the country, like woodworking and carving, have a potential to develop unique designs and a successful secondary wood industry as was demonstrated in Vietnam and Thailand over the last twenty years. Therefore, this project was developed as a strategic intervention to assist the GoL in the realization of the policy on the development of value-added timber industry based on sustainable plantation timber resources.

4 Objectives

The aims of this project were to enhance the range, quality and value of products produced from plantation grown timber in Laos, in particular from plantation eucalypts and teak, and to raise local capacity in timber processing and related R&D. Underpinning objectives were:

Objective 1: To improve timber recoveries through application of enhanced but appropriate processing, drying and manufacturing methods.

Activities:

- Formation of an 'Industry Cluster' of interested sawmills and furniture factories.
- Detailed analysis of the current capabilities of participating companies and identification of relevant strengths, weaknesses, opportunities and threats for timber and furniture industries in Laos.
- Development of recommendations on improved processing, drying and manufacturing processes suitable for application in Laos.
- Provision of training in relevant technologies and methods.

Objective 2: To broaden product design options, in particular by testing and adapting new technologies.

Activities:

- Identifying new technologies, e.g. for bending and joining, that could potentially be introduced to the Lao industry for use with small dimension plantation timbers
- With the networked participants, developing appropriate new product designs using these technologies
- Providing training on processing and manufacturing methods, including OHS issues, to NUOL staff, and relevant industry staff and factory workers, tailored appropriately to each group

Objective 3: To develop appropriate quality control procedures for timber and furniture industries.

Activities:

- Development of detailed Industry Manuals describing timber processing, drying and manufacturing procedures.
- Development of quality control methods for assessment of various production stages and for the final products.
- Supervision of production methods used by the companies involved in the Industry Cluster.

5 Methodology

5.1 Objective 1: To improve timber recoveries through application of enhanced but appropriate processing, drying and manufacturing methods.

5.1.1 Detailed analysis of the current capabilities of the industry and identification of relevant strengths, weaknesses, opportunities and threats for timber and furniture industries in Laos

5.1.2 Establishment of the Industry Cluster

At the outset of the project the Project Steering Committee was formed consisting of two representatives from each partner organisation. Terms of reference were developed for the Committee to ensure that the project objectives would be completed on time and within the budget. A strategy for the project coordination was developed to enable frequent, efficient and open discussions between the project team members.

The Steering Committee members met approximately every 6-11 months (depending on the availability of the Committee members) to discuss and review the project.

The project research team was named "VALTIP" and developed a logo to have its own identity and to facilitate internet communication and distribution of information. The logo is provided below:



As it would be impossible in this project to improve current processing and manufacturing methods in each and every small company in Laos, the "small steps" method was proposed. A network of companies "The Industry Cluster" was established consisting of 9 furniture companies and 1 sawmill which agreed to actively participate in the project. The Cluster was selected by the Project Steering Committee according to strict criteria, with two major requirements being the use of plantation timbers and sustainable production.

The project team was working closely with the Industry Cluster companies on the implementation of the project methodology. The companies were actively participating in the project's on-going technical activities and in social functions.

The companies involved in the Industry Cluster were:

1. Moontheva Wood Processing Factory
2. Khamphay Sana Construction Co. & Agricultural Development Co. Ltd
3. SMP Enterprises.

4. PKK Lao Furniture Company Ltd
5. Kawi Wood Products Co
6. Viengniyom Furniture
7. Siththisone
8. SOM Somsack
9. Sone Sawmill

A "Social Club" was formed consisting of the Industry Cluster members and the project partners organisations. Informal meetings were held "after hours" every 3-4 months aiming to get together, share experience and discuss problems. The meetings also provided an opportunity to update the project members on the project progress and discuss its future directions.

5.1.3 Assessment of the current capabilities of the Industry Cluster companies and development of recommendations on improved processing, drying and manufacturing processes suitable for application in Laos.

The assessment of the current capabilities of the Industry Cluster companies was undertaken by the project VALTIP team in a manner that developed the capacity of the local partners. This process involved researchers from The National University of Laos and The University of Melbourne, as well as an expert in wood machining and training from the Victorian Furnishing Industry Training Centre, Australia, who was involved in the project on consultancy basis.

Each individual company of the Industry Cluster was visited and assessed by the project team. The evaluation included: type of species, logs dimensions and quality, type of lumber produced (dimensions and quality), grading rules used (if any), sawing equipment and sawing techniques, drying and manufacturing methods, woodworking machinery, range of products and their designs, joining methods, quality of final products and failure rate, wood waste, markets, transport, workers' skill and OH&S issues.

In addition to assessing the members of the Industry Cluster, the Burapha Group was visited during the assessment activities. This company is a collaborative partner in the project and has very good production facilities with the majority of wood products being exported to prestigious international markets. The company agreed to provide its production facilities for training the industry members and for implementation of new product designs and improved/new production techniques.

Two training centres available to the industry in the Vientiane Province, the Pakpasak Technical College and the Lao Furniture Industry Association (LFIA) Training Centre, were also evaluated.

The outcomes of the assessment of the individual companies, summary comments and recommendations on the improvements of the industry capabilities are provided in the report " *Detailed Analysis of the Current Capabilities of Companies Involved in the Industry Cluster and Recommendations on Improved Processing, Drying and Manufacturing Processes Suitable for Application in Laos*" (Report No 1).

The assessment allowed the identification of relevant strengths, weaknesses, opportunities and threats for the timber and furniture industry in Laos. SWOT analysis of the Lao industry was undertaken and presented in the above report.

The results of the industry assessment and the proposed recommendations for improvements were presented at the workshop organised in February 2008 in Vientiane. The workshop involved the members of “Industry Cluster”, all participants of the project and relevant government and industry representatives.

In order to identify what strategy could be used to support the development of a successful furniture industry in Laos a detailed analysis of the Vietnamese furniture was undertaken. The Vietnamese industry is one of the fastest growing industries in the world with well established international export markets. Some of the policies and programs used in Vietnam could be adopted in Laos for the development of a competitive furniture industry. The results were documented in a report “*Overview of the Vietnamese Furniture Industry*” (Report No 2).

5.1.4 Implementation of recommended improvements and changes

Recommendations for improvements and changes were documented in the Project Report No 6 “*Implementation of recommended changes in factory layouts*”.

A detailed program was developed for the implementation of the recommendations on improved processing, drying and manufacturing processes suitable for application in Laos. It was agreed that best implementation results would be achieved by working with each individual company of the Industry Cluster. The following plan was developed and followed up:

1. The first stage of the implementation, undertaken in June-August 2008, aimed to provide confidential feedback to each company on the results of the assessment and discuss recommendations on changes and improvements. A set of documents for each individual company was developed and presented to the company's managers during the visits. Each company was provided with a detailed report which highlighted the current deficiencies in the production methods, factory layouts and product quality, as well as suggestions for improvements. Recommendations were also provided on types of woodworking machines needed for production of various types of products and information on prices/suppliers of typical woodworking machines.

Each company was enthusiastic and receptive, eager to learn and to make improvements.

2. Regular visits (every 3-4 months) to each company involved in the Industry Cluster were made by the VALTIP team. The team members spent a lot of time with each individual company explaining the details of the recommendations and assisting in the implementation process.
3. To ensure the project sustainability beyond the project duration, a strong emphasis was placed on a comprehensive training program which was provided to the Lao research team (from the National University of Laos. The training aimed to equip the researchers with skills which would allow them to undertake independent assessment and implementation visits; both to the Industry Cluster companies and to other companies not involved in the project. Templates with checklists and procedures for the assessment of production methods, product quality, OHS procedures and quality control were developed as an important tool for the industry assessment and implementation.
4. Extensive training and research materials on the industry assessment and implementation were provided to the Lao researchers.

5. The first two visits were made jointly by Laos and Australian researchers to demonstrate the implementation procedures to the Lao team. The follow up visits were made by the Laos researchers with assistance of the furniture experts from the Pakpasak Technical College: Mr Pouthone Phothisay, an expert in wood machining and furniture production, and Mr Bounleade, who assisted with assessment of electrical systems in the factories. This plan aimed to train the Lao researchers so that they could carry out the implementation visits without supervision in the future.

Reports were written by Lao researchers after each implementation visit (Reports 22-25).

5.2 Assessment of properties and processing characteristics of young plantation timbers

The following research program was developed to achieve this milestone:

5.2.1 Analysis of plantation timber resources in Laos.

A review on the current and future plantation resources in Laos was undertaken in 2007, with the emphasis on *Tectona grandis* (teak) and *Eucalyptus camaldulensis* plantations. The review included tree planting techniques, volume per hectare for various tree ages and growing rate.

The study was completed in May 2010 and the results presented in the report:

- Boupha, L., Khamphilavong, K., Phengsopha, K., Sichaleune, O., Bouaphavong, D. and Phonetip, K. 2008. *Survey of Teak Plantation in Luangprabang and Xayabury Provinces and Eucalyptus Plantation in Central and Southern Parts of the Lao PDR*. (Report No 3).

In addition, a detailed analysis of Lao plantation resources was undertaken by PhD candidate Somvang Phimmavong as part of his thesis. This work was published in the International Forestry Review:

- Phimmavong, S., Ozarska, B., Midgley, S. and Keenan, R. 2009. *Forest and plantation development in Laos: history, development and impact for rural communities*. 2009. International Forestry Review. Vol.11(4): 47-58. (Report No 8).

5.2.2 Testing of properties and processing characteristics of teak and eucalyptus camaldulensis

Young plantation timbers were selected in Luang Prabang (Teak) and in Vientiane district (*Eucalyptus camaldulensis*) in 2007 and transported to Melbourne. The testing was undertaken at the Wood Technology Laboratory at The University of Melbourne, Burnley Campus.

The testing included:

- Density, stability (unit shrinkage), bending strength (Modulus of Rupture) and stiffness (Modulus of Elasticity). This testing was carried out by Dr Mihai Daian and the results were presented in the report:
 - Daian, M. 2011. *Dimensional Stability and Mechanical Strength Testing for Lao Plantation Timbers (Tectona grandis and Eucalyptus camaldulensis)*. 17 pp. (Report No 10).

- The development of optimal drying schedules, carried out by Mr Gerry Harris. The results were collated in the reports:
 - Harris, G. 2011. *Development of drying schedules for Teak (Tectona grandis)*. Interim Report. (Report No 12).
 - Harris, G. 2011. *Development of drying schedules for Eucalyptus camaldulensis*. Interim Report. (Report No 13).

This activity was completed in December 2010, which was later than expected, due to difficulties in collecting timber in Laos for shipment to Australia, transport matters, fumigation required and finally a long time required to complete the tests.

5.2.3 Wood properties assessment of teak (*Tectona grandis*) plantation at different ages grown in Lao PDR (Laos)

This study is being undertaken by a Masters student at the University of Melbourne, Mr Phongxiong Wanneng (Lao researcher).

This research study aims to assess wood properties of teak at different ages from plantations grown in Laos. The research focuses on the physical and mechanical properties of teak timber comparing the variability of wood properties at different age groups: 10, 15, 20, and 25 years old. The specific properties evaluated are: wood moisture content, dimensional stability, density, specific gravity, static bending - Modulus of Elasticity (MOE) and Modulus of Rupture (MOR), compression and shear strength.

The thesis is due for completion in July 2011.

5.3 Objective 2: To broaden product design options by testing and adapting new technologies.

The results of the assessment of current capabilities of the Industry Cluster companies, completed in 2007, revealed that significant improvements were required in the production methods and product quality. It was identified that the industry needed immediate assistance to improve its domestic production and only after this was achieved, the development of new technologies and new products for the export market could be considered. Therefore, the focus was placed on the implementation of the improvements and changes in the Industry Cluster companies according to the recommendations developed during the industry assessment (see section 5.1.2)

The implementation process was commenced with a training workshop “Quality Improving Techniques for Wood Products” which was held at the Lao Furniture Association on 29th July 2008. The workshop was well attended by the project participants, members of the Industry Cluster and invited guests. The proposed implementation program created a great interest and was unanimously approved.

The proposed program included:

1. In-service visits to the Industry Cluster companies undertaken by the VALTIP team during 2007-2010 (see section 5.1.3).
2. Establishment of “state of the art” wood testing laboratory at NUOL and training provided to researchers at the National University of Laos (see section 5.3.1).
3. Extensive training provided to researchers and industry members (in Australia and Laos).

5.3.1 Establishment of Wood Testing Laboratory at the National University of Laos

An important activity of the project was the establishment of the WoodTech Laboratory at the Faculty of Forestry, National University of Laos.

This process commenced in June 2007 when a new building was established, with the support of the Dean of the Faculty of Forestry, for the future laboratory.

The selection of the type of equipment required for the laboratory was done jointly by Assoc. Prof. Barbara Ozarska, Dr Mihai Daian (UoM) and Assoc. Prof. Latsamy Boupha (NUOL).

Dr Mihai Daian was in charge of purchasing the equipment and training VALTIP researchers in using the testing facilities and standard test methods as well as OH&S procedures.

Various testing instruments and equipment were purchased and installed in the laboratory during 2007-2010 periods.

5.3.2 Training provided to researchers and industry members

The training program included:

A. Training in Australia

An intensive training in Australia on wood processing and furniture manufacturing was provided to a group of Lao project participants.

List of trainees and their organisations:

1. Dr. Lathsamy Boupha - National University of Laos
2. Douangta Bouaphavong - National University of Laos
3. Khamtan Phonetip - National University of Laos
4. Vassana Keomany - National University of Laos
5. Vannitha Phommavong - Burapha Group
6. Khamhoung Khamthongsouk - Burapha Group
7. Sonephet Lathsavong - Burapha Group
8. Phouvong Onnavong - Lao Furniture Industry Association (Training Centre)
9. Saykham Phanthavong - Pakpasak Technical College (Training Centre)
10. Pouthone Phothisay - Pakpasak Technical College (Training Centre).
11. Somvang Phimmavong - Lao PhD student (John Allwright Scholarship)
12. Kaisone Phengsopha - Lao PhD student (John Allwright Scholarship).

The training was undertaken between 26 April and 11 May 2008 according to the following schedule:

- i. *26 April - 3 May, 2008: Timber Training Centre, Creswick, Victoria* (Figure 1).

Training topics: timber drying including air drying, kiln and solar drying, kiln controls, sample boarding, drying degrade and its prevention, principles of the

moisture content and moisture movement during drying, moisture meters, timber stacking, timber grading and OH&S procedures.

ii. 4 - 10 May 2008: Victorian Furnishing Industry Training Centre, Melbourne.

Training topics included:

- Furniture factory layouts and production flow, machine maintenance procedures.
- Furniture production methods: hand and power tools, furniture joints and their performance, adhesives, plan reading, documentation, cutting lists, quality control, use of technology in furniture making industry, occupational health and safety, risk assessments and hazardous materials.
- Applied design in furniture making: design from the shop-floor perspective, model making, design information, drawing techniques.
- Machine processes: crosscut rip-saw and band-saw, surface and panel planer, drilling, sanding, spindle moulding machines.
- Furniture finishing: sanding, timber preparation, staining and finishing methods.
- Visits to large furniture retail stores: IKEA and Harvey Norman.
- Training materials were provided to all trainees.



Figure 1: Training session for Lao trainees at Timber Training Centre, Creswick

B. Training provided to VALTIP team in Laos

- Intensive training on health and safety, laboratory testing procedures, timber standards and on the use of the laboratory equipment was provided by Dr Mihai Daian (The University of Melbourne) to the Lao researchers.
- The VALTIP Lao researchers were trained by the Australian team on industry assessment and implementation procedures in July/August 2008 and in January/February 2009 to enable them to undertake frequent technical review and advisory visits to the industry without supervision of the experienced Australian VALTIP team members (see section 5.1.3).

- Lao VATIP researchers attended various training courses which enabled them to improve their skill in wood science and technology subjects (see the list of training courses in Appendix 1).

C. Training provided to the industry

- A training workshop on “Quality Improving Techniques for Wood Products” was conducted on 29 July 2008 at the Training Centre of the Lao Furnishing Industry Association (LFIA). The workshop was attended by 35 participants including 19 participants from the furniture industry.
- “In-house” training was provided to Industry Cluster companies during the implementation visits undertaken by VALTIP team members (in May 2008, July/August 2008, January/February 2009, July 2009, November/December 2009, April/May 2010, September/October 2010). (Figure 2).
- Collaboration between the VALTIP team, the GTZ / German Development Service (DED) team and other international project teams working in Laos was developed. These partnerships resulted in exchange of training materials, assessment of training requirements and development of training courses.



Figure 2: Training provided by Khamtan Phonetip, VALTIP researcher, to the workers of the Industry Cluster Company.

5.3.3 Introduction of new technologies applicable to small dimensions plantation timbers

Although a slow pace of implementation of the recommended changes was observed while working with the Industry Cluster members, improvements in the production efficiency were reported by some companies by the adoption of recommended new factory layouts, more efficient production methods and improved product quality. Based on these observations the team decided (in February 2010) that wood bending technology could be introduced as a new skill to the Lao furniture industry before the project completion.

Steam bending equipment was built at Pakpasak Technical College which will be used to train the industry in wood bending techniques. Although the equipment was not completed early enough to provide wood bending training to the industry during the term of this project, it is envisaged that the training and implementation of this technology will be undertaken in the future by experienced teachers from the Pakpasak Technical College in assistance of the UoM team.

5.3.4 Developing new product designs using technologies suitable to small dimensions plantation timbers

The product design activities were initiated early in the project duration and were carried out in parallel with the major project research and implementation events.

Due to lack of experienced and trained furniture designers in Laos, the leading role in this important activity was assigned to Mrs Michelle Pataki, an Australian industrial designer with extensive design experience in Australia and internationally.

1. A 'Design Meeting' was held on 30 July 2008 in Vientiane with the aim to discuss the creation of the VALTIP Design Group. The meeting, led by Michelle Pataki, was attended by a few Lao designers and students from the Faculty of Architecture (NUOL). As a result a network of Lao designers "Lao Design Group" was established consisting of the following members:
 - Michelle Pataki Hyams – Chair/Designer
 - Mr Khamvouei Pakaysith – Consultant/Designer
 - Mrs Latsamy Vetsaphong – LFIA Marketing manager, MTP Decoration
 - Ms Manilay Thippalangsy – Thippalangsy Furniture Company
 - Assoc. Professor Manorot – NUOL Faculty of Architecture.
2. One of the major initiatives undertaken by the "Lao Design Group" in collaboration with the VALTIP researchers was the development of "The Furniture Design Competition". The Competition was organized with the following aims:
 - To provide an opportunity for talented students and professional designers in Laos to be involved in an international project.
 - To provide the VALTIP Industry Cluster members with inventive product designs.
 - To facilitate a partnership between designers and furniture companies.

Two entry categories were defined: the students' category and the professionals' category. One of the conditions of entry into the competition was that the design should reflect Lao style and the main material used would be small dimension plantation timbers. The competition was launched on 9 April 2009 by the National University of Laos and was widely advertised by the VALTIP Lao team both locally and nationally. Posters of the Design Competition were also distributed at the Lao "Furniture Fair" in June 2009. The submitted designs were assessed by a jury consisting of the members of the "Lao Design Group". The winners were announced and awarded at the Design Awards Presentation on 27 Jan 2010. The designs were made available to all members of the Industry Cluster with encouragement for the development of prototypes.

3. A set of new designs was developed with detailed drawings of components and innovative joining systems. A report was written: Hyams, M. 2009. *Sketches and detailed drawings of new products' designs for the companies of the Lao Industry Cluster*. (Report No 19).

Some of the proposed designs have been already used by Bourapha Company for the development of prototypes.

5.4 Objective 3: Developing appropriate quality control procedures for timber and furniture industries

5.4.1 Development of detailed Industry Manuals describing timber processing, drying and manufacturing procedures

An extensive library on wood science and technology was established at NUOL.

Manuals, sets of specifications and standards were compiled related to a wide range of timber processing and manufacturing topics. A video on furniture manufacturing was developed for training and teaching purposes. The topics covered were: how to make furniture components, wood machining, wood surface preparation, spraying techniques, gluing, etc.

In addition, a video on safety in wood products industry, developed by the Furniture Industry Association of Australia (FIAA) for the Australian industry, was provided to the Lao companies (permission was given by FIAA).

Teaching materials for undergraduate and postgraduate students at the Faculty of Forestry, NUOL, were provided to lecturers in wood science and technology. These materials consisted of:

- a series of PowerPoint presentations covering all aspects of wood science, wood processing and manufacturing, timber engineering, environmental properties of timber and timber products, wood quality and product design.
- Books and handbooks purchased specifically for NUOL library.
- Sets of scientific publications on various wood related topics.

Extensive reference materials are now accessible at the University Library to students, researchers and the industry.

Formal launching of the training materials was done at the Final Project Workshop held on 18 January 2011 at NUOL, Vientiane.

Selected manuals and publications were translated into the Lao language by the Lao VALTIP team.

5.4.2 Development of quality control methods for assessment of various production stages and for the final products

A set of quality control packages for the assessment of quality of production and final products was compiled by the Australian team in collaboration with DED team working at the Lao Furniture Industry Association Training Centre. The documents included standards, specifications, testing methods, quality control criteria and requirements.

Extensive training was provided to the VALTIP Lao team members on standard testing methods, product quality and performance evaluation procedures applicable to Lao timber and furniture industries.

The Wood Testing Laboratory at the Faculty of Forestry, NUOL, was established, which is well equipped to carry out testing and assessment of quality of raw materials, components, joints and the final products.

5.4.3 Supervision of production methods used by the companies involved in the Industry Cluster

This activity is closely related to the previous activities which were described in details in the Sections 5.1.3 and 5.3.2.

In summary, extensive training on the industry assessment and implementation procedures was provided to researchers from NUOL to enable them to undertake frequent visits to the companies of the Industry Cluster without supervision by the experienced Australian team. The independent visits were carried out every 4-5 months and the results were documented in reports which were then assessed by the Australian team. Feedback on each report was given to the Lao team.

The final visits to all Industry Cluster members were undertaken by the VALTIP team (Australian and Lao members) on 19-23 January 2011 to discuss the project benefits and future needs. During the visits, several improvements and modifications were observed in the production methods and product quality.

6 Achievements against activities and outputs/milestones

Objective 1: To improve timber recoveries through application of enhanced but appropriate processing, drying and manufacturing methods

no.	activity	outputs/ milestones	completion date	comments
1.1	Formation of an 'Industry Cluster' of interested sawmills and furniture factories.	A network of companies working together to improve the industry.	Yr1: m1-2 (Feb 2007)	Based on the selection criteria developed by the Project Steering Committee "The Industry Cluster", consisting of 9 furniture companies and 1 sawmill was formed. The companies were actively participating in the project's on-going activities.
1.2	Detailed analysis of the current capabilities of participating companies and identification of relevant strengths, weaknesses, opportunities and threats for timber and furniture industries in Laos.	<ul style="list-style-type: none"> • Current industry capabilities assessed and described. • Gaps & weaknesses itemised and evaluated. • Opportunities for improvement identified and accepted by industry. • Properties of young plantation timbers documented. 	<p>Y1: m4 (April 2007)</p> <p>Y1: m4 (April 2007)</p> <p>Y1: m5-7 (July 2007)</p> <p>Y1: m8-9 (Sept 2007)</p>	<p>A detailed analysis of the current capabilities of the companies involved in the Industry Cluster was completed and documented. This allowed the identification of relevant strengths, weaknesses, opportunities and threats for the timber and furniture industry in Laos.</p> <p>The report was completed</p> <p>" Detailed Analysis of the Current Capabilities of Companies Involved in the Industry Cluster and Recommendations on Improved Processing, Drying and Manufacturing Processes Suitable for Application in Laos" (148 pages).</p> <p>The assessment of current capabilities of the Industry Cluster companies revealed that the production methods and product development procedures needed to be significantly improved as they did not follow any standards or specifications regarding OH&S, quality and performance. A set of recommendations for improvements and changes in the production methods and products quality were developed for each company and for the industry as the whole.</p> <p>Assessment of properties and processing characteristics of young plantation Lao teak and <i>Eucalyptus camaldulensis</i> was completed at the Wood Technology Laboratory at the University of Melbourne. The testing included density, stability (unit shrinkage), bending strength (Modulus of Rupture) and stiffness (Modulus of Elasticity) as well the development of optimal drying schedules</p>

1.3	Development of recommendations on improved processing, drying and manufacturing processes suitable for application in Laos.	A set of recommendations and analyses for technical, educational and training improvement for various industry groups, in use by industry participants.	Y1: m12 (Dec2007)	<p>The results of the assessment undertaken within the Activity 1.2 formed the basis for the development of recommendations on improved processing, drying and manufacturing processes applicable in Laos. These included:</p> <ul style="list-style-type: none"> - Production methods: efficient sawing of timber, drying, machining, gluing, joining, finishing and assembly into final products, as well as occupational health and safety procedures. - Improved infrastructure which is vital to the industry in order for it to meet the recommendations (purchasing new machinery, equipment, tools). - Provision of technical skills and training. - An efficient and optimal supply chain system designed specifically for the Laos forestry and timber industries. <p>The results of the Activity 1.2 and 1.3 were presented in the detailed report (see Activity 1.2 above).</p> <p>The results of the industry assessment and the proposed recommendations for improvements were presented at the workshop organised in February 2008 in Vientiane. The workshop involved the members of the Industry Cluster, all participants of the project and relevant government representatives. The proposed recommendations were openly discussed at the workshop and approved for the implementation.</p>
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Objective 2: To broaden product design options by testing and adapting new technologies.

no.	activity	outputs/ milestones	completion date	Comments
2.1	Identifying new technologies, e.g. for bending and joining, that could potentially be introduced to the Lao industry for use with small dimension plantation timbers	New technologies and production methods utilising small dimensions timbers, in use by industry participants	Y2: m4-6 (May 2008)	<p>The results of the activities 1.2 and 1.3 revealed that the companies were not ready for adoption of new technologies and production methods.</p> <p>The course of implementation of the recommended changes and improvements confirmed that the process will take much longer than it was originally envisaged. It was recognised that a great effort was required to assist the industry to improve its domestic production with a view to being more efficient and raising employee skills.</p> <p>Therefore the focus was placed on the implementation of the recommended changes and improvements in the Industry Cluster companies.</p> <p>Recommendations for improvements, changes and new production methods were developed for each individual company and presented to the company's managers during the visits in January-February 2009.</p> <p>A training workshop "Quality Improving Techniques for Wood Products" was held at the Lao Furniture Association.</p> <p>Regular visits to each company were made by the VALTIP team (Laos and Australian researchers) during the implementation process.</p> <p>Improvements in the production efficiency were made by some Industry Cluster members due to the adoption of recommended new factory layouts, better sanding methods, more efficient drying systems which decreased timber degrade and distortion and improved utilisation of waste timber.</p> <p>Wood bending technology, new to the Lao furniture industry, was selected as an appropriate technology to be introduced to the Lao furniture industry. Steam bending equipment was built at Pakpasak Technical College which will be used to train the industry in wood bending techniques.</p> <p>Wood bending is considered as one of the most efficient wood value-adding technologies which can be easily adopted by furniture industry if strict quality control procedures are followed.</p>

2.2	With the networked participants, developing appropriate new product designs using these technologies	Range of new designs and products, in use by industry participants	Y3-4 on-going (Apr 2009 and on-going)	<p>Current product designs were assessed and new opportunities identified.</p> <p>A network of Lao designers "Lao Design Group" was formed. A set of new designs was developed with detailed drawings of components and innovative joining systems. A report was completed: Hyams, M. 2009. <i>Sketches and detailed drawings of new products' designs for the companies of the Lao Industry Cluster.</i></p> <p>"The Furniture Design Competition" was organized with the aim to provide an opportunity for talented students and professional designers in Laos and to provide the VALTIP Industry Cluster members with inventive product designs. The winners were announced and awarded at the Design Awards Presentation on 27 Jan 2010. The designs were offered to the Industry Cluster members for development of prototypes.</p> <p>A set of design was developed for the industry use. Several prototypes are now being developed by Burapha Company based on the project designs.</p>
2.3	Providing training on processing and manufacturing methods, including OHS issues, to NUOL staff, and relevant industry staff and factory workers, tailored appropriately to each group	<ul style="list-style-type: none"> • Relevant training programs and materials for NUOL and industry personnel, in use by the relevant organisations. • Linkages between training organisations and industry well established, and functioning to improve standards. • Improved teaching and training capabilities, and higher level of skills among industry workers. 	<p>Y2: m1 (Jan 2008)</p> <p>Y2: m2 (Feb 2008)</p> <p>Y4: m12. (Dec 2010)</p>	<p>The training program was developed. Intensive training in Australia was provided for 12 representatives of participating organisations. The training was undertaken in wood processing (Timber Training Centre, Creswick) and in furniture manufacturing (Victorian Furnishing Industry Training Centre, Melbourne). Training workshop on quality improving techniques for wood products was conducted on 29 July 2008 at the Training Centre of the Lao Furnishing Industry Assoc (LFIA) by the project team. The workshop was very well attended and well received.</p> <p>Collaboration with other international projects in Laos providing training to timber and furniture industries (GTZ, DED) was established. The partnership between the projects focused on the exchange of information, training materials and the development of training courses.</p> <p>An extensive training on the industry assessment and implementation procedures was provided to the researchers from the National University of Laos (members of the VALTIP team) to allow them to undertake frequent visits to the companies of the Industry Cluster without a supervision of the experienced Australian team.</p> <p>Frequent visits and training meetings by the team were undertaken to each member of the Industry Cluster and reports written on each visit.</p>

Objective 3: To develop appropriate quality control procedures for timber and furniture industries.

no.	activity	outputs/ milestones	completion date	comments
3.1	Development of detailed Industry Manuals describing timber processing, drying and manufacturing procedures.	Set of Manuals for the Lao timber and furniture industries, in use by industry participants.	Y2: m12 (Dec 2008)	<p>This Milestone has significant achievements and outputs.</p> <p>An extensive library and teaching materials on wood science and technology was established at NUOL and Pakpasak Technical College.</p> <p>Manuals, sets of specifications, and standards were compiled. A video on furniture manufacturing was developed for training and teaching purposes.</p> <p>The reference materials are now accessible at the University Library to students, researchers and the industry. It should be pointed out that prior to the ACIAR project commencement there were no reference materials on wood science and technology available at the Library at all.</p> <p>The manuals and other documents have been translated into the Lao language by the Lao VALTIP team.</p>
3.2	Development of quality control methods for assessment of various production stages and for the final products.	Set of quality control packages for the assessment of quality of production and final products, in use by industry participants.	Y3: m1-2 (Feb 2009)	<p>A set of quality control procedures was compiled by the Australian team in collaboration with DED team working at the Lao Furniture Industry Association Training Centre. The implementation process was carried out mainly by Lao VALTIP team under supervision of the Australian team.</p> <p>Extensive training on the industry assessment and implementation procedures was provided to the researchers from the National University of Laos (members of the VALTIP team) so that they could undertake frequent visits to the companies of the Industry Cluster without a supervision of the experienced Australian team. Five independent visits (without the Australian team) were undertaken by the Lao team assisted by two Lao experts in wood machining.</p>
3.3	Supervision of production methods used by the companies involved in the Industry Cluster.	On-going industry culture of high quality production and high quality products.	Y2: m7-12 (Dec 2008)	<p>An important accomplishment of the project has been the establishment of the WoodTech Laboratory at the Faculty of Forestry, National University of Laos, which is well equipped with major equipment and testing facilities in the field of wood science and technology. The laboratory is already used for research purposes and for teaching undergraduate and postgraduate students in wood utilisation courses. Intensive training on health and safety, laboratory testing procedures, timber standards and on the use of the laboratory equipment was provided to the Lao researchers.</p>

7 Key results and discussion

7.1 Objective 1: To improve timber recoveries through application of enhanced but appropriate processing, drying and manufacturing methods

7.1.1 Assessment of the current capabilities of the companies involved in the Industry Cluster.

An in depth assessment of the current capabilities of the companies involved in the Industry Cluster was conducted in 2007 which resulted in the development of recommendations on improved processing, drying and manufacturing processes, as well as the identification of relevant strengths, weaknesses, opportunities and threats for the timber and furniture industry in Laos. The assessment revealed that the industry needed immediate assistance to improve its domestic production with a view to being more efficient and raising employee skills.

The details of the assessment were published in the Project Report No 1. The major conclusions of the assessment are summarised below:

- All the assessed companies were using plantation species of various ages, different dimensions and wood quality. The predominant species was teak (*Tectona grandis*), followed by *Acacia magnum*, rosewood (*Dalbergia cochinchinensis* and *Pterocarpus macrocarpus*) and *Eucalyptus camaldulensis*.
- The study revealed that there were no grading rules for lumber available in Laos. There was also lack of tolerances for various timber dimensions.
- The majority of the companies purchased timber as fitches (squares) from various sawmills. Sawn timber was not properly stored for air or kiln drying, which resulted in end splitting of timber and its distortion.
- Only three of the nine companies had kiln drying facilities, with only one of these facilities considered to be an effective production kiln (i.e. The Burapha Group). The two remaining facilities consisted of an in-house designed prototype.
- It was observed that the product development procedures did not follow any standards or specifications regarding product design, quality and performance. Although some products were innovative and well designed, their quality should be improved in order to compete in international markets.
- The production processes in the majority of the assessed companies were not properly designed and managed, with a low productivity level which resulted in low production efficiency.
- Many woodworking machines were old; there was no production flow, as various machining operations were not linked together into one production system. In particular, there was too much wood stored in the production areas of the factories, which significantly limited the space available for machining operations (Figures 3 & 4).

- It was apparent that, there was a lack of skill in the management and organisation of timber production processes. Occupational, health and safety conditions in the factories were very poor (Figure 5). It was evident that the companies urgently needed capital to improve their machinery. Advice was also required on the types of machines needed for various operations, and on proper set up parameters and efficient use of the machinery.
- Gluing of timber components did not follow standard gluing requirements. There was a lack of knowledge on the types of glues to be used for various applications, the importance of timber preparation prior to gluing, and gluing parameters.
- It was observed that the quality of coated surfaces was very poor. There was no proper industrial equipment used for finishing, with the hand brushing method being most commonly applied.
- Many companies were using carved components in their products, with attractive traditional patterns and motifs. This skill and talent should be considered as a great advantage and opportunity for Lao products, as it could be used as a promotional tool for unique designs of “Lao style” which would be difficult to copy.
- Poor wood waste management practices were observed in the majority of the assessed companies. The waste wood was not segregated into boards of different sizes and qualities, but was usually randomly stored in piles all around the factory.
- The majority of companies did not provide any training to their workers. Training was usually provided in-house by more experienced workers.
- The main issues raised by the Industry Cluster members regarding the forest product supply chain were related to the availability of transportation infrastructure and its cost, as well as the quality of raw materials supplied and/or the lack of sourcing raw materials at all.
- The assessed companies provided valuable comments on the current problems and most urgent issues faced by the Lao timber and furniture industries. The most important issues identified were:
 - The Government introduced a new law which did not allow export of raw logs from Laos, but the industry did not have expertise to handle these logs in wood processing and manufacturing.
 - Financial support should be provided to companies by the Government for production improvements.
 - Training was urgently needed in design, production management and proper use of machinery to improve efficiency, product quality and marketing.
 - Support for developing export markets in the neighbouring countries would be a great benefit to the industry.
- The companies stated that technical advice and help were urgently needed in the area of design, quality, productivity and machinery. In particular, the following issues were identified as the priorities:
 - Advice on kiln drying,
 - Information and advice about machinery,

- How to manage the factory and organise the production process to obtain efficient production at low cost,
- Advice on how to improve the quality of wood products,
- Support and guidance on how to access international markets.

All members of the Industry Cluster supported the ACIAR project activities with great enthusiasm, and stated that, in their opinion, the most valuable project benefit for the industry would be advice on *“How to be better and more efficient”*.



Figure 3: Examples of poorly organised production processes



Figure 4: Examples of wood waste in furniture factories



Figure 5: Examples of dangerous working conditions in factories.

7.1.2 Recommendations on the industry improvement and development

The results of the industry assessment formed the basis for the development of recommendations on the improvements of the industry capabilities. These included:

- Production methods and improved infrastructure;
- Technical skills and training required by the industry;
- An efficient and optimal supply chain system adequate to the Laos' forestry and timber industries.

Summary recommendations for improvements and changes required to make the Lao industry competitive on international markets are provided below:

Production methods and improved infrastructure:

- Development and implementation of timber grading rules for timber.
- Introduction of proper wood-drying methods and drying procedures to the industry.
- Improving the quality of surface finish of wood products to meet the requirements of the international markets.
- Investing in some good but basic machinery to improve the production efficiency.
- Investigating financial support options including international aid and low interest rate loans, to allow companies to improve their production facilities.
- Implementation of the Operational Health & Safety measures and procedures in sawmills and furniture companies.
- Development of a range of products utilising small dimensions plantation timbers for export markets.
- Development of production quality control procedures and product performance requirements.
- Providing the Lao industry with a range of operating manuals for the use of equipment, furniture manufacturing processes and furniture factory management (inclusive of basic furniture design, safety processes, and basic standards).

Improving technical skills and training required by the industry, in particular in the following areas:

- Wood drying and wood moisture content requirements.
- Wood machining, gluing, jointing and finishing.
- Product design and the concept of high quality products.
- Optimising the factory layouts and improving production efficiency.
- Operational Health & Safety procedures and requirements.
- Relationship between Pakpasak Technical College and the Lao Furniture Association Training Centre should be improved and an appropriate training program should be developed for the Lao furniture industry utilising both training centres.

Improving supply chain system:

- Government support is required to improve currently disjointed and inefficient supply chain system (e.g. timber quotas, transport cost, high interest rate for loans, high taxes).
- Government should provide assistance in marketing of Lao wood products.
- Development of specialisation and networking between companies should be considered.
- Government should provide assistance in marketing of Lao wood products.

7.1.3 Implementation of recommended improvements and changes

The implementation process aimed to assist the Industry Cluster companies to adopt the recommended improvements and changes in their production methods and products quality.

Each company was considered on individual basis according to its needs, current capability, financial restraints 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.

Each company was provided with a detailed report which included a set of documents:

- Drawings of optimal factory layouts with suggestions how to reorganise the current production flow by changing locations of various machinery, introducing a transport system between machining operations, etc.
- Suggestions for improvements in the manufacturing process and development of more efficient production management, drying methods, joining techniques, products design and quality.
- Set of new designs developed by the project industrial designer, Michelle Pataki, with detailed drawings of components and innovative joining systems. The companies were encouraged to develop prototypes of the designs.

Frequent follow up visits to each company involved in the Industry Cluster were made by the VALTIP team. During the visits the team members were checking if any of the recommended improvements have 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 OH&S. Advice on further improvements was also provided (Figure 6).



Figure 6: VALTIP researchers assessing production methods during implementation visits.

It is envisaged that there were two-fold benefits of the implementation activity:

- An intensive implementation program tailored for each individual company of the Industry Cluster ensured that most effective methods were used to improve the efficiency of the production, product quality and safety of the factory workers. Working with each company on individual basis allowed developing an open relationship between the company managers/owners/workers and the VALTIP 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 continuous basis to underpin the development of efficient and high quality production processes.
- Implementation visits were an excellent learning exercise for young researchers from the National University of Laos. The training provided to them and the experience they gained during the assessment and implementation visits will allow them to undertake similar visits in the future without further assistance of external experts.

The level of adoption of recommended improvements and changes varied among various Industry Cluster members. Some companies only made small improvements while others made considerable improvements in the production efficiency, waste management and product quality.

In particular, a significant increase, up to 50%, in the production throughput for some furniture items was reported by Mr Lorvanxay, the owner of Viengniyom Furniture Company. This was as a result of the adoption of recommended new factory layouts,

segregation of wood wastes according to different quality and dimensions, as well as efficient transportation of material and components around the factory (Figure 7).



Figure 7: Improvements in wood waste management through segregation of timber into sizes and proper storage conditions.

Other companies have also reported improvements in their factories through adopting new factory layouts, improved manufacturing procedures and better utilisation of waste timber (Figure 8).



Figure 8: Well arranged factory layout.

Significant improvements were observed in almost all companies in OH&S practices. Posters on safety requirements were developed by VALTIP team and distributed to each company. The posters aimed to make the factory workers aware of the importance of wearing ear plugs, safety glasses, head protection, shoes, no smoking in the factory as well as precaution while operating woodworking machinery. Trolleys were introduced for moving material between various production stages around the factory. Benches and tables were provided for the workers to stop them working on the ground (Figure 9).



Figure 9: Improvement in OH&S procedures in factories

Strong commitments from the Industry Cluster members and willingness to make improvements have been pleasing indicators that the companies have valued the project's assistance.

7.1.4 Assessment of properties and processing characteristics of plantation grown teak and eucalyptus camaldulensis

Currently, plantation timbers are being processed for furniture mainly for domestic use, with a limited amount of products being exported. The reason is that the products do not meet quality criteria for international markets mainly due to a lack of data and information on wood properties and processing characteristics.

Teak is considered as one of the most valuable timbers suitable for the production of high value wood products (e.g. furniture), due to its superior properties and processing characteristics, in particular, low dimensional movement in changing environmental conditions (very good dimensional stability) and relatively good processing characteristics (easy to dry, machine and glue). This species is being planted in many countries around the world. In Laos, in order to ensure sustainable supply of teak for wood processing industry, teak plantation has been increased rapidly with total area of 15,000 ha.

Several types of Eucalyptus have been grown in Laos during the last 40 years. Eucalyptus plantation are expected to be increased to 100 000 ha by the year 2012.

The knowledge of properties and processing characteristics of the plantation timbers is very important in order to determine their optimum uses for specific products and various service conditions.

The evaluation of timber dimensional stability, bending strength and stiffness for Lao plantation teak and *Eucalyptus camaldulensis* was undertaken within the project. The results of the testing have been presented in the Project Report No 10.

The results are summarised below:

Teak:

- a) Dimensional stability (reduction in dimensions from the initial Moisture Content (MC) to 12% Equilibrium Moisture Content (EMC):
 - in longitudinal direction: 0.27%
 - in radial direction: 1.97%

- in tangential direction : 2.76%.
- b) Modulus of Rupture (MOR) = 116.45 MPa
- c) Modulus of Elasticity (MOE) = 13.89 GPa.

Eucalyptus camaldulensis:

- a) Dimensional stability:
 - in longitudinal direction: 0.16%
 - in radial direction: 2.01%
 - in tangential direction : 2.83%.
- b) MOR and MOE yet to be determined.

Although the mean values of bending strength and stiffness of young plantation timbers were relatively high, high coefficients of variations for these properties were obtained for these properties. This result is consistent with the results of previous studies on testing physical and mechanical properties of young plantation timbers (Ozarska *et al.* 1998, Ozarska 2009). Therefore, a caution should be taken when designing structural components of furniture (e.g., chair legs, sofa frame) using young plantation timbers due to a high variability of their engineering properties. It is recommended that larger sizes of furniture components be used from young plantation timbers in comparison with old-growth wood from the same species to minimize any possible failure caused by a low strength or stiffness value of timber used in one or several structural components of a piece of furniture.

The data on properties of young plantation teak and eucalyptus grown in Laos provides valuable scientific and technical information which will support the development of well designed, high quality wood products made from young plantation timbers which will be the major timber sources for Lao furniture industry in the future.

Development of drying schedules

The utilization of young plantation timber resources for high value wood products requires the development of optimal drying schedules. Proper drying which minimises drying defects in timber is the vital factor in determining the final or finished quality of the product, as non-uniform moisture constant or drying degrade will detrimentally effect machining, gluing and stability.

Although teak is known as a relatively easy timber to dry, eucalypts are generally noted for their problems during drying. In addition, it takes up to the 12 months to dry the timbers using a combination of air drying and kiln drying methods. The most common defects in eucalyptus timbers are checking (internal and surface) and collapse. *Eucalyptus camaldulensis* is particularly susceptible to collapse; therefore it is essential to control the drying process in the initial phases of drying.

Drying schedules for young plantation teak and *Eucalyptus camaldulensis* were developed within the project and the results have been presented in the project interim reports (Reports No 12 and 13).

The following drying schedules were found to provide best results with the majority of boards exhibiting no collapse or surface checking:

Teak:

Dry bulb temperature (°C) /relative humidity (%):

- 35°/63% (for 100mm wide boards). Drying time = 29 days.
- 60°/82% and 60°/75% (150mm wide boards). Drying time = 29 days.

Eucalyptus camaldulensis (100mm wide boards):

Three stages of drying are required as follows:

- 45°/87% - 7 days
- 45°/85% - 18 days
- 45°/80% - 35 days (until 12% MC)

Total drying time = 60 days.

7.1.5 Wood properties assessment of teak (*Tectona grandis*) plantation at different ages grown in Lao PDR (Laos)

Teak is being used in Laos' wood processing and manufacturing industries at different ages of plantation trees, varying from 9 to 35 years old. An important question, which has not yet been answered by any research study, is what is the optimal age of teak trees to be used for high quality products? This information would ensure that the highest productivity of the timber is achieved during its processing and manufacturing for specific products.

In order to answer the above question, a research study was developed within this project aiming to assess selected wood properties of teak plantations at different ages of rotation, in Luangprabang Province. The study is carried out by Mr Phongxiong Wanneng as his Masters thesis at the University of Melbourne. The study will:

- Provide valuable data and information on physical and mechanical properties of teak at different ages of plantation: 10, 15, 20, and 25 years old.
- Enable to determine optimal age of teak trees for various components, products and applications.

To date results have shown that both the physical and mechanical properties of teak plantation wood were not significantly different between different age groups. In particular, the analysis revealed that the properties of 25 years old teak were lower than the properties of timbers of younger age groups. This unpredicted outcome is being further investigated to determine which variables could contribute to this result. According to the literature review, various factors may affect wood properties of plantation timbers, such as the location of plantation site, exposure to wind, rainfall, high or low elevation, trees growing on a hill or on a valley, climate, etc.

During the sample preparation, it was observed that the 25 years old teak sample trees had a high level of decay in the heartwood section which could affect the properties of the timber.

7.2 Objective 2: To broaden product design options by testing and adapting new technologies.

7.2.1 Introducing new technologies for use with small dimension plantation timbers

The assessment of the industry capability conducted in Year 1 of the project duration revealed that “*The industry needs immediate assistance to improve its domestic production with a view to being more efficient and raising employee skills*”. It was concluded that once the companies exhibit proficiency in basic manufacturing procedures and improved quality of products, they can consider implementing new technologies, products and designs.

Wood bending technology was selected as most suitable for the Lao furniture industry because it is one of the most efficient wood value-adding methods, particularly suitable for bending small dimensions components from plantation timbers (Figure 10). Wood bending, as a means of producing curved parts in timber construction, has many advantages over other methods of manufacture, but the main advantage is increased strength and recovery of timber. Up to 100% higher yield can be gained compared to the traditional techniques used in shaping wood. This higher yield, combined with a remarkable higher quality and durability of the finished product, leads to lower production costs and an improved cost benefit to the industry.

As explained in Sections 5.3.3 and Chapter 6, the timeline of the Activity 2.2 aiming to identify new technologies for the Lao companies was postponed to Year 4 to allow enough time for the VALTIP team to work with each individual company on improvements in the current production methods and quality of the final products.

Although the construction of the equipment was not finished on time it is envisaged that the training on wood bending techniques to Pakpasak Technical College staff will be provided by the Australian researchers on a voluntary basis or it will be undertaken as one of the activities of the new ACIAR project being currently developed.



Figure 10: Wood bending rig under construction at Pakpasak Technical College

7.2.2 Development of new designs

The key focus of this activity was on assisting the industry to better utilise and value-add to smaller dimension plantation-grown timber.

The initiative to form the “Lao Design Group” revealed that there was a lack of professional designers who could assist the furniture industry in designing innovative and cost effective products for export markets. A few designers who were working with furniture companies did not have any formal design qualifications but gained their design experience through “self-learning” and practical experience.

There was a lack of any formal furniture design training courses in Laos which created problems for the industry which was keen to develop and produce new products for international markets.

The key factors which determine the success of products on international highly competitive markets are innovative unique product designs of high quality and competitive price. It was apparent that there was an urgent need for developing training in furniture design at various levels of competencies in Laos: such as short-term training courses, diploma and advanced diploma training courses and higher education design degree at the university level. This matter was discussed with the Minister for Industry and Commerce, Lao PDR, the Dean of Architecture (NUOL), the Director of Pakpasak Technical College and the President of Lao Furniture Industry Association.

It is believed that the recommendations for the development of design courses are being seriously considered by the government and the industry stakeholders.

It appears that the Faculty of Architecture would be a good future provider of design courses for timber and furniture industries as it already had well established facilities and experienced lecturers in CAD design and drawings, industrial design, product development, etc.

Several design activities were undertaken by the Project team. The formation of the “Lao Design Group” facilitated the development of network of the current “designers” who could represent the industry in the future dialogue with the government regarding the establishment of formal training in furniture design.

A “Furniture Design Competition”, initiated by the Lao Design Group, aimed at providing an opportunity for talented students and professional designers in Laos, and to provide the Industry Cluster members with inventive local product designs. The submitted designs were assessed by a judging panel consisting of the members of the Lao Design Group. The winners were announced and awarded at the Design Awards Presentation on 27 January 2010 which was widely attended by the Industry Cluster members, representatives from the Lao government, university and training organisations (Figure 11). The major benefit from this initiative was the development of linkages between the designers and the Industry Cluster members as well as providing the companies with several designs which could be freely used for the development of prototypes.



Figure 11: Presentation of awards to the winners of the “Furniture Design Competition’.

A series of product designs utilising small dimension components were developed during the project (Report No19). These were given to each member of the Industry Cluster with encouragement to produce the product prototypes. The designs were particularly relevant to the Burapha Agroforestry Co. Ltd as this company focuses on the use of small dimension components.

To further assist the Industry Cluster members in understanding the importance of the product design, product market assessment and marketing issues, a report *“The link between product design/development and product market assessment and marketing: A case for the Furniture Industry/Products”* was prepared by Dr Mihai Daian. (Report No 11).

The project team recognized that assistance in market research and product marketing should be provided to the Lao furniture industry and this recommendation was communicated to the government.

7.3 Objective 3: Developing appropriate quality control procedures for timber and furniture industries

An important achievement of the project has been the establishment the “State of the Art” Wood Technology (WoodTech) Laboratory at the Faculty of Forestry, National University of Laos.

The laboratory is now well equipped with essential testing equipment and measuring instruments in the field of wood science and technology, such as testing wood properties, wood processing characteristics, wood drying, product quality and performance (Figure 12). The laboratory is already used for teaching undergraduate and postgraduate students in wood utilisation courses, for research projects as well as for providing training and consultancy services to the wood-related industry.

Research and testing equipment includes:

- Instron Universal Testing machine (50kN capacity) which can be used for testing mechanical properties of timber, wood based materials, strength of timber joints and components. The testing machine is being already used for teaching and research on strength properties of timber.

- A new Wood Drying Kiln which was purposely designed and constructed in Vietnam for research, education and training on wood drying. The chamber has a capacity to dry 1-2 m³ of timber with automatic temperature and humidity control. The kiln will have a huge value to the University and to the industry as it will enable the development of drying schedules for plantation and lesser known timbers. The kiln has already created a lot of interest within the timber and furniture companies as it is seen as a prototype which could be used for training.
- Environmental chamber for testing the dimensional stability of Lao timbers, the assessment of the performance of glues and wood products and components in a wide range of climatic conditions. This work will be particularly important for the Lao timber companies wishing to export their products to various countries to ensure that the products will not deteriorate due to extreme climates.
- Measuring instruments (callipers), balance, drying oven.
- Moisture meters, humidity and temperature sensors and data loggers.

Extensive training was provided to the VALTIP Lao team members on the use of the laboratory testing equipment, standard testing methods, product quality and performance evaluation procedures applicable to Lao timber and furniture industries.



Figure 12: Wood testing machine “Instron” and laboratory wood drying kiln.

A library on wood science and technology was established at NUOL which is now widely available to students and industry members. The library’s catalogue includes books, manuals, publications and standards related to a wide range of topics covering all aspects of timber processing and manufacturing. In particular, reference materials on the assessment of quality of production and final products were compiled, including international standards and specifications. In addition, a set of high quality teaching materials in wood science and technology for undergraduate and postgraduate students were provided to the Faculty of Forestry, NUOL.

10 people (NUOL staff, training instructors and several members of the industry) received advanced training in Australia and Laos. In addition, training on various wood value-adding topics was provided to about 60 people in Laos (research and industry participants) during the project term. It is expected that these people will share their knowledge to students and workers in the Lao wood processing industry in the future.

7.4 Other related results and achievements

7.4.1 Effects of downstream timber processing policy on market and trade in Laos

A PhD study “Effects of Downstream timber processing policy on market and trade in Laos” was carried out from February 2008 to February 2011 at the University of Melbourne by Mr Kaisone Phengsopha, a researcher from the Faculty of Forestry, National University of Laos.

The study analysed the economic impact of the downstream timber processing policy on the Lao forest sector. It used historical market data and a global forest product model (GFPM) to simulate the Lao timber market and trade from 2007 to 2020 for different government policy interventions. The GFPM model was modified into a spatial partial equilibrium forest model, Lao Forest Product Model (LaoFPM), in order to determine the levels of consumption, production, price of each commodity in Laos, and the trade flow between 2007 and 2020. This determination was crucial to design a long term development plan of the forest sector in Laos.

Simulation results suggested that restrictions on log and sawnwood exports would not have a significant effect on the forest sectors of Lao’s main timber trading partners. However, it would severely affect the Lao timber sector. The country would face a significant decrease in timber prices due to increased availability of domestic supply. Average prices of logs and sawnwood would be about 10-20% lower compared to the situation without the measure. Although Lao consumers would benefit from a welfare gain of about 11%, the restrictions would penalize timber producers severely, resulting in a decline in welfare in the sector of about 24%. In addition, Laos would lose about US\$76.66 million annually in income from the forest sector between 2007 and 2020.

These results also indicated that the current policy scheme to promote downstream timber processing (DTP) and export of processed timbers would not significantly offset the country’s loss from trade restrictions. Given the results of a restriction scenario as the basis of a comparison, the promotion policy would lower the prices of all timbers in Laos by about 1-5%. Export of plywood would increase dramatically by about 33%, but exports of other finished timbers would increase only slightly. In terms of welfare of the forest sector, Laos would gain only about 1.3% in welfare or a few US\$ million added to its economy. This implied that the country would still suffer from an economic welfare loss of about US\$73.56 million even if the Government were to provide full incentives for the improvement of the DTP industry and allow export of finished products without duty. Instead of restricting exports of logs and sawnwood, an alternative policy that involves increasing duties on these commodities while retaining incentives to support development of DTP is likely to be a more efficient approach to maximize economic benefits from the sector while reducing timber production to sustainable levels (Phengsopha 2011, PhD Thesis).

7.4.2 Forest and plantation development in Laos: history, development and impact for rural communities

A PhD thesis “Forest plantation development, poverty and inequality in Laos: a Dynamic CGE Microsimulation Analysis” is being carried out at the University of Melbourne by Mr Somvang Phimmavong, a researcher from the Faculty of Forestry, National University of Laos under an ACIAR John Allwright Scholarship. The preliminary results of the study are summarised below: (Phimmavong 2011 – draft thesis in preparation)

A dynamic general equilibrium model was used to examine the economy-wide impact of forest plantation development in Laos. Analysis was focused on the Government of Laos' forest policies involving the doubling of the 2003 forest cover by the year 2020.

Preliminary results showed that the forestry policy was likely to contribute a small but positive impact on the Lao economy by increasing the productivities of forestry and forestry related sectors and by stimulating the aggregate values of foreign trade, household consumption as well as domestic supply and absorption.

This thesis also set out a macro-micro economic framework by connecting the dynamic Lao CGE model to a Lao household micro-simulation model. This technique will be then used to assess the plantation impact at the household level. Preliminary simulation results revealed that the establishment of forest plantation (2003-2004) was likely to improve the national economic welfare, especially by creating wealth for rural communities, and different Lao ethnic minorities. Real expenditure per person, which was used as the welfare indicator or "change in mean expenditure per capita", was likely to increase for all types of individuals, and it showed differences across two different urban groups of Laos. For instance, rural individuals, who represent more than 70% of the total Lao population, would tend to have a higher growth in real expenditure per capita (1.9%), compared to those living in urban areas (1.7%). Looking across different regions of Laos, the households in Northern Laos were simulated to have a higher positive welfare gain than the rest of the region. The households in the Vientiane capital could enjoy the positive growth of almost 1.6%, whilst those who live in the Central and Southern Laos would benefit from the positive growth of 1.8% and 1.7% respectively. The effects were also projected to be different for various ethnics groups. For instance, the highest change in real expenditure per person was found in Chine-Tibet ethnic groups. This can be explained by the fact that these ethnics groups which are predominant in Northern Laos, work mainly on rubber plantations. Some of these ethnic groups, who emigrated or have relatives in China obtained financial and technical support from Chinese tree cultivators. From the analysis, it was also clearly shown that the incidence of poverty in Laos has also declined for all types of individuals or households. For instance, the rural population (-1.5%) would witness a fairly higher reduction in poverty than those living in urban areas (-0.4%). At the regional level, the poverty headcount was likely to decline more rapidly for the Southern Laos (-1.8%), compared to the rest of the region, i.e. Vientiane (-0.25%), Central Laos (-1.3%), and North Laos (-1.2%).

As part of his PhD study Mr Phimmavong in collaboration with his supervisors developed a paper "Forest and plantation development in Laos: history, development and impact for rural communities" which was published in *International Forestry Review* (Phimamvong *et al.* 2010).

This paper presents a historical review and overview of the Lao forest sector with the emphasis on the forest plantations and their impacts for rural communities. The major conclusions derived from the paper are as follows:

The establishment of forest plantations has a high potential for improving the national economy and creating wealth for rural communities. But it can also lead to adverse environmental and socio-economic impacts when the policies are ineffective and capacities of the forest-related institutions are inefficient. Much still remains to be done to ensure that forest plantation development can bring about positive outcomes to the Lao environment and rural communities. The Government of Laos needs to enforce the forest-related laws, adopting sustainable forest management practices, and encouraging

all plantation investments to be consistent with international standards, guidelines and codes of practices related to planted forests and trees such as FAO's voluntary guidelines for Planted Forests and Trees, ITTO's guidelines for the establishment and sustainable management of planted tropical forests and CIFOR's code of practice for industrial tree plantation development in the tropics. Furthermore, the Government, international organisations and plantation industries will also need to work closely together in order to ensure that local communities benefit from plantation development. Specifically, transitional difficulties faced by local communities in moving from current land use practices to plantation forestry need to be addressed. Incentives and policy instruments are needed to encourage the combination of out-grower schemes and concessional plantations and to more effectively integrate timber plantations with traditional agricultural livelihoods.

7.4.3 Collaboration between companies and organisations

In order to enhance the collaboration between the project's partners a "Social Club" was established in 2008. Informal "after hours" meetings were held every 3-4 months on a casual, social basis. The locations of the meetings were rotated between various companies' premises (including NUOL). The meetings provided an opportunity to update the Industry Cluster companies on the project progress and discuss urgent issues faced by the companies. It is believed that these social meetings had significant benefits and helped to build openness, trust and partnership between the project partners. In particular, it is believed that the Social Club helped to build a bridge between the industry and research, education and training communities which will provide benefits in the industry development.

The Social Club also facilitated visits to the companies participating in the Industry Cluster. Several visits were made to selected factories which allowed the Industry Cluster members to learn about different approaches in making wood products, production methods, factory layouts, handling waste and safety issues. "Learning from each other" was a new experience to the companies as in the past they used to work "behind closed doors" and sharing their knowledge with others was an unknown experience.

Hopefully, this initiative will encourage the development of a fruitful networking between the companies, in particular in using each other's specialised equipment and machinery and in joint marketing of their products.

The project activities enabled the establishment of better linkages between two major training centres, Pakpasak Technical College and LFIA Training Centre. Experts from both training organisations were involved in the implementation visits to the Industry Cluster members undertaken by VALTIP team. Representatives from both Pakpasak and LFIA training centres participated in two weeks training in Australia.

Several projects funded by various international aid organisations are currently undertaken in Laos aiming to enhance forestry and timber industry. Collaboration with these projects (e.g. GTZ, "Sequa" Asia-Invest and DED teams) was established to ensure that they complement each other rather than compete, and to avoid possible repetitive activities. It is believed that the collaboration will significantly strengthen the entire outcomes of the projects' activities and will build a sustainable, strong, efficient and competitive forestry and timber industry sector in Laos.

An important question which needs to be asked is “how to transfer the project’s findings to the rest of the timber and furniture companies in Laos?” Currently there are about 1,140 timber processing factories in the country; the number decreased from 2,102 in 2006 after the government took steps to modernise the industry in 2007 (Vientiane Times 2010). It is envisaged that the project’s outcomes will be spread to the other companies by the ‘chain reaction’ principles. The benefits of the Industry Cluster members have been certainly observed by other companies which will stimulate them to learn about the recommended production practices developed within the ACIAR project.

Without doubt, some technology transfer of the project findings to the other members of the industry will be feasible due to:

- An active involvement of Lao Furniture Industry Association in the project. This Association has about 60 members which are furniture manufacturing companies. The project’s outputs can be introduced to the companies through LFIA training courses, providing access to research and training materials, as well as facilitating contacts between the companies and the VALTIP team members.
- Expertise in wood processing and manufacturing developed at NUOL will be available to the companies involved in the Lao timber industry.

7.4.4 Providing recommendations to the Lao Government on the support required for the timber industry

The project team was making a great effort to improve research, teaching and training capacity of the Lao timber and furniture industries. Unfortunately, there were certain industry problems (e.g. lack of infrastructure) which could not be solved by the project team as they were outside the project scope and budget. Therefore, the need for the involvement of the Lao Government in the industry development was identified as it has power to impose certain policies and industrial procedures. The need for the government assistance was discussed with the Minister of Industry and Commerce Dr Nam Viyaketh, during his visit to the University and Melbourne (May 2008), as well as during the meetings in Vientiane (22 January 2009) and (2 June 2010) attended by the Project Leader Assoc, Prof. Barbara Ozarska, Dr Mihai Daian and Assoc. Prof. Latsamy Boupha. A document titled "Recommendations on the Assistance Required for Laos Timber Industry Companies" was developed in January 2009 and submitted to the Minister of Industry and Commerce to be considered as a matter of priority.

The summary of the recommendations is provided below with comments on the progress made on their implementation by the GoL.

1. Government assistance in endorsing grading rules, quality control and Occupational Health and Safety standards.

It was proposed that an Action Committee be established, consisting of representatives of the project partner organisations, which would be responsible for negotiations with the Lao Government to impose the use of grading rules, OHS and products quality specifications in the timber sector in Laos. Discussions with the Government were initiated, the formation of the Committee was approved and the program is in progress.

2. Industry Training

It was identified that the Pakpasak Training College should be better utilised and relationships between the school and industry should be improved. In particular,

training courses should be developed jointly by the Pakpasak Training College and Lao Furniture Association Training Centre to maximise training resources. It was proposed that the existing good collaboration between the National University of Laos and Pakpasak be extended through sharing teaching staff and research facilities in providing specialised training and undertaking research for the industry.

Several training courses for the industry have been since developed by Pakpasak Training College and the Lao Furniture Association's Training Centre on collaborative basis (e.g. through provision of teachers for 2 months/year). Training courses in wood drying were organised for the industry at NUOL in collaboration with Pakpasak and LFA training centre.

3. Government assistance to companies in purchasing machinery and in preparing documentation.

The majority of companies expressed concerns that a loan from the government bank had a very high interest rate, 10-12% per year, and needed to be paid back within 1 year. This was very difficult to achieve as, in some cases, the process of purchasing and installation of equipment (e.g. kiln drying facilities) took up to 6-7 months. Therefore it was impossible to expect any production profit within that year. Therefore, financial support options including support for easy access to international aid and incentive to banks to offer low interest rate investment loans should be investigated, to allow companies to improve their production facilities.

As a result, various loan options available to the industry have been compiled by the government which will help the companies to make appropriate decisions.

4. Market research

The industry was concerned that there was lack of information on market trends and overseas markets. The marketing was limited to a "word-of-mouth" kind of promotion, which required a significant effort and resources by individual companies. It was identified that the industry should be provided assistance in marketing of their products. The Government is currently developing a program on providing market research for timber and furniture industries.

5. Education at the National University of Laos

It was recognised that education in design, production management, quality and safety management would provide great long-term benefits to Laos industries and community and, consequently, to the overall economy. As a result, these subjects have been included in the new curricula which are currently under development at NUOL.

In addition, early in the project term (in 2007) the project leader made a contact with the International Finance Corporation and Mekong Private Sector Development Facility. Discussions on possible financial assistance to the Industry Cluster companies were held at several meetings and by email correspondence. A representative of this institution was invited to the project Workshop in 2008, where various opportunities were explained to the industry members.

7.4.5 Negotiations with European companies aiming to provide woodworking machinery for training purposes in Laos

During the assessment of the industry and training capabilities it was recognised that the training machinery available at Pakpasak Technical College is very old (1960s) and

needed to be urgently updated to provide effective training to the industry. As the Pakpasak College does not have finances to purchase the machinery, negotiations were undertaken by Assoc. Prof. Barbara Ozarska with European producers of woodworking machinery about the possibility of donating various machines for training in Laos. A meeting was held at Rimini, Italy, with the owners and managers of the Italian company *SCM Group* to discuss the donation of the machinery. The *SCM Group* is the second largest international company in the design, manufacture and distribution of technologically advanced solutions for the machining of wood and wood based materials. The company management was supportive of the proposal and it is likely that the machinery will be delivered to Pakpasak Training College, Laos, in late 2011 or in 2012.

8 Impacts

8.1 Scientific impacts – now and in 5 years

The project has significant scientific impacts for Lao and international forest science communities. The major impacts are summarised below.

Assessment of young plantation teak and eucalyptus grown in Laos provided valuable scientific and technical data on wood properties and processing characteristics of the species.

In the strategy of Lao Government to year 2020 there is a statement that the research on forest planting and wood properties are very necessary to develop small and medium wood industries to produce high quality products which will meet international standards.

Data and information on properties of teak and eucalyptus available in the scientific literature relates mainly to old-growth timbers. Not much published data is available on the properties and processing characteristics of young plantation timbers which creates problems for the suppliers of raw material and particularly for the wood processing industry. Therefore, the project's research studies on the assessment of young plantation grown teak and eucalyptus timbers provide valuable information to scientific communities around the world and to wood processing industry in Laos:

- Dimensional stability data allows prediction of the movement of wood components in changing environmental conditions. It will be used by designers and manufacturers of furniture during the product development stage to ensure that the movement of components is allowed according to the dimensional stability data.
- Static bending strength (MOR) and stiffness (MOE) values allow structural components of furniture to be designed in a manner that ensures the product will meet engineering design criteria specified in relevant international standards.
- Drying schedules developed within the project will be used by wood processing companies which dry the timbers for high value wood products. Proper drying methods based on optimal drying schedules for different species are extremely important in ensuring that the product quality meets international standards and specifications.

The data on plantation teak and eucalyptus wood properties, due to be published in international journals, will be available to forest scientists in many countries growing these species in plantations. It will also provide important information to other ACIAR funded forestry projects related to the growing and utilisation of teak in Indonesia, Papua New Guinea and the Solomon Islands.

The finding that the wood properties of 10 to 25 year old plantation grown teak are similar will contribute greatly to wood technology science (in Laos and internationally) and make a significant contribution to Lao economy timber industry sector by allowing timber from young plantations to be used in the production of furniture for domestic and export markets.

8.2 Capacity impacts – now and in 5 years

The ACIAR project has provided a significant assistance to Lao government in the implementation of the policy on the development of the downstream wood processing industry. Substantial accomplishments have been attained in building a strong foundation for research, teaching and training in wood processing and wood products for Lao timber sector.

The establishment of Wood Technology Laboratory will have significant benefits to Laotian research and educational communities and to international science as NUOL research staff is now well equipped to undertake high quality research studies on utilization of plantation timbers and lesser known species.

The equipment is being extensively used for practical tutorial classes for undergraduate and postgraduate students in wood science and technology courses and research studies.

The laboratory has already provided an opportunity for NUOL to undertake wood properties research projects funded by various NGOs and international aid organisations. For example, a new research program funded by a Finish organisation, SUFORD, has been assigned to NUOL on testing mechanical and machining properties of Lao lesser known species. Originally, this program was going to be carried out in Vietnam where wood testing facilities are available. However, when SUFORD was advised that NUOL has now a very well equipped wood testing laboratory and well trained researchers, the plan for testing in Vietnam was reconsidered and NUOL was commissioned to undertake the 3-year research testing program. Furthermore, funding has been provided to NUOL to purchase additional wood testing rigs, valued at US \$28,000, for the WoodTech Laboratory. This is an example of the importance of the WoodTech laboratory for research and teaching which, in this case, provided an excellent opportunity for the NUOL to undertake a scientific project of international quality.

The WoodTech laboratory will provide a valuable tool for enhancing research, teaching and training in wood technology and wood production as well as in providing assistance to the timber and furniture industries in product development, using new timber species, new materials, joints and components as well as assessment of the quality of production and products for various international markets.

An extensive library on wood science and technology was established at NUOL. Hundreds reference materials on wood science, wood processing, wood products and quality control are now accessible at the University Library to students, researchers and the industry. It should be pointed out that prior to the ACIAR project commencement there were very few reference materials on wood science and technology available at the library at all. Teaching resources (powerpoint presentations and videos) on all subjects related to wood science and wood technology have been provided to the NUOL lecturers.

VALTIP Lao researchers involved in the ACIAR project had great opportunities to develop a sound knowledge and practical experience in the field of wood technology. They will be the future experts in Laos offering their skills to the timber and furniture industries as well as providing advice to the Lao government and NGO international organisations. Several examples can be already given on the VALTIP researchers' ability to provide a technical support to timber processing companies based on their own skills and expertise:

- Contacting a company in Vietnam, The Vietnamese Wood Machinery, requesting technical services for Khamphaisana factory which included drawings of the workshop layout and planning of wood machinery setup. This task was completed in April 2010.
- Contacting Bonaza Company in Thailand in May 2010 to obtain information on drying kilns, which were then provided to the Industry Cluster in Vientiane area, such as Viengniyome, Somsak, PKK, KAWI.
- Contacting Bonaza company in Thailand regarding a boiler installation based on sawdust for the Khamphaisana factory (a member of the Industry Cluster). The task was completed in August 2010.
- Explaining standards and requirements for wood finishing process and finishing facilities for KAWI and PKK factories (Industry Cluster members) in September 2010. Dr Daian assisted in providing technical information on wood finishing.

The fact that the VALTIP researchers involved in the project were relatively young indicates that the project's activities will enable ongoing support to the Lao wood manufacturing companies.

Involvement of the two technical training organisations (Pakpasak and LFIA Training Centre) in the project activities resulted in significant improvement of linkages not only between the two organisations but also with the industry. The training centres agreed that they will work together, rather than against each other, in providing training courses to the industry. Some training courses held during the last two years have already utilised different skills and expertises in the two training organisations and shared their training instructors in providing specialised short-term courses.

The NUOL and Pakpasak Technical College are the largest educational providers in Lao PDR which offer educational skills to students and the Lao population. Therefore, the empowering of these institutions in the wood processing area will facilitate ongoing capacity building of students and trainees who will ultimately be employed in the Lao forestry sector.

8.3 Community impacts – now and in 5 years

The major Lao project stakeholders found the VALTIP project to be a supportive model for the development of an efficient wood processing industry in Laos, as it assists the Lao government to achieve the *National Export Strategy for the period 2011 – 2015* (NES, 2010), in which the following primary goals have been identified:

- Upgrading Lao furniture to international standards and sustain the domestic market in times when a global financial crisis occurs.
- Developing of human resources in the wood processing sector.
- Building national and provincial furniture and decorative product exhibition centres.
- Modernising tree plantations and wood processing industries by introducing new equipment and state of the art technology into the sector
- Classifying the export of finished wood products into three levels (small, medium and large scale) according to their own permanent clients and market demand starting from restructuring the most mature factories, then gradually expanding over time.

- Modernising the management methods of enterprises and the Government by collaborating on searching for the market penetration instead of just waiting for buyers at home.

Significant benefits have been provided to the companies involved in the Industry Cluster and Burapha Agroforestry Co. Ltd, through the provision of recommendations and then implementation of the recommended improvements in their factories. The project team was working with each company on individual basis providing “in-house” training and advice on how to improve the production methods and overall production efficiency, and how to improve the quality of their products.

The project placed a strong focus on the improvements in the health and safety aspects of workers involved in the timber processing and manufacturing industry. The practices in many wood processing factories were unsafe and were causing serious injuries and deaths of factory workers. The project implemented safe production procedures in the wood working factories. It is anticipated that the Industry Cluster companies have already developed a culture of a safe working environment which will be maintained on on-going basis.

There are several training centres and educational extension services in Laos to educate the workforces of the wood industry sector. Some of the technical schools, such as the Pakpasak Technical College and Thakhek, play a vital role in providing a basic training and providing graduates for the wood industry. Naturally, several employees in the wood-based industry learn “on the job”. However, in many cases, the understanding of good management practices regarding production efficiency, quality control procedures, OH&S practices, quality and long-term performance of products, etc. is extremely limited, compared to that of neighbouring countries. The project developed a sound groundwork for developing efficient training programs for the industry, especially for SMEs which are predominant in Laos. In particular, training “in-house” has been introduced through the VALTIP implementation visits to the Industry Cluster companies.

The project's achievements towards enhancing training in SMEs should be considered as an effective tool for empowering the Lao community to support a sustainable value-adding wood industry in Laos.

It is envisaged that there will be significant community benefits arising from an enlarged forest industry sector, associated with increased employment opportunities in the developed secondary wood processing industry and an increase in farmers' income associated with increased demand for plantation timbers.

8.3.1 Economic impacts

A well developed timber processing and manufacturing sector based on plantation resources has the potential to provide significant economic benefits annually to the national economy. Although a major expansion of the whole industry may take longer time, there is no doubt that adoption of the project findings by the Industry Cluster companies and the members of the Lao Furniture Industry Association will deliver economic impacts within five years of completion of the project.

The adoption of the Industry Cluster model in the project made the companies involved in the Cluster the primary beneficiaries of the project outcomes. These companies were provided with extensive advisory services on how to improve their production efficiency, change old-fashionable machining and joining methods into cost effective less labour

intensive methods, advance waste reduction and utilization, and ultimately improve the quality of the final products.

One of the Industry Cluster companies commented that due to the production changes and improvements made during the project activities the production output increased 50%. It should be pointed out that out of the nine members of the Industry Cluster this company has been the most progressive, very keen to learn and advance its production methods. Therefore, a prediction can be made that the other companies can achieve a similar level of improvements (30-50%) but at a lower pace, likely within next 5 years. The introduction of quality control in the production methods undertaken on periodical basis will hopefully become a routine practice for the Industry Cluster companies which will allow them to increase the profit margin in the future.

Value-adding processing and manufacturing are the areas of the value chain that provide the major part of the value inherent in timber products. Value is added by a factor of 6-10 by processing logs into high quality products. For example, stumpage prices for teak are around US\$20 for a 10-12 year old tree of diameter 15 cm. When flitched, this is worth up to US\$200 per cubic metre. Flitches three metres in length from larger trees of diameter 20 cm will bring up to US\$600 per cubic metre. The value of timber in high quality furniture can reach up to US\$5,000 per cubic meter.

8.3.2 Social impacts

In Laos, four main ethnic groups can be distinguished: Lao Tai-Kadai, Hmong Mien, Mon Khmer, and Sino-Tibetan. The most represented group in the project was the Tai-Kadia, followed by Hmong Mien. Two staff members of the VALTIP project were Hmong Mien; one of them is undertaking the Master study at the University of Melbourne fully funded by the ACIAR scholarship. There were other two staff members from Tai-Kaida group involved in the project, who were also awarded the ACIAR scholarships to undertake the PhD study at the University of Melbourne. In addition, one of the VALTIP team members, who is Sino-Tibetan, was awarded an European Union scholarship to undertake a Master study in Sweden.

It is believed that having participants with diverse ethnic origins involved in the project provided an opportunity to break any barriers among various groups working in the industry and created the foundation for equity, friendship and collaboration.

Female participation in the project was about 20% of the total stakeholders (the project staff, university staff, training school staff, industrial participants), with only several female students actively participating in the workshop and training. In general terms, women played a very minor role (apart from Assoc Prof. Latsamy Boupaha, the Lao project coordinator). This indicates that in future a stronger focus should be placed on women to increase their role in Lao wood industry, in particular in design, quality control, research and training.

The VALTIP Lao team along with experts of the Lao Ministry of Education were actively involved in the development of new Carpentry OH&S Standards and Working Practices. The researchers provided Australian and International standards related to this subject as examples of workable solutions available in other countries.

8.3.3 Environmental impacts

This project has a great potential to provide significant environmental impacts as its activities were focused on the companies using plantation timbers. The introduction of environmentally friendly production methods and eco-friendly designed products will potentially create an on-going culture of production of ecologically sustainable wood products. The project has encouraged the reduction of waste in the furniture production by introducing more efficient wood processing and manufacturing methods, decreasing wood drying degrades utilisation of small dimension timbers and wood off-cuts for various wood components, and introducing new technologies such as wood bending and laminating. These value-added methods will result in more efficient use of timber, thus will enable to produce "more from less".

The Government of Laos is promoting the development of forest plantations based on sustainable management practices as the way to secure future wood raw material available to the timber industry sector. The target by the year 2020 is to plant 500 000 ha. The project has proved that the opportunity exists for the value adding industries to utilise plantation timber resources, further reducing the dependency of the industry on native old growth hardwoods. This should encourage further plantation development within Laos.

The use of sustainable plantation timber and government policy to expand plantation resources provides a great opportunity for the Lao companies in accessing export markets. In particular, a great opportunity exists for the companies using plantation timber to promote their products as certified and coming from sustainably managed forests. This will be possible due to activities of an international aid program The Lao Forest and Trade Platform, funded by TFT/WWF, which aims to develop FSC certification of the community grown teak (village teak), link village teak growers to international markets seeking wood from sustainably managed forests, and offering a price premium for the certified teak. The program also promotes domestic processing of sustainably produced teak through Chain of Custody training and implementation. Close collaboration with this program was established by the VALTIP team and mutual benefits of the collaboration have been already observed.

The demand for wood certification and wood product labelling is increasing noticeably internationally. New legislation have been introduced in Australia, Europe and US to ensure that no wood or wood products derived from illegal sources can be imported into those countries.

If the Lao government and industry follow international environmental policies there will be a great opportunity for the Lao furniture companies to promote their furniture as eco-friendly certified products in international markets.

8.4 Communication and dissemination activities

A summary of the major communication and dissemination activities is provided below:

1. On 30 June 2007 the Steering Committee was formed to ensure that the project milestones and objectives were achieved within the time frame and within the agreed budget. The Steering Committee members met approximately every 6 months to discuss and review the project.

2. Project Team meetings were held on ten occasions when the Australian team visited Laos: June 2007, October 2007, and February 2008, June 2008, July-August 2008, January -February 2009, June 2009, January -February 2010, June 2010, January 2011 (Figure 13). A webpage, available exclusively to the VALTIP team, was developed in 2007 for "free chat" discussions between the team members. The webpage, contained research reports, training materials and manuals, minutes of the project meetings, photo albums related to the assessment visits to the Industry Cluster companies, media releases, news and policies related to the project. The webpage was frequently updated by the VALTIP team and was considered as a very efficient way of communicating between the team members in both countries.
3. A "public" webpage was developed on the project, linked to the University of Melbourne website, to promote the project internationally. The website address is: http://www.forestscience.unimelb.edu.au/research_projects/ACIAR%20Projects/Lao_PDR_Project/Index.html
4. Project newsletters were produced approximately once a year (February 2009, December 2009, August 2010 and the last one, No 4, is in preparation). The newsletters were widely distributed within Laos and in Australia. A positive feedback was provided by many individuals and organisations as the newsletters have been seen as an excellent method of disseminating the project activities and outcomes.
5. The Australian and Lao PDR project leaders met His Excellency Dr Nam Viyaketh MP, the Minister of Industry and Commerce in Vientiane on 22 January 2009 and 2 June 2010. The meetings discussed the project progress and future Government assistance to the Lao timber industry.
6. An effective collaboration with international projects in Laos related to the timber and furniture industries (GTZ, DED) was established. The partnership between the projects focused on the exchange of information on the current capabilities of the timber and furniture companies, sharing information on training programs, exchanging training materials and the development of training courses.
7. A network of organisations involved in assisting the Lao PDR forestry sector, such as DED, TFT, WWF, GTZ, GOPA, SUFORD, SIDA and ACIAR, was established by Mr Boris Saraber from TFT to exchange information on various projects' programs and encourage collaboration. A good example of effective collaboration was the support provided by the Lao Forest and Trade Platform and Burapha, Agroforestry in collecting samples of teak of various ages for the Masters study undertaken by Mr Phongxiong Wanneng.
8. Collaboration with the ACIAR project FST/2004/057 "Enhancing on-farm incomes through improved silvicultural management of teak and paper mulberry plantations in Luang Prabang Province of Lao PDR" was established. A meeting was held in Luang Prabang in February 2009 with the Project Leader Dr Mark Dieters, The University of Queensland, and Dr Sianouvong Savathvong, Vice Dean, Faculty of Agriculture and Forest Resource of Souphanouvong University, to discuss a collaboration between the two ACIAR projects. Further meetings were held in Vientiane in January 2010 and in Luang Prabang in February 2010 and in January 2011 to exchange information on the projects progress and the major outcomes.
9. The Project "Social Club" was established to encourage the members of the Industry Cluster to share their technical experience and knowledge. These meetings assisted with the dissemination of the project's achievements.

(a)



(b)



Figure 13: Project team meetings, (a) with Industry Cluster members, (b) VALTIP team.

10. A number of workshops were held to facilitate dissemination:

- The project inaugural workshop was held in June 2007 attended by the project participating organisations with the aim to describe and discuss the project objectives, methodology and expected outcomes.
- A review workshop was held in February 2008, Vientiane, attended by 43 people, representing the project participants, the members of the Industry Cluster and invited guests to discuss.
- A training workshop entitled “Quality Improving Techniques for Wood Products” was held at the Lao Furniture Association on 29th July 2008, attended by the project participants, the members of the Industry Cluster and invited guests. The major topics discussed during the workshop were: timber drying practices, wood machining, importance of the development of the OH&S practices, improvement of the quality of the wood processing, principles of product design and the importance of design in developing products for export markets, product development process as well as enhancing and developing technical skills within the industry.
- A seminar was held on 9th April 2009 at the Faculty of Forestry, National University of Laos, arranged by the VALTIP team. The purpose of the seminar was to present the project’s progress and to date achievements, and to demonstrate the WoodTech Laboratory to the project partner organisations and relevant governmental institutions i.e. Department of Forestry, Ministry of Agriculture and Forestry, National Agriculture and Forestry Institute (NAFRI), Ministry of Education, Department of Policy MOIC, Agriculture and Forest Division of Vientiane Capital.
- “The Design Awards Presentation” was held on 27 January 2010 at NUOL to announce the winners of “The Furniture Design Competition”. The competition was widely advertised by the VALTIP Lao team both in Vientiane and nationally which caused interest with the Lao community and promoted the project activities.

- The Project Workshop was held on 28 January 2010 at NUOL aiming to discuss the progress of the current project and issues to be considered in a future ACIAR project. The workshop attracted a great number of people from the government, the current project partners, various international funding organisations and the industry.
 - Seminars were presented by the Lao PhD students enrolled at the University of Melbourne during their study visit in Laos, February 2010. The seminars were attended by NUOL staff, the Industry Cluster members and invited stakeholders.
 - The Final Project Workshop was held on 18 January 2011 at NUOL in Vientiane attended by 38 people representing the project partner organisations and invited guests. The Project Leader, Assoc. Prof. Barbara Ozarska summarised the project achievements against the objectives. Assoc. Prof. Latsamy Boupha highlighted the major project outcomes while Dr Mihai Daian summarised the research outcomes. The project benefits to the industry were emphasized by Mr Yothin, the President of LFIA and Mr Vanitha representing Burapha Agroforestry company.
11. Several visits to each company involved in the Industry Cluster were made each year by the "VALTIP" team. After the provision of feedback to the company on the results of the assessment and improvement recommendations follow up visits were made each year to discuss implementation of recommendations provided in the previous stages of the project. The project team spent a lot of time with each individual company to ensure that the recommendations are well understood and the implementation process was fully supported by the company management. Additional visits to the industry companies were undertaken by the VALTIP team according to the project needs.
12. A large number of publications were produced by the project staff as detailed in Section 10.2. These publications enabled effective dissemination of the project outputs to stakeholders in Lao PDR, Australia and other countries.

9 Conclusions and recommendations

9.1 Conclusions

The main focus of the ACIAR project “Value-adding to Lao PDR plantation timber products” was the capacity building (research, education and training) to ensure long-term benefits for the secondary wood processing industry. Improvements and changes in the value added manufacturing processes were made within the network of selected nine companies involved in the Industry Cluster. The pilot studies in the project were undertaken in Vientiane District (with one sawmill located in Luang Prabang).

The strengthening of Lao capacity in plantation wood processing through the project activities promotes empowerment of workers, improved health and safety for workers and progress towards achieving the Government’s development policies. In addition the project has provided a sound base for enhanced value-adding in the wood-based sector and implementation of furniture product development to meet international standards.

The empowerment of researchers, training instructors and industry personnel has improved their technical and management skills, which will stimulate the Lao wood industry to produce higher quality products which could compete on international markets. It will also assist the workers and academics in this sector to have equivalent knowledge and skills to those working in neighbouring countries such Vietnam, Thailand and China.

Finally, the Industry Cluster style of “consultative” management has been one of the project’s successes resulting in improved industry capability and collaboration. Unified implementation of recommended improvements and working in groups with a common goal has been an excellent start in achieving the Government’s mission statement to develop a successful downstream wood processing industry. The project stakeholders consider this achievement as very significant.

For the Lao timber industry to enter overseas markets and withstand international competitiveness, it must strengthen its reputation for quality, long-term performance and reliability and ensure that plantation production and processing are strongly aligned with the international certification policies.

Although significant improvements still need to be made in order to make the Lao industry competitive on international markets, the companies are eager to learn and to implement changes and recommended developments. This enthusiasm combined with the Lao government commitment in maximising timber value adding opportunities indicates that the industry has a good chance of succeeding.

9.2 Recommendations

Although a sound foundation for the development of competitive value added wood industry was established by the project, a lot of effort is still required to achieve the Lao Government’s goal to build up the industry which could produce high quality products for international markets. Therefore, the project team, in consultation with relevant organisations, consultants, stakeholders and funding organisations, developed a series of recommendations for the future R&D activities which are critical in further development of a strong and competitive downstream wood processing industry. The

recommendations cover gaps in the value chain leading to a successful wood processing industries based on sustainable plantation timber resources. The gaps are as follows:

1. Harvesting methods.

Although harvesting is one of the most important stages in the wood processing value chain it has not been addressed in any of the current projects. Currently the cost of raw material for a manufacturer is too high to compete with overseas prices of the final products.

Issues which need to be investigated:

- Optimal age of trees for harvesting. Currently farmers cut 15 years old trees. The results of this project revealed that the wood properties of 10 to 25 year old plantation grown teak are similar which would allow timber from young plantations to be used in the production of furniture for domestic and export markets. Processing characteristics (sawing, drying, machining and gluing) should be investigated to determine optimal processing parameters for timber from different plantation ages.
- Transport of logs from the forest to the roads in remote areas: currently there is a limited distance of 500m which restricts harvesting operations.
- The effect of squaring the logs and/or sawing of logs at the plantation site on the cost of raw material in the value chain.
- Investigating optimal harvesting/ sawing methods: circular saws or mobile sawmills (e.g. Lucas mill), mobile or in fixed locations.
- Impact of harvesting on the environment (currently harvesting is done by unskilled workers).

2. Improving linkages between harvesting, primary and secondary wood processing companies to decrease the cost of raw material available to the secondary wood.

- Investigating an option for the establishment of centralised facilities in the main processing areas (production of square flitches and sawn boards, drying and treatment). This would significantly decrease the cost of raw material. Currently the secondary wood processor is paying for transport of logs of which 50-60% is wood waste (log recovery rate is very low in Laos).
- Developing a logistics model for transport of logs, sawn timber and final products.

3. Developing technologies to expand production of export quality furniture and wood products.

- Introducing new or alternative sawing methods, specific to low quality and low diameter logs, to increase recovery rates which are currently very low.
- Investigating cost effective solar drying technologies applicable to young plantation timber species in Laos.
- Increasing the appearance, durability and quality of wood products to increase the market demand. (e.g. treatment of sapwood which is currently used untreated in high value products).

- Investigating production management methods which would improve the production efficiency and minimise waste.
 - Introduction of design courses in wood products, both structural and appearance. (high education and short/long-term specialised training courses). Collaboration with Lao Construction Association should be established.
 - Developing products for niche markets to develop competitive advantages for Lao industry. This may include combining timber with other materials such as bamboo, rattan, plant fibre.
 - Investigating options for wood waste utilization through developing new products based on wood waste, thinnings and small dimension wood material.
4. Developing a rigorous export-oriented quality assurance (QA) system for timber products. The focus should be placed on linking the marketing benefits provided by QA to the marketing benefits also delivered through the certification of plantation timbers to FSC/CoC.
 5. Enhancing technical skills in wood processing throughout the Laos forest industries
 - Research on the use of plantation resources for veneer production, particle boards, and MDF and structural application of wood.
 - Establishment of a research laboratory with focus on wood anatomy, wood chemistry, wood composites and timber engineering.
 - Curriculum and teaching material upgrade.
 6. Developing a value added timber marketing strategy for Laos including a model for efficient market information for Lao wood products with identification of major players and their roles.

The proposed concept for a new research program is well aligned with the industry and government strategic directions through addressing the challenges and synchronising the production of wood products with processing capacity and market demands.

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10.2 List of publications produced by project

Project Document/Proposal

- ACIAR Project Document FST/2005/100 – Value Adding to Lao PDR plantation timber products

Project Annual Reports

- Annual Report 1st July 2007 to 31 May 2007 (Submitted 23 May 2008)
- Annual Report 1st June 2008 to 31 May 2009 (Submitted 15 May 2009)
- Annual Report 1st June 2009 to 31 May 2010 (Submitted 17 May 2010)

Project Webpage on the University of Melbourne Website

Project Newsletters

- VALTIP Newsletter No 1 (1 March 2009)
- VALTIP Newsletter No 2 (10 December 2009)
- VALTIP Newsletter No 3 (18 August 2010)

Project Major Reports and Publications

1. Ozarska, B., Daian, M., Harris, G., Ashley, P., Boupha, L., Phonetip, K. and Bouaphavong, D. 2007. *Detailed Analysis of the Current Capabilities of Companies Involved in the Industry Cluster and Recommendations on Improved Processing, Drying and Manufacturing Processes Suitable for Application in Laos*. A Report prepared for ACIAR Project FST/2005/100. October 2007. 148 pages.
2. Daian, M. and Ozarska, B. 2007. *Overview of the Vietnamese Furniture Industry – Research Report*. A Report prepared for ACIAR Project FST/2005/100. April 2007. 17 pages.
3. Boupha, L., Khamphilavong, K., Phengsopha, K., Sichaleune, O., Bouaphavong, D. and Phonetip, K. 2008. *Survey of Teak Plantation in Luangprabang and Xayabury Provinces and Eucalyptus Plantation in Central and Southern Parts of the Lao PDR*. 18 pp.
4. Phimmavong, S. 2009. *Economy-wide effects of forest plantation development in Laos: evidence from computable general equilibrium analysis*. PhD Confirmation Report, The University of Melbourne.
5. Phengsopha, K. 2009. *Effect of the Downstream Timber Processing Policy on Timber Supply, Manufacture, and Exports in Lao Forest Sectors*. PhD Confirmation Report, The University of Melbourne.
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10. Daian, M. 2011. *Dimensional stability and mechanical strength testing for Lao plantation timbers (Tectona grandis and Eucalyptus camaldulensis)*. 17 pp.
11. Daian, M. 2011. *The link between product design/development and product market assessment and marketing: A case for the Furniture Industry/Products*. 12pp.
12. Harris, G. 2011. *Development of drying schedules for Teak (Tectona grandis)*. *Interim Report*.

13. Harris, G. 2011. *Development of drying schedules for Eucalyptus camaldulensis*. Interim Report.
14. Phengsopha, K. 2011. *Effects of the downstream timber processing policy on the Lao timber markets*. PhD Thesis. The University of Melbourne. Submitted for examination.
15. Phimmavong, S. 2011. *Forest plantation development, poverty and inequity in Laos: A Dynamic CGE Microsimulation Analysis*. PhD Draft Thesis. The University of Melbourne.
16. Wanneng, P. 2011. *Wood Properties Assessment of Teak (Tectona Grandis) Plantation in Different Ages Grown in Lao PDR (Laos)*. Master Thesis (draft in preparation). The University of Melbourne.
17. Phonetip, K. 2011. *The Quality Improvement of Manufacturing of Burapha Company*. The Final Report for the Master Program in Quality and Environmental Management (in preparation). The University of Boras, Sweden.

Other reports and documents

18. Ozarska, B. Letter from Assoc. Prof. Barbara Ozarska to Dr Nam Viyaketh, Minister, Ministry of Industry and Commerce. LAO PDR. 5 October 2008.
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VALTIP Presentations and seminars

- Phimmavong, S. 2008. *Laos Forest and Forest Plantations: History, development and communities issues*. Presentation at DFES Postgraduate Seminar. The University of Melbourne.
- Phimmavong, S. 2009. *Impact of forest plantation development in Central Laos: evidence from computable general equilibrium and input-output analysis*. Presentation at MSLE Faculty Seminar, Parkville, the University of Melbourne.

- Phengsopha, K. 2009. *The effects of the domestic timber processing policy on Lao timber production, consumption and export*. November 2009. Presentation at the Department of Forest and Wildlife Ecology Seminar, The University of Wisconsin, The United States.
- Phimmavong S. 2009. *Economy-wide impact of forest plantation development in the context of changing trade policy using a CGE modeling approach*. Presentation at MSLE Postgraduate Conference, Dookie, the University of Melbourne.
- Phimmavong S. 2010. *Economy-wide impact of forest plantation development in the context of changing trade policy using a CGE modeling approach*. Presentation at the Faculty of Forestry Seminar, National University of Laos.
- Phengsopha, K. 2010. *Effects of the Downstream Timber Processing Policy on the Lao timber markets*. Presentation at the Faculty of Forestry Seminar, National University of Laos.
- Wanneng, P. 2010. *Wood Properties Assessment of Teak (Tectona Grandis) Plantation in Different Ages Grown in Lao PDR (Laos)*. Presentation at MSLE Postgraduate Conference, Dookie, the University of Melbourne.
- Phengsopha, K. 2010. *Effects of the Downstream Timber Processing Policy on the Lao timber markets*. Presentation at MSLE Postgraduate Conference, Dookie, the University of Melbourne.
- Phengsopha, K. 2011. *Effects of the Downstream Timber Processing Policy on the Lao timber markets*. PhD Completion Seminar. The University of Melbourne.

11 Appendixes

11.1 Appendix 1: List of training courses completed by VALTIP researchers

A. List of training courses completed by Lao VATIP:

- Khamtan Phonetip - Training Course (Ecology links on the carbon stock in the forest and Wood Machines) organized by Melbourne University, Australia, from 6 Feb to 6 March 2009.
- Khamtan Phonetip and Douangta Bouaphavong - Training Course on Environmental Economics, at Vientiane, Laos, organized by WREA, EEPSEA, from 30 June to 4 July 2009.
- VALTIP -Researchers (Douangta, Khamtan and Louxiong) - Training Course on Wood Technology and Wood Chemistry, at the Forest University of Vietnam, Hanoi Capital, from 25 to 30 December 2009.
- Douangta Bouaphavong - Training course the Forest Land scarp Rehabilitation in the Mekong River Basin in Laos-Thailand, from 9 to 24 September 2009.
- VALTIP researchers - Training Course on the Chain of Custody (COC) at the Ministry of Industry and Commerce, in Vientiane, from 6 to 9 July 2009.
- Dr Latsamy Boupha was successful in her application for the prestigious John Dillon Fellowship funded by ACIAR. She spent 6 weeks of intensive management training in Australia, February-March 2010. The skill and experience she has gained will allow her to implement and improve new management methods and practices at the National University of Laos.
- VALTIP researchers attended the Occupational Health and Safety Exhibition on 28 April 2010 held in Vientiane. The health and safety matters are one of the high priorities which need to be urgently implemented within the timber industry in Laos.
- Douangta Bouaphavong - Training Course on the Chain of Custody (COC) system, in Vientiane Province on May 5th 2010.
- Dr Latsamy Boupha completed a training course on Wood-Based Panels: Processes, Properties and Uses, at Walailuck University Thailand, in May 2010.
- VALTIP researchers participated in the distribution of information on the Occupational of Health and Safety in wood working factories in The Ministry of Labour, in May 2010.
- Douangta Bouaphavong and Oudone Sihalern – The training course on the Clean Production from 1st to 3rd October 2010, LNCCI Vientiane Lao PDR.
- Douangta Bouaphavong – Participation in the SPIN Sustainable Product Innovation, Training of Trainer and Expert Workshop, from 14th to 24th March 2011, Vietnam.

B. List of training courses completed by Lao postgraduate students:

Somvang Phimmavong – PhD student at the University of Melbourne:

- SPSS statistics Training, 16 -23 July 2008, the Statistical Consulting Centre of the University of Melbourne.
- Online-courses in General Equilibrium Modeling with GAMS, 27 July to 30 August 2009, Australia.
- Advance training course General Equilibrium Modeling with GAMS: 25-29 January, Singapore.
- International Conference on Economic Modeling, 7-11 July 2010, Turkey.
- Purchase of GAMS Solvers, 9 August 2009.

Kaisone Phengsopha – PhD student at the University of Melbourne:

- SPSS statistics Training, 16 -23 July 2008, the Statistical Consulting Centre of the University of Melbourne.
- Training on the use of The Global Forest Product Model (GFPM), May 2009, SCION "Next Generation Biomaterials", ROTORUA, New Zealand.
- Attending the Third International Faustmann Symposium on "Forest economic in Changing World" in Germany between 28 and 31 October 2009.
- Advanced training on the theory and software of GFPM model to be able to develop the Lao forest product model based on the GFPM framework, 2-14 November 2009. Department of Forest and Wildlife Ecology, The University of Wisconsin, The United States.

Khamtan Phonetip – Masters student at the University of Boras, Sweden:

Six courses undertaken within 1 year Master Program in Quality and Environmental Management:

- Quality and Environmental.
- Integrated Management System in Practice.
- Theory of knowledge and Scientific Methods.
- Advanced Statistical Process Control.
- Risk Management.
- Quality Management Tools.



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Value Adding to Lao PDR Plantation Timber Products

11.2 Appendix 2: List of documents/training materials/standards/etc. submitted to VALTIP project partners

Submission date	Name of submitted material	Format & No. of copies	Submitted to:
2008	Project report No 1: Detailed Analysis of the Current Capabilities of Companies Involved in the Industry Cluster and Recommendations on Improved Processing, Drying and Manufacturing Processes Suitable for Application in Laos	electronic, 1 hardcopy, 20	All VALTIP ACIAR project members
Jan 2009	Project report No 2: Project Annual Report 2007 - 2008 - Barbara	electronic, 1	All VALTIP ACIAR project members
Jan 2009	Project report No 3: Implementation of Recommended Changes in Factory Layouts (New furniture designs using small size timber; Woodworking machines use recommendations for various kind of furniture production; Woodworking machines informative price list; Woodworking machines suppliers list	electronic, 1 hardcopy, 14	All VALTIP ACIAR project members
Jan 2009	Timber Logs grading AUS standards	hardcopy, 1	VALTIP Laos
Jan 2009	Timber use in buildings AUS standards	hardcopy, 1	VALTIP Laos
Oct 2008	SEQUA - Project Title: Upgrading Lao companies in the wood-processing industry for better prospects - CONFIDENTIAL project report	electronic, 1	VALTIP Australia team members
2007-2009	Various Vientiane Times articles about Lao timber industry; Laos_Borderlines report - pdf and video file	electronic, 1	VALTIP Lao + Australia researchers
May 2008	Standard testing method for small specimens of timber OH&S Posters MOR/MOE testing procedure	electronic, 1 hardcopy, 1	VALTIP Lao researchers
Oct 2008	Safety signs and Posters - Vietnam photos	electronic, 1	VALTIP Australia researchers
Sept 2008	Australian Forest and Timber News article: Cyclic system hailed as major breakthrough - Australian Choice Timber Supply Solar Kiln	electronic, 1	Viengnyiom Furniture Factory, Laos
Sept 2008	Australian Choice Timber Supply Solar Kiln - technical specification and price	electronic, 1	Viengnyiom Furniture Factory, Laos
2008	Personal calculations of CO2 emission from burning waste timber	fax	Khamtan Phonetip
May 2008	Emission Estimation Technique Manual for Timber and Wood Product Manufacturing 11 January 2002 Version 1.1	electronic, 1	Khamtan Phonetip
24/10/2008	Teak properties - Internet database	electronic, 1	VALTIP Laos - Researchers
24/10/2008	Teak drying schedules (USA)	electronic, 1	VALTIP Laos - Researchers
May 2008	Emission estimation technique manual for Combustion in boilers Version 3.1 June 2008	electronic, 1	Khamtan Phonetip

May 2008	Emissions Estimation Technique Manual for Aggregated Emissions from barbeques Mayember 1999	electronic, 1	Khamtan Phonetip
May 2008	INCINERATION AND OPEN BURNING OF WASTE - 2006 IPCC Guidelines for National Greenhouse Gas Inventories	electronic, 1	Khamtan Phonetip
May 2008	Utilization of Wood Wastes Generated from Sawmill Operated by Smallholders Distributed in Central Java Province	electronic, 1	Khamtan Phonetip
May 2008	Wood-fired boiler provides 89% of sawmill's energy supply - NZ case study	electronic, 1	Khamtan Phonetip
May 2008	DIRECTIVE 2000/76/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 4 December 2000 on the incineration of waste	electronic, 1	Khamtan Phonetip
May 2008	Report 2 – The potential for wood in a sustainable and competitive Australian renewable energy industry - NAFI	electronic,1	Khamtan Phonetip
May 2008	Report 4 – Converting Wood Waste into Renewable Energy A summary of Biomass Energy Conversion Technologies	electronic, 1	Khamtan Phonetip
May 2008	REGULATION AND CONTROL OF AIR EMISSIONS	electronic, 1	Khamtan Phonetip
May 2008	Bioenergy: A future for the Australian Forest Industry	electronic, 1	Khamtan Phonetip
May 2008	Estimating Emissions From Generation and Combustion Of "Waste" Wood	electronic	Khamtan Phonetip
May 2008	Performance of an Industrial Solar Kiln for drying Timber	electronic, 1	Khamtan Phonetip
May 2008	Solar Kiln Model Description and Development for ying Timber - SOLAR KILN MODEL DESCRIPTION AND DEVELOPMENT FOR YING TIMBER	electronic, 1	Khamtan Phonetip
May 2008	Quality Drying of Hardwood Lumber Guidebook- Checklist - USDA	electronic, 1	VALTIP Laos, Latsamy Boupha
May 2008	Review of the Environmental Impact of Wood Compared with Alternative Products Used in the Production of Furniture - FWRDC	electronic, 1	VALTIP Laos, Latsamy Boupha
May 2008	FWPRDC PN05.2022--plantation thinnings use	electronic, 1	VALTIP Laos, Latsamy Boupha
May 2008	PN97.606 machining trials circular sawing	electronic, 1	VALTIP Laos, Latsamy Boupha
May 2008	PN97.606 final report s1--furniture from young plantation	electronic, 1	VALTIP Laos, Latsamy Boupha
May 2008	PN97.606 final report s2--furniture from young plantation	electronic, 1	VALTIP Laos, Latsamy Boupha
May 2008	PN97.606 final report s3--furniture from young plantation	electronic, 1	VALTIP Laos, Latsamy Boupha
May 2008	PN97.606 finishing trials s1--from young plantation	electronic, 1	VALTIP Laos, Latsamy Boupha
May 2008	PN97.606 finishing trials s2--from young plantation	electronic, 1	VALTIP Laos, Latsamy Boupha
May 2008	PN97.606 gluability trials--from young plantation	electronic, 1	VALTIP Laos, Latsamy Boupha
May 2008	PN97.606 machining trials moulding--from young plantation--part2	electronic, 1	VALTIP Laos, Latsamy Boupha
May 2008	PN97.606 machining trials moulding--from young plantation--part3	electronic, 1	VALTIP Laos, Latsamy Boupha
May 2008	PN97.606 machining trials drilling(boring)--from young plantation--part4	electronic, 1	VALTIP Laos, Latsamy Boupha

May 2008	PN97.606 machining trials CNC routing--part 5	electronic, 1	VALTIP Laos, Latsamy Boupha
May 2008	PN97.606 machining trials planing s1--planing	electronic, 1	VALTIP Laos, Latsamy Boupha
May 2008	PN97.606 machining trials planing s2--planing	electronic, 1	VALTIP Laos, Latsamy Boupha
May 2008	PN97.606 machining trials planing s3--planing	electronic, 1	VALTIP Laos, Latsamy Boupha
May 2008	PN97.606 machining trials sanding--part 7	electronic, 1	VALTIP Laos, Latsamy Boupha
May 2008	PN97.606 timber stability--from young plantation	electronic, 1	VALTIP Laos, Latsamy Boupha
May 2008	PN97.606 engineering properties--from young plantation	electronic, 1	VALTIP Laos, Latsamy Boupha
May 2008	PN006.96 part b--sawing, accel drying--eucalyptus grandis	electronic, 1	VALTIP Laos, Latsamy Boupha
May 2008	PN006.96 part c--drying and utilisation characteristics of eucalyptus globulus	electronic, 1	VALTIP Laos, Latsamy Boupha
May 2008	ADDING VALUE SE NSW Private Forestry Information Sheets	electronic, 1	VALTIP Laos, Latsamy Boupha
28/02/2008	Solar dry kilns for tropical developing countries	electronic, 1	VALTIP Laos
28/02/2008	Solar dry kiln for tropical latitudes	electronic, 1	VALTIP Laos
28/02/2008	DRYING TECHNOLOGY ISSUES IN TROPICAL COUNTRIES	electronic, 1	VALTIP Laos
28/02/2008	Solar kiln dryer model description	electronic, 1	VALTIP Laos
28/02/2008	Drying rate and air circulation in a fully automated solar kiln	electronic, 1	VALTIP Laos
28/02/2008	Low cost solar dry kiln	electronic, 1	VALTIP Laos
28/02/2008	Improvements in solar dry kiln design	electronic, 1	VALTIP Laos
28/02/2008	Small solar heater timber dryer	electronic, 1	VALTIP Laos
28/02/2008	Test of solar dryer in Ghana	electronic, 1	VALTIP Laos
28/02/2008	Solar drying of sawn lumber in Spain	electronic, 1	VALTIP Laos
28/02/2008	Solar drying of timber- a review	electronic, 1	VALTIP Laos
28/02/2008	Temperature control in solar kiln	electronic, 1	VALTIP Laos
28/02/2008	Laos solar dryer - Modern Architects Vientiane	electronic, 1	VALTIP Laos, Peter Fodge
May 2008	Australian Hardwood Best Practice Manual Part 1 + part 2 FWRDC	electronic, 1	VALTIP Laos, Bourapha (end of 2007)
May 2008	Evaluation of Log Grading and Sawing Systems for Low-Quality Logs in East Gippsland	electronic, 1	VALTIP Lao team
sept 2008	ACIAR VALTIP Project 2008 training materials	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	Guarding and safe use of woodworking machinery	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	Wood processing machinery—Safety Part 6: Finishing machinery—Surface planing and thickening machines	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	Wood processing machinery—Safety Part 7: Finishing machinery—Tenoning, profiling and edge-banding machines	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	Wood processing machinery—Safety Part 8: Finishing machinery—Milling tools and circular saw blades	electronic, 1	Markus Hilger, LFIA Training Centre

sept 2008	Approval and Test Specification—Handheld Portable Electric Tools	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	Amendment No. 1 to AS/NZS 3160:2001 Approval and test specification - Hand-held portable electric tools	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	Wood-processing machinery—Safety Part 1: Primary timber milling machinery	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	Wood processing machinery—Safety Part 2: Finishing machinery— Common requirements	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	Wood processing machinery—Safety Part 3: Finishing machinery—Circular sawing machines	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	Wood processing machinery—Safety Part 4: Finishing machinery— Bandsawing machines	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	Wood processing machinery—Safety Part 5: Finishing machinery—Moulding machines and routers with rotating tool	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	Timber—Softwood— Sawn and milled products Part 1: Product specification	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	Evaluation of Log Grading and Sawing Systems for Low-Quality Logs in East Gippsland	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	A workplace hazard identification for the sawmilling and further processing sectors of the Australian timber industry	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	Carpenters and Cabinetmakers (NOC 727) - data sheet	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	SAFETY PROGRAM CARPENTRY	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	OH&S ANSWERS: Cabinet Manufacturing	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	OH&S ANSWERS: Carpenter	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	GUIDELINES FOR THE SAFE USE OF Woodworking Machinery - NZ	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	Health & Safety Safe Use of Woodworking Machinery - Oxford University	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	NATIONAL CODE OF PRACTICE AND GUIDANCE NOTE FOR THE SAFE HANDLING OF TIMBER PRESERVATIVES AND TREATED TIMBER	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	Benchmarking of exposures to wood dust and formaldehyde in selected industries in Australia	electronic, 1	Markus Hilger, LFIA Training Centre
sept 2008	OH&S in Woodworking - HSE.GOV.UK	electronic, 1	Markus Hilger, LFIA Training Centre
2008	Australia training report	electronic, 1	VALTIP team
2008	Laos Plantation report	electronic, 1	VALTIP team
2008	Timber testing reports: No 1, No 2, No 3	electronic, 1	VALTIP team

2009	Teaching resources: lectures in wood science and technology covering 50 topics: power point presentations and written lecture materials	CD	Latsamy Bouppha
2009	Power point presentations with lectures on value-added wood processing, high value wood products and veneer production.	Electronic.	Latsamy Bouppha
2010	Wood bending	printed	VALTIP Lao team
2010	Timber Standards folder	Printed + electronic	VALTIP team
2011	Woodworking machines mechanics	printed	VALTIP Lao team
2011	Furniture marketing	printed	VALTIP Lao team
2011	Understanding wood	printed	VALTIP Lao team
2011	Identifying wood	printed	VALTIP Lao team
2011	Simplified design of wood structures	printed	VALTIP Lao team
2011	Understanding wood finishing	printed	VALTIP Lao team