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Australian Centre for International Agricultural Research

Final report

project

Enhancement of veneer products from acacia and eucalypt plantations in Vietnam and Australia

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1 Executive summary

There has been significant growth in the forest and wood processing sector in Vietnam over the last 20 years such that export value from timber products is now $7.2B. However, 70% of the domestic plantation timber harvested is used for woodchip production with relatively low added value. Acacias and eucalypts are increasingly used for sawing but with recovery rates of approximately 35% or less. Processing timber for veneer can increase the recovery to 75%.

The aim of the project was to promote higher value utilisation of Vietnam's acacia and eucalypt plantations by optimising veneer production from this resource, leading to higher returns to smallholder farmers. The project also examined veneer production from selected species in Australia as a parallel technological improvement and innovation work on wood based composite processes and engineered wood products (EWPs) which can be transferred in Vietnam.

Pilot testing for improvements of household rotary peeled veneer mills and the production of a veneer manual were significant outputs that have the potential to achieve impacts well beyond the project activities. Project activity highlights include pilot interventions at the household peeling level, a peeling manual, and focus on processing plywood products, particularly formply. This is where the majority of veneer is currently being used, particularly in the north of Vietnam, and thus the work focus in this area to achieve the greatest impact.

The training and capacity building activities have been thorough, and broad. The partnership with the German aid and training organisation (Deutsche Gesellschaft für Internationale Zusammenarbeit, GIZ) was particularly positive for industry training. The training manuals produced are available online through the project's website and these resources have been utilised by other ACIAR project collaborators, for example Pryde Furniture in Papua New Guinea. An informative and professional documentary was produced which aired in primetime in Vietnam and is available on YouTube (https://www.youtube.com/watch?v=eC9gdOHg2jo&list=FLeC2NuDQOR3ySX3HU7ekmMg&index=1).

The project team conducted several successful training workshops through the support of the Crawford Fund. Seven project participants have taken up higher degrees (1 MSc, 6 PhD).

The Vietnam Forest University was a successful new partner for ACIAR collaboration. The activities carried out by the University were well executed, techniques and new knowledge have been included in the teaching curriculum, and some project staff who were post-graduate students are now employed in veneer processing and manufacturing firms. Examples of project-generated industry partner collaboration outcomes include the establishment of a veneer training facility with Woodsland Company in Hanoi, the education of small farmer grower groups on wood quality requirements for veneer and the enhanced processing and successful product development with Tien Bo Company.

The impact assessments conducted at the end of the project have further confirmed the potential to improve value along the supply chain from simple interventions. The report showed the increase in profit that can be obtained from participating in the veneer value chain, and improvements in profit resulting from adopting technologies and processing improvements identified in the project.

The opportunity to increase value for plantation growers and provide a local profitable veneer based industry is still apparent. The focus of this research was and still is very relevant to the Ministry of Agriculture and Rural Development (MARD) Forestry Strategy and wood products processing. Following a successful trial of multilaminar veneer products, the Vietnamese Academy of Forest Sciences applied to the Vietnamese Government and

were awarded a 3 year $180K project to further develop multilaminar processes and products.

It is recommended that ACIAR continues research activities in this domain in approximately 4 years' time when the current cohort of post-graduate scholarship recipients return to Vietnam with skills and new knowledge to apply.

2 Background

The Vietnam furniture industry now constitutes one of the key export staples in the national economy. When this project was conceived and developed in 2008, Vietnam exported US$2.8 billion of wooden furniture and other wood products, up from US$2.4 billion in 2007 and US$560 million in 2003. This phenomenal growth, coupled with domestic supply restrictions, has driven an equally rapid rise in Vietnam's timber imports. Vietnamese furniture is exported to over 120 countries. In 2008, 63% by value of Vietnam's furniture exports went to the United States of America (USA) and European Union (EU). A significant constraint to continued expansion is wood supply, and Vietnam imports more than 80% of its wood requirements. Moreover, changes in these markets in response to growing demand for legal wood products from governments, retailers, and consumers puts pressure on Vietnamese exporters and creates uncertainty around future market access. Thus a major challenge facing Vietnamese wooden furniture export companies is obtaining from sources that are both legal and sustainable. Certification is thus increasingly relevant.

The bulk of Vietnam's domestic timber supply comes from its plantations, which produced 5 million m^3 of timber in 2008. Most of the 2.7 million hectares of plantations at this time, however, were established to produce raw materials for pulp and paper. If Vietnam could expand its domestic timber supply it would reduce reliance on imports, some of which currently are from sources that are questionable in terms of legality or sustainability. The future of the industry is therefore linked to Vietnam's international standing as an exporter of legally and sustainably produced goods.

The expanding plantation estate now includes over 1 million ha of acacias, and some 500,000 ha of eucalypts. Established primarily for the production of pulpwood, these plantations are providing raw material for the wood chip industry. The supply of wood for down-stream processing in Vietnam is primarily from small-scale plantations that form a significant part of the rural economy.

Vietnam has, on average, a relatively low timber resource per capita, but has several factors that favour poverty alleviation through community forestry. Among them are: a higher degree of local-level decision making; access in principle to timber rents through benefit sharing arrangements; and exceptional national performance in poverty alleviation dating back to the early 1990s.

About one-third of Vietnam's plantations belong to households to which the sale of trees could provide an important income source. Although Vietnam's acacia and eucalypt plantations have been established primarily for the production of pulpwood, there is increasing use of this resource for the production of sawn timber. For this base product, production plantations require a minimum rotation of 10 years compared with 4 years for pulp and paper, which offer a quicker and more attractive cash flow. Meanwhile, plantation timber quality is declining because of excessive demand and early harvesting of juvenile trees. Whereas trees of 25 cm diameter were once common, only trees with 20 cm diameter and less are now available; the smallest diameter that can be used to make solid wood based furniture is approximately 18 cm.

New technologies to produce veneer (traditionally produced from natural forest and imported timbers) don't require logs as big as those for sawn timber giving rise to an emerging interest in the production of veneer from the plantation resource. Both acacias and eucalypts have demonstrated applicability to the production of veneer, log and wood quality permitting. In Australia, native forest eucalypts, rainforest cabinet woods and plantation pine have been used traditionally. During the period of harvesting of rainforests in northern Queensland, production of sliced veneer was a preferred processing option for brown salwood (a trade name for several acacia species including *A. mangium*). Although acacias and eucalypts have been widely planted internationally over the last 30 years, the use of plantation material for the production of veneer is not well developed, and many

uncertainties remain in terms of the impacts of log and wood quality on product recovery and value, and with respect to optimal processing techniques.

Over the last two decades, Australia has established a resource of over 700,000 ha of eucalypts. Although principally established for the production of pulpwood, the tropical eucalypts established in the north are intended in particular to provide sawn timber. There is also strong interest in investigating options for targeting veneer production from Australian plantations originally established for pulpwood or sawn timber. In this latter case, these still very young plantations often have to be thinned at an age corresponding to pulpwood plantation rotation. If the value of the thinned material is not enough to meet a market, then the plantation economic value is seriously compromised. There is thus an obvious interest in investigating the potential for higher value end uses from fast growing hardwood plantation thinnings. For this kind of raw material, the best processing methods and derived products may be based on veneer. Veneer production has several distinct advantages over solid timber including increased recovery and it can better capture the intrinsic value, quality and beauty of wood. Veneer can also be an easier process to utilise small logs rather than sawn timber processing practices. Numerous product construction options and high value engineered products are also available for veneer.

Vietnam has a large number of veneer plants, mostly very small enterprises. Many operators are now using acacias and eucalypts to produce peeled veneer, and the demand is increasing, however the quality of the veneer obtained is far from optimal.

This project aimed broadly at reducing the impediments to the more extensive use of plantation eucalypts and acacias in the production of high quality veneers, in both Vietnam and Australia. The project was aimed to directly address ACIAR's priorities described in their Annual Operational Plan 2009-2010. In line with this plan, the forestry program for Vietnam sought "higher value plantation forestry products" by "overcoming impediments to the production of high-quality products from sawlogs".

The project initiated from a recommendation from a previous Commonwealth Scientific Investigation Research Organisation (CSIRO) project on the production of sawn timber from plantation eucalypts in Vietnam and China. This was followed by inspections and discussions during visits to selected Vietnamese and private sector processors/manufacturers and partners by Dr Russell Haines (ACIAR), Dr Michael Kennedy (Department of Agriculture, Fisheries and Forestry, DAFF, now department of Agriculture and Fisheries, DAF) and Dr Russell Washusen (CSIRO) in November 2008 and then during a subsequent visit accompanied by Dr Henri Bailleres, the eventual project leader, in February 2010.

During the latter visit, a workshop was arranged in Hanoi designed to discuss and develop the objectives of this project, and to ensure these were complementary to other ACIAR or AusAid projects but also to connect efficiently with the Vietnam-German Forestry Programme, Component 2: Processing, Trade and Marketing of Forest Products (http://www.ptm.org.vn/index.php). It was agreed that the two projects would be developed in close collaboration. The workshop was attended by all partners of this project.

The project also aligned well with DAF priorities. The Queensland processing industry lacked information on processing options for the thinnings or the final plantation crop, and the performance of plantation-sourced material in traditional eucalyptus markets was untested. The project enabled DAF researchers to access a wider range of advanced plantation material than was available from the young stands in Australia, to better answer these questions.

3 Objectives

The aim of the project was to promote higher value utilisation of Vietnam's eucalypt and acacia plantations by optimising veneer production from this resource, leading to higher returns to smallholder farmers. The project also examined veneer production from selected species in Australia as a parallel technological improvement and innovation work on wood based composite processes and engineered wood products (EWPs) which can be transferred in Vietnam.

Underpinning objectives were to:

1. Analyse the existing resource, supply chain and wood processing methodologies and to support markets focusing on both veneer and veneer based products. This includes:

    1.1. Vietnamese Veneer Value Chain Analysis (VCA).
        1.1.1. Summary of Vietnamese acacia and eucalyptus resource.
        1.1.2. Acacia and eucalyptus veneer competitiveness mapping.
        1.1.3. Vietnamese veneer value chain analysis.
    1.2. Analysis of the potential of certification to impact favourably on the Vietnamese veneer and furniture industry
        1.2.1. Tailoring of GIZ's certification protocols for the production of veneers and EWPs
        1.2.2. Identification of research needs specifically for the veneer and EWP value chains.

2. To investigate and optimise current process. This includes:

    2.1. A detailed technical analysis of the current capabilities of the participating companies.
        2.1.1. Veneer processing.
        2.1.2. Product processing.
    2.2. Raw material analysis specifically for veneer production.
        2.2.1. Trees and logs.
        2.2.2. Wood quality analysis.
        2.2.3. Define appropriate veneer log grading standards.
    2.3. To develop optimal veneer processing methods.
    2.4. Test manufacturing performance of selected veneer based products.
    2.5. Development of veneer grading and/or quality control procedures.

3. To test and develop new processing methods and products from veneer. This includes:

    3.1. Processing methods.
        3.1.1. Processing technologies for decorative veneer.
        3.1.2. New commercial adhesive and gluing technologies for green and dry wood.
    3.2. Engineered wood products.
        3.2.1. Plywood.
        3.2.2. Laminated veneer lumber (LVL for non-structural and structural applications).
        3.2.3. Hybrid composites using other species or fibres.

4. Perform an economic impact assessment of veneer processing smallholders and SMEs. This includes:

   4.1. SMEs economic impact assessment.

      4.1.1. Economic performance of selected companies before vs. after innovation.
      4.1.2. Economic performance of innovative vs. non-innovative companies.
      4.1.3. Benchmarking with good international practices.

   4.2. Smallholders' economic impact assessment.

      4.2.1. Impact of plantation rotation on income and employment.
      4.2.2. Impact of innovative process.
      4.2.3. Compare economic impact on households from current situation to innovative companies.

5. To implement education and training related to veneer production and use in manufacturing. This includes:

   5.1. Training.

      5.1.1. Training need assessment.
      5.1.2. Workshops.
      5.1.3. Training courses.

   5.2. Extension and capacity building.

      5.2.1. Information management.
      5.2.2. Publications.
      5.2.3. Extension through associations, smallholder organisations and/or industry bodies and networks.

A detailed description of the methodology employed to achieve these objectives is included in Part 4.

4 Methodology

4.1 Project organisation

The project was a collaborative effort between two Australian research agencies: the Queensland Department of Agriculture and Fisheries (QDAF) Innovative Forest Products team and the University of Melbourne (UoM) School of Ecosystem and Forest Sciences; the German aid agency Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ); Laity's Forests; and participating country teams from the Vietnamese Academy of Forest Sciences (VAFS), the Vietnamese Forestry University (VFU) and the Centre for Agricultural Policy (CAP).

QDAF coordinated the project and conducted work focussed on identification 'best-bet' products for development, current processing optimisation, processing and technologies applicable to Vietnam and Australia, training and capacity building. UoM performed most of the company assessments, identifying research needs for Vietnam and Australia. GIZ were instrumental in holding upper and middle management training in Vietnam and creating the website. Laity Forests were involved in developing certification recommendations for Vietnam. VAFS were mostly involved in resource assessment, within country organisation and management, and optimisation of processing and product testing in Vietnam. VFU were involved in veneer and log grading development and testing, resource analysis, communication and dissemination activities. CAP performed the VCA, competitiveness mapping and economic impact assessment work.

4.2 Report format

During the project, stand-alone reports were produced for discrete objectives and distributed to stakeholders. Generally, the methodology and findings of these reports are summarised in this final report while the full document is appended.

Objective 1: To analyse the existing resource, supply chain and wood processing methodologies and to support markets focusing on both veneer and veneer based products.

The objective had two components: Veneer value-chain analysis; and analysis of potential of certification.

1.1. Vietnamese Veneer Value Chain Analysis (VCA).

Activity in the value-chain analysis followed a two stage process.

1.1.1. Summary of Vietnamese acacia and eucalyptus resource.

The Vietnamese acacia and eucalyptus plantation resources were first analysed via a combination of desktop study and field measurements. Data were sourced from the Vietnam Ministry of Agriculture and Rural Development (MARD) for the desktop study. It evaluated the percentage of forest cover area for each province, the area of natural versus plantation forest cover and the forest categories such as production and protected forest. The areas of plantation acacia and eucalypt species were analysed by age categories from less than 2 to over 8-years-old.

Acacia and eucalypt plantations were selected to characterise tree and wood properties from different aged stands in different provinces with different silvicultural regimes. The following criteria were used to select the plantations:

- large plantation area;
- high annual yield/production;

- at least two provinces selected in each of the northern, central and southern regions.

Following these criteria, seven provinces were selected: Phu Tho, Tuyen Quang, Quang Tri, Binh Dinh, Dak Lak, Binh Phuoc and Binh Duong. Within these provinces different plantation locations were selected with trees of different age classes ranging from 2-11 years-old. Although a number of age classes were selected, priority was given to the older age classes. In Vietnam most acacia and eucalypt plantations have a short rotation with the majority around 7-8 years-old. In some provinces trial sites or scattered trees exist from 10-13 years-old. At each site at least three standard plots were randomly selected with a standard plot size of 10 × 10 m. At each standard plot the number of trees were counted (n) and numbered from 1 to n. Depending on the province, site and species, the number of trees selected for core sampling ranged between 33 and 96.

For each tree within each standard plot the following growth properties were measured: breast height diameter, ovality, and height characteristics consisting of the tree height at 10 cm stem diameter, and the tree height to the first branch. At each standard plot five trees were randomly selected to obtain core samples. Cores were extracted at 1.3 m using a Suunto hand auger. The cores were used to determine heartwood proportion and basic density.

1.1.2. Acacia and eucalyptus veneer competitiveness mapping and 1.1.3. Vietnamese veneer value chain analysis.

These sub-objectives were combined into one process to produce a single report.

This component was achieved via surveying the value chain stakeholders including forest growers, timber traders, veneer and veneer based product processors and furniture manufacturers. Surveys were conducted in Phu Tho, Dak Lak, Hanoi and Binh Buong provinces. In total, 41 forest growers, 6 processors and 3 timber traders were surveyed. The processors consisted of companies producing one or a combination of peeled veneer, plywood, sliced veneer and decorative panels.

The value chain and competitiveness mapping analysis for veneer and veneer-based products included the following qualitative tools:

- value chain mapping,
- linkage and trust analysis,
- governance analysis,
- upgrading analysis, and

the following quantitative tools:

- cost and margin analysis,
- added value distribution analysis,
- wage distribution analysis,
- employment distribution analysis.

1.2. Analysis of the potential of certification to impact favourably on the Vietnamese veneer and furniture industry

1.2.1. Tailoring of GIZ's certification protocols for the production of veneers and EWPs

This sub-objective was originally designed for one of the project's original collaborators - GIZ. GIZ's contract to work in Vietnam finished half-way through the project, Mr Richard Laity from Laity's Forests was contracted to lead this objective. Therefore 'tailoring of GIZ's

certification protocols' was impractical and instead the objective focussed on an assessment of verification systems, cost-benefit analysis of such systems as well as industry surveys. The review assessed the global regional trade agreements, Association of Southeast Asian Nations (ASEAN), Forest Law Enforcement, Governance and Trade (FLEGT), International Organization for Standardization (ISO), Program on Forests (PROFOR), Programme for the Endorsement of Forest Certification(PEFC) and Forest Stewardship Council (FSC) verification systems, and country specific verification, legality and chain of custody systems. As part of this study interviews were conducted with key stakeholders across the value chain, in particular those in the veneer sector. The following four main questions were used for the interviews:

- What have been the positive and negative experiences of having forest certification?
- What are the main barriers for Vietnamese plantation owners and wood processors in achieving forest certification?
- What solutions should be proposed and tested?
- How could we best cooperate to address mutually beneficial outcomes?

1.2.2. Identification of research needs specifically for the veneer and EWP value chains.

This objective was embedded into Objective 2 research components. More specifically the research needs were identified and reported in:

- household mill and small to medium enterprise (SME) company surveys,
- log and veneer grading recommendations,
- company and farmer thickness variation and recovery surveys,
- moisture content variation surveys,
- company veneer grading surveys, and
- solar kiln prototyping report.

Objective 2. To investigate and optimise current process: development of optimal processing methods according to quality and sizes of plantation logs of acacia and eucalypts.

The objective has five components: a detailed technical analysis of the current capabilities of the participating companies, raw material analysis specifically for veneer production, to develop optimal veneer processing methods, to test manufacturing performance of selected veneer based products, and to develop veneer grading and/or quality control procedures.

2.1. A detailed technical analysis of the current capabilities of the participating companies.

2.1.1 Veneer processing

The quality management status of nine small household peeling mills, in rural areas was investigated via site visits and survey questionnaires.

2.1.2 Product processing

The quality management status of eight SMEs producing veneer based products was investigated via site visits and survey questionnaires. Two types of companies were targeted:

- producing sliced and peeled veneers (primary processor),
- manufacturing veneer based products (secondary processor).

Eight companies were selected from various parts of Vietnam so that the survey results could provide a good overview of the veneer industry in the country. The selected

companies specialise in veneer processing (production of peeled and/or sliced veneers) or the production of veneered products and a few companies were involved in both production activities.

2.2. Raw material analysis specifically for veneer production.

2.2.1. Trees and logs and 2.2.2. Wood quality analysis

Quality of trees, logs and wood quality of *Acacia mangium*, *Acacia* hybrid *(A. mangium* × *A. auriculiformis)* and *Eucalyptus urophylla* species were characterised for veneer production. This was achieved through wood and veneer quality processing trials from a total of nine plantation sites, three per species, where each site had a different silvicultural or age regime and had trees of the appropriate age/size class to meet the requirements for veneer production.

For each trial plot, the best location for harvesting the trees was determined based on ease of access. At each location a 15 m radius was delineated. Within each boundary approximately 30 trees were randomly selected and the diameter at breast height over-bark (DBHOB) was recorded. The measurements were taken at approximately 1.3 m from ground level using a diameter tape. Within the same boundary, selected trees had their height of the tree at the 1st branch measured as well as the height of the tree where the stem is 10 cm in diameter.

A subset of trees were selected for harvesting, the number of which varied but was sufficient enough to produce 20-30 billets 1.5 m long with small-end diameters over 130 mm. Each billet had its large and small end diameters, heartwood proportion, log form (sweep, taper and ovality), number of knots and stiffness measured and/or calculated. Log stiffness was measured acoustically using the CIRAD Forêt Bing device as described by Brancheriau and Baillères (2002).

Billets were transported to the Tien Dong Company for peeling. Prior to peeling they were measured for end splits and then rounded up on a lathe. The rounded diameter was measured. After peeling each veneer sheet had its dimensions measured and the green recovery was calculated. The veneer was pre-air dried for 1-2 days before steam press drying at 100°C for 1-3 minutes. Veneer quality was assessed by visual grading in accordance with *AS/NZS 2269.0:2008* (Standards Australia, 2008). After grading the veneer gross recovery (maximum recovery of dry graded veneer), net recovery (recovery of saleable product) and grade recovery (recovery split per grade class) were calculated.

During peeling, 150 mm veneer strips were removed at 800 mm wide intervals along the veneer ribbon. These strips were dried and used to determine veneer moisture content, density, stiffness (using Bing!) and shrinkage using a novel image analysis technique.

2.2.3. Define appropriate veneer log grading standards.

To define appropriate veneer log grading standards, a review of existing international and local grading rules used for peeled veneer logs was undertaken. The review consisted of a combination of desktop study of relevant literature and a survey of four SMEs utilising their own ‘in-house’ log grading systems. The international and within country rules were appraised for their suitability of application to Vietnamese plantation-grown resource. Subsequently, a grading system for plantation peeled veneer logs was proposed.

2.3. Develop optimal veneer processing methods

For this project component a number of sub-components were employed including: determining optimum parameters for rotary lathe settings; characterising the variation in veneer thickness, moisture content, green recovery, log form and veneer squareness in SME’s and household mills; veneer grade classification in rural peeling mills, modification of

lathe to improve thickness variation and recovery in a household mill, and development of a solar prototype veneer dryer.

Optimum parameters for rotary lathe settings were conducted using three plantation species from Vietnam: *Acacia mangium, Acacia mangium* × *A. auriculiformis, Eucalyptus urophylla,* and three from Australia: *Corymbia citriodora* subsp. *variegata, Eucalyptus cloeziana, Corymbia torelliana* × *C. citriodora* subsp. *variegata.* The experimental design was based on the provision of 90 discs for each plantation species. For each species, representative trees were selected and felled to extract short billets approximately 600 mm in length. The billets were rounded up on a spindle-less lathe to remove any irregularities and/or ovality then placed in a jig and cross cut using a sliding bed circular sawmill (KaraMaster® Sawmill) to extract 25 mm thick discs. The discs were saturated in water to prevent drying out between sawing and packaging in plastic film for shipping to Cluny, France. Using the micro-lathe, combinations of three separate parameters were trialled for each species. Within each parameter the following multiple variables were trialled: veneer thickness (1 mm and 3 mm), knife clearance angle (-1°, 0°, +1°), and nosebar pressure (5%, 10%, 15% of base pressure). After the discs were peeled, suitable green veneer strips (not too brittle nor too stiff) were placed singularly in an apparatus known as the SMOF (Système de Mesure de l'Ouverture des Fissures, open checks measurement system). SMOF data were analysed to determine veneer evolution and checking characteristics such as check depth, position and distribution.

The variation in peeled veneer thickness, green recovery, log form and veneer squareness were characterised in SME's and household mills. Five SMEs and eight rural household mills were chosen for these studies. For each company, 30 or more 1.3 m long logs were selected. The log form was characterised by measuring small and large end diameters to calculate ovality, taper and initial log volume. Sweep was calculated by quantifying the amount of bend in a log. Logs were rounded and the diameter was remeasured prior to peeling. After peeling, veneer sheet dimensions were measured, including width, length and thickness. This allowed the calculation of veneer thickness variation between sheets and expressed as the variation in thickness along the veneer ribbon. Usable veneer volume was calculated to provide green recovery results. Veneer squareness was calculated via the ratio of the veneer sheet diagonal corner-to-corner dimensions.

As a separate study, the moisture content variation of peeled veneer was characterised for four companies. For comparative purposes, the selection comprised companies peeling and drying their own veneer, and companies buying peeled, dried veneer. For those companies peeling their own veneer, veneer used for testing was selected in approximate even proportions from the outer, inner and core parts of the log. Approximately 30-90 veneer sheets were tested per company. Some companies air dry their veneer while others pre-air dry and then steam-press final-dry their veneer. For the former, moisture content was sampled before and after air-drying. For the latter, moisture content was sampled before and after air drying, and after steam-press drying. During moisture content sampling, from each sheet of veneer, two samples (10 x 10 cm) per drying stage were cut approximately 5 cm from the veneer edges to avoid edge drying effects where sheets overhung or touched the ground during air-drying. To prevent moisture loss during transport from the company to the laboratory, all samples were individually wrapped in plastic immediately after they were cut, and appropriately labelled. The moisture content of each sample was determined in the VAFS laboratory by applying the oven-dry methodology described in the Vietnamese standard *TCVN 7756-3:2007* (EN322). For two of the companies, the dried veneer moisture content was determined by the oven-dry method and compared with the moisture content output using a moisture meter.

Eight rural veneer peeling mills in northern Vietnam were selected to investigate the peeled veneer grade quality using the recently released Vietnamese veneer grading standard, *TCVN 10316:2014*. All veneer graded was produced from *Eucalyptus urophylla (*Timor white gum*),* from 6 to 7-year-old trees and harvested from local plantations. For each mill,

15 logs were randomly selected, peeled to veneers and then the veneers were graded using both the face and core veneer grading criteria.

Using results from the thickness variation study, the company producing veneer with the largest variation in thickness, Tho company, was selected as a pilot study to modify their peeling lathe to improve veneer thickness variation. During company surveys we discovered engineer, Mr Thieu, located in the city of Yen Bai in Yen Bai province, approximately 100 km north-west of Hanoi. Mr Thieu, a mechanical, suggested that he was already modifying lathes located in small household mills in the area with great success. Mr Thieu was contracted to modify the Tho company lathe with the inclusion of new modified rollers. The modifications included a knurled finish, larger diameter shafts and better quality bearings. Before and after the modification, 15 logs were peeled and the thickness variation of the resulting veneer was measured. The green veneer recoveries before and after modification were also calculated.

Through household surveys it was discovered that veneer processing stops during the wet season because veneer can't be air-dried without moulding. As a response, we designed and constructed a small prototype, low-cost, passive solar drying kiln. The kiln was constructed at VAFS using a steel frame and nylon sheeting. Two trials were conducted, each drying ten veneer sheets during periods of rain. The moisture content of veneer sheets was measured to investigate drying rate.

2.4. Test manufacturing performance of selected veneer based products

The objectives of this component were to evaluate the physical and mechanical properties of current plywood products manufactured for common structural applications according to the Vietnamese standards. Four panels per product were selected from four different companies operating in the wider Hanoi area. The product from two companies was packaging plywood made from acacia using urea formaldehyde adhesive. The product produced by the third company was acacia formply made using phenol formaldehyde adhesive. The final company product tested was an acacia-bamboo hybrid formply manufactured using phenol formaldehyde adhesive. Test samples were sourced from various positions within the sheets. Test samples were used to determine: moisture content, density, modulus of elasticity (MoE), modulus of rupture (MoR), shear bond quality, chisel test bond quality and shear strength.

2.5. Development of veneer grading and/or quality control procedures

This work commenced with a review of existing international and within-country grading rules used for structural and decorative veneers to appraise them for suitability of application for the Vietnamese plantation-grown resource. The review included definition of the various grade criteria, a tabulated comparison of international standard rules per criteria, and a review of current non-standard rules being used in Vietnam. At the end of the review process, the Vietnamese Forestry University instigated the development and release of Vietnamese veneer grading standard *TCVN 10316:2014* for grading substrate and face grade peeled veneer. The standard was developed through consultation with a committee of industry representatives and based on the Chinese peeled veneer grading standard *LY/T 1599-2002*. A case study, utilising the new standard was undertaken. This case study utilised data from previous project work to characterise and analyse *Acacia mangium*, *Acacia* hybrid *(A. mangium* × *A. auriculiformis)* and *Eucalyptus urophylla* at three stages: tree, log and peeled veneer quality.

Objective 3. To test and develop new processing methods and products from veneer

This objective consisted of two main components: to test and develop new processing methods, and engineered wood products.

3.1. Processing methods.

3.1.1. Processing technologies for decorative veneer.

A review of current literature was conducted on multilaminar veneer including: history, manufacturing methods, properties and performance, uses, patents, manufacturers and suppliers.

Laboratory trials were subsequently performed to produce multilaminar blocks from peeled veneer, and to evaluate the quality of the blocks manufactured from the *Acacia* hybrid, *Acacia mangium* and *Eucalyptus urophylla* for the application of multilaminar panels for furniture production. Prior to manufacture, peeled veneer was equalised to a moisture content of 8%. The veneer was hot pressed first into 20 mm LVL sheets using urea formaldehyde adhesive using a 10-minute press time. Three press temperature treatments (100, 110 and 120°C) were tested and eight panels were pressed per treatment. The panels were 25 cm × 40 cm. Samples were removed from each panel to measure density, thickness swelling, moisture content, bond strength, MoR, MoE and axial nail withdrawal resistance.

3.1.2. New commercial adhesive and gluing technologies for green and dry wood.

This project component aimed to develop a gluing system using this adhesive technology that enables the removal of defects from a green log and reconstruct the defect-free segments into a clear billet. All plantation hoop pine (*Araucaria cunninghamii*) material included in the study was supplied by Austral Plywood, Brisbane, Australia. The project comprised three studies:

Part 1: The Automated Bond Evaluation System (ABES) was used to select two suitable adhesives to bond green timber (moisture content in excess of 80%) and produce a strong flexible bond as determined by a three-point stress bending test.

Part 2: A method to texturise the bonding surface of the timber was developed to increase the tooth and area of adhesion, allowing fibres from each surface to interlock.

Part 3: Using the optimum adhesive established from Part 1 and the texturising process from Part 2, a green-glued billet clear of defect was processed through the lathe. Veneers were subsequently subjected to a natural drying process at an equilibrium moisture content of approximately 4% MC in a solar kiln and the bond line integrity was re-evaluated.

3.2. Engineered wood products.

3.2.1. Plywood.

This research proposed an alternative technique to fill voids between the bamboo strips of veneer/bamboo formply, by application of a mix of bamboo sawdust/wood particles/coconut fibres and PF resin applied internally during construction. Acacia hybrid peeled veneers were purchased from the Tien Bo company. Original veneer sizes were 1300 mm × 650 mm × 1.7 mm with moisture content varying from 8% to 9% as tested at the Vietnamese Academy of Forestry Science (VAFS) laboratory. Bamboo samples were processed into strips with the following dimensions: width (20-25 mm); length 1300 mm and thickness 3 mm. Moisture content of the bamboo strips prior to adhesion was determined to be between 8% - 10%. Bamboo strips had wet adhesive applied and then were re-dried to a final moisture content between 13% - 15%. Three different particulate materials were used to make the various filler mixes including 1 mm particle size bamboo sawdust, 2.5 mm coconut fibre and 5 mm peeled veneer particle. Different ratio of particles to resin content were trialled viz 1:0.25, 1:0.5 and 1:1 ratios. There were nine treatments and one control

experiment, where each experiment produced fifteen 300 × 300 × 12 mm panels for testing. Samples were extracted from each panel to test for: density, MoE, MoR, bond quality and shear strength.

3.2.2. Laminated veneer lumber (LVL) for non-structural and structural applications.

From the multilaminar blocks produced in *Objective 3.1.1*, a non-structural LVL multilaminar table was produced to highlight this potential new value-added product to the Vietnamese industry. The veneer was specifically selected to provide an aesthetic mix of colour variation.

A demonstration gazebo structure made from multilaminar LVL veneer and solid wood glulam was used to showcase these products using adhesives developed for difficult to glue species, using an innovative hidden connector system. The design of the structure was provided by the University of Queensland, School of Architecture. Multilaminar wood blocks were assembled from combining plywood panels, which were then sawn and dressed to produce posts and rafters. Plantation-grown Gympie messmate (*Eucalyptus cloeziana*) was used for the multilaminar components.

Glulam was manufactured by gluing individual pieces of sawn timber to produce beams for a variety of elements for the structure. The timber was graded, dried and bonded together with the grain running parallel. As with multilaminar wood the strength-reducing characteristics which might be present in a single piece of timber are dispersed in the glulam product. These were manufactured using lengths of seasoned spotted gum (*Corymbia citriodora* subsp. *variegata)* which were sourced from resource characterisation trials in south-east Queensland.

A multilaminar hybrid table/bench was produced to highlight the potential to add value to young plantation eucalypt resources in Australia. The multilaminar bench was created from multiple elements that have the ability to swing on a pivot joint to allow different configurations, for example swinging up some elements to provide a table. Each element was manufactured from multilaminar panels with alternating veneers of shining gum (*Eucalyptus nitens*) and red mahogany (*Eucalyptus resinifera*) giving an alternating light brown and dark red variation across the panel. Seventeen panels at 1300 mm × 1170 mm and consisting of eight, 3 mm veneers were laid up. Each middle veneer was oriented perpendicular to the others for additional rigidity in the final element. Fifteen panels were used for the manufacture of the seating elements with each panel producing four segments. The remaining two panels were used for the manufacture of the legs. Locating dowel holes (9 mm ø) were incorporated into the design to aid with alignment. Three machined bench segments were adhered together a polyurethane to create a single composite element.

3.2.3. Hybrid composites using other species or fibres.

This work component shared the procedure and methodology for the veneer/bamboo hybrid formply work outlined in *Objective 3.2.1*.

Another product developed under this objective were bamboo structural panels, comprising of bamboo rings adhered between radiata pine structural plywood panels. The DAF team successfully manufactured and tested 300 × 300 mm prototype panels for shear strength properties and determined the manufacturing process appropriate to produce full sized panels. Radiata pine (*Pinus radiata*) 7 mm structural plywood was used as the skin for the panels, with bamboo rings adhered in between using the polyurethane adhesive. Full length panels were also produced and were tested under bending and compression at the University of Queensland. Digital Image Correlation (DIC) technology was utilised to evaluate the performance of the panel in three dimensions.

Objective 4. To perform an economic impact assessment of veneer processing smallholders and SMEs during the project, and to investigate potential for new value creation.

The two components of this work were combined such that the smallholder and SME impact assessment were reported together over two reports. The first included a literature review for research design and economic impacts, while the second was the economic impact assessment for smallholders and SMEs detailing the performances of innovative vs non-innovative companies and comparing the economic impacts over a number of scenarios. The following methods are presented as per each report.

Literature review

The purpose of the review was to provide a direction for research design in order to prepare economic impact assessment surveys. The review consisted of the following three components:

Methodology: the section presented hypotheses and economic impact assessment methods. Theoretical frameworks to analyse strategy, value chain, and evaluate effectiveness of company's operations were presented.

Acacia and eucalypt growing households: a literature review was conducted on economic impacts of acacia and eucalypt growing for various purposes (paper pulp, wood chips, saw logs, construction materials).

Wood processing companies: a literature review was conducted on a variety of products, markets, strategy, value chain, economic efficiency at companywide as well as production unit levels.

Economic impact assessments

The assessment work on the economic impact of the project focused on the following questions:

- What aspects of the project are fully implemented? How to realise or measure them?
- What aspects of the project are left behind, or not implemented at all? What are the reasons for these?
- What are the expected results of the project achieved? What are the impacts in the short and long terms?
- What are the unexpected results of the project?
- What are the lessons learnt from the implementation of the project and what are the issues that other programs/ projects could do to improve?

Based on critical assumptions identified in developing the theory of change, five key evaluation questions for economic impact assessment for the project were as follows:

1. Which veneer processing households/ enterprises intend to implement interventions?
2. Does the project successfully propose new technology as anticipated?
3. Does the project successfully transfer new technology as anticipated?
4. Do participating veneer processing households/ enterprises have higher economic efficiency than those not participating as a result of the project interventions?

5. Do acacia and eucalypt growing households have higher economic efficiency as a result of the project interventions?

The economic impact assessments relied on primary and secondary data sources. Primary data were collected mainly through surveys during project implementation and at the end of the project. For SMEs, we focused on three companies: Hoa Lan and Bui Gia whose managers participated in the training courses under the project, and Tien Bo who received technical support from the project in producing bamboo formwork. For households we surveyed six households which produced veneer sheets and 80 households growing acacia and eucalyptus for paper pulp/wood chips or veneer sheet processing.

Semi-structured questionnaires were used to conduct in-depth interviews with enterprises and acacia- and eucalypt-growing households. Probabilistic Risk Assessment (PRA) was applied to acacia and eucalypt growing households to identify risk and uncertainty issues related to the production of sawlogs. For enterprises and households which produce veneer sheets, data were analysed twice - before and after the technical intervention or training courses. For households growing acacia and eucalyptus for paper pulp/wood chips or veneer sheet processing, data were collected once. The analysis was based on two scenarios: growing for 2 cycles (as usual) and growing for 1 cycle with a double planting time (advanced), assuming constant production cost and fixed output prices.

Objective 5. To implement education and training related to veneer production and use in manufacturing

This objective contains two main components: training, and extension and capacity building.

5.1. Training

5.1.1. Training need assessment

The first part of this component consisted of a case study of performance management at the Woodsland Company near Hanoi. The case study consisted of an account of the company's background history and a survey questionnaire of middle management personnel. In total 62 company middle managers were surveyed.

A secondary survey was conducted across the project participants to assess training needs. Eight companies were selected across various parts of Vietnam so that the survey results could provide a good overview of the veneer industry in the country. All the companies visited were using (but not exclusively) plantation timbers grown in Vietnam. The predominant species were *Acacia mangium, Acacia* hybrid and *Eucalyptus urophylla.*

5.1.2. Workshops

In approximate chronological order the following workshops were held over the course of the project:

1. 'Basics of non-destructive testing (NDT) assessment of static stiffness and strength by vibration analysis held by DAF at VAFS for VAFS and VFU researchers in 2014.
2. 'Value Chain Analysis workshop' held by Centre for Agricultural Policy (CAP) at MARD for policy makers in 2014.
3. 'Peeled veneer and plywood production training workshop in Vietnam' held by DAF and VAFS at the Am Ha commune (Northern Vietnam) for SMEs and farmer households in 2015.
4. 'Peeled quality management training workshop' held by UoM, DAF and VAFS at VAFS for company management and technical staff in 2015.

5.1.3. Training courses

A total of six training courses were held by GIZ In collaboration with the partner associations of the Vietnamese-German Forestry Programme, Handicraft and Wood Industry Association of Ho Chi Minh City (HAWA) and Vietnam Timber and Forest Product Association (VIFORES). The training courses were held at the Woodsland Company training centre for a combination of middle management, company CEOs, supervisors and marketing managers between March 2012 and April 2014. The training topics were:

1. Three internal training sessions for Woodsland Company.
2. Production management / increasing efficiency in the veneer processing department.
3. Corporate and market strategies and promotion of veneer.
4. Middle management course – modules 1 to 3.

Over the course of the project Crawford fund training was successfully tendered to train Vietnamese research staff in Australia. Crawford Fund training was held for each successive year in the project totalling five training courses covering a wide range of subjects across the veneer processing value chain, including management and improved research skills.

Two best practice documents were produced for the VAFS laboratory on chisel glue-bond testing and laboratory practice.

Funding was granted for a selection of key Vietnamese researchers to travel to Laos to undertake training in peeled veneer processing using high-end electronic peeling machinery.

5.2. Extension and capacity building

5.2.1. Information management

During the first months of the project GIZ in conjunction with a contracted web designer developed the project ‘Veneer Value’ website. The website was later managed by VFU in June 2014 after GIZ’s contract finished.

Prior to the project final workshop, a 30-minute television documentary was prepared by VAFS and DAF researchers outlining the main objectives, outcomes and impact of the project. The documentary was professionally filmed and edited by Vietnam’s leading network VTV6.

5.2.2. Publications

During the course of the project the following publications were produced:

- GFA/GIZ middle management training manuals
- GFA/GIZ production management workshop manual
- GFA/GIZ veneering flat surface manual
- GFA/GIZ veneer and plywood production workshop manual
- DAF SME peeled veneer processing manual (this document is currently being developed into book format for full publication)
- DAF smallholder veneer manufacturing manual.

5.2.3. Extension through Associations, smallholder organisations and/or industry bodies and VAFS (formerly FSIV) networks

Extension activities included participation in a range of conferences throughout the project to present the project work to the international community. Conferences and topics presented include:

- IAWSc 2015 Conference – resource assessment presentation and paper
- IAWSc 2015 Conference - multilaminar table presentation and paper
- Quebec 2015 Conference – resource assessment presentation and paper
- IUFRO 2014- Acacia conference presentation
- International Scientific Conference on Hardwood Processing 2013 - Florence, Italy

The Veneer Award was organised by GIZ in 2013 aimed at providing Vietnamese design students a platform to design products from veneer and veneer based products, with the chance for two winners to travel to Australia for further training. The award was announced at the HAWA Home Fair in November 2013 and the award was presented by DAF staff at the HAWA Furniture Fair in 2014. DAF and UoM organised for the awardees to travel to Australia to participate in design training at RMIT in 2015.

An ACIAR blog was written and uploaded regarding Crawford Fund training in 2016 titled, ‘A new generation of products from forest plantations and agri-fibre residues’.

A total of six newsletters were produced, sent to industry partners and uploaded on the project website throughout the project.

5 Achievements against activities and outputs/milestones

Objective 1: To analyse the existing resource, supply chain and wood processing methodologies and to support markets focusing on both veneer and veneer based products.

no.	activity	outputs/ milestones	completion date	comments
1.1	Vietnamese Veneer Value Chain Assessment (VCA)	Summary report of Vietnamese acacia and eucalyptus resource (PC & A)	15-11-12	Reports: 1.1.1_Resource_report
		Acacia and Eucalyptus veneer competitiveness mapping (PC)	18-08-16	Report: 1.1.2_1.2.3 Mapping and VCA
		Vietnamese veneer value chain analysis and opportunities for improvement (PC).	18-08-16	
1.2	Analysis of the potential of certification to impact favourably on the Vietnamese veneer and furniture industry.	Tailoring of GIZ's certification protocols (PC)	30-06-15	Reports: 1.2.1a_Certification_report 1.2.1b_Certification_summary_VN NB: As GIZ was unavailable to do this work, tailoring their protocols was not relevant.
		Identification of research needs specifically for the veneer and engineered wood products value chains (PC)	30-06-15	Research needs identified from components of these reports: 2.1.1&2a_Household mill surveys 2.1.2&2b_SME company surveys 2.2.3_Log grading recommendations 2.3.1b_Company_Thickness_variation and recovery_part 1 2.3.1c_Farmer_Thickness_variation and recovery_part 2 2.3.1d_MC_variation 2.3.1e_Company_veneer_grading 2.3.1g_Solar kiln prototype

PC = partner country, A = Australia

Objective 2. To investigate and optimise current process: development of optimal processing methods according to quality and sizes of plantation logs of acacia and eucalypts.

no.	activity	outputs/ milestones	completion date	comments
2.1	Detailed technical analysis of the current capabilities (processing and manufacturing) of the participating companies.	Evaluation of sliced and peeled veneer processing companies. Current capabilities of SMEs evaluated and documented.	5-04-13	Reports: 2.1.1&2a_Household mill surveys 2.1.1&2b_SME company surveys
		Evaluation of companies on product manufacturing. Current capabilities of SMEs evaluated and documented.	5-04-13	Reports: 2.1.1&2a_Household mill surveys 2.1.1&2b_SME company surveys
2.2	Raw material analysis specifically for veneer production	Quality analysis for veneer production of trees and logs.	5-04-13	Report: 2.2.1&.2_Resource_quality
		Wood quality analysis for veneer production.	5-04-13	Report: 2.2.1&.2_Resource_quality Combined report with above
		Define appropriate veneer log standards, suitable silviculture regime, proper taxa and genetic material.	29-09-14	Report: 2.2.3_Log grading recommendations
2.3.	Develop optimal veneer processing methods	Optimal processing methods developed and documented. Results presented at workshop (PC & A).	29-04-15 28-05-15 3-11-15 27-01-16 26-10-15 24-05-16 5-11-15	Reports: 2.3.1a_Optimal_peeling_micro-lathe 2.3.1b_Company_Thickness_variation and recovery_part 1 2.3.1c_Farmer_Thickness_variation and recovery_part 2 2.3.1d_MC_variation 2.3.1e_Company_veneer_grading 2.3.1f_Lathe modification 2.3.1g_Solar kiln prototype
2.4	Selected veneer based products manufacturing performance	Range of products will be selected and tested for existing decorative applications (PC).	15-03-16	Report: 2.4.1_Mechanical assessment_NOT FOR PUBLISHING NB: Results questionable and unsalvageable.
2.5	Development of grading and/or quality control procedures	Documentation of product and quality control procedures (A).	16-05-14	Report: 2.5.1_Veneer_grading_rules

Objective 3. To test and develop new processing methods and products from veneer:

no.	activity	outputs/ milestones	completion date	comments
3.1	Processing methods	Evaluation of processing technologies for decorative veneer, including multilaminar wood veneer to produce new decorative effects (A).	15-08-14 11-04-14	Reports: 3.1.1&3.2.2_Evaluation and manufacture of EWP for furniture 3.1.1b_Evaluation_decorative veneer
		Identify and test new commercial adhesive and gluing technologies for green and dry wood (A).	11-04-14	Report: 3.1.2_Green gluing billets
3.2	Engineered wood products	3.2.1 Plywood: formply and overlay flooring will be targeted (PC).	23-02-15	3.2.1&3_Hybrid_composite_formply
		3.2.2 LVL for non-structural and structural applications (for furniture industry) (A).	15-08-14 30-7-15 16-06-16	3.1.1&3.2.2_Evaluation and manufacture of EWP for furniture 3.2.2b_Demonstration_gazebo 3.2.2c Multilaminar bench
		3.2.3 Hybrid composite (with other species or fibres) (A & PC).	23-02-15 16-06-16	3.2.1&3_Hybrid_composite_formply 3.2.3 Bamboo ring composite panel

PC = partner country, A = Australia

Objective 4. To perform an economic impact assessment of veneer processing smallholders and SMEs during the project, and to investigate potential for new value creation.

no.	activity	outputs/ milestones	completion date	comments
4.1	**SMEs** economic impact assessment (PC)	4.1.1. Economic performance of selected companies before innovation analysed Economic performance of selected companies after innovation analysed 4.1.2. Economic performance of innovative vs. non-innovative companies analysed 4.1.3. Benchmarking with good international practices reported	29-04-14 20-06-16	**Reports:** 4.1.1_4.2.1_Economic Impact_preliminary report 4.1.1_4.2.1_Economic Impact_end Project
4.2	**Smallholders** economic impact assessment (PC)	4.2.1. Impact of plantation rotation on income and employment analysed 4.2.2. Impact of innovative processes analysed (lathe modification) 4.2.3. Economic impact on households from their current situation to innovative companies compared	29-04-14 20-06-16	**Reports:** 4.1.1_4.2.1_Economic Impact_preliminary report 4.1.1_4.2.1_Economic Impact_end Project

PC = partner country, A = Australia

Objective 5. To implement education and training related to veneer production and use in manufacturing

no.	activity	outputs/ milestones	completion date	comments
5.1	Training	Training needs assessments for veneer processors (A & PC).		Reports: 5.1.1a_Thu Nguyen thesis 5.1.1b_company training assessment
		Workshops (A & PC).	24-03-13 24-03-13 18-07-13 4-05-13 28-04-15 28-04-15 09-12-15 03-12-14	Outputs: 5.1.2a_Marketing Strategy_workshop 5.1.2b_Production Management_workshop 5.1.2c_Veneering flat surfaces manual 5.1.2d_Veneer and plywood production workshop 5.1.2e_Veneer processing_Acacia plantations 5.1.2f_Vibration analysis 5.1.2.g_Veneer quality workshop 5.1.2h_VCA workshop itinerary
		Training manual and training courses (A & PC).	04-06-12 20-12-15 13-05-16 14-10-14 14-10-14 22-02-14 22-03-14 26-04-14 26-04-14 04-11-15 29-10-15	Outputs: 5.1.3a_Crawford training report_2012 5.1.3b_Crawford training report_2015_Veneer Award 5.1.3c_Crawford training report 2016 5.1.3d_QC_chisel_test 5.1.3e_QC_Good Laboratory Practice 5.1.3f_Middle Management_module 1 5.1.3g_Middle Management_module 2 5.1.3h_Middle Management_module 3 5.1.3i_Middle Management_manual 5.1.3j_DAF_training_package_2015 5.1.3k_Farmer_Peeling training report

5.2	Extension and capacity building	Information management including veneer and EWP manuals (PC & A)	Website accessible from 30-10-12	Document: 5.2.1_website_sample NB: Handed over to VFU July 2104 Documentary aired 03-07-2016 on VTV6
		Publications: New modules with a set of training documents and materials. (PC & A)	 22-02-14 22-03-14 26-04-14 26-04-14 15-07-13 28-10-15 10-05-16 22-06-15	Reports: 5.1.3f_Middle Management_module 1 5.1.3g_Middle Management_module 2 5.1.3h_Middle Management_module 3 5.1.3i_Middle Management_manual 5.1.2c_Veneering flat surfaces manual 5.1.2d_Veneer and plywood production workshop 5.2.2a_SME veneer processing manual 5.2.2b_Manufacturing_Manual
		Extension: Conferences attended and Veneer Design Award completed. Six project newsletters were prepared and delivered (A & PC)	5-11-14 5-11-14 5-10-15 15-09-15 15-09-15 4-11-15 18-11-15 23-06-16 09-10-13 09-01-13 23-12-13 29-04-14 26-05-15 04-11-15 16-05-16	5.2.3a_IAWS_Resource_assessment_presentation 5.2.3b_IAWS_resource assessment paper 5.2.3c_IAWS_multilaminar paper 5.2.3d_Quebec_paper2015 5.2.3e_Quebec_presentation2015 5.2.3f_AcaciaConference_2014 5.2.3g_DesignAward 5.2.3h_ACIAR blog_EWP panels 5.2.3i_Italy conference poster 5.2.3j_VN_newsletter1 5.2.3k_VN_newsletter2 5.2.3l_VN_newsletter3 5.2.3m_VN_newsletter4 5.2.3n_VN_newsletter5 5.2.3o_VN_newsletter6

		Capacity built through postgraduate scholarships	Ongoing	PhD Mr Ngoc (VFU) – UoM Australia PhD Mr Hoan (VFU) - Griffith Uni. Australia PhD Mr Tung (VFU) - UQ Australia

PC = partner country, A = Australia

6 Key results and discussion

The following section provides the reader with the key results for each objective including discussion points where necessary. Comprehensive results can be found in the output reports and documents for each objective outlined in the comments of Section 6 and Appendix 1.

Objective 1: To analyse the existing resource, supply chain and wood processing methodologies and to support markets focusing on both veneer and veneer based products

The objective has two components: Veneer value-chain analysis; and analysis of potential for certification.

1.3. Vietnamese Veneer Value Chain Analysis (VCA).

1.1.1. Summary of Vietnamese acacia and eucalyptus resource.

A desktop study of the Vietnamese and eucalyptus resource, with 2011 data provided from MARD, resulted in the following 2011 snapshot:

- The majority of Vietnam's forests are concentrated in the Northeast, South Central Coast and North Central Coast regions excluding the heavy populated cities of Hanoi, Ho Chi Minh and the Mekong Delta region.
- Vietnam has a total of 13.52 million ha of forest comprising of 10.28 million ha natural forest and 3.23 million ha plantation forest. The largest proportion of natural and plantation forests is used for producing forest products.
- 75% of the forest plantation estate is used for producing forest products.
- 47% of forest plantations are owned by smallholder farmers indicating that improvements in the use, productivity and value of this resource should have significant benefit to farmers' incomes (Figure 6.1).

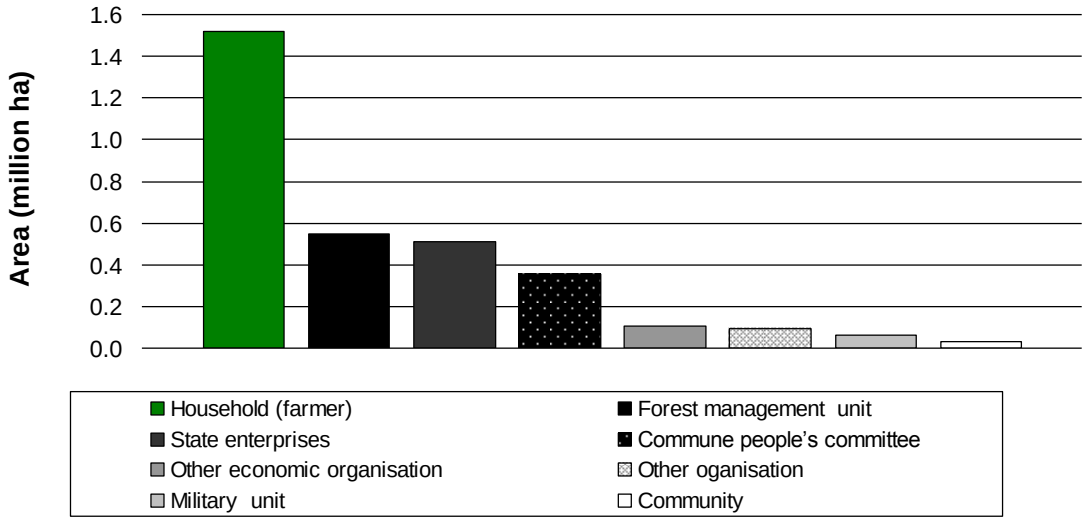

Figure 6.1. Area of plantation forests according to ownership

- 43% of the plantation forests are purely acacia species plantations; approximately 6% are purely eucalyptus plantation (Harwood and Nambiar, 2014). The initial impetus for planting these species was to export logs and chips for pulp and paper production.
- New plantings of eucalyptus and mixed plot species have remained relatively constant over the past decade. In the past two years 77% of forest plantations in

Vietnam have been solely acacia species. Figure 6.2 shows the area of plantation forests according to age class and species. The recent mass planting of acacia species is evident.

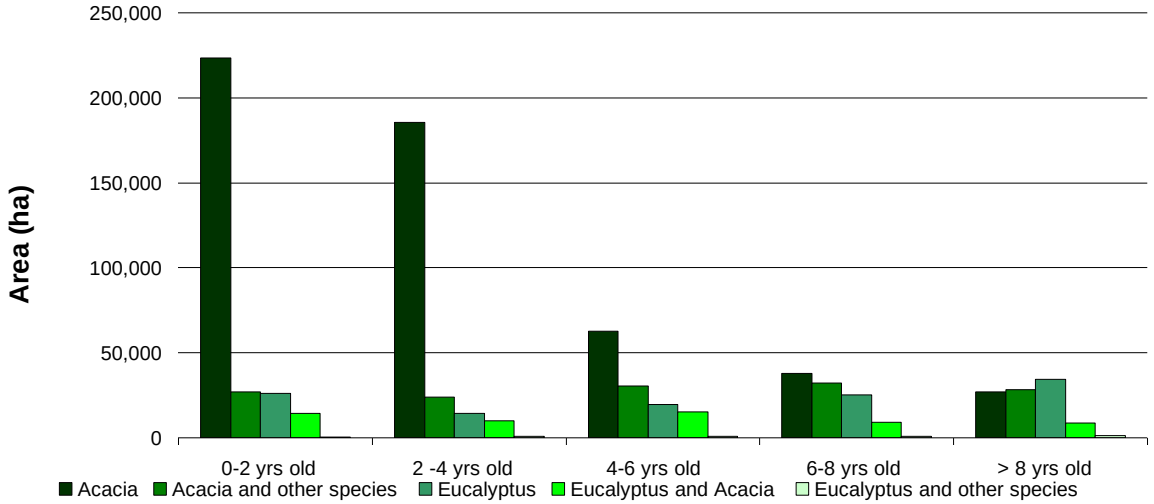

Figure 6.2. Area of plantation forests according to age class and species

The main results obtained from the tree and wood property characterisation study were:

- Generally, the average breast height diameter, tree height, heartwood proportion and basic density of trees increased with age from 2-11 years. An example of this trend is shown for *A. mangium* in Figure 6.3 to Figure 6.6. Anomalies in this trend tend to occur in higher stocked plantations where growth is inhibited.
- At 7-years of age, larger diameter and taller trees can be expected in areas with alluvial soils followed by basaltic then ferralitic soils.
- Faster-grown trees tend to have lower basic densities at 7-years of age.

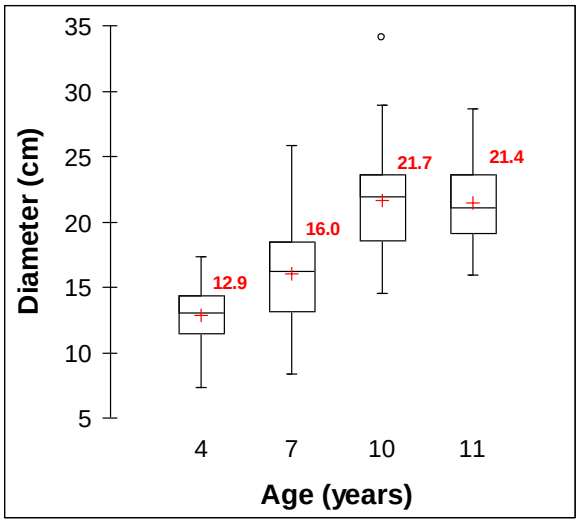

Figure 6.3. *A. mangium* diameter variation with age

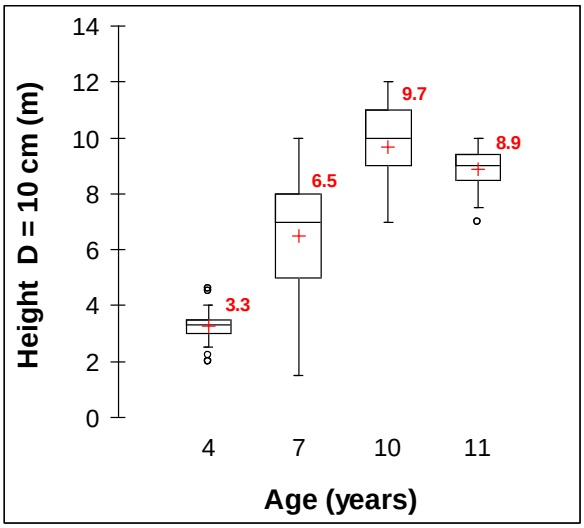

Figure 6.4. *A. mangium* height at diameter = 10 cm variation with age

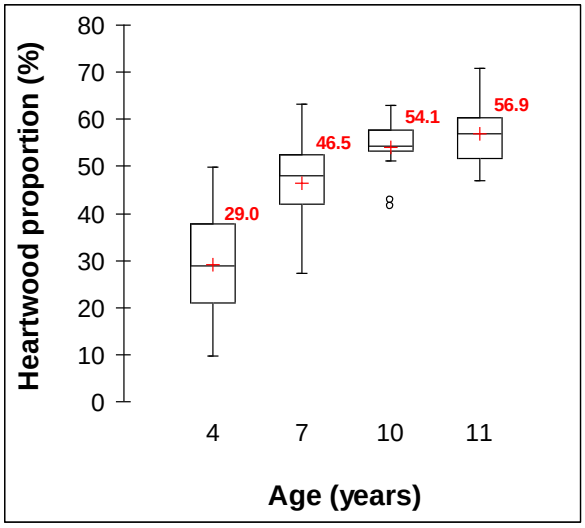

Figure 6.5. *A. mangium* heartwood proportion variation with age

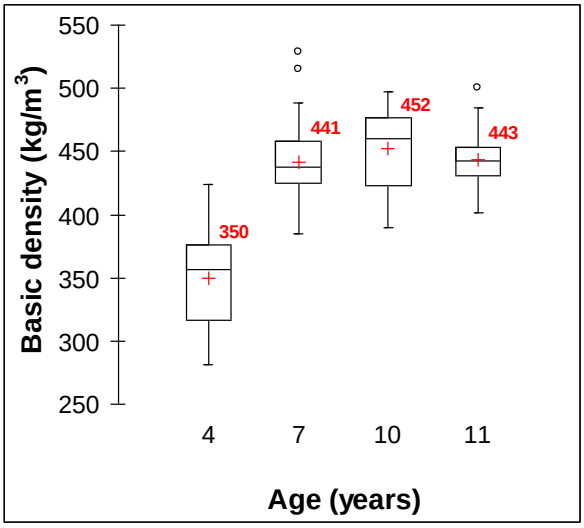

Figure 6.6. *A. mangium* basic density variation with age

- Average tree diameter, heartwood proportion and basic density of *A. mangium* were highest at 7 and 10/11 years of age compared with the other species grown in the same location. These are important properties for higher veneer recovery and profit. *Eucalyptus urophylla* had the lowest breast height diameter and heartwood diameter under the same scenario.
- Breast height diameters measured for 7-year-old *Acacia* hybrid were consistent with those observed in a survey of acacia wood processing factories conducted by Harwood and Hai (2009) for ACIAR projects FST2006/87 and FST 2008/07. Basic densities measured in this study were lower than expected for the hybrid and *A. mangium* compared to recently published figures (Dinh Kha, Harwood et al. 2012).

1.1.2. Acacia and eucalyptus veneer competitiveness mapping and 1.1.3. Vietnamese veneer value chain analysis.

Key findings of the veneer competitiveness mapping and VCA study were:

- The most popular trading method for growers was to sell their whole plantation to a timber collector or trader. Timber traders negotiate a spot purchasing agreement with timber growers based on buying the whole plantation at a single price with almost no measurement or log quality classification. Veneer producing companies rarely purchased raw materials directly from growers.
- Most timber processors were not competent at identifying appropriate log grades for the production of peeled and sliced veneers. For peeled veneer production, both facility and technical standards needed to be improved. Low quality peeling machines were a key factor contributing to the low quality of peeled veneers. Spindleless lathes mainly imported from China provided uneven thickness in finished veneers. In addition, peeled/sliced processors commonly used inappropriate technical parameters for peeling and slicing which resulted in high thickness variation.
- For production of plywood and other types of veneer-based products, processing facilities were much better. However, inappropriate and poor technology application processes for drying, storage and bonding were still problematic in these operations.
- In the plywood value chain, the total value added created from the value chain was Vietnamese 3.4 M dong for each 1 m^3 of veneer logs equivalent. Veneer plywood processors generated the largest added value of 45%, followed by timber growers (29%), veneer processors (18%), and finally timber traders (6%).
- In the wood chip value chain, the total value added along the value chain was Vietnamese 0.8 M dong (100%) for each 1 m^3 wood chip logs equivalent. Pulpwood

processors generated the largest added value (48%), followed by timber traders (36%), and finally timber growers (16%).

- It was estimated that 70% of acacia and eucalypt timbers were used for wood chips, 15% for sawn wood, 10% for peeled veneers and 5% remaining for roundwood applications.
- In order to enhance production and use of plantation acacia and eucalypt for production of veneers and veneer based products, Vietnam can pursue two competitive strategies:
  - reduce the cost of production for veneer and veneer based products to compete with China, at least in the domestic market (low cost strategy)
  - enhance export of high quality veneer and veneer based products to the world (high quality strategy).
- The main cost expenses forming product cost were raw material cost, labour cost, management cost, and depreciation cost. Of these, raw material cost, especially, raw wood material cost accounted for 60% of product price.

1.2. Analysis of the potential of certification to impact favourably on the Vietnamese veneer and furniture industry

1.2.1. Tailoring of GIZ's certification protocols for the production of veneers and EWPs

The assessment of certification protocols and recommendations provided the following key results:

- There is a long history of standard development and forest certification in Vietnam including multiple attempts for recognition of the national forest standard by FSC. Both FSC and the national scheme to be endorsed by PEFC have set ambitious targets for national standards to be completed by end of 2016. The growth of areas certified has been slow, with only one company certified by FSC between 2006 and 2011; however there was significant growth since then as shown in Figure 6.7.

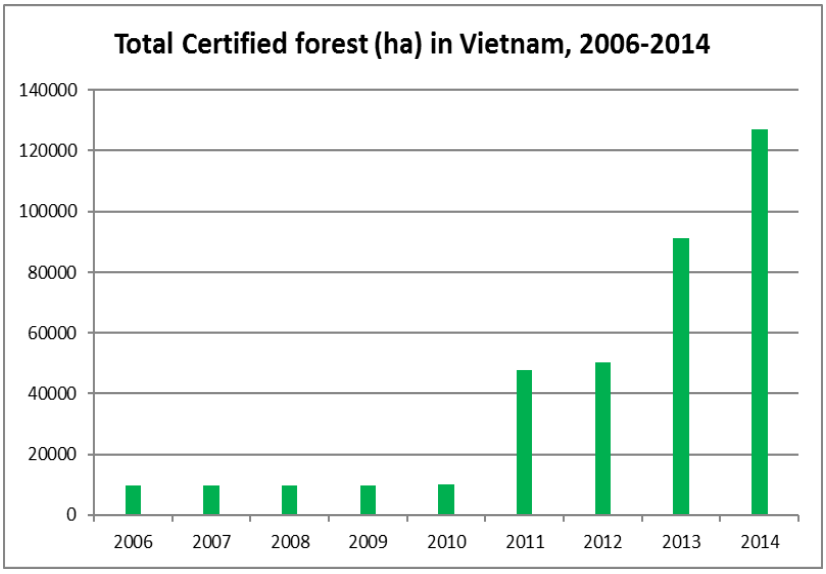

Figure 6.7.Total certified forest (ha) in Vietnam, 2006-2014

- Financial and technical support were critical reasons why Vietnamese forest managers achieved certification, although such support cannot be effective without commitments by forest owners. Overall success has been limited with, as of July 2015, Vietnam having only 133,632 ha and 11 organisations achieving FSC certification. Of this total certified area, approximately 83,000 ha was plantation forest, representing less than 3

percent of Vietnam's 3.2 million hectare plantation estate. As of November 2014, Vietnam had 389 Chain of Custody (CoC) certificates granted to timber processing and export enterprises, five of which were PEFC (MARD, 2015).

- The uncertainty in regards to costs and return on investments in certification requires further analysis which should reflect the true costs and the true benefits to forest growers. It is important to note that, to date, the development of FSC and other systems has often been subsidised through international agencies.
- The trend to proof of legality as the basis for market access requirements was acknowledged at the 2013 November PEFC Stakeholder Dialogue, Kuala Lumpur, where Ms Cindy Squires from the International Wood Products Association stated that "Legality is becoming the higher concern and sustainability is secondary". This sentiment mirrors those expressed by Vietnamese furniture manufacturers.
- Overall, alternatives to FSC provide outcomes that are similar in terms of legality or sustainability. However, these alternatives are usually achieved at a lower cost, the market for auditors is more competitive and less onerous than those for FSC certification, and ongoing savings may be achieved under such systems.
- It is unclear whether the current commitment to, and focus on, certification by the FSC will be maintained, or will be replaced by alternatives such as PEFC, ISO, Voluntary Partnership Agreement (VPA), or simplified CoC/legality approaches, and this question is particularly important as legality becomes a principle for access to some high-value international markets.
- Irrespective of the approach adopted, it is clear that political and trade relationships between trading partners will continue to have a dominant influence on the level of success in maintaining and strengthening the Vietnamese forest and forest products industry, especially that based on acacia plantations. This was because consumers were essentially indifferent to international initiatives designed to develop sustainability credentials and continue to be influenced primarily by price and design.

1.2.2. Identification of research needs specifically for the veneer and EWP value chains.

The main research needs to improve the production of veneer and EWPs were identified through a series of industry SME and smallholder surveys. The results included:

- ensure optimal lathe settings to reduce thickness variation of veneer
- investigate drying methods to increase the number of working days during the year which are affected by wet season
- improving the quality of the rollers to benefit veneer quality and mill profit.
- provision of a standard log grading tool
- provision of a standard veneer grading tool
- provision of a training to minimise moisture content variation between veneers.
- provision of a training on all aspects of the value chain
- provision of a processing chain best practice manual
- improvement of selection of adhesives for specific EWPs
- technical parameters for gluing and pressing need to be investigated by the project team and the results transferred to the industry
- training in quality assurance testing methods.

Objective 2. To investigate and optimise current processes: development of optimal processing methods according to quality and sizes of plantation logs of acacia and eucalypts

The objective had five components: a detailed technical analysis of the current capabilities of the participating companies; raw material analysis specifically for veneer production; develop optimal veneer processing methods; test manufacturing performance of selected veneer based products, and to develop veneer grading and/or quality control procedures.

2.1. A detailed technical analysis of the current capabilities of the participating companies.

2.1.1 Veneer processing

The quality management survey of small household peeling mills in rural areas north of Hanoi revealed:

- the main species being processed was *Eucalyptus urophylla* with an average diameter of 7 cm
- no standards were used to grade logs prior to peeling
- logs were generally stored outdoors with no cover
- the most common veneer thickness produced was 1.7 mm
- the air-drying process depends very much on weather conditions (Figure 6.8). For this reason, the mills can only work about 20 days per month and for 6-7 months per year.

Figure 6.8. Examples of uncontrolled veneer air-drying at the surveyed mills

- the quality of rollers significantly influenced the thickness variation of veneers and the profit of the mills because they can be easily worn or broken.

The research needs based on these surveys were provided in the previous section.

2.1.2 Product processing

The quality management survey of SMEs producing veneer-based products from sliced and peeled veneers revealed improvements were required in the following areas:

- thickness variation
- grade quality of veneer according to product specification or intended use
- moisture content of veneer
- veneer jointing method
- selection of glue for intended use
- gluing application according to the supplier instruction
- pressing parameters
- glue bond quality
- moisture content of the substrate
- sanding of veneered products
- type of coating used and its application

- storage and packing of the final products
- improving process operations and optimising layout design
- occupational health and safety (OHS) conditions in the factories.

2.2. Raw material analysis specifically for veneer production.

2.2.1. Trees and logs and 2.2.2. Wood quality analysis

Characterisation of *Eucalyptus urophylla, Acacia mangium* and *Acacia* hybrid *(A. mangium* × *A. auriculiformis)* indicated that some species performed better than others in terms of certain tree, log and peeled veneer properties. For instance:

- *A. mangium* was better suited to appearance veneer products based on comparatively (with age) higher heartwood proportion, and less frequent, smaller knots. This species did however display a higher level of ovality, which affects overall recovery and could be site or clone specific. This requires further investigation.
- *Acacia* hybrid had comparatively more frequent, larger knots making this a good species for use in substrate veneer or multilaminar veneer where the knots are dispersed in the final product.
- *E. urophylla* was better suited to structural products where its comparatively higher stiffness was more important for example for LVL beams, formply or structural plywood. Note: AH, AM, and EU represent *Acacia* hybrid*, Acacia mangium* and *Eucalyptus urophylla* respectively

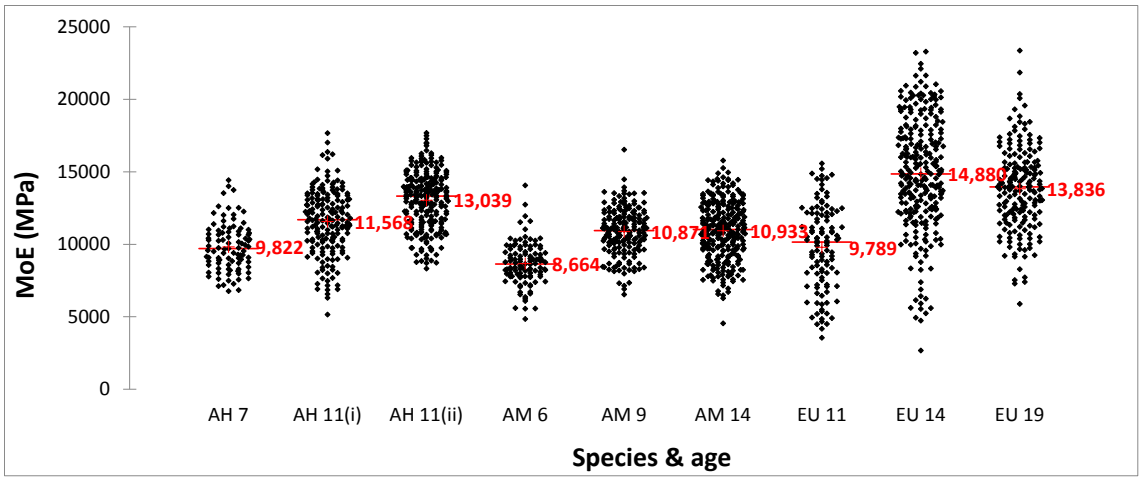

Figure 6.9. Distribution of veneer sheet stiffness (MoE)

A very high proportion of the recovered veneer only met the requirements of D-grade in accordance with Australian and New Zealand standard AS2269.0:2008 (where A grade is the best quality) with a small proportion meeting the requirements of higher grade qualities, with the exception of 14- and 19-year-old *Eucalyptus urophylla*. The higher proportion of C and B grade veneers produced from 14- and 19-year-old *Eucalyptus urophylla*, with 35% of B grade (face veneer) attained for the 19-year-old plantation, highlights the potential for this species to produce higher quality veneer at 14 years-old, more so than *Acacia mangium* at the same age, and much higher quality as the age increases. These results promoted the necessity to investigate the economic benefits of longer duration rotations.

2.2.3. Define appropriate veneer log grading standards.

A log grading system for plantation peeled veneer logs in Vietnam was proposed based on a review of international standards and within country, company specific, log grading rules. To align with the Vietnamese veneer grading standard TCVN 10316:2014, the log grading rules

included grade criteria for log knots, bend, end splits, holes, decay, mould and the inclusion of metal objects. Two log grades, 'A' and 'B' are proposed as shown in Table 6.10.

Table 6.10. Proposed log grading rules

Criteria	Grade A	Grade B
Knot	maximum diameter ≤ 10cm	unlimited
Bend	maximum 3% no multiple bends	maximum 4% no multiple bends
Total end split	total split ≤ 10% log length	total split ≤ 20% log length
Holes/insect holes	maximum diameter ≤ 5cm	maximum diameter ≤ 20 cm
Decay	not permitted	permitted
Mould	not permitted	permitted
Metal objects	not permitted	

2.3. Develop optimal veneer processing methods

Results of the micro-lathe optimal peeling parameters for the six species tested are provided in Table 6.11.

Table 6.11. Micro-lathe optimal peeling parameter results

Species	Pre-conditioning	Thickness (mm)	Compression rate (%)	Clearance angle (°)
Corymbia citriodora	essential	1	5 or 10	+1
		3	5	+1
Eucalyptus cloeziana	essential	1	5 or10	+1
		3	5	+1
Corymbia hybrid	recommended	1	5 or 10	+1
		3	5	+1
Acacia auriculiformis	recommended	1	15	+1
		2	15	+1
Acacia mangium	recommended	1	15	+1
		2	15	+1
Acacia hybrid	recommended	1	15	+1
		2	15	+1

A summary of the key results follows:

- pre-conditioning (heating or steaming) was recommended for high density species such as *Corymbia citriodora* (spotted gum) and *Eucalyptus cloeziana* (Gympie messmate)
- peeling 1 mm veneer was relatively problem free, especially with the acacias
- 2 mm veneer required careful settings; low compression rate caused deeper checks especially when combined with a positive clearance angle
- high density wood didn't allow high compression rates but required firm pressure on the nosebar to maintain drive on the knife
- incidence and severity of checking increased with increased pressure.

A comparison of moisture content variation between companies, within companies and between different types of drying produced the following summarised results:

- For companies implementing kiln drying in their process the moisture content of veneers sheets after drying was 5.2% to 10%. This meets moisture requirements to produce veneer based panels using both UF and PF adhesives.

- Companies using air-dried veneers (imported and dried in-house) faced the challenge of higher average moisture contents, and a larger moisture content range. For the three companies investigated using air-dried veneer to produce plywood, the moisture content ranged from 11 to 26%. For each of these companies the range was outside the recommendation for using UF glue (around 14 % upper limit). This posed the danger of negatively impacting product quality due to blowout and delamination. Ideally companies importing and or using air-dried veneer should use another means of final drying the veneer such as a kiln, steam press or solar dryer.
- The moisture meter used in this study was able to predict, with 95% confidence, the oven dry veneer moisture content within a range of ± 2.5 %. With this in mind, moisture meters should be frequently used to measure final dried moisture content of veneer in companies as a guide to detect unwanted high moisture content veneers prior to production.

A comparison of peeled veneer thickness variation and recovery between smallholder operations revealed the following results:

- Logs with large sweep produced less veneer recovery.
- For most smallholders, the thickness varied significantly from the outside of the log to the inside and was attributed to the low quality lathes used.
- The variation in veneer thickness recorded for each company was outside the Vietnamese veneer grading standard (TCVN 10316:2014) tolerances. These tolerances are more likely to be enforced for veneers exported to countries which strictly control the variation of veneer thickness. It seems that wider tolerances are accepted within the Vietnam veneer processing industry.

A comparison of peeled veneer thickness variation and recovery between SMEs revealed the following results:

- For all five companies, the variation in veneer thickness was well outside that stipulated by the Vietnamese standard *TCVN 10316:2014 Rotary Veneer* (TCVN, 2014), however the average thickness was close to the target nominal thickness for each company. This indicates that the companies set up the lathes to target their respective target thickness with some degree of accuracy.
- The variation in thickness was significantly less for two companies importing veneer compared to the three peeling their own veneer (Figure 6.12). The main reason for this was that veneers in Hai Nam and Khoa Long companies were graded for thickness before importing according to these companies standards.
- For the three companies peeling their own veneer, Trung Thanh produced veneer with the least variation which was also evident when observing the trend of variation from log pith to periphery; the trend levelled out close to core outwards. The thickness variation was largest for the Tien Bo company which showed an almost linear trend of increasing from the log core to periphery. The tighter variation in thickness resulting from the Tien Phat and Trung Thanh companies was likely due to these companies using more sophisticated electrically adjusted (for thickness) spindleless lathes compared with the Tien Bo lathe which used mechanical adjustment.

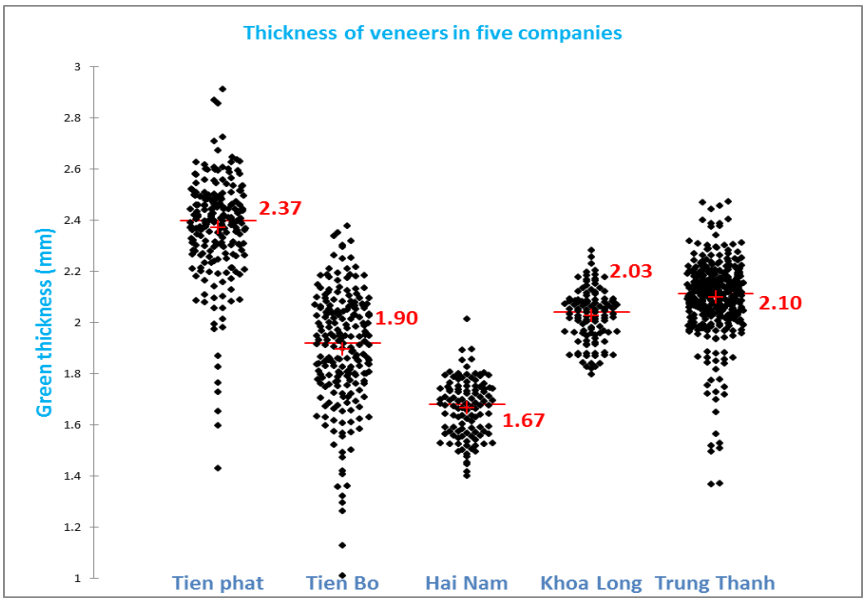

Figure 6.12. Distribution of thickness from the five SME companies.

- The green recovery was much lower for Tien Phat company (64%), than Tien Bo company (76%) and Trung Thanh company (82%) (Figure 6.13). The difference in recoveries was exacerbated by poor log form but was also attributed to the different efficiencies of each peeling process. For instance, extra waste was produced by machinery/clipper failure and improper rounding (rounding too much or too little) at Tien Phat.

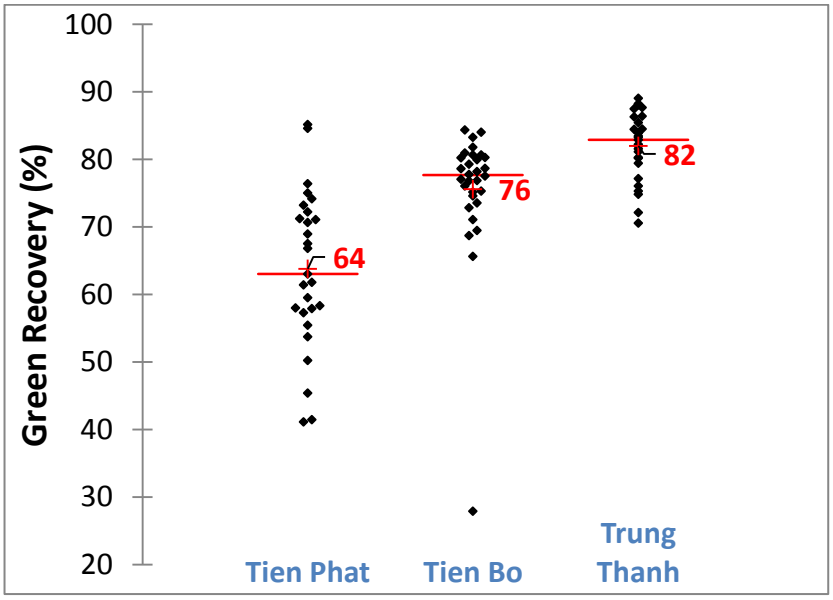

Figure 6.13. Distribution of green recoveries for SMEs peeling their own veneer

As the Tien Bo Company produced veneer with the highest thickness variation, it was selected as a pilot study to modify their peeling lathe to improve veneer thickness variation. The results of the modification were:

- The lathe modification significantly improved the thickness variation of peeled veneer. Before the lathe was modified only 5% of veneers were within the thickness tolerance specifications outlined in the Vietnamese veneer quality standard. After the modification, 72% of veneers were within the specification.

- By reducing the veneer thickness variation via the lathe modification, an extra 16% in green veneer recovery was achieved which translated to more profitability.

Drying veneer sheets in a prototype, passive solar-dryer, located outdoors during rain, resulted in the reduction of moisture content to below the threshold for mould development after a predicted 4 days. The structures are simple to construct with readily available and low cost materials and tools.

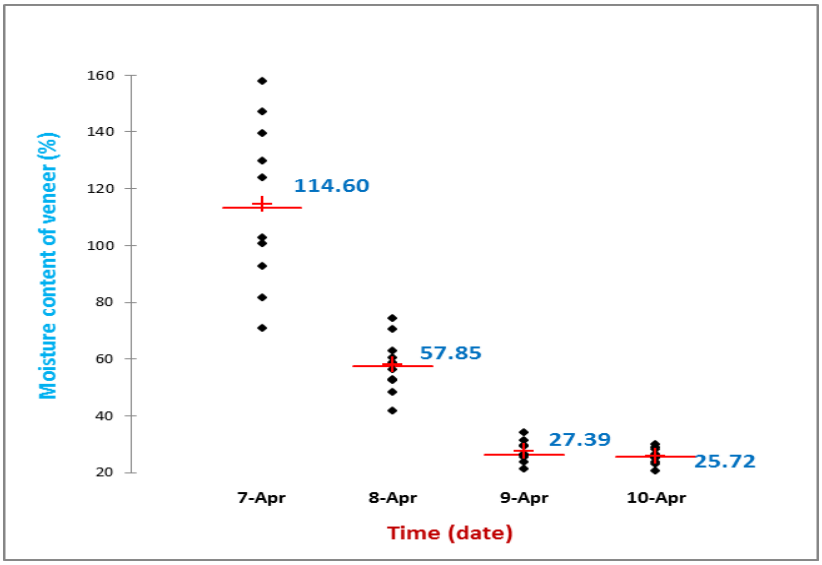

Figure 6.14. Reduction of moisture content of 10 veneer sheets, over a 3-day period, using the prototype dryer.

2.4. Test manufacturing performance of selected veneer based products

As part of the objective the manager of the VAFS mechanical testing lab was responsible for the determination and evaluation of physical and mechanical properties of veneer-based products sourced from Vietnam manufacturers.

The outcome of this trial was to be presented as a scientific report. Therefore the report should have included a section outlining the scientific methods applied, the presentation of findings as well as a chapter interpreting the results and subsequent conclusions and recommendations.

Action plans with milestones were established and frequently updated and revised as it became apparent that the manager and his team struggled to meet the agreed deadlines.

It became apparent that sample material had been compromised as methods and procedures advised by DAF had not been followed correctly. New material was sourced from the same manufacturers and sample preparation and testing was repeated.

The results of this second batch of samples were also ambiguous resulting in a lengthy attempt to understand and improve the quality of results and to present the consolidated outcomes as a scientific document. Finally, the results generated were deemed too inaccurate and ambiguous for publication.

The resulting outcome was a recommendation that VAFS mechanical engineering staff undergo further training.

2.5. Development of veneer grading and/or quality control procedures

A review of international veneer grading standards resulted in a simplified guide, equating veneer appearance grades for each standard as provided in Table 6.3.

Table 6.3 Comparative international veneer grading standards guide

Country Standard	Aus. / NZ 2269.0:2012	USA PS 1-95	Europe EN 635.2&3	Russia GOST 99-96.1&2	Canada 0151-09	China LYT-1519	Vietnam TCVN 10316
Grade	S & A	N & A	E & I	E & I	B	I	I
	B	B	II	II	C f/b	II	II
	C	C	III	III	C	III	III
	D	D	IV	IV		IV	IV
						V	V

A compilation of the grade criteria for each defect, grade and standard was also developed. These guides provide useful tools for veneer exporters.

Some international standards include tolerances for thickness variation of veneer. Most standards that are plywood focussed instead include thickness tolerances for the final plywood product.

A review of the non-standardised or 'in-house' peeled veneer grading rules currently being used within Vietnam provided the following conclusions:

- All of the standards used by the companies had fewer grade defects than the international standards. This may be a result of lower quality expectation of the domestic and export markets.
- The company standards were mostly stipulated by the customer of veneer or veneer based products.
- The smaller companies tended to include less defect criteria in their grading rules than larger companies.
- Decay, holes, sound and loose knots are the most common defects assessed during grading.
- The small household companies tend to grade for mould. This is relevant to these companies that do not have drying facilities other than air-drying. Air-drying veneer in Vietnam, particularly in the wet, humid months produced veneers with mould due to the retarded drying rate.
- The hole defect had varying interpretations for the in-house standards. For some companies, holes are restricted to absence of knots or insect attack. For other companies, particularly the small companies peeling small young plantation material, holes included large 'wane' holes caused by peeling logs of poor form and inclusion of veneer from the log periphery.

The case study to analyse the effectiveness of the recently released Vietnamese (TCVN 10316:2012) veneer grading compared to the Australian/New Zealand (AS/NZS 2269.0:2012) standard, provided the following results:

- The Vietnamese rotary peeled veneer grading standard for face veneer produced similar results when compared to the Australia/New Zealand standard, in terms of identifying the most limiting defect and the ratio of grade for each defect.
- For this study the most limiting defects were loose knots, holes, splits, sound knots and discoloration which are common defects found in young plantation acacia and eucalypt logs.
- In this case study, the inclusion of the knife mark and mould defects in the Vietnamese face veneer standard downgraded more of the high quality veneer than the Australian/New Zealand standard. Both of these defects are preventable.

Objective 3. To test and develop new processing methods and products from veneer

This objective consisted of two main components: to test and develop new processing methods, and engineered wood products.

3.1. Processing methods

3.1.1. Processing technologies for decorative veneer

A review of current literature on multilaminar veneer resulted in an account of the history, manufacturing methods, properties, performance, uses, patents, manufacturers and suppliers. The review of manufacturing methods was of particular importance as it underpinned the methods used for subsequent product development work described in following sections.

Laboratory trials to evaluate the quality of samples manufactured from *Acacia* hybrid, *Acacia mangium* and *Eucalyptus urophylla* for the application of LVL panels for furniture production produced the following outcomes:

- For the dry chisel glue bond test, 100% of samples achieved the highest bond quality value.
- However, bond quality values for the wet condition Type C bond test were very poor with most glue-lines not meeting standard requirements. The results indicated that the adhesive used (UF 9128) was not suitable for high moisture content. The type C bond test was designed for products which can be used in long term exposure to high humidity or short term to extremely high humidity.
- Shear strength results were acceptable.
- To minimise curvature within LVL, two cross bands were recommended for LVL with a thickness greater than 20 mm.

For multilaminar samples the following results were produced:

- Both dry and type C chisel glue-bond tests produced high bond quality values.
- Shear strength results were acceptable.

In the case where products are to be used for long term in high humidity environments, melamine formaldehyde or melamine urea formaldehyde were strongly recommended.

3.1.2. New commercial adhesive and gluing technologies for green and dry wood.

Using the Salisbury Research Facility's Automated Bond Evaluation System (ABES), six potential adhesives to bond green material were shortlisted to two. They were chosen based on their superior strength properties from the ABES testing.

Testing of the two adhesives was performed in end-glued sawn boards via three-point bending tests. The best performing adhesive was then selected to perform full scale trials for gluing and peeling green logs.

A number of test methods were used to produce a desirable textured surface at the end of the logs prior to gluing. This included testing a variety of rotating bristles, an impact bristle and a high pressure water blaster; however, the best result was produced by cross-cutting logs using a large variable speed circular saw (Figure 6.15).

Figure 6.15. Surface roughening after cross-cutting with a circular saw

Using the optimum adhesive and log surface roughening technique, pressed and glued log billets (Figure 6.16) were successfully peeled providing peeled veneer free of knots (Figure 6.17a) with structural integrity for handling and drying (Figure 6.17b).

Figure 6.16. Pressed and glued green billets ready for peeling


(a)

(b)

Figure 6.17. Knot-free hoop pine veneer (a) and veneer after drying (b)

3.2. Engineered wood products.

3.2.1. Plywood.

The research undertaken to provide an alternative technique to seal voids between the bamboo strips of veneer/bamboo formply was performed to improve the lifespan of this product. The research tested the application of a mix of bamboo sawdust/wood particles/coconut fibres and PF resin applied internally during construction and produced the following results:

- In general, all of the mixed filler contributed to improve the density and strength of treated panels including, MoE, MoR, shear strength and tensile strength. Among the filler material tested, veneer particles had the advantage of price, were easiest to mix with adhesive and had the overall highest strength properties compared to other materials.

- Filler to glue ratios of 1:0.25 and 1:0.5 was much easier to fill the gaps than the 1:1 ratio due to lower viscosity.
- Glue mixing and filling of mixed material to the gap between bamboo strips was cumbersome but our purpose of reducing the gaps and improve the properties was achieved.
- Further work on improving mixing and filling methods will improve productivity in industry.

3.2.2. Laminated veneer lumber (LVL for non-structural and structural applications).

From the multilaminar blocks produced in *Objective 3.1.1*, a non-structural LVL multilaminar table was produced to highlight this potential new value-added product for the Vietnamese industry. The veneer was specifically selected to provide an aesthetic mix of colour variation. The table was presented at the Vietnam International Furniture and Home Accessories Fair in Ho Chi Minh City during March 2015, and during project workshops where it received much attention from industry (Figure 6.18).

The activities conducted in order to construct a demonstration structure from plantation eucalypt engineered wood products proved that this wood material can be successfully used to manufacture multilaminar veneer components and glulam elements. The resulting outdoor gazebo was an aesthetically pleasing structure highlighting the potential for EWPs for a range of outdoor applications (Figure 6.19).

At the time of writing this report, the multilaminar bench was still under construction (Figure 6.20). All of the multilaminar elements were CNC routed and press glued and sanded. Each individual element will have all veneer faces finished including grain filling and sanding and all sharp edges will be smoothed and rounded to remove the possibility of splinters. The final product will have a finishing coat of polyurethane to seal the product and to highlight the colour variation resulting from the alternating veneers of shining gum and red mahogany. The final products will be placed in the gazebo at the Salisbury Research Facility to complete the show piece.

(a)

(b)

(c)

Figure 6.18. Construction of multilaminar table (a) the finished product (b) and exhibited at the 2015 HAWA Fair in Ho Chi Minh City.

(a) (b)

Figure 6.19. Close up of roof frame elements (a) and the completed gazebo (b)

(a) (b)

Figure 6.20. Bench/table individual elements (a) and representation of finished product (b), from Better Homes and Gardens, March 2014

3.2.3. Hybrid composites using other species or fibres

This work component shared the results for the veneer/bamboo hybrid formply work outlined in *Objective 3.2.1*.

Another product developed under this objective was a hybrid composite comprising bamboo rings adhered between radiata pine structural plywood panels. DAF manufactured and tested 300 × 300 mm prototype panels for shear strength properties (Figure 6.21) and determined the manufacturing process appropriate to produce full sized panels.

Figure 6.21. Single layer design test panel undergoing shear testing

Full length panels were tested under bending (Figure 6.22) and compression at the University of Queensland. Digital Image Correlation (DIC) technology was utilised to evaluate the performance of the panel in three dimensions. At the time of writing this report the data were

yet to be analysed and compared with alternative construction products. Further examination of the properties of the panel will include assessing the shear strength. Furthermore, the structure will be evaluated for insulation efficacy, fire resistance, and acoustic isolation properties.

(a) (b)

Figure 6.22. (a) Double layer full length panel undergoing a bending test (b)

Objective 4. To perform an economic impact assessment of veneer processing smallholders and SMEs during the project, and to investigate potential for new value creation

The objectives of this work were combined such that the smallholder and SME impact assessment were reported together over two reports. The first included a literature review for research design and economic impacts, while the second was the economic impact assessment for smallholders and SME's detailing the performances of innovative vs non-innovative companies and comparing the economic impacts over a number of scenarios. The following results are presented as per each report.

Literature review

Key results from the economic impact assessment literature review included:

- The review presented the main economic impact assessment research question, 'will veneers and veneer based products manufacturers generate superior earnings by (a) improving revenues due to introduction of new products, or achievement of higher product quality or (b) reducing costs due to application of optimal manufacturing processes?'
- The proposed methodology to answer this question was to conduct two economic impact assessment surveys, consequently (i) baseline survey and (ii) endline survey. The survey sample included households and companies that participated in the project.
- The theoretical framework to achieve this goal was presented and consisted of: assessment of competitiveness strategies, competitiveness advantage and economic efficiency indicators.
- An overview of wood processing companies in 2014 revealed that Vietnam had approximately 2,000 wood processing units in which 240 were foreign companies and more than 400 domestic companies participated in exporting.
- At this time the product categories of the Vietnam wood processing industry included mostly furniture (indoor and outdoor), kitchen fittings, flooring, and toys.
- Traditional markets of the wood processing industry were the United States, Europe and Japan which accounted for 70% of total export turnover. Potential markets are being explored such as India, Russia, and Central Asia.
- Most of the wood processing companies were found to not have a solid business strategy. They primarily tended to follow operational effectiveness (continuously find solutions to improve effectiveness) rather than define a strategy.
- A review of a number of veneer processing and veneer-based product manufacturing companies revealed inefficiencies in: veneer thickness variation, drying and moisture content control, adhesive utilisation, grading of logs and veneer, storage, marketing and sales, and business planning.

Economic impact assessments

Within the framework of this 4-year project, the project teams implemented the following activities:

- Organised training courses on technical support in new technology for wood processing for businesses, planted forest households and processing wood households. Introducing basic knowledge on peeled veneer and plywood production, issues on raw material quality and product quality, product quality control and product classification/grading. Experience exchange and brainstorming on improper practices in production, aimed at raising knowledge of producers and improving effectiveness of peeled/sliced veneer production.

- Organised workshops, meetings with different actors from policy making agencies, local governments at all levels, businesses, planted forest households and processing wood households.
- Upgraded machines and equipment for wood processing households/ enterprises.
- Developed new products with high market potential.

All activities of the project have helped to improve awareness of the role and benefit of veneer processing. The technical support of the project in terms of training and new technology applications brought some change in wood production and processing of the households and enterprises. The efficiency was much improved and income for local people and businesses increased compared to the traditional production of wood chips or pulp. These activities formed the basis of the economic impact assessment results.

Impact on enterprises

The following summarises the impact of technical guidance to Vietnamese enterprises:

- For the Hoa Lan Wood processing company, after receiving technical guidance through the training courses, had better input classification. Moreover, in terms of technical errors, the company controlled the humidity during drying and selected better quality glue. Therefore, non-compliant products during processing were reduced from 3-4% to 2%. The quality of final products improved significantly. In economic terms this translated to an increase in annual profit of 1.6%, when the non-compliant products were reduced by 1%, and 3.1% when reduced by 2%. Not only did improving wood processing methods through technical guidance help wood processing companies to reduce their cost and increase their profit, their product quality ensured better competitiveness in the market.
- The project supported Tien Bo to test the quality of bamboo/veneer hybrid formply, and gave advice on plywood drying, plywood pressing, mould prevention, and arrangement and storage in accordance with appropriate techniques. The project team cooperated with Tien Bo to shorten their hot-pressing time by 20%, resulting in improved productivity. This translated to a reduction of labour and electricity costs of around 3% increasing profits up to 25%. Additionally, with an estimated 4% increase in throughput the company improved their profitability by a further 37% assuming the company sells their product at the same price.

Impact veneer processing households

The following summarises the impact of household surveys, longer rotation age scenario analysis, training and technical interventions to Vietnamese veneer processing households:

- According to survey results in Dak Lak province, households with forest tree plantations up to 8-years-old which are sold for peeled veneer had a higher annual income than that of households with 4-year-old forest trees sold as wood chips. For the 8-year cycle, households harvest once, incurring less production cost, while receiving higher output quality, higher price, and higher income.
- In Am Ha, Phu Tho province, a medium size plywood processing household which peels logs of eucalyptus or acacia to form veneer by machine with a monthly output of 500 m^3 / month gained an additional income of up to Vietnamese 8-10 billion don/ year by transitioning from wood chips to veneer processing. In addition, their use of workers helps to create jobs, and reduce poverty for many other households.
- In Dong Son commune, Yen The district, Bac Giang province, many households established their peeled/ plywood production, and plywood export since 2010. A medium size plywood processing household had a total capacity of 300 m^3/ month and gained a household income of up to Vietnamese 200-300 million dong/ year. Each processing household used 8-10 workers and each worker received an average salary of 5.2 million Vietnamese dong per month. Therefore, peeled/ plywood production also

helped creating jobs and income for workers in the commune which improved the living standard of local people.

- The project conducted training at Am Ha, Ha Hoa, Phu Tho companies in a village that has a long tradition of forest planting and wood processing from planted forests. The impact was very positive on the behaviour of the head of wood processing households. All trained households assessed concluded that content of the training was useful, helping them to expand their knowledge, techniques of production, storage, sorting inputs and outputs for veneer production. Households began to change and adjust their manufacturing processes in accordance with the technical recommendations provided. The techniques from this training were also applied in Bac Giang province. The exact mid- to long-term impact of this training is yet to be determined.
- We have tried to assume some potential impacts based on scenario analysis which predicted the economic impact if households applied some basic content of the training courses. The focus was on analysing economic efficiency scenarios for two technical contents including logs (input) classification/grade and peeled veneer (output) classification/grade. The monthly household income could increase by 3-7% depending on log recovery.
- In terms of technical intervention, the modified lathe roller designed in Bac Giang province proved to be very successful. This technical support of the project was highly appreciated by producers and was seen as a model that can be replicated at the local as well as many other areas on peeled veneer production.
- After using the new technique, households only had to replace bearings every two months with the same replacement cost. In addition, the new roller also helped to improve veneer quality with more stable thickness, saving inputs, labour cost and increasing production time of the households. The technical guidance may help producers to increase their volume of veneer production by about 3 % and annual income by about 6 %. This economic impact of this intervention may be significant if it is replicated throughout Bac Giang and across the country.

One limitation when implementing economic impact assessment to acacia and eucalypt growing households is that we were unable to evaluate economic benefits of the households using pre- and post- comparison design. Due to the project's duration being much shorter than typical rotation cycles of acacia and eucalypt for veneer processing (over 10 years), we could only use post-non-equivalent comparison design to evaluate the economic impact. We overcame this difficulty by using scenario analysis based on surveyed information and expert advice to provide a broad view instead. It would be beneficial to re-assess the companies affected by the interventions on an annual basis over the next five or so years to better quantify the mid- to long-term impacts of this project.

Objective 5. To implement education and training related to veneer production and use in manufacturing

This objective contains two main components: training, and extension and capacity building.

5.1. Training

5.1.1. Training needs assessment

The case study performed by GIZ at the Woodsland Company of 62 middle managers showed that middle management personnel lacked important technical and management skills. There were significant concerns about the cooperation between departments. The company did not have a clear performance evaluation system which partly created unfair feeling among employees about salary, compensation, benefits and promotion. Delegation, empowerment and participation in decision making processes were also wishes that supervisors expected from company executives. They also expected company's leaders to pay more attention to employees who were committed and loyal. Positive feedback received was that leaders of the company were aware of these problems and they were willing to find ways to improve the company's weaknesses.

A second survey conducted across the project participant companies revealed that training and human resource development represented one of the main components to be considered in the Vietnam veneer industry. The training should address all aspects of veneer processing and manufacturing, such as the production of peeled and sliced veneers, veneered products (plywood, veneered furniture, engineered flooring, moulded veneered components) and related topics, such as production management practices, including production flow, quality control, machinery maintenance and safe working conditions. Specific training courses for workers and supervisors should be offered.

5.1.2. Workshops

A summary of the workshops held over the course of the project is provided in Table 6.4 and includes the content, target group, date, duration and number of participants.

Table 6.4 Summary of workshops

No	Content	Target group	Time	Duration (day)	# participants
1	Vibrational analysis and stiffness	Researchers	Mar 2014	1	10
2	VCA workshop	Policy makers	Dec 2014	1	28
3	Peeled veneer and plywood production	SMEs and farmer households	Oct 2015	12	43
4	Peeled quality management	Company managers and technical staff	Dec 2015	1	34
	Total	**4 workshops**			**115**

5.1.3 Training courses

A summary of the training courses held by GIZ are provided in

Table 6.5 includes the target group, date, duration, number of participants and effective training days.

Table 6.5. Summary of GIZ training courses

No	Training course	Target group	Time	Duration (day)	# parti-cipants	Training days
1	3 internal trainings for Woodsland	Supervisors and workers in the veneer department	Mar 2012 Jan 2013 Mar 2013	1 1 1	20 5 15	20 5 15
2	Production Management & Increasing Efficiency in Veneer Processing Department	Middle management	Jan 2013	1.5	22	33
3	Corporate and Market Strategies and Promotion of Veneer	CEO and marketing managers	Jan 2013	1	10	10
4	Veneering of Surfaces	CEO & middle management	Jul 2013	4	27	108
5	Middle management course – Module 1-3	Middle management	Feb 2014 Mar 2014 Apr 2014	2 2 2	17 13 14	34 26 28
	Total	**5 trainings**			**143**	**279**

Over the course of the project Crawford fund training was successfully tendered to train Vietnamese research staff in Australia. Crawford Fund training was held for each successive year in the project totalling five training courses (Table 6.6 and Figure 6.23) covering a wide range of subjects across the veneer processing value chain, including management and improved research skills.

Table 6.6 Summary of Crawford Fund training courses

No	Content	Target group	Time	Duration (day)	# parti-cipants	Training days
1	Peeling overview and quality control	Senior researchers and sawmill managers	May 2012	5	5	25
2	Vibrational strength testing and image analysis (shrinkage)	Researcher	Dec 2013	5	1	5
3	Mechanical properties testing and multilaminar production	Senior researchers	Jul 2014	10	2	20
4	Peeling, drying, plywood manufacture, research management	Researchers	Feb 2015	10	9	90
5	Agri-fibre and LVL manufacture	Middle management	May 2016	10	3	30
	Total	**5 trainings**			**20**	**170**

The two best practice documents produced for the VAFS laboratory on chisel glue-bond testing and laboratory practice are currently in use as training guides for researchers.

(a) (b) (c)

(d) (e)

Figure 6.23. Crawford Fund training in 2012 (a), 2013 (b), 2014 (c), 2015 (d) and 2016 (e)

A selection of key Vietnamese researchers travelled to Laos to undertake training in peeled veneer processing using high-end electronic peeling machinery (Figure 6.24).

Figure 6.24. Vietnamese and Laos researchers training to use electronic peeling machinery

5.2. Extension and capacity building

5.2.1. Information management

The website has been instrumental in providing project partners and the greater community with access to project reports and regular newsletters (Figure 6.25). The total number of site visits during the period of June 2014 to May 2016 was approximately 49,000.

The project documentary prepared by VAFS and DAF researchers was aired across the country during prime time viewing at 7:30 pm, Sunday 3 July 2016. It is also available on

YouTube at the following link:

https://www.youtube.com/watch?v=eC9gdOHg2jo&list=FLeC2NuDQOR3ySX3HU7ekmMg&index=1

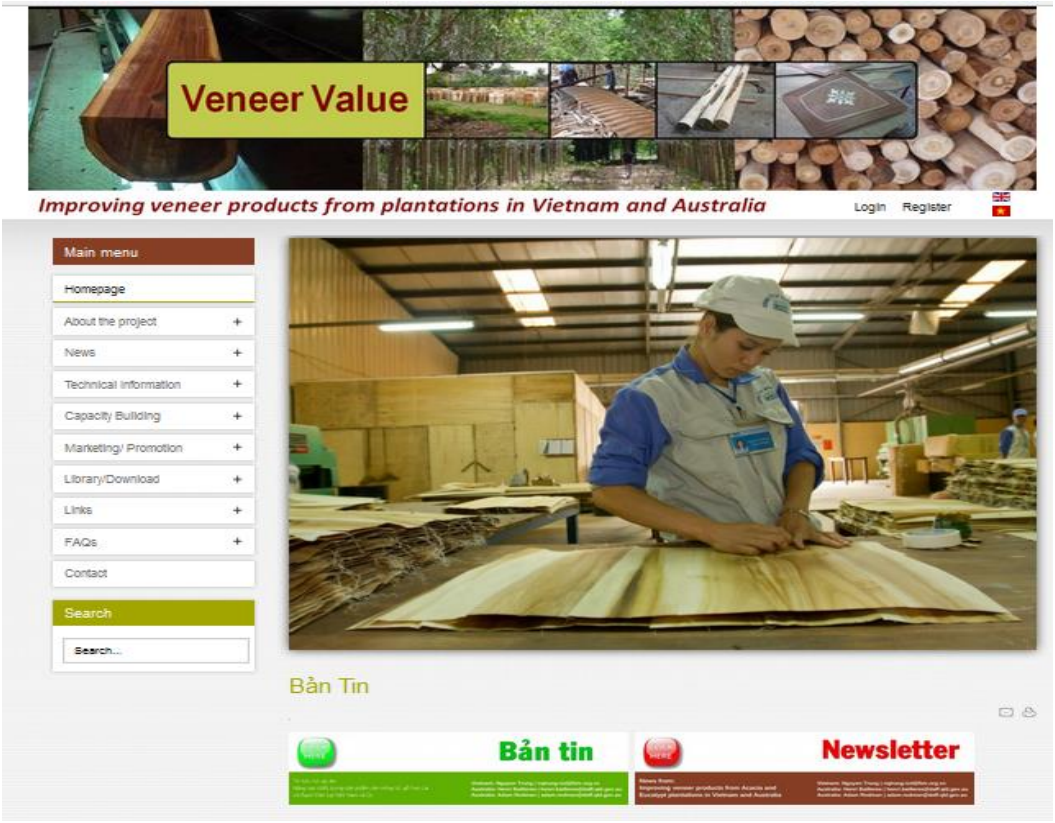

Figure 6.25. Project website page

5.2.2. Publications

During the course of the project the following publications were uploaded to the project website and disseminated to industry:

- GFA/GIZ middle management training manuals
- GFA/GIZ production management workshop manual
- GFA/GIZ veneering flat surface manual
- GFA/GIZ veneer and plywood production workshop manual
- DAF SME peeled veneer processing manual (this document is currently being developed into book format for full publication)
- DAF smallholder veneer manufacturing manual

5.2.3. Extension through Associations, smallholder organisations and/or industry bodies and FSIV networks

Conferences were attended by researchers throughout the project and posters and papers were presented. A total of nine researchers attended four conferences producing one poster, seven presentations and four conference articles.

The Veneer Award proved a success with the top two awardees participating in design training at RMIT in 2015 (Figure 6.26). The awardees have since gained employment in Vietnam in their chosen profession.

An ACIAR blog was written and uploaded regarding Crawford Fund training in 2016 titled, ‘A new generation of products from forest plantations and agri-fibre residues’.

(a) (b)

Figure 6.26. Veneer Award winning designs (a) and award winners attending RMIT training (b)

A total of six newsletters were produced (Figure 6.27), sent to industry partners and uploaded on the project website on the following dates:

- 1st issue: Jan 2013
- 2nd issue: Oct 2013
- 3rd issue: Mar 2014
- 4th issue: Jan 2015
- 5th issue: July 2015
- 6th issue: March 2016

Figure 6.27. Sample newsletters

7 Impacts

7.1 Scientific impacts – now and in 5 years

Reliable inventory data for Vietnam's acacia and eucalypt plantations were compiled into a single document. This provides means for policy and planning activities and allows for further investigation into the economic impact of harvesting age on smallholder profitability now and in the future.

A second report provided an analysis of the quality attributes of typical Vietnam acacia and eucalypt resources covering a range of age classes, sites and silvicultural regimes. Nine trials were assessed to provide the dataset. The results provide stakeholders with an indication of the qualities expected from plantations at different ages and allows direction of resource to appropriate products so that growers achieve corresponding value for their logs. Further the results will allow investigations into plantation management impacts on wood qualities, value and profitability. The methods developed to analyse the quality of plantations and wood quality provide a platform for Vietnamese researchers to perform ongoing analysis for the industry to facilitate future policy and investment decision making.

The development of optimal processing techniques by high-end micro-lathe research provides lathe operators with the necessary lathe setting information to improve peeled veneer quality. Vietnamese researchers have been trained to measure the quality of veneer in terms of thickness and moisture content variation. This allows them to service the industry and provide scientific solutions to improve peeled veneer quality in the future. They can advise mills on the best lathe setting parameters to use per species. With their contacts with engineers the industry is now equipped to make modifications to their lathe equipment by using improved rollers and bearings which, through the project case study, was proven to significantly improve veneer quality, recovery and profitability.

The cheap solar drying prototype design has the potential to radically improve productivity of smallholder farmers by increasing their annual throughput by approximately 30%, which in turn would provide more profitability to the households. As household workers are generally paid by volume of output, their wages are also likely to increase if households adopt veneer solar drying.

The method to manufacture multilaminar veneer has been optimised providing Vietnamese research institutes with the means to technically advise manufacturers wanting to make this product. The interest generated by this project has prompted MARD to fund a 4-year project, secured by VAFS, to develop multilaminar product manufacturing in Vietnam.

VAFS scientific staff were trained in good laboratory practice and the protocols have been adopted across all disciplines within the VAFS research facility.

The successful development of gluing green knot free billets to produce high grade veneer in Australia has gained interest within the Australian industry. Big River Timbers has expressed interest in running their own trials using the methods developed in this project to increase their veneer value and reduce waste.

The development of the gazebo and multilaminar bench showcases the potential of adding value to short rotation plantation hardwoods by producing structural and aesthetic products. We demonstrated to the Australian industry that such products are possible with careful R&D into wood properties and adhesives in association with engineers and architects. This resulted in a number of state, national and international projects being developed in the Engineered Wood Products arena.

The development of middle management training materials and their subsequent dissemination into the public domain on the project website, were recommended to Mike O'Connell, manager of Pryde Furniture in Papua New Guinea (PNG) and are now used within his company to train staff. This highlights an important cross-over of information between

ACIAR projects as Pryde Furniture is involved in ACIAR project FST/2014/065: Development of durable engineered wood products in PNG and Australia.

7.2 Capacity impacts – now and in 5 years

The Crawford Fund training programs have provided VAFS and VFU scientists with many new techniques and tools to optimise current veneer and composite manufacturing in the Vietnamese industry as well as methods to maintain quality assurance and future research measurement techniques. New capacities include veneer quality and wood property measurement techniques as feedback mechanisms for quality control. Non-destructive technologies based on vibration analysis to assess mechanical properties of logs and veneer was purchased through the project and researchers were trained in the theoretical principles and practical use of the equipment. This equipment and training will enable researchers to apply acoustic assessment technology to other projects. This rapid, reliable and accurate system will replace standard destructive testing protocols and equipment (i.e. universal testing machines) for some mechanical properties. Additionally, equipment and a process for measuring veneer shrinkage through optical scanning were established in the Vietnam Forestry University, providing a simple and reliable system.

Researcher training activities within country covered full data gathering from standing trees assessment, harvested log mensuration and billet preparation, peeling data and laboratory protocols. Three VAFS researchers received on-site training in critical inspection and review of manufacturing facilities and operations. These staff will be able to confidently undertake future industry surveys.

Four undergraduate students and a graduate student from VFU have been undertaking their thesis studies related to the project content. Three researchers from VFU and VAFS received John Allwright Fellowship PhD scholarships:

- Nguyen, Thanh Tung, University of Queensland, Brisbane
- Nguyen, Bao Ngoc, University of Melbourne, Burnley
- Nguyen, Hai Hoan, Griffith University, Gold Coast.

VAFS staff attended a workshop on certification in Ho Chi Minh. The Programme for the Endorsement of Forest Certification (PEFC) was presented to industry representatives outlining current and potential pathways for the Vietnamese wood sector. Through this participation, the VAFS team gained a broad understanding of international legality and sustainability mechanisms to fulfil international market requirements. VAFS is now leading decisions and policy for forest certification in Vietnam.

Richard Laity & Associates established and developed links with the Hue University and the Ho Chi Minh University through the certification objective activities exposing ACIAR activities across educational institutions.

Two graduates from VFU, as a result of their involvement in industry interviews, log and veneer grading development, have commenced employment with the industry partner Woodsland—one of the larger manufacturing companies involved in the project. One graduate is employed as a quality control foreman in the plywood section and has responsibility for material selection. The second graduate is also involved in quality control, working in the sliced veneer line.

Four undergraduate students from VFU have completed their graduation thesis using veneer material generated through project activities. They used the acoustic equipment and grading techniques taught to them by the project researchers.

The multilaminar table development process has led to a project managed by VAFS and funded by MARD to a value of $A180,000.

Mr Long, CEO of Bui Gia Interior Decoration Company in Hanoi, credits the training his staff received during the project for the improved quality and productivity in his company. He stated that Bui Gia has increased their production of veneer tenfold; from 300 m^2/month prior to participating in the project up to current output of 3,000 m^2 /month.

Vietnamese researchers attended a two-week intensive veneer processing training course at the Fred Lane Composites Centre and other laboratories at the DAF Salisbury Facility (see Section 4 Training). This training was designed to equip the researchers with detailed knowledge of the entire process from the log yard, through to rotary peeling, grading, gluing and quality control. Each participant returned to Vietnam with a hardcopy of the training course notes and videos. Components of this training are now used in VFU for their undergraduate curriculum.

Australian researchers have improved their capacity in grading and peeling small plantation logs on an international scale.

7.3 Community impacts – now and in 5 years

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

7.3.1 Economic impacts

The resource characterisation component provided researchers with the necessary tools to assist industry representatives and government policy makers in making informed, future investment decisions.

The project VCA made a number of recommendations to improve the economic return from plantations through education, policy standards and pricing schemes.

The lathe modification case study was shown to improve household income by 6%. This could significantly improve the livelihoods of farmer's households and their workers if implemented widely across these communities in Vietnam in the future.

Economic impact assessment scenario analysis predicts a 3-7% increase in household income by implementing log grading selection for veneer logs. Similarly, the utilisation of the new Vietnamese standard veneer grading rules is predicted to increase household income by 11 to 33%.

The economic impact assessment predictions forecasted that by reducing non-compliant veneer through training and best practices could increase company profits by up to 3%.

The reduction in pressing time implemented at the Tien Bo Company was shown to increase the company profits by 25-37%.

Switching from 4-year-old woodchip plantations to 8-year-old plantations was predicted to improve household profits up to 45%.

As a result of training activities, the Bui Gia Interior Decoration Company reported a 20% increase in throughput from 2014 to 2015 resulting in corresponding increased revenues.

7.3.2 Social impacts

The VCA recommendations recognised mid-term social improvements through education to improve the quality of resource and profitability. Through training programs and industry visits, Vietnamese veneer facilities incorporated continuous improvement programs and re-organisation of practices. This resulted in improved morale amongst the workers which further engendered well-being.

Female researchers in Vietnam institutions VAFS, VFU, CAP were heavily involved in activities and well represented in project meetings. For example, Ms Trinh Hien Mai (Figure 7.1) has held an activity management role for the duration of the project.

Figure 7.1. Dr Trinh Hien Mai, researcher with the Vietnam Forestry University presenting the workshop agenda at the International Academy of Wood Science function in Hanoi, 2015.

VAFS collaborated with HAWA to organise a training course on veneer applications in furniture design and ten of the 25 delegates attending were female (Figure 7.2). This gender ratio provided an excellent example of the suitability of women in the industry and the attractiveness of timber design as a career path option for women in Vietnam.

Figure 7.2. Delegates at the Veneer in Furniture training course, Ho Chi Minh City, August 2014.

7.3.3 Environmental impacts

A key philosophy of the training and discussions with company representatives was the awareness of efficient utilisation of resources. Improved processing results in less waste throughout the processing stages with the incentive of improved profits, encouraging a culture of environmental awareness for wood processors.

The certification models presented within the project allowed decision makers to develop a fair certification scheme appropriate to smallholders, with the intention of reducing illegal logging.

With the uptake of veneer and log grading, and improved thickness variation and recovery through better lathe utilisation and modifications, less waste product will result leading to better resource utilisation in the future.

7.4 Communication and dissemination activities

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

Publications

In total 33 publications were produced during the project period ranging from technical reports, training manuals, seminar and workshop reports. The reports are listed in section 10.2 of this report.

Co-ordination meetings

Various co-ordination meetings were conducted throughout the project. They are listed in detail in the project annual reports but in summary include:

- Skype meetings between objective leaders from DAF, UoM, VAFS and VFS.
- Teleconferences between objective leaders from DAF, UoM, VAFS and GIZ.
- In country management meetings between DAF/UoM and VAFS/VFU/GIZ.
- Interstate management meetings between DAF and UoM.

Workshops

A total of four workshops were held over the course of the project aimed at providing industry, management and policy makers with key project outcomes and/or hands on demonstrations. The workshop details follow:

1. ‘Basics of NDT assessment of static stiffness and strength by vibration analysis held by DAF at VAFS for VAFS and VFU researchers in 2014.
2. ‘Value Chain Analysis workshop’ held by CAP at MARD for policy makers in 2014.
3. ‘Peeled veneer and plywood production training workshop in Vietnam’ held by DAF and VAFS at the Am Ha commune (Northern Vietnam) for SMEs and farmer households in 2015.
4. ‘Peeled quality management training workshop’ held by UoM, DAF and VAFS at VAFS for company management and technical staff in 2015.

Training courses

A total of six training courses were held by GIZ In collaboration with the partner associations of the Vietnamese-German Forestry Programme, HAWA and VIFORES. The training courses were held at the Woodsland Company training centre for a combination of middle

management, company CEOs, supervisors and marketing managers between March 2012 and April 2014. The training topics were:

1. Three internal training sessions for Woodsland Company.
2. Production management / increasing efficiency in the veneer processing department.
3. Corporate and market strategies and promotion of veneer.

Middle management course – modules 1 to 3.

Successful Crawford Fund applications allowed key Vietnamese scientific staff, over five successive years to be trained in a wide range of subjects. The information imparted was subsequently disseminated among their institution peers. In particular, some aspects of the training are now taught in the VFU curriculum.

Competitions

The Veneer Award was organised by GIZ in 2013 aimed at providing Vietnamese design students a platform to design products from veneer and veneer based products, with the chance for two winners to travel to Australia for further training. The award was announced at the HAWA Home Fair in November 2013 and the award was presented by DAF staff at the HAWA Furniture Fair in 2014. DAF and UoM organised for the awardees to travel to Australia to participate in design training at the Royal Melbourne Institute of Technology (RMIT) in 2015.

TV documentary

Prior to the project final workshop, a 30-minute television documentary was prepared by VAFS and DAF researchers outlining the main objectives, outcomes and impact of the project. The documentary was professionally filmed and edited by Vietnam's leading network VTV6. The documentary is also available on YouTube at the following link:

https://www.youtube.com/watch?v=eC9gdOHg2jo&list=FLeC2NuDQOR3ySX3HU7ekmMg&index=1.

Newsletters

A total of six project newsletters were produced during the course of the project and were submitted to industry stakeholders as well as uploaded onto the project website. The newsletters were produced approximately at 6-8 month intervals providing project stakeholders with regular updates of key project activities and outcomes.

Website

The website www.veneervalue.com was launched mid-2012. It delivered information and news about the project and encouraged communication between industry, research and stakeholders. It provided a useful way to document and store outputs, communicate project activities, and build the project profile. The website was originally hosted by GFA/GIZ, and then moved to VFU halfway through the project when GIZ's role finished. To a large extent, the website succeeded in meeting its objective as a communication tool to provide information about the project, stimulate interest and discussion about veneer and veneer based product processing.

Website statistics is available for the last half of the project when VFU hosted it. From June 2014 to May 2016 the website had a total of 49,000 individual hits. GIZ training manuals are now being used by Pryde Furniture in PNG as a direct result of their availability on the website.

ACIAR Blog

An ACIAR blog was written and uploaded regarding Crawford Fund training in 2016 titled, 'A new generation of products from forest plantations and agri-fibre residue'.

8 Conclusions and recommendations

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

8.1 Conclusions

This project investigated aspects from the plantation (inventory, characteristics, quality) through to recovery and product development. In addition to practical processing outputs to optimise facilities, economic aspects were considered. Important material properties for veneer were reported, showing that 7-year-old plantations were suitable for veneer processing. Initial stocking rates may impact growth and properties and higher stocking might not necessarily equate to higher returns to growers at the end of the rotation.

It was found that growers tend to sell plots to a third party agent rather than direct to the processor. At the commencement of the project processors lacked knowledge of grade quality and specifications for purchasing veneer sheets, but the project proposed grading rules for peeler logs and explored grading systems for peeled veneer based on international standards. This activity coincided with the adoption of the official Chinese veneer grading standard by the Vietnamese standards committee which now provides clear grade quality specifications for producers and buyers. The project identified an increasing trend in certification, though this has mainly occurred through external agency assistance.

Experiments conducted during the project resulted in optimisation of processing methods and a clear understanding of the 'peelability' of targeted species. The project built on expertise in lathe engineering in relation to output quality which has resulted in electronically controlled spindleless lathe installations in Australia, Fiji Islands and Lao PDR. Additionally, the project team's improved knowledge led to a case study in Phu Tho province to successfully modify a commonly used household low-grade lathe to improve output recovery and quality. Importantly, gains were made through reducing thickness variation (one of the key reasons for downgrade and price reduction in the market). Improvements during the course of the project were seen in peeling, drying and gluing.

Veneer moisture content and thickness variation were identified as the main quality impediments and were characterised and improved through machinery modifications and training.

An original method to glue green logs together after having defects docked (for example branch whorls/knots) and subsequently peel the logs was developed in Australia. These trials resulted in the successful production of clear, defect-free veneer from a traditionally knotty resource.

A prototype drying system was developed with the ability to provide low-cost drying solutions during the wet season in Vietnam.

A number of new innovative engineered wood products were developed, the highlight being the prototype multilaminar table produced by VAFS and showcased at the HAWA furniture fair. Other feature products included the development and testing of bamboo/veneer hybrid panels, design and construction of a glulam and LVL veneer gazebo, and a multilaminar bench seat/table in Australia.

Following a successful trial of multilaminar veneer products, VAFS applied and were awarded a 3-year $A180,000 project to develop multilaminar techniques further.

The economic impact conducted at the end of the project indicated significant financial benefits from the project and future activities in the veneer supply chain, extending from producers to manufacturers.

The project provided excellent researcher training opportunities, both in Vietnam, and in Australia. Five training workshops were supported by the Crawford Fund during the project,

providing hands-on skill development for 20 participants, the majority of which were staff from VAFS and VFU.

There was an excellent industry focussed training program managed by GFA/GIZ, which provided 143 industry personnel with training in diverse topics ranging from marketing, manufacturing processes, and quality control. In addition, workshops were held across stiffness testing, value-chain analysis and plywood production to researchers, policy makers and SME/farmers respectively.

The project has contributed to improving the skills of female researchers, particularly at the VFU. The key collaborator from VFU, Ms Mai, has gained in confidence and ability through the project and been a key project participant.

The project team was repeatedly successful in securing Crawford funding, and seven project participants have taken up higher degrees (one MSc and six PhD).

8.2 Recommendations

The project outcomes have extended the capacity of researchers in VFU and VAFS and provided them with many learning experiences. Both SME and larger companies have also benefitted from training, processing and product development activities. The following recommendations are suggested for future research and development directions and follow-up assessments:

It is recommended that HAWA host a workshop in Ho Chi Minh City to disseminate project findings to industry stakeholders in southern Vietnam. Perhaps some further support for a similar workshop in the north would also be appropriate.

During development of subsequent R&D projects it is recommended that potential partners undertake a scoping study to better understand Vietnamese collaborators' capacities to more effectively build the project structure and realistic objectives.

ACIAR and project leaders should ensure appropriate international expertise can partner with local institutions. If necessary, budget changes should be considered to allow this. This is especially true where local capacity is deemed insufficient and where international expertise is available to mentor in country participants.

The video documentary was a late development in this project and the team recommends that future projects consider using this medium early in the project life to provide better promotional impact and early awareness.

ACIAR should consider funding a further project on veneers from plantation timbers. This could be funded in 3-4 years' time when some of the John Allwright Fellows from this project will have returned with new high level skills. There is still a real opportunity to increase value for smallholder plantation producers through utilisation into higher value products. It is likely there are improvements to be made to increase the quality and profitability in the use of plantation timber in the plywood sector; scope for development of multilaminar products; and opportunities to utilise higher grade acacia and eucalypt veneer in furniture and interior design on face panels.

A future project should carry out a thorough value chain analysis as a scoping study that would inform project design. This study could include some members from the current project who are now overseas studying for higher degrees. On their return to Vietnam, they could commence with the VCA and then follow on to play a key role in a project. This could occur in about three to four years.

MARD (VNFORESTS) should consider the standardisation of a veneer log grading system, such as that proposed by the project team.

Long term administration of the website should be considered to store the project outputs and provide ongoing support to industry.

VAFS need to ensure translation of the Veneer Technical Production Manuals in Vietnamese to facilitate wider uptake of the information provided.

There is a need to distribute information more broadly to both disseminate results and promote the VAFS and VFU as centres of expertise. For example, we recommend that VAFS and VFU take the initiative to work with the Provincial Extension Departments, and Departments of Co-operatives and Vietnam Farmers Union to disseminate the Veneer Manual.

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10 Appendixes

10.1 Appendix 1:

The project output documents are packaged with this report presented in a folder of pdf documents. The documents are numbered such that they link to the project objectives and have the following titles:

1.1.1_Resource_report

1.1.2_1.2.3 Mapping and VCA

1.2.1a_Certification report

1.2.1b_Certification_summary_VN

2.1.1&2a_Household mill surveys

2.1.1&2b_SME company surveys

2.2.1&.2_Resource_quality

2.2.1_2.2.2_VN_resource_quality

2.2.3_Log grading recommendations

2.3.1a_Optimal_peeling_micro-lathe

2.3.1b_Company_Thickness_variation and recovery_part 1

2.3.1c_Farmer_Thickness_variation and recovery_part 2

2.3.1d_MC_variation

2.3.1e_Company_veneer_grading

2.3.1f_Lathe modification

2.3.1g_Solar kiln prototype

2.4.1_Mechanical assessment_NOT FOR PUBLISHING

2.5.1_Veneer_grading_rules

3.1.1&3.2.2_Evaluation and manufacture of EWP for furniture

3.1.1b_Evaluation_decorative veneer

3.1.2_Green gluing billets

3.2.1&3_Hybrid_composite_formply

3.2.2b_Demonstration_gazebo

3.2.2c_Multilaminar bench

3.2.3 Bamboo ring composite panel

4.1.1_4.2.1_Economic Impact report_End Project

4.1.1_4.2.1_EconomicImpact_preliminary report

5.1.1a_Thu Nguyen thesis

5.1.1b_company training assessment

5.1.2a_Marketing Strategy_workshop

5.1.2b_Production Management_workshop

5.1.2c_Veneering flat surfaces manual

5.1.2d_Veneer and plywood production workshop

5.1.2e_Veneer processing_Acacia plantations

5.1.2f_Vibration analysis

5.1.2g_Veneer quality workshop

5.1.2h_VCA workshop itinerary

5.1.3a_Crawford training report_2012

5.1.3b_Crawford training report 2015_Veneer Award

5.1.3c_Crawford training report 2016

5.1.3d_QC_chisel_test

5.1.3e_QC_Good Laboratory Practice

5.1.3f_Middle Management_module 1

5.1.3g_Middle Management_module 2

5.1.3h_Middle Management_module 3

5.1.3i_Middle Management_manual

5.1.3j_DAF_training_package_2015

5.1.3k_Farmer_Peeling training report

5.2.1_website_sample

5.2.2a_SME veneer processing manual

5.2.2b_Manufacturing_Manual

5.2.3a_IAWS_Resource_assessment_presentation

5.2.3b_IAWS_resource assessment paper

5.2.3c_IAWS_multilaminar paper

5.2.3d_Quebec_paper2015

5.2.3e_Quebec_presentation2015

5.2.3f_AcaciaConference_2014

5.2.3g_DesignAward

5.2.3h_ACIAR blog_EWP panels

5.2.3i_Italy conference poster

5.2.3j_VN_newsletter1

5.2.3k_VN_newsletter2

5.2.3l_VN_newsletter3

5.2.3m_VN_newsletter4

5.2.3n_VN_newsletter5

5.2.3o_VN_newsletter6