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Australian Centre for International Agricultural Research

Final report

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2 Acronyms and initialisms

ACIAR	Australian Centre for International Agricultural Research
APKJ	Jepara Small-scale Furniture Producers Association
ASMINDO	Indonesian Furniture Industry and Handicraft Association
CIFOR	Center for International Forestry Research
CLT	Cross Laminated Timber
DAFF	Queensland Department of Agriculture, Fisheries and Forestry
DEEDI Innovation	Department of Employment, Economic Development and
DPI&F	Queensland Department of Primary Industries and Fisheries
FORDA	Forestry Research and Development Agency, The Ministry of Forestry
FRK IFJ	Forum Rembug Klaster, Industri Furnitur Jepara
IPB	Bogor Agricultural University
ISI	Institut Seni Indonesia (Indonesian Art Institute)
JUN	Jati Utama Nasional
MC	Moisture content
MFA	Microfibril angle
OH&S	Occupational health and safety
PIKA	Technical College of Wood Technology
PUSTEKOLAH FORDA	Forestry Engineering and Forest Product Processing Center,
PVAc	Polyvinyl acetate
RMIT	Royal Melbourne Institute of Technology
RPM	Research Program Manager
SMEs	Small and medium-sized enterprises
SVLK	Timber Legality Verification System
UF	Urea formaldehyde
UGM	Universitas Gadjah Mada (Gadjah Mada University)
UoM	The University of Melbourne

3 Executive summary

Indonesia is the world's eighteenth largest furniture exporter, with exported products worth US$2.8 billion in 2013. Jepara, located in Central Java, is well known for its crafted wooden furniture, which is made primarily from teak and mahogany from plantation/community forest. The furniture industry in this region employs approximately 170,000 people and is characterised by around 12,000 small and medium-sized enterprises (SMEs) and a small number of large, mainly export oriented producers. The competitiveness of the furniture companies has been constrained by weaknesses in production and product quality skills, process and technology deficiencies and low wood recovery rates.The ACIAR project '*Improving added value and small medium enterprises capacity in the utilisation of plantation timber for furniture production in Jepara region'* was developed with the overall aim to support the Indonesian furniture industry by enhancing value-adding from plantation timber production based on teak and mahogany. The research focussed on the development and implementation of optimal and efficient processing techniques to facilitate a broader range of new designs and high-quality new products.

The project was led by the University of Melbourne with the project partners representing education, research and training institutions as well as industry organisations and furniture SMEs. The members of these organisations have formed a cohesive network with a strong culture of collaboration. The project was focused on applied research and development activities, with the dissemination of research outputs to the industry through extensive training provided by the project partners. A network of sixteen 'Industry Champions' companies was established which represented the various types, sizes and models of the Jepara furniture industry and the various aspects of wood processing and manufacturing (from sawing to finishing). The project team members worked closely with these companies on the implementation of the project methodology scaling up the dissemination process to companies outside the network. This approach was effective.

The project provided a significant contribution to wood science and technology both in Indonesia and internationally, and to the timber industry sector by increasing the utilisation of timber from young plantations in the production of furniture for domestic and export markets. Research studies conducted by the project's research teams have been well documented and published. The list of the project publications is impressive and comprises: 48 scientific publications and 96 project reports and data sheets. In particular, a valuable output of the project research activities is a book entitled *'Furniture from plantation timber. A manual for furniture manufacturers in the Jepara region of Indonesia'* The 221-page manual comprises a series of guides, prepared in both English and Bahasa, which combine the knowledge of Australian and Indonesian wood scientists involved in the project working closely with local sawmillers and furniture manufacturers in Jepara. The aim of the manual is to contribute to improved processing efficiency, product quality and worker safety.

The key research findings include the development of drying schedules, treatment methods and improved manufacturing technologies for plantation timbers. The intermediate scientific outcomes are that both researchers and wood manufacturing companies at Jepara are already using the information produced by the project to improve their efficiency and the quality of their wooden products.

The project has encouraged the reduction of waste in sawmilling and furniture production by introducing more efficient wood processing and manufacturing methods, decreasing wood drying degrades, utilising small dimension timbers and wood off-cuts for various wood components, and introducing new technologies such as wood bending and laminating. These value-added methods will result in the more efficient use of timber, thus it will enable companies to produce 'more from less'.

The project placed a strong focus on improving health and safety aspects of timber processing and manufacturing. Many of the current practices are unsafe and may cause serious injuries and deaths of factory workers. Standard safety signs were placed in the factories and the team has also donated personal protection equipment to many enterprises.

A strong emphasis was placed on disseminating the research findings to furniture companies in the Jepara region, including those outside the industry cluster groups. This was done through involving these companies in project workshops, seminars and training courses and disseminating the project outputs through newsletters, training notes and data sheets. Twenty training courses were provided, which were attended by over 500 industry members. Course notes were prepared for each participant in Bahasa Indonesia. The training participants rated the courses very highly.

The results of the impact assessment undertaken close to the project completion date revealed that there has been a 40% increase in sales turnover of the Industry Champions after various training courses provided by the project, and their income has increased by about 50%. It is estimated that 50 firms have undertaken some adoption of the project outputs.

It is believed that the network that was developed within the project will provide sustainable long-term capacity improvements and will offer significant benefits to the Jepara furniture industry, such as the following:

- enhanced research capacity of the project partner organisations will have direct benefits to the industry by educating and training technical experts in wood processing and manufacturing, product development, waste management, quality control and production efficiency
- improved training for the timber and furniture industry
- improved technical skills within the industry
- strengthened networks between Jepara furniture companies
- improved design network through the establishment of links between designers and the furniture companies
- increased awareness of workplace safety and export product quality requirements.

The following recommendations have been developed for future research and development activities, which would cover gaps in the value chain leading to a successful furniture industry based on sustainable plantation timber resources:

- A future project should be developed which would extend research and technology transfer activities to other furniture industry regions in Indonesia.
- The technical research expertise of the FST/2006/117 project and value chain analysis approach of the FST/2007/119 project should be combined. This would significantly strengthen the capacity of the project teams by merging technical and social skills and expertise needed in addressing key elements of the value chain in processing plantation grown timbers.
- Further research on wood drying, preservation and manufacturing technologies applicable to young plantation timber species in Indonesia should be conducted.
- Activities on improving design of wood products by involving existing design schools and designer groups should be continued.
- The proposed concept for a new research program is well aligned with the industry and government strategic directions by addressing the challenges and synchronising the production of wood products based on sustainable timber resources.

4 Background

Indonesia has one of the largest furniture export industries in the world with total export revenue of US$2.8 billion in 2013, positioning the country as the world's eighteenth largest furniture exporter. The country ranked third for furniture exports in South-East Asia after Vietnam and Malaysia (Furniture & Furnishing Export National, 2014). Furniture products are exported to at least 88 destination countries and Indonesia's domestic sales in furniture and homewares are worth over US$700 million annually (ASMINDO, 2014).

Wood furniture is the traditional mainstay of the Indonesian furniture sector; it made up 58.1% of the industry's total exports in 2010. Central Java and Jepara are the main centres for the wood furniture industry with teak, mahogany and reclaimed wood the most popular materials for local and international markets. Jepara is well known for its crafted wooden furniture, which is made primarily from teak. There are about 12,000 wood furniture companies in Central Java and Jepara, which employ approximately 170,000 people, and most of which are small and medium-sized enterprises (SMEs). The furniture industry accounts for approximately 26% of the Jepara District gross domestic product.

In 2007–08, during the development phase of this Australian Centre for International Agricultural Research (ACIAR) project, the furniture manufacturing processes in Jepara and other regions in Indonesia were characterised by poor production management and a lack of optimisation in production systems. These shortcomings resulted in low production efficiencies, low timber recovery rates, low quality of products in service and the creation of a significant volume of timber waste. The range of products manufactured by the furniture companies in Jepara was limited and there was a strong focus on outdoor furniture for export purposes. The designs of these products were simple and were often copied from overseas catalogues and exhibitions. As the result, furniture manufacturers in Indonesia, and Jepara specifically, were becoming less competitive. Although total furniture exports were still significant, the market position of furniture manufacturers decreased. It was therefore identified that the Indonesian furniture industry was facing several challenges and that major improvements were required to facilitate the expansion of furniture production and exports. A support program was required that would work to enhance products by improving their quality and design; introduce more efficient and innovative manufacturing processes relevant to young plantation timber resources; and increase utilisation of lesser used species. The industry's dependence on plantation timbers as a raw material could make it more competitive in the global market due to a growing demand for 'green products'.

Considering the above evidence, there was an obvious need to improve and expand the plantation timber processing and manufacturing industry through the development and implementation of optimal and efficient processing techniques to facilitate a broader range of new designs and high-quality new products. The opportunity was also identified to build a much stronger national capability in timber processing research and development, education and training, which would have strong links with the timber processing and furniture industries (this interaction was practically non-existent in 2007–08 when the project was developed).

The project proposal was developed jointly by the Australian and Indonesian partners based on extensive experience in wood processing and wood product manufacturing, discussions with industry organisations (Indonesian Furniture Industry and Handicraft Association [ASMINDO], Perum Perhutani) and inspections of several SMEs at Jepara.

The proposed project was directly aligned with ACIAR's priorities as described in the Annual Operational Plan 2007–08. According to this plan, the forestry program for Indonesia 'will emphasise both community-based agroforestry systems for income generation in eastern Indonesia and improvement of the sustainability and value capture from major plantation species, including acacia and teak'.

It was recognised that the project could assist in promoting the development of competitive timber processing and furniture industries in Indonesia based on optimal utilisation of sustainable plantation and agroforestry timbers. Therefore, the project was also aligned with ACIAR's Indonesian research priorities, which highlight the importance of 'capturing more value from forestry plantation species through improved processing technologies and development of new products matched to appropriate markets'.

It was identified that the project had the potential to decrease poverty in small villages in the Jepara region through the involvement of local people, both women and men, in the production of high-value wood products. This involvement could include making wood craft components or working in production facilities.

In Australia, the project was linked with existing research programs at the School of Forest and Ecosystem Science of the University of Melbourne (UoM) and the Queensland Department of Primary Industries and Fisheries (DPI&F) currently the Queensland Department of Agriculture, Fisheries and Forestry (DAFF). Combining the expertise of the UoM and DPI&F proved advantageous in addressing the project elements of timber processing, furniture manufacturing and product development.

In Indonesia, research and training expertise from the Forest Product Research and Development Centre (FORDA), Bogor Agricultural University (IPB), Universitas Gadjah Mada (UGM) and Technical College of Wood Technology (PIKA), were utilised to cover various aspects of wood processing such as sawing, preservative treatment, solar drying and gluing.

The project involved collaboration with another ACIAR project in Indonesia, managed by the Center for International Forestry Research (CIFOR), namely FST/2007/119 'Mahogany and teak furniture: action research to improve value chain efficiency and enhance livelihoods'. The overall aim of the CIFOR project was to improve the performance of small-scale furniture enterprises in Jepara that use teak and mahogany.

5 Objectives

Aim: The aim of the project was to support the Indonesian furniture industry by enhancing value-adding from plantation timber production based on teak and mahogany.The objectives were:

Objective 1: To increase timber recoveries and furniture quality through the improvement of processing and manufacturing methods for teak and mahogany timbers.

Activities:

1. Detailed analysis of the current processing and manufacturing methods, production efficiency and production infrastructure of the small and medium-sized enterprises (SMEs).
2. Development of optimal sawing methods according to quality and sizes of young plantation logs.
3. Implementing preservative treatment of young plantation timbers to increase products price and life service.
4. Development of optimal drying methods through the improvement of the current practices and the introduction of alternative drying methods.
5. Improvement of current manufacturing processes to increase production efficiency and reduce wood waste.
6. Investigation of options for finishing wood components and/or wood products to improve their performance and quality.
7. Development and implementation of quality control procedures for all processing stages and final products.

Objective 2: To explore new manufacturing technologies for new products and new designs, that would be competitive on international markets.

Activities:

1. Identifying new manufacturing methods which would allow the introduction of new products and designs according to market demand.
2. Investigation of new products which would utilise lower quality and small dimension timbers to reduce currently very high wood waste.
3. Creating database and promotion of alterative species for high-value furniture production.

Objective 3: To increase Indonesian timber processing research and training capacity.

Activities:

1. Enhancement of research and training capabilities in timber processing, value-added production and product development
2. Development and implementation of training for SMEs, with a focus on quality control in production and products and occupational health and safety (OH&S).
3. Development of a strong and efficient link ‘Industry–research–training–education’ which would stimulate industry continuous and sustainable development and competitiveness.

Objective 4: To monitor and analyse economic impact of improvements and innovations introduced to SMEs during the project duration.

Activities:

1. Development of the monitoring and assessment methods and performance indicators for individual project activities.
2. Improvement and adjustment of the project strategies according to the assessment results.
3. Valuation of the total economic impact of the project

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6 Methodology

6.1 Project location

The project was based in Jepara, Central Java (Figure 1). This region is well known for its furniture industry, which employs approximately 170,000 people. The industry structure in Jepara is characterised by around 12,000 small and medium-sized enterprises (SMEs) and a small number of large, mainly export oriented producers.

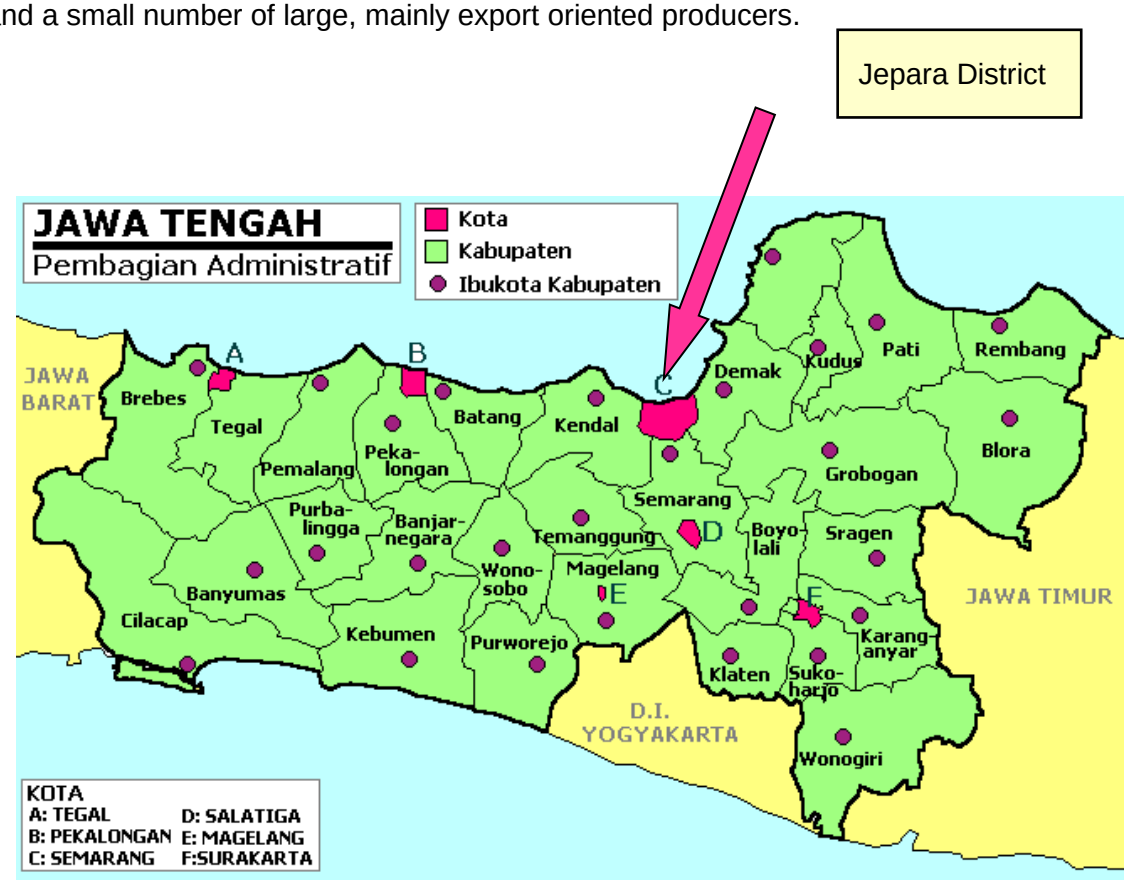

Figure 1. Location of Jepara in Central Java.

Source: <http://mapsof.net/map/central-java-province>

Popular furniture tree species such as teak *(Tectona grandis)* and American mahogany (*Swietenia macrophylla)* were established in Indonesian plantations to provide a home-grown resource for local craftspeople and manufacturers. Plantation logs come primarily from the state-managed Perum Perhutani reserves and community forests, and over recent years the trend is of decreasing log size and quality. Facing increasing competition in global markets for wooden furniture, the Jepara industry should seek to improve operations and marketing to maintain long-term competitiveness.

Although the majority of the project research activities were carried out at the partners' laboratories, the implementation of research findings and training for the industry members were conducted in Jepara.

6.2 Research methods

The project was focused on applied research and development activities. The dissemination of research outputs to the industry was through extensive training run by the research partners and the Technical College of Wood Technology (PIKA).

In particular, the project applied the following methods for each activity and objective:

Objective 1: To increase timber recoveries and furniture quality through the improvement of processing and manufacturing methods

Activity 1.1 Detailed analysis of the current processing and manufacturing methods, production efficiency and production infrastructure of the SME companies

- As it would be impossible to improve current processing and manufacturing methods in each and every small company in Jepara, the 'small steps' method was adopted. This method was developed within the Australian Centre for International Agricultural Research (ACIAR) project FST/2005/100 (Ozarska et al. 2007). In that project a network of 'Industry Cluster' companies was established with which researchers worked on implementation of improved production methods and the project research findings. In this ACIAR project a network of sixteen companies ('Industry Champions') was established. The Industry Champions represented the various types, sizes and models of the Jepara furniture industry and the various aspects of wood processing and manufacturing (from sawing to finishing). The project team members worked closely with these companies on the implementation of the project methodology. The first activity was a detailed analysis of the current capabilities (processing and manufacturing) of the Industry Champions. The results of the assessment were documented and provided to each participating company.
- SWOT analysis was undertaken to identify relevant strengths, weaknesses, opportunities and threats for the SME furniture industry in Jepara.

Activity 1.2 Development of optimal sawing methods according to quality and sizes of young plantation logs

- The results of the assessment (Activity 1.1) were used for the development of recommendations for improvements and changes in the current sawing methods used by the companies.
- Based on the outcomes of the above assessment, a research program on sawing young plantation timbers was developed.
- Various options for sawing methods and technologies were evaluated using research facilities and scaled-up production facilities.
- Optimal methods were selected and implemented.

Activity 1.3 Implementing preservative treatment of young plantation timbers to increase products price and life service

- The results of the assessment (Activity 1.1) formed the basis for the development of recommendations for preservative treatment of sapwood. Previously, untreated sapwood was inappropriately used in the production of outdoor furniture.
- A research program on preservative treatment for sapwood of young plantation timbers was developed.
- Various options for preservative treatment of sapwood were evaluated using research facilities and scaled-up production facilities.

- The reduction of the colour difference between sapwood and heartwood of teak using a heat treatment method was investigated.
- Optimal treatment methods were selected and suggested to the companies in Jepara.

Activity 1.4 Development of optimal drying methods through the improvement of the current practices and the introduction of alternative drying methods

- Based on the results of the assessment (Activity 1.1), recommendations for timber drying in the Jepara region were developed.
- Detailed plans on the proposed improvements and modifications in drying of young plantation timbers were developed.
- Various options for timber drying methods, technologies and systems were evaluated using research facilities and scaled-up production facilities.
- Optimal methods were selected and suggested to wood drying companies.

Activity 1.5 Improvement of current manufacturing processes to increase production efficiency and reduce wood waste

- Recommendations for improvements and changes to current production methods used by the companies were proposed according to the outcomes of the industry assessment undertaken within Activity 1.1.
- Various options for optimisation of production methods used in manufacturing wood products were investigated and suggested for implementation by the relevant companies.

Activity 1.6 Investigation of options for finishing wood components and/or wood products to improve their performance and quality

- Based on the results collected in Activity 1.1, a detailed research program was developed for finishing wood products.
- Research studies were conducted in laboratory conditions and then proposed for implementation in appropriate industrial facilities.

Activity 1.7 Development and implementation of quality control procedures for all processing stages and final products

- Detailed quality control procedures were developed for every stage of the processing process and for the final products, including product specifications and occupational health and safety (OH&S) procedures.

Objective 2: To explore new manufacturing technologies for new products and new designs which would be competitive on international markets

Activity 2.1 Identifying new manufacturing methods which would allow the introduction of new products and designs according to market demand

- Based on the assessment of the capabilities of the participating SMEs, the project team identified which new technologies and production methods would be suitable for Jepara SMEs. The identification of new technologies and production methods took into consideration financial constraints.
- A Furniture Design Competition was developed. The aim of Design Competition was to link furniture designers in Central Java with furniture companies in Jepara.

Activity 2.2 Investigation of new products which would utilise lower quality and small dimension timbers to reduce currently very high wood waste

- In order to reduce the large amounts of wood waste currently produced by the SMEs, an investigation was undertaken on suitable technologies and new products that would utilise lower quality and small dimension timbers. The findings were disseminated to the industry via training courses.

Activity 2.3 Creating database and promotion of alternative species for high-value furniture production

- A database of alternative wood species (from community forests, plantation forests or agroforestry) suitable for high-value furniture production was developed and disseminated to the industry through publications and data sheets.

Objective 3: To increase Indonesian timber processing research and training capacity

Activity 3.1 Enhancement of research and training capabilities in timber processing, value-added production and product development

- A detailed analysis of research capabilities relevant to the project activities was undertaken at each partner organisation. A map of collaborative arrangements between the project partners was developed.
- A detailed program for the enhancement of research facilities and expertise was jointly developed and implemented (purchasing research equipment, postgraduate studies in Australia, specialised research training courses).

Activity 3.2 Development and implementation of training program for SMEs, with a strong focus on the quality control in production and products and OH&S

During the first 2 years of the project training was provided, mainly to the Industry Champions and some Jepara Small-scale Furniture Producers Association (APKJ) companies. However, following the project Mid-Term Review, the ACIAR Research Program Manager (RPM) suggested that increased effort should be put into disseminating project research results through an enhanced training program, which was to be directed towards a large number of Jepara companies.

In the Mid-Term Review, the ACIAR RPM made the following comments:

> '*The project is progressing extremely well and is on track with almost all of its planned activities, which is very good considering the complexity of the project design and number of partners. It was agreed that no major changes were needed to the original planned activities and that the work on the introduction of new technologies should proceed. However, two additional issues were identified related to dissemination of project outputs which may require a variation to the project. Given the substantial amount of technical research been undertaken and reported on and the enormous number of wood manufacturers in Jepara that could benefit from the knowledge generated by the project, it was agreed that the project needed to improve the dissemination during the final two years. Two important elements were identified for which the project leader will develop a proposed variation. The first relates to undertaking a series of workshops and seminars to assist with the wider dissemination of project results to the Jepara wood manufacturing businesses. The second relates to consolidating all the technical outputs in a consolidated publication in Bahasa and English at the end of the project.' (Bartlett, 2011).*

It was agreed that it was critical that the project findings were disseminated not only to the Industry Champions, which were directly involved in the project, but also to other companies within the Jepara furniture industry sector (which amounted to about 12,000 enterprises). This was a difficult task, made all the more difficult in that it was not

adequately budgeted for in the original project design. Following discussions with team members, a training program for enhanced dissemination of the project results was developed and endorsed by the RPM. Supplementary funding was provided by ACIAR for additional training courses, seminars and workshops for the Jepara furniture industry.

Activity 3.3 Development of a strong and efficient link 'Industry–research–training–education' which would stimulate industry continuous and sustainable development and competitiveness

- A cohesive collaboration between the project partners and the industry was established during the project duration. Details are provided in Section 8.2.

Objective 4: To monitor and analyse economic impact of improvements and innovations introduced to SMEs during the project duration

Activity 4.1 Development of the monitoring and assessment methods and performance indicators (in close collaboration with Center for International Forestry Research [CIFOR] Project) for individual project activities

- Key performance indicators for the project activities were developed and then assessed by the ACIAR RPM.
- A questionnaire for the monitoring and assessing the project activities was developed.

Activity 4.2 Improvement and adjustment of the project strategies according to the assessment results

The assessment was undertaken by the team led by Dr Dede Rohadi (CIFOR), and the results documented (Ref: Report No. 44). The study was conducted to obtain empirical validation on the effectiveness of the research project in achieving its goals. The specific objectives of the impact assessment study were as follows:

- to analyse the effectiveness of the project activities that had been carried out
- to analyse the social acceptance and technology transfer of innovations introduced by the project
- to collect and analyse the feedback (critiques, suggestions and expectations) from targeted people for improvement in conducting similar activities in the future.

There were three impacts assessed within the project:

- Scientific Impact, meaning knowledge application changes based on the research findings of the project
- Capacity Impact, meaning improvement in project participants' knowledge and skills, particularly those who were provided training by the project
- Community Impacts, broadly meaning the social, economic and environment impacts of new knowledge introduced by the project, even though some interviewed people were not directly involved in the project. Furthermore, these community impacts were categorised into economic, social and environment impacts.

Primary data was collected using three methods: questionnaires, field observations and interviews. Questionnaires aimed to collect information from local people in the Jepara region. The respondents were grouped into two categories: participants who were 'directly involved' in the project and those who were not directly involved ('non-participants') in the project. In total there were 34 respondents for the 'directly involved' participants category and 27 respondents for the 'non-participants' category.

The report authors conducted field observations on 22–24 June 2013 by visiting the locations of some SME wood furniture businesses in Jepara. Observations were conducted based on the non-participatory technique, where the authors observed the activities carried out by the industry. These field observations were conducted to verify the data and information obtained from the questionnaires.

Twenty key informants, functioning as stakeholder representatives, were then interviewed. The key informants included government employees (Jepara Forest Service Officers) and professionals who were mainly members of Jepara Small-scale Furniture Producers Association (APKJ). During field observations and interviews, secondary data from published and unpublished references were also collected. The data and information were then analysed through quantitative and qualitative approaches.

Activity 4.3 Valuation of the total economic impact of the project

An 'Impact Analysis' Team was appointed to undertake the final assessment of the project. A questionnaire was developed, which was used as a guideline to collect the information and the data. Three methods were used to gather the data: a participatory approach, a questionnaire and focus group discussions. The participatory approach was conducted by questioning 1 or 2 people from the Industry Champions during data collection. The participatory approach was chosen in order to reduce the influence of the project members during data collection. An important factor in the participatory approach was the active contribution from the member of the industry during planning and data collection. Multi-purpose sampling was selected to control the size of the sample without reducing the accuracy.

The results of the study were summarised under the following headings:

- Change of perception. After improving knowledge, it was also important to explore how the members of the selected industry changed their perceptions in relation to high-quality products derived from high-quality processes and whether they gained a better understanding of raw materials.
- Adoption technology/implementation and economic impact. This describes how the introduced technology could be adopted by the companies.
- General overview of the project. General comments were required to gain insights into how selected companies perceived the project.

6.3 Project partners and research teams

The project was led by the University of Melbourne (UoM), in collaboration with the Australian partner, the Queensland Department of Agriculture, Fisheries and Forestry (DAFF). The Australian project partners have a proven track record in implementing ACIAR forest industry projects and collaboration with international partners, in particular in South-East Asia and Pacific regions.

The principal partners in Indonesia were as follows:

- Forest Research and Development Agency (FORDA)
- Bogor Agricultural University (IPB)
- Universitas Gadjah Mada (UGM)
- Technical College of Wood Technology (PIKA)
- Forum Rembug Klaster, Industri Furniture Jepara (FRK IFJ)
- Center for International Forestry Research (CIFOR).

At the beginning of the project term, five research teams were formed consisting of research experts from the project partner organisations with the following expertise: sawing, timber treatment, drying, value-adding manufacturing and finishing. The team members worked together throughout the project, learning from each other, developing research linkages and friendships.

A local office was established in Jepara and the Project Field Officer, Mrs Nurul Izza, was appointed to the project. The Field Officer played an important role by linking the project researchers with the Industry Champions, assisting in the 'field' research activities, assisting to implement research outputs, and disseminating project information by communicating with furniture companies.

A close collaboration with the project team of FST/2007/119 provided benefits in the efficient dissemination of the project outcomes. As both projects targeted the same users (sawmill and drying companies, furniture producers and finishing companies, designers and industry associations), knowledge transfer methods were shared in order to enhance the impacts of the project's outputs. Clearly, the projects complimented each other.

7 Achievements against activities and outputs/milestones

Objective 1: To increase timber recoveries and furniture quality through the improvement of processing and manufacturing methods

No.	Activity	Outputs/ Milestones	Completion date	Comments
1.1	Detailed analysis of the current processing and manufacturing methods, production efficiency and production infrastructure of the SME companies. (UoM, DAFF, FORDA, UGM, IPB)	Network of industry champions formed.	Yr1, m3	*Completed*. Network of 16 Industry Champions was formed.
		Current capabilities of SMEs evaluated and documented.	Yr1, m8	*Completed.* Current capabilities of the Industry Champions were assessed and six reports written. The results of the industry assessment formed the basis for the development of recommendations on the improvements of the industry capabilities.
		SWOT analysis completed.	Yr1, m9	*Completed.*
		Workshop on the assessment results completed and documented.	Yr1, m10	*Completed.* One-day workshop with the Industry Champions was held on 6 August 2010 in Jepara. The assessment results were discussed with the Industry Champions and stakeholders.
1.2	Development of optimal sawing methods according to quality and sizes of young plantation logs. (FORDA, DAFF, UGM)	Detailed research program on sawing developed and approved by all partners.	Yr2, m1	*Completed.* Sawing Research Team developed a detailed program on research activities and sub-activities for the project.
		Research on various sawing methods completed and documented. Workshop completed.	Yr2, m2 till Yr3, m6	*Completed.* A report was written. The results were published in the *Journal of Forest Products Research* (Indonesian journal) and presented to the Jepara industry at the 2nd Annual Workshop on 29 October 2011.
		Optimal sawing methods selected and implemented.	Yr5, m3	*Completed*. Implementation visits to sawing companies were carried out and training conducted on 3 March 2014. Research on girdling teak trees was on-going. 'Quality operations manual on sawing' was completed.
		Monitoring and modification completed. Recovery rates analysed.	Yr5, m6	*Completed*. Benchmark recovery study completed. The study was repeated in September 2014 to monitor any improvements. Further visits and training were carried out in Year 5.
1.3	Implementing preservative treatment of young plantation timbers to increase products price and life service. (DAFF, UoM, FORDA, IPB, UGM)	Detailed research program on treatment of sapwood developed and approved by all partners.	Yr2, m1	*Completed*. Treatment Research Team developed a detailed program on research activities and sub-activities for the project.
		Research on treatment methods completed and documented.	Yr2, m4 till Yr4, m6	*Completed.* Details provided in Section 7.2.2.

		Optimal treatment methods selected and implemented.	Yr4, m12	Boron soaking treatment, a safe and affordable treatment, was found to be the most appropriate for SMEs in Jepara. The finding was discussed with the industry during a preservative training course and described in a datasheet. Three companies implemented this treatment method.
		Monitoring of treatment used by the industry. Results documented.	Yr5, m6	Current preservative treatment in Jepara was observed and the effectiveness of the method was tested in laboratory conditions. It was found that traditionally preserved timber in Jepara is not resistant to insects. The results were presented at the Furniture Value Chain Symposium (CIFOR), 14 February 2013.
1.4	Development of optimal drying methods through the improvement of current practices and the introduction of alternative drying methods. (UoM, FORDA, UGM)	Recommendations for drying options developed.	Yr2, m1	*Completed.*
		Detailed research program on drying developed.	Yr2, m2 till Yr3, m6	*Completed.*
		Optimal drying methods and schedules developed and documented. Results presented at workshop.	Yr2, m3 till Yr4, m6	*Completed.* Optimal drying schedules for six wood species were completed and presented at the 3nd Annual Workshop. Papers were written and published.
		The drying methods and schedules implemented. The industry capable to drying timber without significant degrade.	Yr4, m12 Yr5, m10	*Completed.* A pilot drying chamber designed and built for SMEs in Jepara is now being used by the Industry Champions and APKJ companies. Another chamber was built by a company in Jepara based on the design of the pilot chamber. Implementation visits were continued in Year 5. Three training courses on wood drying were delivered.
1.5	Improvement of current manufacturing processes to increase production efficiency and reduce wood waste. (UoM, FORDA, IPB)	Recommendations for improvements developed. Research program developed, documented and discussed at a workshop.	Yr2, m1 Yr2, m2	*Completed* and the report written. *Completed*. The program of manufacturing activities and sub-activities was developed and documented by the Manufacturing Research Team.
		Optimisation of production methods investigated. The results documented.	Yr2, m2 till Yr4, m4	*Completed.* The team members visited Industry Champions and recommend changes and improvements to production methods.
		The proposed methods implemented in Industry Champions' companies. Production efficiency and wood waste monitored.	Yr2, m3 till Yr4, m12 Yr5, m1 till Yr5, m12	Implementation visits to individual companies were undertaken on a regular basis. The team found that the process of changes and improvements varied between companies but in general it was a slow process depending on the company's willingness to change and capital cost required.

1.6	Investigation of options for finishing wood components and wood products to improve their performance and quality. (UoM, FORDA, IPB)	Research program developed.	Yr1, m10 Yr2, m2	*Completed*. The program of finishing activities and sub-activities was developed and documented by the Finishing Research Team.
		Research completed. Performance criteria for various products in various applications specified.	Yr2, m5 till Yr4, m6	*Completed*. Extensive research studies were carried out and the results documented and published.
		The proposed technologies implemented and monitored.	Yr4, m1 and Yr4, m12	*Completed*. Implementation visits were carried out. The Finishing Research Team worked cooperatively with the finishing companies by suggesting better finishing and drying layouts, conditions, handling and quality improvements.
1.7	Development and implementation of quality control procedures for all processing stages and final products. (UoM, DAFF, FORDA, IPB, UGM)	Set of quality control packages developed.	Yr3, m12	*Completed.* A Manual was completed, which comprised technical data sheets on sawing, preservative treating, drying, manufacturing and finishing processes.
		Testing methods for the assessment of various stages of production and products quality documented.	Yr4, m6	*Completed*. Two reports were written, one on Indonesian standards and one on International standards, methods and specifications related to furniture production methods, quality control and requirements for furniture applicable to SMEs.

Objective 2: To explore new manufacturing technologies for new products and new designs, which would be competitive on international markets

No.	Activity	Outputs/ milestones	Completion date	Comments
2.1	Identifying new manufacturing methods which would allow the introduction of new products and designs according to market demand. (UoM, UGM, IPB, FORDA, FRK IFJ, CIFOR)	Plan for developing various technologies and products completed.	Yr3, m1	*Completed.* Various options for manufacturing methods and products were presented and discussed at the 2nd Annual Workshop.
		Workshop to brainstorm the proposed plan completed.	Yr3, m2	*Completed*. Workshop was held on 29 October 2011. Wood bending and wood gluing/laminating were selected as the priorities for further research and development. However, it was agreed the implementation of these technologies needed to be postponed until current production methods were significantly improved.
		Assessment and development of required infrastructure completed.	Y4, m6	*Completed*. Wood bending and gluing/laminating technologies were selected as most suitable for SMEs in Jepara. Two Indonesian researchers were trained in Australia on wood bending. Methodology was developed and equipment was constructed at PIKA and UGM. Research on wood gluing was carried out at FORDA. Report on gluing was written.

2.2	Investigation of new products which would utilise lower quality and small dimension timbers to reduce currently very high wood waste. (UoM, DAFF, UGM, IPB, FORDA, FRK IFJ, CIFOR)	Range of new products suggested and discussed at workshop.	Yr4, m2	*Completed.* The IPB Team wrote a literature review on options for products made from low-quality, small dimension timbers. Suggestions on the development of wood products using small dimension wood and off-cuts was discussed at the Annual Workshop No. 3 in December 2012.
		Program to involve local communities in design and production developed.	Yr3, ongoing	*Completed.* Survey of design skills in Jepara was conducted. Furniture Design Competition was organised in Year 5 and successfully completed. The winners were awarded by attendance at a 1 week training course in furniture design in Melbourne. Training course on furniture design was then conducted involving the winners, local designers and furniture companies. Linkages between the designers and companies were developed.
		New products developed.		
2.3	Creating database and promotion of alterative species for high-value furniture production. (FORDA, IPB, UGM).	Database completed and documented.	Yr2, m12 – ongoing	*Completed*. A book on 21 species was completed and published by FORDA.
		Promotion of alternative species undertaken.	Yr3, m1 – ongoing	*Completed*. Book on 152 species was published and widely distributed to the industry. In total, 126 books were distributed to the Industry Champions, APKJ, designers and other companies in Jepara. Pamphlets on selected species were developed and distributed to Jepara companies.

Objective 3: To increase Indonesian timber processing research and training capacity

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1	To increase Indonesian timber processing research and training capacity.	Map of collaborative arrangements between project partners completed and documented.	Yr1, m3	*Completed.* Research capabilities of each collaborative partner were identified and documented. Research teams specialising in the five aspects of processing and manufacturing were formed.
		Program for enhancement of research capabilities developed and implemented.	Yr2, m2 till Yr4, m12	*Completed*. Priorities for enhancement of research capabilities were identified for each partner organisation and appropriate programs were implemented accordingly (for research equipment, research, training and education). Each partner organisation was involved in various research and training activities according to its capabilities.

3.2	Development and implementation of training program for SMEs, with a strong focus on the quality control in production and products and OH&S. (UoM, FORDA, IPB, UGM, DAFF, PIKA, FRK IFJ, CIFOR)	Training programs, specifications and quality procedures revised and developed.	Yr3, m6 – Ongoing	*Completed.* In total, 20 training courses were conducted. Very positive feedback was received from the industry participants.
		Selected project members trained in Australia.	Yr4, m12	In total 14 researchers from FORDA, IPB and PIKA visited Australia for training.
3.3	Development of a strong and efficient link 'Industry–research–training–education' which would stimulate industry continuous and sustainable development and competitiveness. (UoM, FORDA, IPB, UGM, DAFF, PIKA, FRK IFJ, CIFOR)	Collaborative arrangements well established with successful research outcomes by project research activities. Specialisation and networking well developed and the progress monitored.	Yr2, m6 and ongoing	Effective collaboration between the project partners was established. Five research teams consisting of researchers from all project partner organisations worked well together and developed a positive relationship with the Industry Champions as well as the APKJ companies. Specialised expertise and equipment available at different organisations enabled a wide range of research projects to be undertaken. A series of training courses on different subjects was provided to the industry.

Objective 4: To monitor and analyse economic impact of improvements and innovations introduced to SMEs during the project duration

No.	Activity	Outputs/ milestones	Completion date	Comments
4.1	Development of the monitoring and assessment methods and performance indicators (in close collaboration with CIFOR project) for individual project activities. (UoM, FORDA, IPB, UGM, DAFF, CIFOR)	Monitoring and assessment methods and performance indicators documented.	Yr2, m2	*Completed.* The key performance indicators were developed and approved by the ACIAR Research Program Manager.
4.2	Improvement and adjustment of the project strategies according to the assessment results. (UoM, FORDA, IPB, UGM, DAFF, CIFOR)	Project strategies adjusted according to the assessment results.	Yr2, m6 and then every 6 months	The assessment was completed and report written by the team of researchers from CIFOR.

4.3	Valuation of the total economic impact of the project. (UoM, FORDA, IPB, UGM, DAFF, CIFOR)	Impact of the project objectives evaluated, monitored and documented.	Yr3, m6, Yr4, m6, Yr5, m6	The final assessment was undertaken by the 'Impact Analysis' Team, which consisted of researchers from UGM, IPB, PIKA and FORDA. The results were presented in a report.

8 Key results and discussion

8.1 Objective 1: To increase timber recoveries and furniture quality through the improvement of processing and manufacturing methods for teak and mahogany timbers

Detailed analysis of the current processing and manufacturing methods, production efficiency and production infrastructure of the SMEs

A detailed assessment of current processing and manufacturing methods, production efficiency and production infrastructure of the small and medium-sized enterprises (SMEs) was undertaken in order to develop a comprehensive understanding of the current processing and manufacturing capabilities of the Jepara furniture industry.

A network of 'Industry Champions', companies willing to actively participate in the project, was established. This was done through active involvement of the participating organisations in the project, in particular Forum Rembug Kluster, Industry Furniture Jepara (FRK IFJ). It was agreed that the network of Industry Champions should consist of companies representing various types of micro-cluster models that characterise the furniture industry in Jepara: small, medium and large-sized companies reflecting the various aspects of wood processing and manufacturing.

The companies were selected according to the criteria developed by the project partner organisations (Appendix 1). Sixteen companies were selected as the members of the Industry Champions (Table 1).

Table 1. Companies selected as Industry Champions.

No.	Name of company	Aspects of processing and manufacturing	Number of employees
1	Raisa	Drying, manufacturing, preservative treating and finishing	207
2	El Artsindo	Treatment, manufacturing and finishing	300
3	Kecik Mirror Arts	Manufacturing and finishing	14
4	Sugiyanto	Sawmilling, drying and manufacturing	12
5	Solikhin	Sawing, manufacturing and finishing	10
6	Sugiman	Drying and manufacturing	13
7	Lima Saudara	Drying and manufacturing	9
8	Hartoyo	Drying and manufacturing	35
9	Prasetya Indra Brata	Sawmilling and drying	12
10	Bhakti Usaha	Sawmilling	23
11	Karya Jati	Sawmilling	12
12	Proliman	Drying	4
13	Elok Sejati	Manufacturing	12
14	Erick Finishing	Finishing	24
15	Cipta Mandiri	Drying and manufacturing	17
16	Mandiri Mebel	Drying and manufacturing	6

The analysis of the capabilities of the Industry Champions included all major processing and manufacturing stages of the production process:

- sawing
- preservative treatment
- drying
- manufacturing
- finishing.

Five teams of researchers were formed to undertake the assessment study and to continue the project activities related to sawing, preservative treating, drying, manufacturing and finishing. The researchers were selected from the project partner organisations according to their expertise and skills in the relevant processing and manufacturing methods. Each team appointed a Team Leader, who was responsible for coordinating the assessment activities and preparing the final report.

Each individual Industry Champion was assessed by the relevant team according to the type of facilities and aspects of processing and/or manufacturing undertaken by the company (Appendix 2).

Members of the teams visited the companies between November 2009 and January 2010. The assessments were based on the templates developed by the members of each team prior to their visits. The templates consisted of a list of important data and information to be collected during the visits. Each visited company agreed to cooperate by providing access to their facilities and data pertaining to their operations. A discussion with the manager or owner of the company was held to decide which changes and improvements were feasible, taking into account financial or other constraints.

The assessment showed that the companies varied in their manufacturing ability, output and knowledge. The companies were rated on a sliding scale ranging from ‘beginning’ to ‘experienced’.

The observations and notes made during the visits were used as the basis for writing a detailed report on each individual company where they were assessed for a specific aspect of the production process. The results of the assessment were discussed in detail with each individual company on a confidential basis.

The individual reports were then combined into five final reports:

1. Sawmilling Assessment Report (Ref: Report No. 2)
2. Treatment Assessment Report (Ref: Report No. 3)
3. Drying Assessment Report (Ref: Report No. 4)
4. Manufacturing Process Assessment Report (Ref: Report No. 5)
5. Finishing Assessment Report (Ref: Report No. 6).

The reports provided details about the assessments. The assessments covered all aspects of the processing and manufacturing processes applied by the Industry Champions, as well as general comments on current industry practices and recommendations for improvements and changes. However, as the detailed assessment report for each Industry Champion was confidential in nature, a General Summary Report was developed with the aim of providing summary information about the assessments (Ref: Report No. 7). The findings described in the General Summary Report were presented at the Project Workshop held in Jepara on Friday, 6 August 2010.

The outcome of the assessments of the Industry Champions was the identification of areas where improvements could be made and further developments were necessary to

assist the companies in becoming internationally competitive. The major findings and recommendations were as follows:

- Sawmilling practices require improvement. In particular, sawing patterns and their characteristics, saw types and blades, mill design, mill efficiency, optimising the breakdown of the saw log, saw doctoring (sharpening, tensioning etc.) and operator safety were noted as areas requiring improvement.
- Timber species used by companies in Jepara are susceptible to attack by borers. Protection with wood preservative chemicals is required if the products made with these timbers are to have long and useful service lives.
- Timber drying methods require improvement.
- It was observed that the product development procedures did not follow any standards or specifications regarding product design, quality and performance. Although some products were innovative and well designed, their quality should be improved in order to compete in international markets.
- The production processes in the majority of the assessed companies were not properly designed and managed. A low productivity level resulted in low production efficiency overall.
- Many woodworking machines were old and there was no production flow, as various machining operations were not linked together into one production system. In particular, there was generally too much wood stored in the production areas of the factories, which significantly limited the space available for machining operations.
- Further training and upskilling in the areas of mill management and the organisation of timber processes would be beneficial. Improvements to occupational health and safety and mill conditions should be undertaken.
- Advice was required on the types of machines needed for various operations, and on proper set up parameters and efficient use of the machinery.
- Standard gluing requirements were not always followed in the gluing of timber components. Further information and training on the types of glues to be used for various applications, the importance of timber preparation prior to gluing, and gluing parameters, would be of benefit.
- It was observed that the quality of coated surfaces was generally very poor. Hand brushing was the most common method of applying surface coatings, with little evidence of industrial equipment, such as paint sprayers, being used.
- Many companies used carved components in their products, with attractive traditional patterns and motifs. This skill and talent should be considered an advantage and an opportunity for Jepara products.
- The majority of the assessed companies did not follow best practice in wood waste management. The waste wood was not segregated into boards of different sizes and qualities and was usually randomly stored in piles located around the factory.
- The majority of companies did not provide training to their workers. When training was conducted, it was usually provided in-house by more experienced workers.

Visual examples of the assessment visits are provided on Figures 2 and 3.

Figure 2. Examples of wood waste at furniture companies.

Figure 3. Examples of furniture manufacturing operations.

Following the assessment process, a detailed program was developed for the implementation of the recommendations on improved production methods suitable for application by the Industry Champions.

The following program was developed and followed up:

1. The project teams made regular visits (every 4–6 months) to the Industry Champions (Figure 4). During the visits the team members checked whether the recommended improvements were being implemented by the company; discussed any problems and obstacles that prevented the implementation; and provided advice and in-house training on various aspects of production, machinery and OH&S. Advice on further improvements was also provided.
2. Each team developed a detailed working plan to complete the research studies within the project term. The key achievements accomplished by the five research teams are described in Section 7.2.

Figure 4. Discussion between collaborators during implementation visits to the Industry Champions.

8.2 Major research outputs

8.2.1 Sawing research studies

A sawing recovery study was conducted at five Industry Champions in Jepara. The study revealed that the sawing recovery in Jepara ranged from 70 to 80%. These recoveries were relatively high due to the live sawing pattern used and the fact that sawn boards were not edged or re-sawn into square pieces at the mill. The implementation visits and training on sawmilling during the project term have enhanced the size of the sawn boards (target size) and the OH&S standards in the sawmills (Ref: Report No. 2 & 11).

A review of metal detector technologies and their suitability for Jepara sawmills was conducted and recommendations were provided to all stakeholders. The detector is used to identify metal in a log before sawing. The identified metal, such as nails and left over metal pieces, are then removed to avoid saw-tip damage and to extend the service time of the saw (Ref: Report No. 8 & 31). The report revealed that the use of metal detectors is a feasible and affordable option for Jepara sawmills.

The principles of lean management and waste minimisation, as relevant to sawmilling practice, were reviewed and summarised in a report (in English and Bahasa) for the benefit of the Industry Champions and other SMEs in Jepara. To aid in outreach, the report was converted into a datasheet in Bahasa Indonesia (Ref: Report No.26 & 32).

Wood machining characteristics of six species of timber were analysed: bayur *(Pterospermum javanicum),* sungkai *(Peronema canescens), s*uren *(Toona sureni),* angsana (*Pterocarpus indicus*)*,* lamtoro (*Leucaena leucocephala)* and jabon *(Anthocephalus cadamba).* Observation included five machining operations: planing, moulding, sanding, boring and peeling. Total percentage of defects was determined in order to group the wood species into five classes and to anticipate necessary treatment in machining. All wood species studied were classified as having good machining properties.

8.2.2 Preservative treatment research studies

Wood anatomical properties of four timber species commonly used for furniture were studied in relation to the possibility of powderpost beetle attack. The species assessed were: teak (*Tectona grandis*), mahogany (*Swietenia* sp.), mindi (*Melia azedarach*) and trembesi (*Samanea saman*). The aim of the study was to determine the possibility of wood penetration by egg-laying beetles. The study revealed that wood vessel diameters greater than 100 µm allowed adult powderpost beetles to lay their eggs, allowing for timber infestation and damage. The vessel diameter of teak and mahagony wood was less than 100 µm, so these timbers were classified as resistant to powderpost beetle attack. The

vessel diameter of trembesi and mindi was greater than 100 µm, so these timbers were classified as non-resistant to powderpost beetle attack, meaning these timbers could potentially be infected and damaged by powderpost beetles (Ref: Report No. 24).

Current wood treatment methods in the Jepara timber industry were assessed. The majority of the treatment processes involved brushing and soaking with timber preservatives. Poor practices involving chemical handling and worker safety were observed (Ref: Report No.3). Various preservative treatments and chemicals potentially available to the industry were reviewed and evaluated for their suitability. A soaking treatment method using boron-based preservatives was determined to be an affordable treatment process for the Jepara industry (Ref: Report No. 23).

Research on steaming (as a pre-treatment) and preservative treatment of four species of timber was carried out: teak (*Tectona grandis*), mahogany (*Swietenia* sp.), mindi *(Melia azedarach*), and trembesi *(Samanea saman*). The treated timbers were exposed to beetle and termite attack. Results showed that steaming enhanced permeability and improved preservative retention and penetration of the timbers. Treated timber became resistant to beetle and termite attack (Ref: Report No. 23). The soaking preservative treatment is feasible for permeable timber, however pre-treatment is important for impermeable timber. Steaming is one possible pre-treatment method to enhance timber permeability in the Jepara timber industry.

Other treatment methods for furniture timbers were also considered including diffusion, vacuum pressure, microwave and heat treatments. Diffusion trough brushing of furniture components provides shallow penetration of preservatives, while preservative penetration is deeper with the vacuum pressure method. The vacuum pressure method is a relatively quick treatment process; however, the equipment is expensive and is only suitable for large capacity companies. Microwave treatment enhances wood permeability for deeper preservative penetration, particularly in heartwood (Ref: Report No. 9). Heat treatment of teak not only improves its durability but also reduces the colour difference between sapwood and heartwood (Ref: Report No. 27).

Five wood species were tested against subterranean termites in order to investigate the durability of those timbers when used for outdoor furniture. Teak, mahagony, trembesi, rubberwood and mindi were vacuum pressurised using boron preservatives and tested against subterranean termites in field and laboratory conditions. Results showed that the treatment met the treatment standard; however, the boron-based preservative is not effective for outdoor purposes. Boron preservatives leached during outdoor exposure and the wood samples were attacked by subterranean termites in the field as well as in the laboratory (Ref: Report No. 40 & 41).

8.2.3 Wood drying research studies

During initial assessment of wood drying methods used in Jepara, it was found that in general poor wood drying techniques were practised. Practitioners demonstrated a poor understanding of correct drying procedures and practices. In addition, it was noted that it was common practice within the Industry to dry semi-finished components in the kilns; often this was carried out in conjunction with lumber drying (i.e. green boards). This practice of drying assembled components is not recommended as it results in severe distortion (i.e. warping, cracking) in the finished products (Ref: Report No. 4).

In addition, the Drying Team also observed that only a limited number of companies used moisture meters for continual monitoring of moisture content (MC). There also appeared to be no moisture determination equipment (i.e. balance or/and oven) for checking MC of samples using the oven dry method. Sample boards or resistance pins were also not found, suggesting continual monitoring of the drying progress of stacks of timber was not common practice (Ref: Report No. 4).

Moisture content of air dried material across the main timber species ranged from 18 to >30% and kiln dried material varied from 6 to 16%. The stated target MC for the industry for kiln dried material was in the order of 8–12%. These MC variations resulted from a general lack of methodology in determining final MC in dried material (either air dried or kiln dried) and poor drying practices within the industry. In addition there appeared to be limited use of moisture meters in determining the actual MC of the material prior to production. There was also a general lack of understanding of basic wood water relationships and the ramifications of using boards with differential MC within the same component (Ref. Report No. 4). These wood drying issues were later addressed through training.

Following the Mid Term Review, FORDA provided funding to enable an affordable drying chamber for SMEs to be built in Jepara to demonstrate best practice wood drying processes. A drying chamber of 6 m (length) $\times$ 4 m (width) $\times$ 3 m (height) was designed and built in Sinanggul Village, Mlonggo, Jepara (Figure 5). The chamber was equipped with a stove heated by wood waste and two powerful exhaust fans to circulate the hot air. During the trial, the chamber performance was relatively good. Two and a half cubic metres of teak was dried to 10% moisture content in 3–5 days, while 8 m^3 mahagony was dried to 9% in 13 days (Ref: Report No. 37). The companies in Jepara were very impressed with the kiln and one of the companies in Jepara built a similar, but larger capacity, chamber.

Figure 5. The completed drying chamber.

Drying properties of seven wood species from young plantation forests used in Jepara were investigated: teak (*Tectona grandis*), mahogany (*Swietenia* sp.), mindi (*Melia azedarach*), trembesi (*Samanea saman*), lamtoro (*Leucaena leucocephala*), bayur (*Pterospermum javanicum*) and angsana (*Pterocarpus indicus*). The study showed that drying properties of timber from young plantation are relatively poor. The dried timber had a tendency to develop drying defects such as warping, honeycombing and checks. The study concluded that wood drying schedules for young plantation timbers should be carefully determined (Ref: Report No. 28 & 34).

A study on the possibility of using solar kilns in Indonesia was conducted. This study revealed that drying of timber using solar energy is feasible in the majority of the locations around the island of Java. Given the low cost of solar kilns (compared with conventional kilns) and the abundance of solar energy in the region, a moderately sized solar kiln (i.e. 22 m^3) may be accessible for most SME furniture manufacturers, particularly in the Jepara region (Ref: Report No. 35).

Suggestions and recommendations for improving drying techniques and kiln operations were provided through implementation visits to companies. A number of companies applied the changes as suggested (Ref: Report No. 36).

8.2.4 Manufacturing research studies

Analysis of the current recovery rate in furniture production was conducted and documented (Ref: Report No. 5). The study was undertaken in selected furniture companies (Industry Champions) with the aim of determining the recovery rate from the purchased raw material through to the final products. The study revealed that the average recovery rate of furniture components in Jepara was 62%. This rate met the criterion on wood based products recovery set up by the Director General of Forest Production Management (2009). However, the remaining 38% of the recovery rates of furniture components were below this requirement (Ref: Report No. 33). The study provided valuable information, which was then used to develop recommendations for improvements in wood recovery in furniture manufacturing processes, for example, through improving waste utilisation, creating more efficient production processes and producing higher quality wood products.

Research on the suitability of a steam wood bending technique for Jepara furniture companies was conducted. Bending equipment was designed and constructed at the Technical College of Wood Technology (PIKA) for training purpose and at the Universitas Gadjah Mada (UGM) for research on bending characteristics (minimum radius of curvature and bending quality) of mahogany and teak (Figure 6). Two Indonesian researchers were trained in Australia, at Mr Ross Annels' workshop, Cooroy, Queensland, from 29 October until 2 November 2012. Mr Annels is an experienced, internationally recognised expert in wood bending. The training allowed the researchers to learn about various methods of wood bending, gain practical experience and determine which methods were most suitable for furniture companies in Jepara (Ref: Report No. 42 & 43).

Figure 6. Wood bending equipment at UGM for research studies on the bending characteristics of furniture timbers.

Two training courses on wood bending were conducted for Jepara furniture manufacturers at PIKA, Semarang (more details are provided in Section 7.4.1). The bending technology was implemented by several small furniture companies in Jepara (Figure 7). It should be pointed out that wood bending, as a means of producing curved parts in timber construction, has many advantages over other methods of manufacture, but the main advantage is increased strength and recovery of timber. Up to a 100% higher yield can be gained compared with the traditional techniques used in shaping wood. This higher yield, combined with a remarkable higher quality and durability of the finished product, leads to lower production costs and an improved cost benefit to the industry.

Figure 7. Implementation of wood bending technique by small furniture companies.

Research on gluing/laminating properties of six furniture timber species from plantation forests was completed by the Forest Product Research and Development Agency (FORDA) team (Ref: Report No. 46).

- mahogany (*Swietenia* sp.)
- angsana (*Pterocarpus indicus*)
- bayur (*Pterospermum javanicum*)
- lamtoro (*Leucaena leucocephala*)
- trembesi (*Samanea saman*)
- sungkai (*Peronema canescens*).

Adhesives used in the study were as follows: isocyanate (exterior adhesive), polyvinyl acetate (PVAc) and urea formaldehyde (UF) (interior adhesives). The assessment of glue bond strength was carried out by testing shear strength of the glueline according to Japanese standard (JAS 111, 1996). The results showed that for outdoor furniture, isocyanate or resorcinol adhesives should be used and for indoor furniture, UF or PVAc is recommended.

Utilisation of small dimension timber for furniture production in Jepara was investigated (Ref: Conf. Paper No. 10). The study showed that the use of this type of timber is not popular within the furniture industry because most of the furniture companies are not aware of the basic properties of small dimension timber from small diameter logs. The research results showed that small diameter logs and small dimension timbers are particularly suitable for glue laminated products (glulam) and cross laminated timber (CLT) panels, which could be used as furniture raw material. In some cases, furniture products made from glulam processed from small dimension timber and recycled wood, can be sold for a higher price than those made of solid timber.

A research study entitled ‘Producing the cross laminated timber (CLT) from alternative species as raw materials of furniture industries’ was conducted. Two species were tested using an isocynate adhesive: jabon *(Anthocephalus cadamba)* and African wood *(Maesopsis eminii)*. Three different amounts of glue spread were tested: 280 g/m^2, 310 g/m^2 and 340 g/m^2. The results demonstrated that both species are suitable for CLT production, an increase of glue spread does not improve properties of CLT and CLT made from jabon is more stable than from African wood (Ref: Conf. Paper No. 7).

The implementation of improvements and changes in production efficiency and product quality at the Industry Champions was carried out on a continual basis until the project completion date. The suggested changes and their implementation were documented (notes, photos and sketches/drawing) in implementation reports developed for each Industry Champion (Ref: Reports No. 12–22). The level of adoption of recommended

improvements and changes varied among the different companies. Some companies made only small improvements while others made considerable improvements in production efficiency, waste management and product quality.

8.2.5 Finishing research studies

A research study on the enhancement of the surface appearance of tropical woods from community forests was carried out by application of an ammonia fuming technique. The experimental result showed that ammonia fuming could significantly change the natural colour of nangka (*Artocarpus heterophyllus*), waru (*Hibiscus tiliaceus*), African wood (*Maesopsis eminii*), akasia mangium (*Acacia mangium*), mahogany (*Swietenia* sp.), teak (*Tectona grandis*) and puspa (*Schima wallichii*). Heartwood was observed to generate more significant changes in colour compared with the sapwood. Fresh (green) wood generated more prominent change in colour than the air dried wood. The woods treated by ammonia fuming showed an increase in resistance against termite attack (Ref: Journal Publ. No. 3).

Trials on the application of oil-based and water-based wood finishes were performed at the Bogor Agricultural University (IPB) laboratory. The performance of the water-based wood finish was compared with the oil-based wood finish using teak and mahogany timbers. The experimental results showed that teak and mahogany could be finished by using either oil-based or water-based wood finishes. Both types of finish performed well, particularly with imparting a high resistance against household chemicals. Wood samples finished with water-based finishes suffered mechanical damage of 1.55% and weight loss of 0.52%, while no damage was observed on the samples finished with oil-based finishes.

Two research studies on the durability of water-based wood finishes on fast growing wood species were completed. The research aim was to determine the applicability of natural wood staining by the ammonia fumigation method and its effectiveness against dry wood termites (*Cryptotermes cynocephalus*). The water-based lacquer finish was also tested to assess its durability against household chemicals, the hot and cold test, and cross cut tests. The wood species studied were as follows:

- Study No. 1: manii (*Maesopsis manii*), angsana (*Pterocarpus indicus*), teak (*Tectona grandis*), kaboril (*Hymenaea courbaril*), mahogany (*Swietenia* sp.), nangka (*Artocarpus heterophyllus*), rasamala (*Altingia excelsa*) and sawo (*Manilkara kauki*).
- Study No. 2: akasia mangium (*Acacia mangium*), jengkol (*Archidendron parviflorum*), kemang (*Mangifera kemanga*), laban (*Vitex pubescens*), lamtoro (*Leucaena leucocephala*), manglid (*Manglietia glauca*), waru (*Hibiscus tiliaceus*), puspa (*Schima wallichii*) and oak (*Quercus* sp.).

The test results showed that ammonia fumigation increased the aesthetic value of the timber (colour and pattern look natural) and increased the durability of the timber. In addition, visual observations of the condition of the finishing lacquer against household chemicals with intervals of 1 hour and 24 hours, and hot and cold tests, indicated that the water-based lacquer provided a durable layer of resistance (Ref: Report No. 39).

A research study was carried out to determine juvenile and mature transition rings for fast growing sengon (*Paraserianthes falcataria*) and jabon (*Anthocephalus cadamba*) timbers. The occurrence and the characteristics of juvenile wood in these timbers were based on density, fibre length and microfibril angle (MFA). Density was measured along radii from pith to bark by X-ray densitometry. Fibre length and MFA were measured on isolated segmented rings, 1 cm in width from pith to bark, by visual interpretation on maceration and microtome samples. The segmented regression model and visual interpretation of radial patterns of variation in fibre length and MFA revealed that juvenility in sengon and jabon extends up to 7 years. Fibre length and MFA appear to be reliable anatomical indicators of age demarcation between juvenile and mature wood, although maturation

age varies slightly between the fibre length and MFA. The maturation rings were estimated to start at segmented rings 17 and 18 (by the fibre length), and 18 and 20 (by MFA) for sengon and jabon respectively (Ref: Conf. Paper No. 6 and Journal No. 3).

An investigation of the effect of heat treatment on wood properties and finishing quality was carried out with the aim of increasing colour homogeneity and wood quality of teak and mahogany timbers. Two heat treatment methods were used in this research, i.e. oven and steaming methods. Treatments were set at 90, 120 and 150 ˚C for 2, 4 and 6 hours. Physical and mechanical properties were then evaluated. To understand the effect of heat treatment on finishing quality, water-based finishes were applied on heat-treated wood after 2 hours treatment. The tests performed were the cross cut test, coin test, gloss test and delamination test. The study revealed that dimensional stability was improved by an appropriate heat treatment method (Ref: Conf. Paper No. 12).

8.3 Objective 2: To explore new manufacturing technologies for new products and new designs which would be competitive on international markets

New manufacturing methods applicable to low quality, small dimension timbers and which would reduce currently very high wood waste

The selection of value-adding manufacturing technologies suitable for SMEs in Jepara was based on discussions with the industry and results of the assessment of the current capabilities of the companies. Wood bending and wood gluing/laminating were selected as the propriety technologies that were particularly suitable for use with small dimension plantation timbers. These technologies would also allow the introduction of new products and designs.

- Bending technology using simple equipment can provide improved recovery, less waste and innovative designs in furniture and handicrafts. Steam bending was identified as suitable for the industry as it is cost effective and easy to implement by small companies and workshops. Researchers and training instructors were trained on the principles of wood bending technology including bending parameters and equipment required for development and implementation of the method. Details of research and development on wood bending are provided in Section 7.2.4 ‘Manufacturing research studies’.
- Gluing and laminating of timber elements and components is one of the most important processes in manufacturing wood products. The utilisation of small dimension, inferior quality plantation timbers requires joining timber pieces into larger components through edge and surface laminating and finger jointing. Many types of adhesives are on the market and their uses depend on many factors, such as type of timber species, type of joints, final products, applications (structural or non-structural), service conditions (indoor or outdoor), type of species and availability of gluing equipment. Several studies were conducted on the gluing properties of various plantation species, laminating small dimension timbers into glulam panels and CLT for furniture production (see Section 7.2.4).

8.3.1 Improving product design skills available for Jepara companies

A review of the design skills was undertaken with the aim of identifying design skills, design education and training available to furniture manufacturers in Jepara. The survey revealed that although there were many well-trained designers in the region they were not utilised by furniture companies.

In order to identify good local designers and link them with furniture companies, a Furniture Design Competition was organised by the project Manufacturing Team. A brief for the competition was developed, which described the following important issues:

- conditions of entry
- subject
- design requirements
- assessment criteria
- submission requirements
- rules and regulations
- declaration.

The competition included two categories of designers: professional designers and students. The furniture items to be designed for the competition were as follows:

- a chair for the professional category
- a coffee table for the student category.

One of the criteria for the competition entry was that the design should reflect the 'Jepara Style'. The main material used should be one of the plantation timbers included in the Australian Centre for International Agricultural Research (ACIAR) project: teak (*Tectona grandis*) or mahogany (*Swietenia* sp.), or an alternative furniture species: angsana, lamtoro, suren, sungkai, trembesi, bayur and jabon.

The competition was open to all designers from Central Java province, including Yogyakarta. In total 33 submissions were received for the 'coffee table' category and 12 in the 'chair' category. Judges met to select five designs from each category for making into prototypes. The prototypes were made, followed by the final judging. Three winners from each category were selected (Figures 8 and 9). The first and second place winners of each category were awarded with an intensive furniture design training course in Australia.

Figure 8. The winners of the student category (coffee tables).

Figure 9. The winners of the professional designers' category (chairs).

The training course 'Furniture design and the application of the design into finished furniture products' was arranged for six Indonesian designers at Royal Melbourne Institute of Technology (RMIT), School of Architecture and Design, Melbourne, on 18–22 November 2013 (Figure 10). The training was provided to four winners of the Furniture Design Competition and two training instructors in furniture design from PIKA. The training was supported by ACIAR project funds, Crawford Fund and the University of Melbourne (UoM) (Ref: Report No.44).

The aim of the training was to teach the participants about the principles of sustainable design and provide them with a general knowledge in the design methodologies associated with the modern furniture manufacturing industry.

Feedback from the participants indicated the training course exceeded their expectations. In the post-course survey they highlighted that the course provided them with immense benefits as they were able to gain new experience and knowledge from Australian experts in furniture design and learned about the 'Australian concept' of furniture manufacturing, which incorporates design; product development and prototyping; smart manufacturing methods based on production optimisation; packaging; and marketing. In Indonesia, furniture design is a standalone process without any linkages with the manufacturing process. Therefore, designers are isolated and not directly connected with furniture companies. The trainees clearly stated that they are now convinced that the Australian concept should be introduced to the Indonesian furniture industry and they are committed to transfer the knowledge they learned through appropriate channels, such as the furniture design associations, furniture training colleges and universities.

In fact, the six designers shared their skills and experiences gained in Australia with furniture manufacturers and designers in Jepara, as part of the ACIAR project activities:

- They participated in the Project Annual Workshop held on 7 December 2013 in Jepara and explained to the workshop participants what they learned in Australia.
- They provided training to furniture designers on 22–23 February 2014 in Jepara.

This is undoubtedly excellent proof that the skills they acquired during the training in Australia will be transferred to furniture designers, design students and manufacturers in Indonesia.

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

- Mrs Geraldine Oei Ria Oktavilia: Student at PIKA, Semarang, Java
- Mrs Juliani Juwono: Teacher at PIKA Vocational School. She teaches Technical Drawing of Furniture
- Mr Roshikhin: Freelance Furniture Designer in Jepara, Java
- Mr Arif Zainudin: Student in Institut Seni Indonesia (Indonesian Art Institute) (ISI), in Solo, Java
- Mr Antonius Sugianto: Lecturer in furniture design and manufacturing at PIKA, Semarang
- Mr Nuriyanto: Furniture Designer in a furniture company in Surabaya, Java.

Figure 10. Participants of the Furniture Design Competition supported by the Crawford Fund.

8.3.2 Creating database and promotion of alternative species for furniture production

An extensive database on alternative species was developed and published in two books:

- Book ‘Alternative wood species for furniture and creative industry’, published by FORDA, presents the basic data and information on 21 plantation/community forest wood species that are suitable for creative industries such as handicraft and furniture. Data includes: botanical name; trade/commercial name; geographic distribution; general features/characteristics of wood (with pictures of wood structure and wood macroscopic features for wood identification); physical, mechanical and drying properties; as well as machining and gluing properties. Potential utilisation of each species, based on the wood properties and characteristics, is also discussed (Ref: Book No. 3).
- Book ‘Wood species for furniture’ (*Jenis Kayu Untuk Mebel*). This book focuses on 152 wood species grown in Indonesia that are suitable for furniture. Wood

properties and processing characteristics of the species are described on 327 pages (Ref: Book No. 5).

The books were widely distributed to the industry. In total, 126 books were distributed to the Industry Champions, the Jepara Small-scale Furniture Producers Association (APKJ), designers and other companies in Jepara. In addition, pamphlets on selected species were developed and distributed to companies in Jepara.

8.4 Objective 3: To increase Indonesian timber processing research and training capacity

8.4.1 Development and implementation of training program for SMEs

During the first 2 years of the project, training courses were mainly provided to the Industry Champions and some APKJ companies. However, following suggestions by the Research Program Manager (RPM) on the project Mid-Term Review, an increased effort was put towards the wider dissemination of project results to the Jepara wood manufacturing businesses for the remaining years of the project. Each of the five research teams developed a program of training in consultation with the industry. The training was widely advertised within the Jepara furniture industry. As requested by the industry, the training focused on practical aspects of selected topics, including practical sessions at PIKA and at selected companies in Jepara.

In total, 20 training courses were conducted on various topics selected as priorities by the industry and a total of 509 industry personnel were trained. Each training course was highly attended not only by Industry Champions and APKJ members but also by other SMEs in the Jepara region. Course notes were prepared for each participant in Bahasa Indonesia and the majority of the courses involved both classroom and practical activities. Each course was assessed by the participants to give them an opportunity to provide comments and recommendations for future training. Enthusiasm and positive feedback from the participants showed that the training program was well appreciated and successful.

The summary of the training courses is provided in Table 2 and the details of each course are provided in Appendix 3.

Table 2: Summary of Training Courses conducted by the project.

Course Title	Date	Participants	Topics
Sawmilling No. 1	April 2011	16	Understanding sawmilling theory
Wood drying No.1	May 2011	23	Understanding wood drying theory
Wood manufacturing No.1	July 2011	21	Safe and appropriate manufacturing for wooden furniture
Wood finishing No.1	Oct. 2011	25	Wood finishing—an introduction
Preservative treatment	March 2012	40	Simple and cheap wood preservation
Wood finishing No.2	May 2012	28	Water-based finishing
Jigs for wood machinery	July 2012	25	Jigs for circular saw and spindle moulder
Wood drying No.2	September 2012	35	How to solve wood drying problems
Wood construction and fitting	March 2013	25	Wood construction and fitting for wooden furniture
Cost of production and furniture pricing	March 2013	34	Cost production and furniture pricing theory
Wood finishing No.3	June 2013	25	Factors affecting wood finishing quality
Wood bending No. 1	August 2013	25	How to bend wood
Wood drying No. 3	Sept 2013	22	How to set proper wood drying process

Wood packaging	Sept. 2013	17	The science behind the wood product's packaging
Wooden furniture design	Febr. 2014	18	Technical knowledge on furniture design
Sawmilling No. 2	March 2014	31	The right tool for the right work
Wood bending No.2	April 2014	22	How to apply steam bending
Gluing and jointing	May 2014	21	Choosing the right adhesive
Wood waste management and occupational health and safety trainings	August 2014	31	Organise wood waste and work safely
Pricing products and marketing	September 2014	25	How much does it cost and how to sell it

The details on the training courses are provided in a book (Ref: Books, No. 14).

Examples of training courses are shown in Figures 11–13.

Figure 11. Wood sawing training (left) and wood drying training course (right).

Figure 12. Wood finishing training (left) and jig for circular saw and spindle moulder training (right).

Figure 13. Wood bending training course (left) and wood gluing training (on right).

8.4.2 Capacity building

The achievements in research and industry capacity building are provided in Section 8.2.

8.5 Objective 4:

Two impact assessments of the project were undertaken in Year 4 and Year 5 of the project term.

1. The impact assessment study No. 1 was conducted by a team from the Center for International Forestry Research (CIFOR) to obtain empirical validation on the effectiveness of the project in achieving its goals. The results of the study were presented in a report (Ref: Report No. 45) and were widely distributed to the project partners. According to the study's results, the companies involved in the survey reported an increase in sales turnover by 40% after attending various training courses, and their income has increased by about 50%. The data indicates the positive economic impact the project has had on the development of the furniture industry in Jepara.
2. The impact assessment study No. 2 was undertaken by a team consisting of four researchers involved in the project (Figure 14). General comments on the project were as follows (Ref: Report No. 47):
    - A good collaboration has been developed between the selected companies and the ACIAR project.
    - All selected companies showed improvement in knowledge and perception about how to improve the quality of production and products.
    - Several suggested technologies have been adopted but it is not easy to measure the economic impact of the project, but an increasing efficiency and reducing waste and defect definitely provide substantial benefits to the companies.
    - The selected companies are happy to disseminate their new knowledge to other companies.

More details on the impact assessment results are provided in Section 8 'Impacts'.

Figure 14. Focus group discussion during impact assessment in one of the selected companies.

8.5.1 Other related results and achievements

Four researchers from Indonesian research and educational institutions (three from FORDA and one from UGM) were awarded PhD scholarships funded by John Allwright Fellowships. They are all enrolled at the UoM.

1. Karnita Yuniarti, PhD thesis (2010–14): 'Intermittent drying of *Eucalyptus saligna*'. The thesis was submitted in January 2015 and is now under examination. The main aim of this research was to investigate the use of an intermittent drying method for *E. saligna* in order to improve the drying quality. The results were compared with continuous drying methods traditionally used for wood drying. The study revealed significant improvements in drying quality of *E. saligna* using intermittent drying.

   Jamaludin Malik, PhD thesis (2012–16): 'Enhancing timber quality of jabon wood (Anthocephalus cadamba) for high-quality products by treatment through densification and impregnation with merbau extractives'.

2. Currently, jabon wood is one of the popular fast growing timber species in Indonesia, which is planted widely by both industrial forest plantation companies and by local communities. However, the majority of timber harvested from fast grown plantation resources, including jabon, has not yet complied with raw material requirements for good quality products such as furniture components or flooring because of its inferior properties (such as lower density and dimensional instability). The principal objective of this research is to investigate whether the combined treatment of densification by compression and impregnation by merbau extractives will enhance wood properties of jabon. The research is innovative and will bring new knowledge to wood science and technology through investigating a novel approach to enhancing the properties of very young plantation species.

   Ratih Damayanti, PhD thesis (2012–15): 'Wood quality of young fast grown plantation teak (Tectona grandis Linn.) for high-value products. Measures of crystallinity as a non-destructive indicator of wood properties'.

3. Jati Utama Nasional (JUN) is one of the fast growing teak plantations widely cultivated in Indonesia. This teak has been grown to be harvested after 5 years. However, the suitability of this fast grown JUN teak in terms of wood quality is unknown. The aims of the research study are to investigate the wood properties of JUN teak and determine the potential of JUN for high-value products. These investigations will be done by examining the timber's physical properties, among other characteristics, and applying crystallinity as a novel non-destructive indicator of dimensional stability and hardness.

Comprehensive data and information obtained from this study will be important in determining the suitability of such young material for high-quality products, and it may assist in solving the raw material supply problem in forest industries. Comparison with that of mature teak may answer the question: how well do the properties of young fast grown teak compare with mature teak?

4. Using crystallinity and other quantifiers of the crystalline nature of wood as a non-destructive test for predicting dimensional stability/shrinkage and hardness properties has never been investigated before, and it has the potential to provide a means of predicting shrinkage and hardness properties in standing trees. Data and information obtained from the study will be also be beneficial to tree breeding programs.

   Vendy Prasetyo, PhD thesis (2015–18): 'The advanced process in utilisation of young plantation tropical timbers to ensure maximum wood yield'. This study is due to start in March 2015. It is envisaged that Mr Prasetyo's PhD study will develop opportunities for the utilisation of young small dimension timbers (solid wood and veneers) through the introduction of wood optimisation, which will combine wood processing methods and the quality of trees and logs. The materials obtained from the processing (sawn timber, veneers or wood off-cuts) will be glued and laminated into high-quality products using advanced gluing technology available in Australia.

9 Impacts

9.1 Scientific impacts – now and in 5 years

The project has significant scientific impacts for Indonesian and international wood science and technology communities. Research studies conducted by research teams have been well documented and published. The intermediate scientific outcomes are that both researchers and wood manufacturing companies at Jepara are already using the infomormation produced by the project to improve their efficiency and the quality of their wooden products.

The list of the project publications is impressive and comprises the following:

- 14 books
- journal publications
- 21 conference papers and 5 posters
- 47 research reports
- 49 data sheets.

The publications are available at FORDA and on the project website. The website is temporarily not accessible due to administration issues at FORDA but will be made available again in April 2015.

A valuable output of the project research activities is a book entitled ‘Furniture from plantation timber. A manual for furniture manufacturers in the Jepara region of Indonesia’ (Ref: Book No. 12). The 221-page manual comprises a series of guides, prepared in both English and Bahasa, which combine the knowledge of Australian and Indonesian wood scientists involved in the project working closely with local sawmillers and furniture manufacturers in Jepara. The aim of the manual is to contribute to improved processing efficiency, product quality and worker safety.

The manual covers critical aspects of the key stages of furniture production: sawmilling, drying, preserving (treating) timber, and manufacturing the final furniture products. It also draws on some important areas of wood science such as water in wood, decay processes and insect attack, which provide the basis for drying and preserving timber correctly. In addition, there are guides to good business practice, including the benefits of cooperatives, and to health and safety in the woodworking industry.

The manual consists of eight parts:

1. Wood science: Wood growth and properties, softwoods and hardwoods, water in wood, wood breakdown, insect attack and decay
2. Saws, sawmilling and safety: Using bandsaws, circular saws and chainsaws safely; using metal detectors in sawmills and organising log yards
3. Preserving timber: Treating timber, chemicals, processes, equipment, control and safety
4. Colouring teak: Reducing differences in colour between sapwood and heartwood in teak
5. Drying timber: Timber seasoning requirements for making high-quality furniture, wood drying
6. Manufacturing: Appearance, stability, engineering and processing properties for furniture; joints, gluing and laminated wood components (e.g. glulam)
7. Health and safety in the woodworking industry: Identifying potential hazards, adopting sound practices and managing a healthy and safe workplace

8. Business strategies: Lean Culture and Cluster Cooperatives for furniture businesses in Jepara.

The content of the other books is summarised below:

- 'Furniture and handicraft quality improvement of eco-label wood: problems and solutions'. Book (in Bahasa Indonesia) (Ref: Book No. 1).

  This 120-page book contains 8 chapters on the following topics: unique nature of wood, wood basic properties for furniture and handicraft, optimisation of furniture and handicraft processes, simple drying, gluing and finishing, wood waste utilisation, management quality towards successful furniture and handicraft business and eco-label certificate for environmentally friendly products.

- 'Wood drying problems and solutions'. Book (in Bahasa Indonesia) (Ref: Book No. 2).

  This 85-page book discusses problems and solutions relating to the wood drying process. It presents various methods of wood drying, drying defects and types of wood drying kilns.

- 'Alternative wood species for furniture and creative industries'. Book (in Bahasa Indonesia) (Ref: Book No. 3).

- Basic properties of 21 alternative wood species, which are suitable for further production, are described in this book. The properties include physical and mechanical, machining, gluing, natural durability and specific patterns of the wood.

- 'Wood machining: science and process technology'. Book (in Bahasa Indonesia) (Ref: Book No. 4).

  This 343-page wood manufacturing book contains 10 chapters covering topics from the basic knowledge of wood properties through to the principles of wood machining operations. The book explains how industry can implement the knowledge and includes information on the occupational health and safety (OH&S) aspects of wood manufacturing.

- 'Wood species for furniture'. Book (in Bahasa Indonesia) (Ref: Book No. 5).

  This book focuses on the 152 wood species grown in Indonesia that are suitable for furniture. Basic knowledge and properties of the 152 wood species are described on 327 pages (Ref: Book No. 5).

- 'Technical production and quality control in wood processing'. Book (in Bahasa Indonesia) (Ref: Book No. 6).

  This 106-page book contains 5 chapters. It discusses all aspects of woodworking production including production techniques, leadership in production and quality control.

- 'Raw material preparation and selection processes'. Book (in Bahasa Indonesia) (Ref: Book No. 7).

- This 93-page book discusses the selection and preparation processes of wooden materials including log grading, sawing, drying and preservative treatment of sawn timber.

- 'Wood identification for furniture'. Book (in Bahasa Indonesia) (Ref: Book No. 8).

  This book focuses on the macro identification of wood for furniture.

- 'Wood products designing, business and management'. Book (in Bahasa Indonesia) (Ref: Book No. 9).

This book provides advice on starting a woodworking business and management strategies for woodworking businesses, including wooden furniture. It also explains strategies for anticipating loss and managing business risk.

- 'Wood machining'. Book (in Bahasa Indonesia) (Ref: Book No. 10).

  This book is a technical guideline for wood machining for woodworking industries. It provides a step-by-step 'do it yourself' guideline on all aspects of wood machining including sanding, routing and edging as well as safety requirements for wood machining.

- 'Assessing the practice of drying process by wood-based furniture small-medium enterprises in Jepara', Indonesia (Ref: Book No. 11).

  This is a book chapter in 'Contribution matters'. The chapter describes the results of a comprehensive survey undertaken to assess the technology and equipment used by the small and medium-sized enterprises (SMEs) for drying timber and to determine the knowledge gap in the basic drying principles.

- Three additional books were published that compile all of the research reports (Ref: Book No. 13), publications (books, journal papers and conference papers) (Ref: Book No. 14), and training materials (Ref: Book No. 15).

Over the next 5 years, research outputs of the project will continue to be widely disseminated to both Indonesian and international scientific communities through publications in peer reviewed journals and presentation at forest products research conferences. More papers will be published. This allows the project findings on the utilisation of plantation timbers to be made available to scientific communities around the world, wood processing industry in Indonesia and other Australian Centre for International Agricultural Research (ACIAR) funded forestry projects related to the growing and utilisation of similar species. In addition, the four PhD students will complete their studies at the University of Melbourne (UoM), which will bring new knowledge to wood science and technology through providing novel approaches to enhancing the properties of very young plantation species.

9.2 Capacity impacts – now and in 5 years

At the commencement of the project there was a notable lack of collaboration between major research, education and training centres and a lack of linkages with the timber and furniture companies, in particular SMEs. Therefore, a strong emphasis of the project was on enhancing training, and research and development capacity, to improve the skills level of the domestic industry.

The analysis of research capabilities of each partner organisation was undertaken at the project commencement stage, which enabled specialised expertise to be identified and priority research areas to be assigned to various project activities and tasks. Five research teams were formed from the project partner organisations consisting of research experts in sawing, preservative treating, drying, value-adding manufacturing and finishing. Three of the research teams were led by Indonesian researchers and two by Australian researchers, with only one Australian researcher in each team. The team members worked together throughout the project learning from each other, developing research linkages and creating friendships. This facilitated development of expertise in wood processing, manufacturing and product development, which was previously fragmented and dispersed across many institutions in Indonesia (Forest Product Research and Development Centre [FORDA], Bogor Agricultural University [IPB], Universitas Gadjah Mada [UGM] and Technical College of Wood Technology [PIKA]). Identifying experts within the partner organisations has also encouraged the development of specialisation in different research areas to avoid duplication.

It is evident that during the 5 years of the project term, the project made significant achievements in capacity building, mainly through the collaborative action research and the development of strong network linkages between partner organisations representing education, research, training and the industry. The intermediate outcomes from this capacity building is that the 23 wood science researchers are using their new skills to improve the effectiveness of wood science research and the 500 wood manufacturing workers are using the new skills and knowledge to improve the efficiency of the manufacturing processes and the quality of the wooden products.

During Years 4 and 5 a strong emphasis was placed on disseminating the project findings, not only to the Industry Champions but also to Jepara Small-scale Furniture Producers Association (APKJ) members and other SMEs in the Jepara region. This was done through involving these companies in project workshops, seminars and training courses and disseminating the project outputs through newsletters, training notes and data sheets. Twenty training courses were provided, which were attended by over 500 industry members. Each course was evaluated by its participants on criteria such as content, benefits and methods of presentation. The participants rated the courses very highly.

According to the impact assessment study conducted in the final year of the project, all interviewed companies (6 members of the Industry Champions and 3 APKJ companies) agreed that the project significantly improved their knowledge on wood processing and manufacturing (Ref: Report No. 47) through their attendance at annual workshops and training courses.

The results of the impact assessment on knowledge enhancement are summarised in Table 3.

Table 3. The results of impact assessment in relation to change of knowledge (Ref: Report No. 47).

Parameters	**Positive answer 'Yes'**
Company participated actively in the Annual Workshops of the project	67%
Members of the project visited/provided technical assistance to the company	100%
Company actively participated in the training series of the project	89%
Company believed that it received beneficial information relating to their business	100%
Company received useful information from the training	100%

In order to improve the capacity of Jepara furniture companies, the project, with financial support from FORDA, has built wood drying facilities that can be used by SMEs under the management of the APKJ association. This initiative provides substantial benefits to the local companies. For instance, a similar kiln of a larger capacity has been recently built by one of the local businesses in Jepara to dry its own timber and provide drying services to other companies.

Nineteen Indonesian researchers from the partner organisations visited Australia for short courses to become familiar with relevant Australian research and technical education providers or training in specific technical areas. This activity was supported by additional funding provided to the project by the Research Program Manager (RPM) after the Mid-Term Review.

Four Indonesian researchers were awarded John Allwright Fellowships to undertake PhD studies at the UoM (three from FORDA and one from UGM). One has already submitted the thesis for examination. Their education at the UoM, the university with international rankings of world universities placing it as number 1 in Australia and number 33 in the world (Times Higher Education World University Rankings 2014-2015), will enhance the research and science capacity in Indonesia.

In addition, the Indonesian project leader Dr Krisdianto Sugiyanto was awarded a prestigious John Dillon Fellowship. The focus of his training is research management and leadership.

The project leader submitted an application for funding to The Crawford Fund to support the training course in Melbourne for furniture designers from Central Java. The application was successful and the Crawford Fund Committee agreed to fund this activity to the level of A$10,000. Four designers, the winners of the Furniture Design Competition, and two training instructors from PIKA, participated in an intensive training course on various aspects of furniture design. Feedback from the participants indicated the training course exceeded their expectations and in the post-course survey they highlighted that the course provided them with immense benefits as they were able to gain new experience and knowledge from Australian experts in furniture design and learned about the 'Australian concept' of furniture design and manufacturing. In Indonesia, furniture design is a standalone process without any linkages with the manufacturing process. Therefore, designers are isolated and not directly connected with furniture companies. The trainees clearly stated that they are now convinced that the Australian concept should be introduced to the Indonesian furniture industry and they are committed to transfer the knowledge they learned through appropriate channels, such as the furniture design associations, furniture training colleges and universities.

Good collaboration was established with a parallel ACIAR project FST/2007/119 'Mahogany and teak furniture: action research to improve value chain efficiency and enhance livelihoods'. Researchers involved in both projects continue to strengthen their relationships by undertaking collaborative projects and developing applications for further funding.

A Memorandum of understanding was signed in 2014 between MoU and IPB with the aim to 'collaborate in academic and research activities on the basis of mutual benefit'. The Memorandum of understanding is part of the UoM international collaboration program aiming to promote and support joint PhD opportunities, exchange academic staff, organise lectures and/or symposia, and establish short-term student opportunities. This collaboration will have substantial outcomes in capacity building within the Indonesian and Australian education sectors.

It is envisaged that a strong and efficient link 'Industry–research–training–education' established within the project will stimulate continuous and sustainable development and competitiveness over the next 5 years.

9.3 Community impacts – now and in 5 years

9.3.1 Economic impacts

Two comprehensive impact assessment studies were conducted during Year 4 and Year 5.

In the first study, conducted by the Center for International Forestry Research (CIFOR) team (Ref: Report No. 45), the majority of respondents stated that their knowledge has increased significantly due to the project activities, particularly in sawing, drying, manufacturing and finishing. Implementation of suggested innovation technologies was as follows: 17% on wood drying, 26% on wood preservation, 30% on manufacturing, 43% on sawing and 52% on finishing. This rather low rate of implementation should be considered relatively normal as most of the participants were still in the learning stage when the survey was undertaken (Year 4 of the project term) and were attempting to understand the theory behind wood processing. It is common knowledge that wood technology innovation is a long process. The summary of the project impact to furniture companies in Jepara is shown in Table 4.

According to results of the survey there has been a 40% increase in sales turnover of the interviewed Industry Champions after various training courses provided by the project, and their income has increased by about 50% (Ref: Report No. 45). The data may be not statistically significant; however it indicates positive economic impact on the development of the furniture industry in Jepara. It should be highlighted that economic impacts are relatively difficult to measure in the short time of the project duration.

Table 4. Summary of project impact to targeted people in Jepara (Ref: Report No. 45).

Wood processing aspects	Percentage of participants who stated knowledge improvement	Percentage of participants who stated innovation technology positively	Percentage of participants who implemented innovation technology from the project	Percentage of participants who disseminated innovation technology
Sawing	53.30	65.22	43.48	43.48
Wood drying	50.00	65.22	17.39*	34.78
Wood preservation	29.35*	47.83	26.00*	21.74*
Manufacturing	35.65	41.30	30.43*	36.96
Wood finishing	50.00	60.89	52.00	43.48

Key: * = significantly different at the level of 95%

The second impact assessment was undertaken close to the project completion date. This assessment involved interviews, participatory approach and focus group discussion with 9 companies (6 members of the Industry Champions and 3 APKJ companies) on the improvement of knowledge, the change of perception on the product quality as well as the implementation of the project outputs and financial impact of changed practices on individual businesses.

Undoubtedly there have been benefits to individual businesses, but how far the benefits have spread within the industry will not be clear for several years, considering slow rate in implementing technical innovation. A best estimate is that perhaps 50 firms have undertaken some adoption of the project outputs (Kile, 2014).

Examples of economic benefits identified by the interviewed companies are provided below, separately for each production stage (Ref: Report No. 47):

Sawmilling

The company that implemented the improved sawing method reduced the saw kerf allowance from 26 mm to 23 or 24 mm in the 20 mm board thickness. As a result, the sawing recovery increased from 60 to 70%. In the sawmilling industry, the sawn board production is about 40 m^3 per month. The recovery improvement of 10% is equal to a savings of about 4 m^3/month, which is equivalent to about Rp12 million per month.

Wood drying

The final moisture content (MC) of wood used in furniture production should be 10% or less as required by international standards. Previously, the final MC of sawn boards varied between 10 and 15% and products were rejected due to the high and uneven MC within one product. The proper wood drying control in SMEs introduced by the ACIAR project enabled a reduction in the final MC to 10% or less, which reduced the number of rejected products and improved sales.

Appropriate timber stacking can reduce defects to about 30% for every batch (about 2 m^3) and moisture in the timber is more evenly distributed. Drying defect reduction of 30% could save about Rp1.5 million per batch, which is about Rp4.5 million per month. The

proper stacking and drying schedule can decrease the drying time from 12 days to 10 days. Normal operation costs for 12 days drying time is Rp4.2 million (Rp350,000 per day), which is reduced to Rp3.5 million per kiln.

A wood drying facility was built in one company as a pilot project. The company is now building another larger wood drying facility. The new kiln will be able to increase the economic benefit by about 5%. The company could sell about 5–10 containers every year at the cost of Rp300 million per container. The additional benefit to the company could reach Rp60–120 million per year.

Treatment

Implementing wood treatment has not shown direct economic impacts; however the treatment improves the durability of wood products, which results in improved satisfaction levels with customers.

Manufacturing

SMEs that applied best practice gluing techniques as mentioned during the training have reduced their number of failures in the gluing process.

Two SMEs have applied the wood bending technology introduced by the project. It was claimed that the steam bending technology could save raw material inputs of 5–15%.

Finishing

Wood finishing training courses were conducted three times. The implementation of proper wood finishing by SMEs was claimed to improve economic benefits by 30–50%. Improvements relate to appropriate finishing selection, techniques and finishing skills.

General

All selected companies claimed benefits through the improved knowledge and perceptions about how to improve the quality of wooden furniture products.

New technologies suitable for the Jepara industry, which were investigated within the project, have been disseminated through training and implementation visits. Some of the technologies were adopted by SMEs. Companies have identified that improving production efficiency, producing fewer defects and reducing waste have provided economic benefits, but it is a long process until these benefits can be measured.

Selected companies stated that the project has provided many benefits not only to the owners, but also to the workers who have improved their skills.

9.3.2 Social impacts

The social advantages of training and development of skills undertaken within the project are obvious: there are many benefits in having a skilled and dedicated work force.

Female participation in the project has been relatively high with several female team members actively participating in research and training activities and many female industry members (about 30%) attending training courses.

The project has significantly improved networking between small-scale furniture producers in Jepara, which will provide long-term benefits to the industry.

It should be also pointed out that the project placed a strong focus on improving health and safety aspects of timber processing and manufacturing. Many of the current practices are unsafe and may cause serious injuries and deaths of factory workers. Standard safety signs were placed in the factories and the team has also donated personal protection equipment to some enterprises. About 1,000 pairs of ear plugs, 30 safety glasses and 800 safety masks were distributed.

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

It is anticipated these activities will enhance the workers' safety awareness and will develop a culture of a safe working environment on an on-going basis.

9.3.3 Environmental impacts

This project has the potential to provide significant environmental impacts as its activities have focused on value-adding technologies applicable to plantation timbers.

The project has encouraged the reduction of waste in sawmilling and furniture production by introducing more efficient wood processing and manufacturing methods, decreasing wood drying degrades, utilising small dimension timbers and wood off-cuts for various wood components, and introducing new technologies such as wood bending and laminating. These value-added methods will result in the more efficient use of timber, thus it will enable companies to produce 'more from less'.

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

The demand for wood certification and wood product labelling is increasing noticeably internationally. Timber legality legislation has been introduced in Australia, Europe and the United States to ensure that no wood or wood products derived from illegal sources can be imported into those countries. Companies producing wood products from plantation timbers in Jepara now have an opportunity to obtain Timber Legality Verification System (SVLK) certification, which was introduced by the Indonesian government in 2010 as part of a move to eliminate illegal logging in the country. The certification is mandatory and has been applied in industrial forest concessions, production forest concessions and community plantation forests. The government has allocated Rp3 billion (US$316,856.78) from the state budget to help small-scale producers obtain SVLK certification. Small-scale producers can participate and establish a cooperative to apply for group SVLK certification. This provides an opportunity to the furniture companies in Jepara to apply and develop SVLK certification as they have already formed strong cooperative groups (the Industry Champions and APKJ members) within the project activities. Currently, around 60% of the country`s furniture industries have adopted SVLK. Some furniture companies in Jepara have already implemented SVLK.

The SVLK will provide Jepara furniture producers greater access to the global market as it guarantees buyers that the wood and wood-based products originate from legal practices and are sourced in an environmentally friendly manner.

In the next 5 years, an increasing volume of the fast-growing teak, JUN (Jati Unggul Nusantara), will be ready for harvest and the yield is likely to encourage more people to plant teak. The results of research studies on plantation and fast growing teak and other species will enable the industry to utilise these timbers with confidence they are grown and harvested on a sustainable basis.

The introduction of environmentally friendly production methods and eco-friendly designed products will potentially create an on-going culture of production of ecologically sustainable wood products.

9.4 Communication and dissemination activities

The development of efficient communications between the project partners has been identified as the priority activity in the project strategic program. Therefore, a communication program was developed at the outset of the project to allow all project

partners to actively participate in the project management and to disseminate the outputs of the project activities to all members of the project.

At the project's initial meeting the Project Steering Committee was formed. The Committee consisted of two representatives from each partner organisation, including the industry representative. Terms of reference were developed for the Steering Committee to ensure that the project objectives and activities would be completed on time and within the budget. The Steering Committee members met approximately every year (depending on the availability of the Committee members) to discuss and review the project.

A logo was developed for the project, to facilitate internet communication and distribution of information (Figure 15).

Figure 15. The logo that was developed for the project.

A webpage for the project team was developed to facilitate efficient communication between the team members. The webpage contains information on the meetings, minutes of the project meetings, project documents, research reports, presentations, photo albums related to research activities, media releases, news and policies related to the project.

The project newsletters were published, which provided an update on project progress, major activities undertaken, important outcomes and events. In total four newsletters were produced. The newsletters were widely distributed within Indonesia and in Australia. Positive feedback was provided by many individuals and organisations as the newsletters were seen as an excellent method of disseminating the project activities and outcomes.

The project leader communicated with the country coordinator, the Indonesian leader and team members on a regular basis (by emails, on-line discussions and meetings) in order to discuss, monitor and review the project activities, identify any problems and modify and adjust research plans and methods accordingly.

A local office was established in Jepara and the project Field Officer was appointed to the project. The role of the Field Officer was to facilitate communication between the project researchers and the companies in Jepara (Industry Champions, APKJ and other SMEs), organise the ‘field’ research activities, advertise training courses, provide support in implementation visits and disseminate research outputs to the furniture companies.

Regular project team meetings were held in Indonesia for a number of reasons: to review the project progress; discuss important matters related to activities undertaken by five research teams; discuss the training program, equipment and financial issues; and to discuss future activities. Research members from the project partner organisations attended the meetings. Australian members attended the meetings during their visits to Indonesia.

Four Annual Workshops were held to facilitate dissemination of information and assess project progress.

Several implementation visits to each Industry Champion were made each year by the project teams. After the provision of feedback to the company on the results of the assessment and improvement recommendations, follow-up visits were made each year to discuss implementation of recommendations provided in the previous stages of the project. The project team spent a lot of time with each individual company to ensure that the recommendations were well understood and the implementation process was fully

supported by the company management. The teams undertook additional visits to the industry companies according to the project needs.

An effective program for communicating and disseminating the project findings to stakeholders in Indonesia, Australia and others was developed and accomplished by publishing research outputs in appropriate scientific and professional journals and presenting the results at relevant scientific and professional conferences, seminars and workshops. These publications enabled effective dissemination of the project outputs within professional networks and the scientific and forest industry communities.

The team members presented their research results to the industry members and all other project stakeholders at seminars, workshops, training courses and conferences. In total 83 powerpoint presentations were made (Appendix 4).

Collaboration with the ACIAR project FST/2007/119 ‘Mahogany and teak furniture: action research to improve value chain efficiency and enhance livelihoods’ was established. Frequent meetings were held in Jepara and in Bogor between the leaders of the two projects as well as between researchers of the partner organisations to exchange information on progress of the projects and major project outputs.

10 Conclusions and recommendations

10.1 Conclusions

The project objectives of utilising plantation grown timbers for furniture production, improving added value, and increasing capacity of small and medium-sized enterprises (SMEs) in Jepara were difficult aims to achieve. The wood furniture businesses in this region employ approximately 170,000 people. There are about 12,000 wood furniture companies in Central Java and Jepara, most of which are SMEs. The major challenge of this project has been 'how to disseminate the project findings and improve current processing and manufacturing methods in such a large number of companies', many of which operate on low margins and with limited capacity to secure finance for new machinery.

The key learnings from the project are as follows:

1. The 'small steps' method was adopted at the beginning of the project through the establishment of a network of companies called 'Industry Champions'. During the first 2 years of the project, researchers worked on the implementation of improved and new production methods with the Industry Champions and some Jepara Small-scale Furniture Producers Association (APKJ) companies. Following a recommendation made at the project Mid-Term Review, it was agreed that the project findings needed to be disseminated not only to the Industry Champions, who were directly involved in the project, but also to other companies within the Jepara furniture industry sector. ACIAR provided supplementary funding for additional training courses, seminars and workshops for the Jepara furniture industry which resulted in 509 industry personnel being trained. This initiative proved to be very successful and demonstrated the importance of the Project Mid-Term Review process—when the project activities can be revised and improvements made.
2. The project was primarily focused on applied research and development activities, with the dissemination of research outputs to the industry through extensive training provided by the research partners and the Technical College of Wood Technology (PIKA). This approach was effective. The project provided a significant contribution to wood science and technology both in Indonesia and internationally, and to the timber industry sector by increasing the utilisation of timber from young plantations in the production of furniture for domestic and export markets.
3. It is believed that the network that was developed within the project will provide sustainable long-term capacity improvements and will offer significant benefits to the Jepara furniture industry, such as the following:
    - enhanced research capacity of the project partner organisations will have direct benefits to the industry by educating and training technical experts in wood processing and manufacturing, product development, waste management, quality control and production efficiency
    - improved training for the timber and furniture industry
    - improved technical skills within the industry
    - strengthened networks between the Industry Champions, APKJ and with other companies
    - improved design network through the establishment of links between designers and the furniture companies
    - increased awareness of workplace safety and export product quality requirements.

Research outputs of the project have significant scientific impacts for both Indonesian and international scientific communities. The project findings on the utilisation of plantation timbers cover critical aspects of the key stages of furniture production: wood properties and processing characteristic, sawmilling, drying, preserving (treating) timber, manufacturing the final furniture products as well as modification of young inferior quality timbers to enhance their properties.

Research on gluing/laminating properties, utilising the following adhesives: isocyanate, polyvinyl acetate and urea formaldehyde, for six furniture timber species was completed.

- mahogany (*Swietenia* sp.)
- angsana (*Pterocarpus indicus*)
- bayur (*Pterospermum javanicum*)
- lamtoro (*Leucaena leucocephala*)
- trembesi (*Samanea saman*)
- sungkai (*Peronema canescens*).

The results showed that for outdoor furniture, isocyanate or resorcinol adhesives should be used and for indoor furniture, UF or PVAc is recommended.

The project also contributed to the wider understanding of the wood properties of Indonesian timbers through two publications:

'Wood species for furniture' (*Jenis Kayu Untuk Mebel*)'. This book details the wood properties and processing characteristics of 152 wood species grown in Indonesia that are suitable for furniture.

'Alternative wood species for furniture and creative industry', This book presents the basic data and information on 21 plantation/community forest wood species that are suitable for creative industries such as handicraft and furniture.

So far, no research studies have been undertaken with the aim to address the whole value-adding production process for young plantation timbers. As such this project's research findings provide a valuable contribution to scientific communities around the world, research communities and wood processing industry in Indonesia and other Australian Centre for International Agricultural Research (ACIAR) funded forestry projects related to the growing and utilisation of similar species.

10.2 Recommendations

The project partners represented education, research and training institutions as well as industry organisations and furniture SMEs. The members of these organisations have formed a cohesive network with a strong culture of collaboration.

It is envisaged that the experience gained by the participants within the project will prepare them for future collaborative work and will establish strong linkages, which should continue after the project is completed. However, it is important to cement the project outcomes with stronger foundations and move on to the next stage. Hence there is a need to identify and document the priorities that should be addressed in future research studies to enable the momentum built to date by the enthusiasm of all partners to continue into the next phase.

The following recommendations were developed for future research and development activities, which would cover gaps in the value chain leading to a successful furniture industry based on sustainable plantation timber resources:

- The future project should extend research and technology transfer activities to other furniture industry regions in Indonesia.
- The technical research expertise of the FST/2006/117 project and value chain analysis approach of the FST/2007/119 project should be combined. This would significantly strengthen the capacity of the project teams by merging technical and social skills and expertise needed in addressing key elements of the value chain in processing plantation grown timbers.
- PIKA's first-rate training and dissemination capacity should be better utilised in the new project through assigning a larger role for this organisation.
- Further research on wood drying, preservation and manufacturing technologies applicable to young plantation timber species in Indonesia should be conducted.
- Activities on improving design of wood products by involving existing design schools and designer groups should be continued.

The proposed concept for a new research program is well aligned with the industry and government strategic directions by addressing the challenges and synchronising the production of wood products based on sustainable timber resources.

11 References

11.1 References cited in report

- Anon. 2009. Rule of Director General of Forest Production Management No. P.13/VI-BPPHH/2009 dated 9 November 2009 about Recovery of Processed Wood of Primary Forest Products Industry. Jakarta.
- ASMINDO, Indonesian Furniture & Handicraft Association. At <http://www.asmindo.or.id/>, accessed 13 February 2015.
- Bartlett, T. 2011. FST/2006/117 – Comments on Mid-Term Review.
- Furniture & Furnishing Export National. Industry News. Sept.– Oct. Issue 2014. At <http://www.furnitureandfurnishing.com/index.php>, accessed 13 February 2015.
- JAS 111, 1996. Japanese Agricultural Standard for Structural Glued Laminated Timber. Japan Plywood Inspection Corporation.
- Kile, G. 2014. Project Review Report. Prepared for ACIAR.
- Ozarska, B., Daian, M., Harris, G., Ashley, P., Boupha, L., Phonetip, K. and Bouaphavong, D. 2007. 'Detailed analysis of the current capabilities of companies involved in the industry cluster and recommendations on improved processing, drying and manufacturing processes suitable for application in Laos'. A report prepared for ACIAR Project FST/2005/100. October 2007. 148 pages.

11.2 List of publications produced by project

11.2.1 Books

- Marsoem, S.N., Praptoyo, H., Kasmudjo, Prayitno, T.A., Listyanto, T., Hadikusumo, S.A. and Sutapa, J.P.G. 2010. 'Peningkatan Kualitas Mebel dan Kerajinan Kayu Ekolabel: Masalah dan Solusi'. (*Furniture and handicraft quality improvement of eco-label wood: problems and solutions*). Book (in Bahasa Indonesia), Cakrawala Media, Yogyakarta.
- Marsoem, S.N., Praptoyo, H., Kasmudjo, Prayitno, T.A., Listyanto, T., Hadikusumo, S.A. and Sutapa, J.P.G. 2011. 'Pengeringan Kayu: Masalah dan Solusi'. (*Wood drying problems and solutions*). Book (in Bahasa Indonesia), Cakrawala Media, Yogyakarta.
- Damayanti, R., Malik, J. and Yuniarti, K. 2012. 'Jenis Kayu Alternatif untuk Mebel dan Industri Kreatif'. (*Alternative wood species for furniture and creative industries*). Book (in Bahasa Indonesia), FORDA, Bogor, Indonesia.
- Darmawan, W., Rahayu, I.S., Padlinurjaji, I.M. and Pandit, K.N. 2012. 'Pengerjaan Kayu, Ilmu-Ilmu Penunjang dan Teknologi Proses'. (*Wood machining: science and process technology*). Book (in Bahasa Indonesia), IPB Press, Bogor.
- Krisdianto and Dewi, L.M. 2013. 'Jenis Kayu untuk Mebel'. (*Wood species for furniture*). Book (in Bahasa Indonesia), FORDA, Bogor, Indonesia.
- Istoto, Y.E., Kasmudjo, Tantowi, A.E., Praytino, T.A. and Adhitjahyo. 2013. 'Teknik Produksi dan Kontrol Kualitas'. (*Technical production and quality control on wood processing*). Book (in Bahasa Indonesia), Faculty of Forestry, Gadjah Mada University, Yogyakarta.

- Kasmudjo, Marsoem, S.N., Hadikusumo, S.A. and Sulistyo, J. 2013. 'Proses Pemilihan dan Penyiapan Bahan Baku Kayu'. (*Raw material preparation and selection processes*). Book (in Bahasa Indonesia), Faculty of Forestry, Gadjah Mada University, Yogyakarta.
- Kasmudjo, Marsoem, S.N. and Praptoyo, H. 2013. 'Identifikasi Kayu untuk Mebel'. (*Wood identification for furniture*). Book (in Bahasa Indonesia), Faculty of Forestry, Gadjah Mada University, Yogyakarta.
- Marsoem, S.N., Sulistyo, J. and Kasmudjo. 2013. 'Desain Produk Kayu: Bisnis Usaha dan Manajemen'. (*Wood products designing, business and management*). Book (in Bahasa Indonesia), Faculty of Forestry, Gadjah Mada University, Yogyakarta.
- Marsoem, S.N., Sulistyo, J. and Kasmudjo. 2013. 'Pemesinan Kayu'. (*Wood machining*). Book (in Bahasa Indonesia), Faculty of Forestry, Gadjah Mada University, Yogyakarta.
- Harris, G., Ozarska, B., Yuniarti, K., Listyanto, T., Sudohadi, Y.S., Hadikusumo, S. and Adhitjahjo, I. 2011. Assessing the practice of drying process by wood-based furniture small-medium enterprises in Jepara, Indonesia. A Book chapter in 'Contribution matters'. PPI Australia, 2 July 2011.
- FST/2006/117 Project team. 2014. 'Furniture from plantation timber. A manual for furniture manufacturers in the Jepara region of Indonesia'. Published by Department of Agriculture, Fisheries and Forestry, Queensland, Australia. 221 pages.
- Team. 2014a. Book of Reports.
- Team. 2014b. Book of Publications.
- Team. 2014c. Book of Training Materials.

11.2.2 Journal publications

- Malik, J. and Hopewell, G. 2009. Improving sawn recovery of sawn timber by live-sawing pattern to make lose ware lumber for furniture material in Jepara region. *Jurnal Penelitian Hasil Hutan* 29(4):331–342.
- Darmawan, W., Nandika, D., Rahayu, I., Fournier, M. and Marchal R. 2013. Determination of juvenile and mature transition ring for fast growing sengon and jabon wood. *Journal of Indian Academy Wood Science*. DOI 10.1007/s13196-013-0091-x.
- Darmawan, W., Rahayu, I.S., Nandika, D. and Widyana, L. 2011. Pengembangan fumigasi ammonia sebagai metode finishing dan pengawetan. *(Development of ammonia fuming as finishing and preservation method). Jurnal Ilmu dan Teknologi Hasil Hutan* 4(1):34–39.
- Basri, E. and Wahyudi, I. 2013. Sifat dasar kayu jati plus perhutani dari berbagai umur dan kaitannya dengan sifat dan kualitas pengeringan. *(Wood basic properties of jati plus perhutani from different ages and their relationship to drying property and quality). Jurnal Penelitian Hasil Hutan* 31(2). (in Bahasa Indonesia).
- Darmawan, W., Nandika, D., Massijaya, M.Y., Kabe, A., Alipraja, I., Rahayu, I. and Ozarska, B. 2013. Lathe check characteristics of fast growing sengon veneers and their effects on LVL glue-bond and bending strength. *Journal of Materials Processing Technology.*
- Listyanto, T., Lukmandaru, G., Pramadya, C., Siswanto, D. and Hattori, N. 2011. Relationship between wood properties and developed drying schedule of inferior

teak (*Tectona grandis* L.f.) and Mahogany (*Swietenia macrophylla* King). *Journal of Indonesian Wood Research Society* 1(2).

- Fadillah, A.M., Hadi, Y.S., Massijaya, M.Y. and Ozarska, B. Resistance of preservative treated mahogany wood to subterranean termite attack. 2014. *Journal of the Indian Academy of Wood Science* JIAW-D-14-00022R1.
- Jasni, Krisdianto and Ozarska, B. 2013. Serangga perusak kayu di industri mebel Jepara. (*Insects attacking wood in Jepara furniture industries*). *FORPRO: scientific magazine in forestry and forest products* 2(2):36–39. December. (in Bahasa Indonesia).

11.2.3 Conference papers and proceedings

- Izza, N., Massijaya, M.Y. and Hadi, Y.S. 2010. Lesson learned from 'Raisa House of Excellence' on how to control termite attack for furniture products. Proceeding of The 7th Conference of the Pacific Rim Termite Research Group, Singapore 1–2 March 2010. p. 51–54.
- Ozarska, B. 2013. Suitability of young inferior quality plantation timbers for furniture. Keynote Speech. Proceeding on The 3rd Symposium of Indonesian Wood Research Society (IWORs), 3–4 November 2013, Yogyakarta.
- Massijaya, M.Y. Basri, E., Harris, G., Ozarska, B., Malik, J., Damayanti, R. and Hadi, Y.S. 2012. Wood drying problems and possible solutions for small enterprises of wood furniture industries in Jepara region. Proceeding of the INAFOR Conference, 5 – 7 December 2011, Bogor.
- Jasni, Damayanti, R., Norton, J. and Krisdianto. 2012. Simple preservative treatment of four wood species for small and medium furniture industries. Proceeding of the INAFOR Conference, 5–7 December 2011, Bogor.
- Jasni, Damayanti, R., Kirsdianto and Malik, J. 2012. Ketahanan empat jenis kayu terhadap serangan rayap. *(Durability of four plantation wood species against termite)*. Paper presented in The Indonesian Entomologist Congress and National Seminar (PEI), 24–25 January 2012, Bogor. (in Bahasa Indonesia).
- Darmawan, W., Rahayu, I., Fournier, M. and Marchal, R. 2012. Determination of juvenile and mature transition ring for fast growing sengon and jabon wood. Paper presented in The 4th Symposium of Indonesian Wood Research Society (IWORs), 7–8 November 2012, Makassar.
- Fajriani, E., Kabe, A., Rahayu, I.S., Massijaya, M.Y. and Hermawan, D. 2012. Physical and mechanical properties of cross laminated timber made of Jabon (*Anthocephalus cadamba*) and afrika (*Maesopsis eminii*) influence of wood species and level of adhesives. Paper presented in The 4th Symposium of Indonesian Wood Research Society (IWORs), 7–8 November 2012, Makassar.
- Hernawati, S., Hadi, Y.S. and Jasni. 2012. Resistance of three wood species from community forests with boron preservatives against subterranean termite attack. Paper presented in The 4th Symposium of Indonesian Wood Research Society (IWORs), 7–8 November 2012, Makassar.
- Izza, N., Massijaya, M.Y. and Hadi, Y.S. 2012. Improving added value and small medium enterprises capacity in the utilization of plantation timber for furniture production in Jepara region. Paper presented in The 4th Symposium of Indonesian Wood Research Society (IWORs), 7–8 November 2012, Makassar.
- Massijaya, A. and Massijaya, M.Y. 2012. The utilization of small diameter logs for Jepara furniture production. Paper presented in The 4th Symposium of Indonesian Wood Research Society (IWORs), 7–8 November 2012, Makassar.

- Verinita, L., Hadi, Y.S. and Jasni. 2012. Resistance of three wood species from community forests to subterranean termite attack. Paper presented in The 4th Symposium of Indonesian Wood Research Society (IWORs), 7–8 November 2012, Makassar.
- Widyorini, R. 2012. The effect of heat treatment on wood properties and finishing quality of teak and mahagony. Paper presented in The 4th Symposium of Indonesian Wood Research Society (IWORs), 7–8 November 2012, Makassar.
- Basri, E., Harris, G., Abdurachman and Ozarska, B. 2012. Drying schedule of four wood plantations species for furniture. Paper presented in The 4th Symposium of Indonesian Wood Research Society (IWORs), 7–8 November 2012, Makassar.
- Basri, E., Krisdianto and Ozarska, B. 2012. Development of simple and affordable drying chamber for small and medium enterprises furniture in Jepara. Paper presented in The 4th Symposium of Indonesian Wood Research Society (IWORs), 7–8 November 2012, Makassar.
- Jasni, Krisdianto and Ozarska, B. 2012. Durability test of treated mahogany wood against drywood termite. Paper presented in The 4th Symposium of Indonesian Wood Research Society (IWORs), 7–8 November 2012, Makassar.
- Damayanti, R., Pandit, I.K., Febrianto, F. and Pari, G. 2013. Anatomical properties of Jati Unggul Nusantara. Poster presented in The World Teak Conference, Bangkok, 24–27 March 2013.
- Abdurachman and Malik, J. 2013. Pemanfaatan glulam kayu trembesi untuk industri mebel. (*The use of glulam trembesi wood for furniture industries*). Paper presented in The National Seminar of Technology to Improve Value-Added of Forest Products, Bogor, 30 April 2013. (in Bahasa Indonesia).
- Basri, E., Supriadi, A. and Rahmat. 2013. Teknik dan analisis keuangan pengeringan kayu dengan tungku pemanas di IKM, Jepara. (*Technical and financial analysis of heating stove wood drying system for Small and Medium Enterprises in Jepara*). Paper presented in The National Seminar of Technology to Improve Value-Added of Forest Products, Bogor, 30 April 2013. (in Bahasa Indonesia).
- Fadillah, M., Hadi, Y.S. and Jasni. 2013. Resistance of preservative treated mahagony wood from Jepara furniture industries to subterranean termite attack. Paper presented in The 5th Symposium of Indonesian Wood Research Society (IWORs), 7–8 November 2013, Balikpapan.
- Massijaya, A. 2013. Financial analysis of the utilization of small diameter logs for furniture production. Paper presented in The 5th Symposium of Indonesian Wood Research Society (IWORs), 7–8 November 2013, Balikpapan.
- Solikhin, A., Hadi, Y.S. and Massijaya, M.Y. 2013. Wood drying characteristics of furniture industry in Jepara Regency, Central Java. Paper presented in The 5th Symposium of Indonesian Wood Research Society (IWORs), 7–8 November 2013, Balikpapan.

11.2.4 Conference posters

Posters

- Massijaya, M.Y., Nugroho, N., Ozarska, B. and Ando, N. 2011. Utilization of small diameter logs from community forest for furniture raw material. Fundamental properties of Glulam. Poster at The 3rd International Symposium of Indonesian Wood Research Society (IWoRS). 3–4 November 2011, Yogyakarta.

- Darmawan, W. and Massijaya, M.Y. 2011. Echo finishing application in some wood species. Poster at The 3rd International Symposium of Indonesian Wood Research Society (IWoRS), 3–4 November 2011, Yogyakarta.
- Fehrmann, J., Hopewell, G. and Malik, J. 2011. Using metal detectors in sawmills-a recommendation for Jepara. Poster at The 3rd International Symposium of Indonesian Wood Research Society (IWoRS), 3–4 November 2011, Yogyakarta.
- Jasni, Damayanti, R. and Norton, J. 2011. Portable and simple preservative treatment plant for small and medium furniture industries. Poster paper presented at the International Conference of Indonesia Forestry Researcher (INAFOR), 5–7 December 2011, Bogor.
- Damayanti, R, Pandit, I., Febrianto, F. and Pari G. 2013. Anatomical properties of Jati Unggul Nusantara. Poster presented at The World Teak Conference in Bangkok, 24–27 March 2013.

11.2.5 Research reports

- Ozarska, B., Yuniarti, K., Malik, J. and Hopewell, G. 2009. Summary on partner organizations capabilities *(Ringkasan kemampuan organisasi partner).*
- Hopewell, G., Subandi, A. and Malik, J. 2010. Initial Assessment Reports Part 1. Sawing *(Laporan penilaian awal Bagian 1. Penggergajian).*
- Ozarska, B., Hadikusumo, S., Listyanto, T., Karyanto, O., Darmawan, W. and Norton, J. 2010. Initial Assessment Reports Part 2. Treatment *(Laporan penilaian awal Bagian 2. Pengawetan kayu).*
- Harris, G., Listyanto, T., Yuniarti, K., Hadi, Y.S., Adhitjahyo, I., Hadikusumo, S. and Malik, J. 2010. Initial Assessment Reports Part 3. Wood Drying *(Laporan penilaian awal Bagian 3. Pengeringan kayu).*
- Ozarska, B., Massijaya, Y., Subandi, A., Prasetyo, V.E., Yuniarti, K., Marsoem, S.N., Putranto, P.N., Hopewell, G. and Norton, J. 2010. Initial Assessment Reports Part 4. Manufacturing *(Laporan penilaian awal Bagian 4. Pengolahan kayu).*
- Darmawan, W., Widyorini, R., Yuniarti, K., Putranto, P.N., Ozarska, B. and Hopewell, G. 2010. Initial Assessment Reports Part 5. Finishing (Laporan penilaian awal Bagian 5. Finishing).
- Ozarska, B., Malik, J., Listyanto, T., Hopewell, G., Massijaya, M.Y., Hermawan, D., Subandi, A., Rahayu, S., Hadikusumo, S. and Widyorini, R. 2010. General Assessment Reports *(Laporan umum penilaian awal).*
- Fehmann J. and Hopewell, G. 2011. The use of metal detectors for sawmill in Jepara *(Penggunaan pemindai logam untuk penggergajian di Jepara).*
- Torgovnikov, G. 2010. Microwave teak wood modification for preservative treatment *(Perlakuan kayu jati dengan gelombang mikro untuk pengawetan kayu).*
- Ozarska, B. 2010. SWOT Analysis of the Jepara Furniture Industry *(Analisa SWOT industry mebel di Jepara).*
- Malik, J., Hopewell, G., Hermawan, D. and Hadikusumo, S.A. 2010. Study on current sawn recovery of sawmilling in industry champions' facilities Jepara *(Penelitian tentang rendemen penggergajian pada beberapa industri champion di Jepara).*
- Ozarska, B., Subandi, A., Malik, J., Prasetyo, V.E., Massijaya, M.Y., Rahayu, S., Damayanti, R., Sulistyo, J. and Ashley, P. 2010. Report on implementation visits to industry champions: Lima Saudara *(Laporan kunjungan: Lima Saudara).*

- Ozarska, B., Subandi, A., Malik, J., Prasetyo, V.E., Massijaya, M.Y., Rahayu, S., Damayanti, R., Sulistyo, J. and Ashley, P. 2010. Report on implementation visits to industry champions: Els Artsindo *(Laporan kunjungan: Els Artsindo).*
- Ozarska, B., Subandi, A., Malik, J., Prasetyo, V.E., Massijaya, M.Y., Rahayu, S., Damayanti, R., Sulistyo, J. and Ashley, P. 2010. Report on implementation visits to industry champions: Solikhin Furniture *(Laporan kunjungan: Solikhin Furniture).*
- Ozarska, B., Subandi, A., Malik, J., Prasetyo, V.E., Massijaya, M.Y., Rahayu, S., Damayanti, R., Sulistyo, J. and Ashley, P. 2010. Report on implementation visits to industry champions: Ketjik Mirror and Art *(Laporan kunjungan: Ketjik Mirror and Art*).
- Ozarska, B., Subandi, A., Malik, J., Prasetyo, V.E., Massijaya, M.Y., Rahayu, S., Damayanti, R., Sulistyo, J. and Ashley, P. 2010. Report on implementation visits to industry champions: Hartoyo Furniture *(Laporan kunjungan: Hartoyo Furniture*).
- Ozarska, B., Subandi, A., Malik, J., Prasetyo, V.E., Massijaya, M.Y., Rahayu, S., Damayanti, R., Sulistyo, J. and Ashley, P. 2010. Report on implementation visits to industry champions: Sugianto Furniture *(Laporan kunjungan: Sugianto Furniture).*
- Ozarska, B., Subandi, A., Malik, J., Prasetyo, V.E., Massijaya, M.Y., Rahayu, S., Damayanti, R., Sulistyo, J. and Ashley, P. 2010. Report on implementation visits to industry champions: Cipta Mandiri *(Laporan kunjungan: Cipta Mandiri).*
- Ozarska, B., Subandi, A., Malik, J., Prasetyo, V.E., Massijaya, M.Y., Rahayu, S., Damayanti, R., Sulistyo, J. and Ashley, P. 2010. Report on implementation visits to industry champions: Mandiri Mebel *(Laporan kunjungan: Mandiri Mebel)*.
- Ozarska, B., Subandi, A., Malik, J., Prasetyo, V.E., Massijaya, M.Y., Rahayu, S., Damayanti, R., Sulistyo, J. and Ashley, P. 2010. Report on implementation visits to industry champions: Sugiman *(Laporan kunjungan: Sugiman)*.
- Ozarska, B., Subandi, A., Malik, J., Prasetyo, V.E., Massijaya, M.Y., Rahayu, S., Damayanti, R., Sulistyo, J. and Ashley, P. 2010. Report on implementation visits to industry champions: Elok Sejati *(Laporan kunjungan: Elok Sejati)*.
- Ozarska, B., Subandi, A., Malik, J., Prasetyo, V.E., Massijaya, M.Y., Rahayu, S., Damayanti, R., Sulistyo, J. and Ashley, P. 2010. Report on implementation visits to industry champions: Raisa *(Laporan kunjungan: Raisa)*.
- Jasni and Damayanti, R. 2010. Report on portable/demonstration/pilot treatment plant for preservative treatment *(Laporan kajian perlengkapan pengawetan kayu portabel).*
- Damayanti, R. and Jasni. 2010. Report on wood structure assessment *(Laporan kajian struktur anatomi beberapa kayu).*
- Ozarska, B. 2010. International standards, methods and specifications related to furniture production methods, quality control and requirements for furniture applicable to SMEs *(Kajian standard international produksi mebel: metode, spesifikasi dan persyaratan untuk UKM).*
- Hopewell, G. 2010. Application of lean manufacturing principles in Jepara sawmills through the industry champions *(Aplikasi prinsip pengolahan kayu yang efektif melalui industry champion).*
- Kaiser, P., Norton, J., Hopewell, G. and Baillieres, H. 2010. The impact of heat treatment on the colour and durability of teak sapwood *(Pengaruh perlakuan pemanasan terhadap perubahan warna gubal kayu jati).*

- Basri, E., Harris, G., Abdurachman and Ozarska, B. 2011. Drying of four wood species from West Java Community Based Forest *(Pengeringan empat jenis kayu dari hutan rakyat di Jawa Barat).*
- Malik, J. and Damayanti, R. 2011. Review of Indonesian standards for furniture *(Kajian standard produk mebel di Indonesia).*
- Hopewell, G. 2011. Using chainsaws in sawmills—recommendations for Jepara *(Penggunaan gergaji rantai di penggergajian—rekomendasi untuk Jepara).*
- Fehmann, J. and Hopewell, G. 2011. Using metal detectors in sawmills—recommendation for Jepara *(Penggunaan pemindai logam di penggergajian—rekomendasi untuk Jepara).*
- Hopewell, G. 2011. Lean processing Part 1—an introduction for Jepara *(Pengolahan yang efektif Bagian 1—pengenalan di Jepara).*
- Malik, J. 2011. Analysis of the current recovery rate in the furniture production of selected industry champions companies *(Analisa rendemen pembuatan mebel di beberapa industry champion).*
- Basri, E. 2011. Drying schedules of six wood species from West Java *(Jadwal pengeringan enam jenis kayu dari Jawa Barat).*
- Harris, G. 2012. The use of solar kilns in Indonesia *(Penggunaan pengeringan tenaga matahari di Indonesia).*
- Hadikusumo, S.A. and Purnomo, H. 2012. Improving drying schedule and local oven design *(Peningkatan jadwal pengeringan dan desain oven lokal di Jepara).*
- Ashley, P. 2012. Report on visits to furniture companies in Jepara, October 2012 *(Laporan kunjungan ke industri mebel di Jepara, Oktober 2012).*
- Basri, E. and Krisdianto. 2012. Affordable drying chamber for small enterprises furniture in Jepara *(Dapur pengeringan yang terjangkau oleh masyarakat Jepara).*
- Darmawan, W. 2012. Characteristics of ammonia fumigation-results and durabililty of waterbased finishing lacquer coated wood species from community forest *(Karakteristik fumigasi ammonia dan ketahanan kayu yang difinishing dengan bahan pelarut air).*
- Hernawati, Hadi, Y.S. and Jasni. 2012. The subterranean termite resistance test of boron treated of three wood species from community based forest *(Ketahanan tiga jenis kayu dari hutan rakyat yang diawetkan dengan pengawet boron).*
- Verinita, L., Hadi, Y.S. and Jasni. 2012. The subterranean termite resistance test of boron treated of two wood species from community based forest *(Ketahanan dua jenis kayu dari hutan rakyat yang diawetkan dengan pengawet boron).*
- Purnomo, H. and Abdurachman. 2012. Report on wood bending course in Australia *(Laporan training pelengkungan kayu di Australia).*
- Purnomo, H. 2012. Making simple wood bending tools with low pressure steam method *(Pembuatan peralatan pelengkungan kayu sederhana dengan uap bertekanan rendah).*
- Ozarska, B. 2013. Final report for Crawford Fund on training course 'furniture design and the application of the design into finished products' *(Laporan akhir Crawford fund pada pelatihan desain mebel dan aplikasi desain menjadi produk jadi).*
- Rohadi, D., Herawati, T. and Lastini, T. 2013. Impact assessment report *(Laporan pengaruh kegiatan proyek).*

- Abdurachman and Krisdianto. 2014. Gluing properties of six wood species for furniture *(Sifat perekatan enam jenis kayu untuk mebel).*
- Listyanto, T. 2014. Impact assessment report for ACIAR project FST 117/2006. 15 pages.

12 Appendix 1: Criteria for Selection of Industry Champions

The criteria were developed by the project partner organisations at the Project Workshop and Technical Meeting held in Bogor on 28 July 2009. The criteria were as follows:

- The network of Industry Champions should consist of companies representing various types of micro-cluster models that characterise the furniture industry in Jepara: (a) small; (b) medium; and (c) large companies.
- The companies should be involved in at least one of the aspects of wood processing and manufacturing: sawmilling, preservative treating, drying, manufacturing and finishing.
- The companies should use sustainable timber resources.
- The companies should have the capability to expand.
- The companies should have a local owner (not owned by an overseas investor).
- The companies should be enthusiastic.
- The companies should be willing to collaborate and share experiences with other companies.
- The companies should be willing to change and improve current practices.
- The companies should be willing to participate in training programs and train their workers.
- The companies should be committed to being involved for the duration of the project period.

13 Appendix 2: Production aspects assessed by the project team for each Industry Champion

Table 4. Production aspects assessed for each Industry Champion.

No.	Name of the Industry Champions	Type of production aspect assessed				
		Sawing	Drying	Treatment	Manufacturing	Finishing
1	Raisa	N	X	X	X	X
2	Els Artsindo	N	C	X	X	X
3	Kecik Mirror Arts	N	N	N	X	C
4	Sugiyanto	X	X	N	X	N
5	Solikhin	C	N	N	X	C
6	Sugiman	N	X	N	X	N
7	Lima Saudara	N	X	N	X	N
8	Hartoyo	N	X	N	X	N
9	Prasetya Indra Brata	X	X	N	N	N
10	Bhakti Usaha	X	N	N	N	N
11	Karya Jati	X	N	N	N	N
12	Proliman	N	X	N	N	N
13	Elok Sejati	N	N	N	X	N
14	Erick Finishing	N	N	N	N	X
15	Cipta Mandiri	N	X	N	X	N
16	Mandiri Mebel	N	X	N	X	N

Legend:

X **Assessment was made**

N **Assessment was not made as the production aspect was not available**

C **Process is carried out by the company but assessment was not allowed or was not made available**

14 Appendix 3: Training courses provided to the industry

1. **Sawmilling No. 1, 19 April 2011 *(Penggergajian kayu)***

   Location: Maribu, Jepara
   Participants: 16
   Topics: Understanding sawmilling theory
   List of materials:

   - Standard on sawing efficiency (*Standar efisiensi penggergajian*)
   - Wood properties related to sawn quality (*Beberapa sifat kayu yang mempengaruhi kualitas kayu gerggajian*)
   - Work safety (*Keselamatan kerja*)
   - Metal detector (*Pendeteksi logam*)
   - Target size of sawn timber (*Ukuran kayu gergajian yang dituju*).

2. **Wood drying No. 1, 22–23 May 2011 *(Pengeringan kayu)***

   Location: Maribu, Jepara
   Participants: 23
   Topics: Understanding wood drying theory
   List of materials:

   - Wood water relationship (*Hubungan kayu dan air*)
   - Lumber stacking (*Penumpukan kayu*)
   - High speed kiln design (*Desain dapur pengering*)
   - Lumber kiln drying (*Dapur pengering*)
   - Solar drying system (*Sistem pengeringan kayu tenaga surya*)
   - Drying schedules (*Jadwal pengeringan*)
   - Drying defects (*Cacat pengeringan kayu*)
   - Storage and shipping (*Penumpukan dan pengangkutan dengan kapal*)
   - Demonstration of wood drying/stacking/temperature settings *(Praktek pengeringan, penumpukan dan penyetelan suhu*).

3. **Wood manufacturing No. 1, 24–25 July 2011 (*Pengolahan kayu*)**

   Location: PIKA, Semarang
   Participants: 21
   Topics: Safe and appropriate manufacturing for wooden furniture
   List of materials:

   - Working space design (*Desain tempat kerja*)
   - Furniture making lay out (*Lay out tempat kerja pembuatan mebel kayu*)
   - Fatigue (*Kelelahan*)
   - Working environment (*Lingkungan kerja*)
   - Working tool (*Perkakas kerja*)
   - Basic static machines 1 (*Dasar mesin tetap 1*)
   - Planing machine (*Mesin serut*)
   - Sanding and finishing machines (*Mesin ampelas dan finishing*)
   - Joining type machines (*Mesin penyambung*)
   - Moulding and shaping machines (*Mesin moulder dan pembentuk*).

4. **Wood finishing No. 1, 8–9 October 2011 *(Finishing kayu)***

   Location: PIKA, Semarang
   Participants: 25

Topics: Wood finishing—an introduction
List of materials:

- Wood finishing (*Finishing*)
- Wood finishing control quality (*Pengendalian kualitas finishing*)
- Wood finishing: definition, purpose, material and process (*Finishing kayu: definisi, tujuan, bahan dan proses*).

5. Preservative treatment, 28–29 March 2012 *(Pengawetan kayu)*

Location: Maribu, Jepara
Participants: 40
Topics: Simple and cheap wood preservation
List of materials:

- Wood—Its origin and properties *(Kayu—asal dan sifat-sifatnya*)
- Causes of timber degrade (*Penyebab kerusakan kayu*)
- Treatment chemicals (*Bahan kimia pengawet*)
- Preparing timber for treatment (*Persiapan kayu untuk diawetkan*)
- Timber treatment processes (*Proses pengawetan kayu*)
- Treatment levels (*Tingkat pengawetan kayu*)
- Control over treatmen records (*Pengendalian catatan pengawetan*)
- After treatment (*Perlakuan setelah pengawetan*)
- Safety and the environment (*Keselamatan dan aspek lingkungan*).

6. Wood finishing No. 2, 26–27 May 2012 *(Finishing kayu)*

Location: PIKA, Semarang
Participants: 28
Topics: Water-based finishing
List of materials:

- Volatile organic compounds (*Bahan organik yang mudah menguap*)
- Introduction of PROPAN finishing products (*Pengenalan bahan finishing PROPAN*)
- Melamine finishing system (*Bahan finishing melamine*)
- Polyurethane system (*Bahan finishing polyurethane*)
- Testing and application of water-based finishing product (*Pengujian bahan finishing berbahan dasar air*)
- Ultran Lasur
- Water base system (*Bahan finishing berbahan dasar air*)
- Aqua Politur (*Politur berbahan dasar air*).

7. Wood drying No. 2, 29 September 2012 *(Pengeringan kayu)*

Location: Maribu, Jepara
Participants: 35
Topics: How to solve wood drying problems
List of materials:

- Wood drying (*Pengeringan kayu*)
- Wood water relationship *(Hubungan air dan kayu)*
- Stacking (*Penumpukan kayu*)
- Water and wood (*Air dan kayu*)
- Wood drying vs wood preservation (*Pengeringan kayu vs pengawetan kayu*).

8. Jigs for wood machinery, 30 June to 1 July 2012 *(Pembuatan jig untuk pengolahan kayu)*

Location: PIKA, Semarang
Participants: 25
Topics: Jig for circular saw and spindle moulder
List of materials:

- Basic concept of jig (*Prinsip dasar jig*)
- Circular saw (*Mesin gergaji circle*)
- Splindle moulder saw (*Mesin spindle moulder*)
- Quality standar of splindle moulder (*Standar kualitas mesin frais*).

9. Wood construction and fitting, 2–3 March 2013 *(Konstruksi kayu dan fitting mebel kayu)*

Location: PIKA, Semarang
Participants: 25
Topics: Wood construction and fitting for wooden furniture
List of materials:

- Furniture fittings and hardware (*Fitting dan peralatan untuk membuat mebel kayu*)
- Installation of drawer, types of hinges (*Pemasangan laci, tipe hinges*)
- Wood construction (*Konstruksi mebel kayu*)
- Construction for solid wood furniture (*Konstruksi kayu solid*)
- Construction for panel furniture (*Konstruksi papan panel*).

10. Cost of production and furniture pricing, 23 March 2013 *(Perhitungan dan penentuan harga produk mebel kayu)*

Location: Maribu, Jepara
Participants: 34
Topics: Cost production and furniture pricing theory
List of materials:

- Interest and business feasibility (*Bunga dan kelayakan usaha*)
- Concept of various costs (*Konsep variasi biaya*)
- Calculating the price of products (*Perhitungan harga barang*).

11. Wood finishing No. 3, 15–16 June 2013 *(Finishing kayu)*

Location: PIKA, Semarang
Participants: 25
Topics: Factors affecting wood finishing quality
List of materials:

- The importance of sanding (*Pentingnya pengampelasan*)
- Sayerlack finishing (*Produk finishing sayerlack*).

12. Wood bending No. 1, 31 August to 1 September 2013 *(Pelengkungan kayu I)*

Location: PIKA, Semarang
Participants: 25
Topics: How to bend wood
List of materials:

- Wood bending: an introduction (*Pengenalan pelengkungan kayu*)
- Wood bending for high-quality products (*Pelengkungan kayu untuk produk berkualitas*).

13. Wood drying No. 3, 7 September 2013 *(Pengeringan kayu 3)*

Location: Maribu, Jepara

Participants: 22
Topics: How to set proper wood drying process
List of materials:

- Basic timber drying principles (*Prinsip pengeringan kayu*)
- Wood water relationship: water in wood (*Hubungan kayu dan air: air dalam kayu*)
- Simple drying kiln and control systems (*Pengeringan sederhana dan sistem kendalinya*).

14. Wood packaging, 28 September 2013 *(Pengepakan/pengemasan)*

Location: PIKA, Semarang
Participants: 17
Topics: The science behind the wood product's packaging
List of materials:

- Choosing the right material for packaging (*Pemilihan bahan pengemas/pengepak*)
- Packaging methods (*Cara mengemas/mengepak*)
- Packaging safety (*Keselamatan pengemasan*)
- Insurance (*Asuransi*)
- Packaging standard (*Standar pengemasan/pengepakan*).

15. Wooden furniture design, 22–23 February 2014 *(Desain mebel kayu)*

Location: PIKA, Semarang
Participants: 18
Topics: Technical knowledge on furniture design
List of materials:

- Introduction to wooden furniture design (*Pengantar desain mebel kayu*)
- Knowledge on the material (*Pengetahuan tentang bahan*)
- Construction in the design (*Konstruksi dalam desain*)
- Basic knowledge on design (*Pengetahuan dasar desain*)
- Inside the design (*Unsur dalam desain*).

16. Sawmilling No. 2, 3 March 2014 *(Penggergajian)*

Location: Maribu, Jepara
Participants: 31
Topics: The right tool for the right work
List of materials:

- Basic sawmilling theory (*Dasar pengetahuan tentang penggergajian kayu*)
- The right tool for the right work (*Pemilihan peralatan yang tepat untuk pekerjaan yang sesuai*)
- Increasing the sawmilling yield (*Peningkatan rendemen kayu*)
- Health and safety (*Keselamatan dan kesehatan kerja*).

17. Wood bending No. 2, 5–6 April 2014 *(Pelengkungan kayu 2)*

Location: PIKA, Semarang
Participants: 22
Topics: How to apply steam bending
List of materials:

- Bending theory (*Teori pelengkungan kayu*)
- Steam bending (*Pelengkungan dengan pengukusan*)

- Bending technique (*Teknik melengkungkan kayu*).

18. Gluing and jointing, 17–18 May 2014 *(Perekatan dan penyambungan kayu)*

Location: PIKA, Semarang
Participants: 21
Topics: Choosing the right adhesive
List of materials:

- The importance of gluing (*Perlunya perekatan*)
- Types of adhesives (*Beberapa tipe perekat*)
- Types of jointing (*Beberapa cara penyambungan*)
- Proper gluing methods (*Cara perekatan yang benar*)
- Gluing application (*Perekatan*)
- Glue strength testing methods based on JAS standard (*Pengujian sifat perekatan berdasar Standar Jepang*).

19. Wood waste management and occupational health and safety trainings, 30–31 August 2014 *(Pengelolaan limbah dan keselamatan kerja)*

Location: PIKA, Semarang
Participants: 31
Topics: Organise wood waste and work safely
List of materials:

- Wood waste management (*Pengelolaan limbah kayu*)
- Work safety (*Keselamatan kerja*)
- Exploring wood waste (*Eksploitasi limbah kayu*).

20. Pricing products and marketing, 14–15 September 2014 *(Penentuan harga produk dan pemasarannya)*

Location: PIKA, Semarang
Participants: 25
Topics: How much does it cost and how to sell it
List of materials:

- Bank interest (*Suku bunga bank*)
- Business feasibility (*Kelayakan usaha*)
- Calculating depreciation (*Perhitungan depresiasi*)
- Concept and type of costs (*Konsep dan tipe biaya*)
- Cost calculation (*Perhitungan biaya*)
- Case study: calculating the selling price of the product (*Studi kasus: perhitungan harga barang*)
- The important role of marketing for SMEs (*Perlunya pemasaran bagi IKM*)
- Understanding basic concepts of marketing (*Pengertian konsep dasar pemasaran*)
- The development of customer value (*Pengembangan nilai customer*)
- Strategic planning (*Rencana strategis*)
- Segmentation targeting and positioning (*Pembagian segmen, target dan posisi*)
- Marketing mix (*Pemasaran campuran*)
- Brand management in SMEs (*Manajemen merk di IKM*)
- Online marketing for SMEs (*Pemasaran melalui media online bagi IKM*).

14.1 List of powerpoint presentations presented by the project team members at various events

Power point presentations:

1. Hopewell, G. 2010. Assessment of the current capabilities of the Industry Champions. Sawing process. Presentation to Jepara furniture community and ACIAR research partners at the Annual Workshop, 6 August 2010.
2. Kaiser, P. 2010. Impregnation and colouration—teak sapwood. Presentation to Jepara furniture community and ACIAR research partners.
3. Norton, J. 2010. Treatment assessment and research activities. Presentation to Jepara furniture community and ACIAR research partners at the Annual Workshop, 6 August 2010.
4. Harris, G. 2010. Assessment of the current capabilities of the Industry Champions. Drying process. Presentation to Jepara furniture community and ACIAR research partners at the Annual Workshop, 6 August 2010.
5. Ozarska, B. 2010. Assessment of the current capabilities of the Industry Champions. Manufacturing process. Presentation to Jepara furniture community and ACIAR research partners at the Annual Workshop, 6 August 2010.
6. Darmawan, W. 2010. Assessment of the current capabilities of the Industry Champions. Finishing process. Presentation to Jepara furniture community and ACIAR research partners at the Annual Workshop, 6 August 2010.
7. Ozarska, B. 2010. Project progress review. Presentation at the Project Steering Committee Meeting. 9 August 2010.
8. Hopewell, G. 2011. Sawmill metal detecting (in English and Bahasa Indonesia). Training material. Presentation to Jepara furniture community, April 2011.
9. Malik, J. 2011. Standard on sawing efficiency (in English and Bahasa). Training material. Presentation to Jepara furniture community, 19 April 2011.
10. Marsoem. S.N. 2011. Understanding wood properties as an initial tools in improving sawing result. Training material. Presentation to Jepara furniture community, 19 April 2011.
11. Subandi, A. 2011. Safety in sawmilling (in Bahasa Indonesia). Training material. Presentation to Jepara furniture community, 19 April 2011.
12. Hermawan, D. 2011. Sawing pattern, standard size. Training material. Presentation to Jepara furniture community, 19 April 2011.
13. Subandi, A. 2011. ‘5R’ Manufacturing. Training material.
14. Subandi, A. 2011. Warehouse Layout. Training material.
15. Jasni, Damayanti, R. 2011. Implementing preservatives treatment of young plantation timbers to increase products price and life services (Activity 1.3), presented in Coordination meeting of the Treatment Team held at Forda, 18–19 April 2011 to discuss the research plan of wood preservation and training material for preservation training.
16. Basri, E. 2011. Solar drying system, drying schedules, defects and storage (in English and Bahasa). Training material: drying. Presentation at the drying training course in Semarang, 22 May 2011.
17. Hadi, Y.S. 2011. Wood—water relationship and lumber stacking (in Bahasa). Training material: drying. Presentation at the drying training course in Semarang, 22 May 2011.

18. Hadikusumo, S.A. 2011. High speed kiln design and lumber kiln drying (in Bahasa). Training material: drying. Presentation at the drying training course in Semarang, 22 May 2011.
19. Massijaya, M.Y. and Hermawan, D. 2011. Timber Legality Assurance System (TLAS) Training material: manufacturing. Presentation at the manufacturing training course in Semarang, 24–25 July 2011.
20. Sulistyo J. and Prasetyo, V.E. 2011. Workplace design. Training material: manufacturing. Presentation at the manufacturing training course in Semarang, 24–25 July 2011.
21. Subandi, A. 2011 Standard machines and machining. Training material: manufacturing. Presentation at the manufacturing training course in Semarang, 24–25 July 2011.
22. Subandi, A. 2011. Safety tools. Training material: manufacturing. Presentation at the manufacturing training course in Semarang, 24–25 July 2011.
23. Subandi, A. 2011. Production layouts. Training material: manufacturing. Presentation at the manufacturing training course in Semarang, 24–25 July 2011.
24. Prasetyo, V.E. and Sulistyo, J. 2011. Factory environment and labour fatigue issues. Training material: manufacturing. Presentation at the manufacturing training course in Semarang, 24–25 July 2011.
25. Darmawan, W. and Massijaya, M.Y. 2011. Wood finishes and equipment. Training material: finishing. Presentation at the finishing training course in Semarang, 8–9 October 2011.
26. Widyorini, R. and Prayitno, T. 2011. Quality control In finishing. Training material: finishing. Presentation at the finishing training course in Semarang, 8–9 October 2011.
27. Putranto, P.N. 2011. Application technique of oil and water based wood finishes. Training material: finishing. Presentation at the finishing training course in Semarang, 8–9 October 2011.
28. Ozarska, B. 2011. Manufacturing Team—summary progress report. Presentation at the 2nd Annual Workshop, Jepara, 29 October 2011.
29. Damayanti, R. 2011. Database on alternative wood species for furniture and creative industries. Presentation at the 2nd Annual Workshop, Jepara, 29 October 2011.
30. Malik, J. 2011. Indonesian standards for furniture. Presentation at the 2nd Annual Workshop, Jepara, 29 October 2011.
31. Ozarska, B. 2011. Project activities for next 12 months. Presentation at the 2nd Annual Workshop, Jepara, 29 October 2011.
32. Basri, E. 2011. Summary of wood drying problems in industries, training, and research in wood drying of four species (in English and Bahasa). Presentation to Jepara furniture community and ACIAR research partners at 2nd Annual Workshop, 29 October 2011.
33. Jasni. 2011. Improving added value and SME capacity in the utilisation of plantation timber for furniture production in Jepara region of Java, Indonesia: Wood Preservation. Presentation at the 2nd Annual Workshop, Jepara, 29 October 2011.
34. Jamhari. 2011. Industry perspectives and comments. Presentation at the 2nd Annual Workshop, Jepara, 29 October 2011.

35. Darmawan, W. and Massijaya, M.Y. 2011. Progress report on technical activities and research on finishing. Presentation at the 2nd Annual Workshop, Jepara, 29 October 2011.
36. Damayanti, R. 2012. Wood—its origin and properties (in Bahasa). Training material: preservative treatment. Presentation at the preservative treatment training course in Jepara, 28–29 March 2012.
37. Jasni. 2012. Causes of timber degrade (in Bahasa). Training material: preservative treatment. Presentation at the preservative treatment training course in Jepara, 28–29 March 2012.
38. Barly. 2012. Treatment chemicals (in Bahasa). Training material: preservative treatment. Presentation at the preservative treatment training course in Jepara, 28–29 March 2012.
39. Hadi, Y.S. 2012. Preparing timber for treatment (in Bahasa). Training material: preservative treatment. Presentation at the preservative treatment training course in Jepara, 28–29 March 2012.
40. Barly. 2012. Timber treatment processes (in Bahasa). Training material: preservative treatment. Presentation at the preservative treatment training course in Jepara, 28–29 March 2012.
41. Hadikusumo, S. 2012. Treatment levels (in Bahasa). Training material: preservative treatment. Presentation at the preservative treatment training course in Jepara, 28–29 March 2012.
42. Barly. 2012. Control over treatment—records (in Bahasa). Training material: preservative treatment. Presentation at the preservative treatment training course in Jepara, 28–29 March 2012.
43. Jasni. 2012. After preservative treatment (in Bahasa). Training material: preservative treatment. Presentation at the preservative treatment training course in Jepara, 28–29 March 2012.
44. Hadi, Y.S. 2012. Safety and the environment (in Bahasa). Training material: preservative treatment. Presentation at the preservative treatment training course in Jepara, 28–29 March 2012.
45. Darmawan, W. 2012. The Importance of volatile organic compound in wood finishing at the training on finishing 26–27 May 2012 at PIKA Semarang.
46. Ozarska, B. 2012. Development of downstream value-adding in timber industries in South-East Asia and Pacific region. The University of Melbourne Seminar, Burnley Campus, 10 June 2012.
47. Subandi, A. 2012. Jig for wood machinery (spindle moulder, table saw, band saw). Presented at manufacturing training in PIKA Semarang on 30 June – 1 July, 2012.
48. Widyorini, R. and Prayitno, T.A. 2012. Application of water based finishing and quality testing of finishing (In English and Bahasa). Training material: finishing. Presentation at the finishing training course in Semarang, 26–27 August 2012.
49. Basri, E. 2012. Pengeringan kayu. Presentation at the drying training course in Jepara, 29–30 September 2012.
50. Hadikusumo, S.A. 2012. Current drying technology and how to improve it (In English and Indonesian). Training material: drying. Presentation at the drying training course in Jepara, 29–30 September 2012.
51. Basri, E. 2012. Continuing of wood drying training (in Bahasa). Annual Workshop, Jepara, 8 December 2012.

52. Basri, E. 2012. Wood drying activities in 2012. Project Progress Review (in English and Bahasa). Annual Workshop, Jepara, 8 December 2012.
53. Darmawan W. 2012. Technical activities and research on finishing. Annual Workshop, Jepara, 8 December 2012.
54. Hadikusumo, S.A. 2012. Improving drying schedule and local oven design. Project Progress Review (in English and Bahasa). Annual Workshop, Jepara, 8 December 2012.
55. Hermawan, D. and Abdurachman. 2012. Sawing activity—wood machining characteristics. Annual Workshop, Jepara, 8 December 2012.
56. Hopewell, G. 2012. Sawing team activities 2012. Annual Workshop, Jepara, 8 December 2012.
57. Jasni. 2012. Identification of powder post beetles that attack wooden furniture and their prevention in Jepara. Annual Workshop, Jepara, 8 December 2012.
58. Ozarska, B., Subandi, A., Abdurachman, Mussijaya, Y., Hermawan, D. and Purnomo H. 2012. Manufacturing Team activities in 2012. Annual Workshop, Jepara, 8 December 2012.
59. Subandi, A. 2012. Training for SMEs in Jepara. Past, current and future programs. Annual Workshop, Jepara, 8 December 2012.
60. Ozarska, B. 2012. Project progress review. ACIAR Steering Committee Meeting No 3. Semarang, 9 December 2012.
61. Sugianto, A. 2013. Wood construction. Presented at wood construction training in PIKA Semarang, 2–3 March 2013.
62. Adhitjahjo, I. 2013. Cost of production. Presented at cost of production training in Maribu Jepara on 23 March 2013.
63. Krisdianto. 2013. Changing the shape, improving the value. ACIAR 2006/117 Project in Jepara. Presentation for Jepara's Member of Parliament in Bogor.
64. Hermawan, D., Hopewell, G. and Marsoem, S.N. 2013. Summary of sawmilling project activities in Jepara. ACIAR Project FST 2006/117 Annual meeting, Jepara, 7 December 2013.
65. Jasni, Yusuf S.H. and Krisdianto. 2013. Wood preservation activities in 2013. ACIAR Project FST 2006/117 Annual meeting, Jepara, 7 December 2013.
66. Basri, E. and Hadikusumo S. 2013. Wood drying: current activities for ACIAR Project FST 2006/117. ACIAR Project FST 2006/117 Annual meeting, Jepara, 7 December 2013.
67. Ozarska, B., Massijaya, M.Y. and Subandi, A. 2013. Summary of ACIAR project manufacturing activities. ACIAR Project FST 2006/117 Annual meeting, Jepara, 7 December 2013.
68. Ozarska, B. 2013. Summary of project activities in 2013. ACIAR Project FST 2006/117 Annual meeting, Jepara, 7 December 2013.
69. Purnomo, H., Abdurachman and Dewi L.M. 2013. Wood bending activities in 2013. ACIAR Project FST 2006/117 Annual meeting, Jepara, 7 December 2013.
70. Subandi, A. 2013. ACIAR Furniture Design Competition (AFDC) report. ACIAR Project FST 2006/117 Annual meeting, Jepara, 7 December 2013.
71. Subandi, A. 2013. 2013 Trainings summary and evaluation. ACIAR Project FST 2006/117 Annual meeting, Jepara, 7 December 2013.

72. Krisdianto, Rohadi, D. and Herawati T. 2013. The project impact assessment report. ACIAR Project FST 2006/117 Annual meeting, Jepara, 7 December 2013.
73. Krisdianto. 2013. Changing the shape, improving the value. ACIAR 2006/117 Project in Jepara. Presentation to ACIAR delegation visit at CIFOR headquarters, 19 June 2013.
74. Krisdianto. 2013. Changing the shape, improving the value. ACIAR 2006/117 Project in Jepara. FORDA's research collaboration evaluation. December 2013.
75. Basri, E. 2014. Summary of activities and achievements of wood drying. Final meeting, 1 November 2014.
76. Darmawan, W., Widyorini, R., Subandi, A. and Ozarska, B. 2014. Summary of activities and achievements of wood finishing. Final meeting, 1 November 2014.
77. Ozarska, B. 2014. Project final review. Final meeting, 1 November 2014.
78. Hopewell, G., Hermawan, D., Subandi, A., Hadikusumo, S.A., Marsoem, S.N., Malik, J. and Sugiyanto, K. 2014. Summary of activities and achievements of sawmilling. Final meeting, 1 November 2014.
79. Listyanto, T. 2014. Impact assessment of ACIAR FST 2006/117.
80. Ozarska, B. 2014. Summary of activities and achievements of manufacturing. Final meeting, 1 November 2014.
81. Subandi, A. 2014. Aciar furniture design competition. Final meeting, 1 November 2014.
82. Subandi, A. 2014. Aciar training activity. Final meeting, 1 November 2014.
83. Jasni, Norton, J., Hadikusumo, S.A., Hadi, Y.S., Krisdianto, Damayanti, R., Listyanto, T. and Sulistyo, J. 2014. Summary of activities and achievements of wood treatment. Final meeting, 1 November 2014.