Market Preference of Wood Characteristics and Properties of Plantation Grown Teak (*Tectona grandis* Linn.F) in Laos

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Abstract: In this study, we assessed the relationship between the price of teak timber and wood characteristics and properties. We interviewed one hundred teak buyers from wood sawmilling and manufacturing companies in Vientiane Capital, in Luang Prabang Province, Northern Laos. Our statistical analysis for manufacturing companies, revealed that 1) the price of timber from teak plantation is statistically correlated with wood characteristics and property such as heartwood, log diameter, log length, wood colour, and wood defect, 2) for non-wood defect, wood properties are not considered important by buyers since they do not consider wood properties when deciding on what timber to purchase, and, 3) buyers reject decay and pipe in timber. On the other hand, the analysis for wood sawmilling companies further revealed that 1) large heartwood proportion, large diameter size and long logs are most preferred by buyers, 2) decay, pipe, insect hole, bend, and knot hole are classified as worse wood defects and negatively impact the decision to purchase timber, 3) wood properties are not considered important for the buyers, and 4) there is significant relationship between price and wood features such as long dimensions (log length and diameter) and heartwood proportion. Our study suggests that while meeting timber market demands, wood processors and manufacturers need to have a clear understanding of the value of timber using tools such as communication on the specific qualities and quantities in order to seek the market efficiency for teak timber.

Keywords: Laos, wood characteristics, wood property, teak plantation, teak timber, prices, wood demand

1. Introduction

Laos has observed a rapid expansion in teak plantation over the past couple of decades. Much of this increase took place in the northern part of Laos. Most of the teak plantations are driven by smallholder investments. Teak production are mostly supplied to the domestic markets or exported to regional markets (Midgley et al. 2015). There is a high demand for domestic wood in Laos, with approximately 300,000 m$^3$ required per year. This figure is expected to increase to 600,000 m$^3$ per year by 2020 (MAF 2005). Midgley et al. (2017) states that the total volume of teak timber exported from Laos to neighboring countries (China, Vietnam and Thailand) is approximately 12,959 m$^3$ with an average price $467/m^3$. Based on this data, the value of teak wood export from Laos can be estimated to be about $6 million which accounts for approximately 1.5-2.5% compared to the total of all wood species exported from the country.

Teak timber is an important resource to the Lao wood processing and manufacturing industries. The plantations range in ages between 10-30 years and have variable wood characteristics and values (Boer and Seneanachak 2016; Midgley et al. 2007). About 95 % of unprocessed teak timber was exported as logs or square logs to neighboring countries (Midgley et al. 2017). More recently, Lao Government strongly supported wood industries in processing finished products by formulating a Prime Minister order No.15/2016 (PMO15) to ban export of raw wood material from both natural and plantation forests (PMO 2016). The effects of the PMO15 have been mixed with increasing investment and employment in wood processing sector in Laos, but financial returns to teak growers are relatively smaller compared to other economic agents in the teak value chains (Maraseni et al. 2018; Smith et al. 2018b). In addition, global markets preferences and prices of teak timbers also vary broadly based on several factors such as plantation sites, timber dimensions and wood qualities (grades) (Jayawardhane et al. 2015).

To date, there are no studies examining buyers’ preference of wood characteristics and properties of teak plantation in Laos. We lack international timber grading standards or consistent rules which may translate timber characteristics into market price. This is primarily due to unavailability of information on market requirement and preference for wood characteristics and properties. There appears the need to develop a clear system of timber grading standards and prices between growers.
and buyers. In an economic system, goods and services in a market are assumed to be homogeneous. In other words, there is no difference between them (Davidson and Malano 2005). If the goods and services are separated according to quality attributes that each possesses, then we no longer have a homogenous product (teak), but rather different grades of teak, each demanded by buyers in different industries. Thus, growers sell different qualities to processors who demand quality.

The trading system between teak growers and buyers is complicated and at times confusing. Previous studies of wood characteristics and properties often ignore the influence of markets or accounted for buyers’ preferences, particularly the relation between wood characteristics, wood properties and price of timber, both of which can be classified as demand orientated approaches (Washusen and Innes 2008). Wood characteristics and properties were mainly determined from the technical specification of the timber, which is a supply orientated approach. In other words, there appears to have been little research on market needs of wood characteristics and properties (Nolan et al. 2005). This can limit the availability of suitable plantation resources for different markets with price transparency for tree growers and buyers being non-existent (Hopewell et al. 2015).

Past studies of teak wood properties were mainly centered on the variations of physical and mechanical properties in relation to the effects of tree age, site conditions and silvicultural managements (Anish et al. 2015; Darmawan et al. 2015; Izekor and Fuwape 2010; Shukla and Viswanath 2014; Wanneng 2012). However, the link between wood properties and wood value has been poorly understood.

This paper assesses the relationship between price of teak timber and wood characteristics and properties. It is envisaged that the results of this study will benefit teak growers, processors, and manufacturers in Laos and other tropical countries. This helps the processors or buyers who need a particular quality of wood, as they no longer must dispose of low-quality timber which they cannot use. This could lead to significant money savings. To produce high value and high-quality wood finished products which would meet domestic and international market requirements, the knowledge and information of market preferences of wood characteristics and properties are required for all levels of producers dealing with teak plantation.

2. Materials and Methods

2.1. Terminology

To assess the key determinants of wood characteristics and properties on market price of teak plantation, it is useful to first define the key terms used in the current analysis namely wood characteristics, properties, plantation, timber, log, and log grade. On the one hand, wood characteristics refers to the visual appearances or features of log and squared log such as heartwood, colour, knot, bend, pipe, buttress, decay, end check and split, etc. In this study “wood characteristics” also include log sizes (diameter and length). On the other hand, wood properties refers to the structure of the tree or log, that is wood hardness, strength, stiffness, durability, density, and unit shrinkage. Wood characteristics are the visual features of wood, and sometimes are referred to as wood “defects”. They include knots, colour, size, grain-pattern, heartwood-sapwood proportions, decay, buttress/wane, and bend (Bhat and Indira 1997).

Knot is the portion of a branch that is embedded in wood by the natural growth of a tree (Indian Standards Institution 1968). A cross-sectional shape of the knot is usually circular or oval. Based on the shape and type, wood knots are classified into three different categories; sound or fix knot, unsound or loose knot, and hallow knot. Log end splits are defined as splits reaching the log periphery, where the maximum, external end-split length along the length of the log is measured (Hopewell et al. 2015). The rest of terms used in this paper have been comprehensively explained by Richter (2015).

Plantation is an intensively managed stand of trees of either native or exotic species. Timber refers to all log, squared log, standing tree and sawn-board timber. According to Food and Agricultural Organization of the United Nations (FAO 2001), a forest plantation is an afforested or reforested space, which is cultivated by planting or/and seeding of either native or introduced species. The area should contain forest stand of at least 0.5 ha with a minimum tree crown cover of 10 per cent and total tree height of more than 5 meters. In contrast to earlier definitions, rubber trees and cork oak are now categorized as forest plantations as well.

Log is defined as a stem of wood cut from a tree with different diameters and lengths defined by
growers or buyers. Log grade refers to quality class of a log based on its wood characteristics and/or wood properties. In Laos, log grading is only performed on the sawn logs. There are two existing log grading rules in Laos; natural log and plantation log grading rules. The natural log grading rules were developed by the Lao Government, which has a long history of updating the process from 1990 to 2007 (MAF 2007). Plantation log grading rules is a new development in Laos. Log grades are classified from Grade A to Grade D. Grade A refers to the highest quality log, Grade B is a medium quality log, Grade C is a low-quality log, and Grade D. This log grading rules for plantation species (mainly for teak species) in Laos are explained by (Hopewell et al. 2015).

2.2. Research site and data collection

In 2005, there were 160 sawmills, 954 furniture workshops and two plywood producers in Laos, which employed over 22,000 workers (MAF 2005). A more recent report by the Ministry of Industry and Commerce (MOIC) states that the total number of wood sawmilling and manufacturing companies in Laos is 1,627 (MOIC 2015). This number included 45 pure wood sawmills, 388 mixed sawmilling (primary) and manufacturing (secondary) companies, 868 pure manufacturing companies (furniture), and 326 small or local household furniture workshops. A more recent report by Smith et al. (2018a) also states that many Laos sawmills closed down due to low standards used in their production and product quality. In total, 83 low standard sawmills closed down in Sayaboury Province, and 40 sawmills in Luang Prabang Province. The total number of all wood sawmilling and manufacturing companies which remained operational in Laos was 1,504 in 2018. Further to that only 1220 companies remained operational in 2020 while the number of local furniture processors also decreased from more than 1000 processors to only 130 (Phimmavong et al. 2021).

The sites of this study are two provinces of Laos, namely Luang Prabang Province, Northern Laos and Vientiane Capital in the central part (Figure 1). Most teak buyers in Laos are wood saw-
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millers and wood manufacturers and these groups of people were therefore included in this study. The names and contact details for both teak saw-millers and wood manufacturers were obtained from the Provincial Offices of Industry and Commerce (POIC) of Vientiane Capital city and Luang Prabang Province, which were the sites of this study. POIC has a key role in managing wood processing and manufacturing in the province. To achieve the aims of this study, we identified the process principally from a buyers’ perspective rather than from a producers’ perspective of the technical aspects of teak plantations. This approach starts out by surveying the buyers of logs from teak plantations in order to determine their key requirements for wood characteristics and properties. Then, these wood characteristics and properties that are derived need to be conveyed back to the suppliers or growers. Finally, recommendations need to be made to suppliers or growers of teak so they can adjust or improve their current practices to ensure that buyers’ requirements are adequately met. As previously mentioned, the main teak buyers in Laos are sawmillers or processors and wood manufacturers. Thus, the assessment of buyers’ requirements for wood characteristics and properties need to be targeted. The key information collected from the buyers’ side should be:

- The desirable wood characteristics and wood properties they perceive in the logs they buy;
- The particular proportions of wood characteristics and properties required and accepted;
- The perceived value of characteristics, properties and volumes of the timber; and
- The buyers’ willingness to pay certain prices for particular wood characteristics and properties for specific end-uses.

The desirable wood characteristics and properties were then ranked according to those deemed most important. A multiple regression “price-quality model” of teak plantations could be applied and used to explain the relationships between wood characteristics, properties and log price. Furthermore, the wood characteristics and properties of teak plantation were also assessed in order to compare these to the buyers’ requirements. Plantation teak suppliers in Laos are mostly local small-holders or private growers. Teak timber types and finished products were measured and assessed for wood characteristics, and the frequency of their occurrence. Wood characteristics included heartwood proportion, bend, pipe, end split, end check, knot, knothole, decay, insect, buttress/want, and wood colour.

One hundred volunteers of teak buyers of wood sawmilling and manufacturing companies in the study sites were randomly selected for the interview, from a total of 186 companies in the two provinces which covered more than half of the total sample. We interviewed all 24 companies in Luang Prabang Province and picked 76 companies (162 companies) at random in Vientiane Capital. Both formal and informal surveys were undertaken between March and May 2017. The survey involved semi-structured interview technique where the questionnaire was prepared before the survey, and deep-open discussions were also held during the interview. The major questions asked in this survey were, for example;

- How old is the timber from the teak plantation when they are sold?
- What teak products are processed and manufactured?
- What is the frequency of occurrence of a given wood characteristics on a teak timber type (ex. round log, square log, and finished products)?
- Which wood characteristics and properties are important based on buyers’ preferences?
- How do buyers assess teak wood characteristics and properties and pay for the timber?
- What specific value of wood characteristic and property are accepted for which specific wood products by the buyer?

The deep-opening questions were also raised during the interview, for instance,

- What improvements do buyers suggest for wood suppliers or teak growers?
- What do buyers suggest changing or developing in logs/sawn boards quality, log grading rules and prices in the country?
Descriptive statistical analysis and non-statistical analysis was implemented. Statistical packages, SPSS for Window was used for statistical analysis.

3. Results and Discussion

3.1. Frequency of wood characteristics

Teak timber types and finished products were measured and assessed for wood characteristics, and the frequency of their occurrence. The research question used in this assessment was what are the frequencies of wood characteristics and properties that are present in teak timbers and finished products? Wood characteristics included heartwood proportion, bend, pipe, end split, end check, knot, knothole, decay, insect, buttress/want, and wood colour.

The results showed that knot, white-sapwood, end-split, insect hole and soft pith-decay are predominantly found in teak wood products by 45.20%, 18.60%, 16.20%, 10.90% and 9.10% respectively (Figure 2 and 3). It has been noted that end split occurred only on the decorative products (ceiling, flooring and walls) due to the fact that teak plantations in Laos mostly grown by private-smallholders where over 80% of the growers do not thin and prune their own teak plantations (MAF 2001). In addition, teak timber used in Lao wood processing and manufacturing are not separated quality grades for specific finished products. Lao teak furniture-products are produced from both mixed heartwood and sapwood.

![Figure 2. Frequency of occurrence of teak wood characteristics in wood products, square logs and round logs.](image)

The frequency of occurrence of square log, knot, end-split, and wane are 28.93%, 20.25% and 19.42% respectively. Knot, buttress, and bend are major characteristics appearing on round log at 29.89%, 17.79% and 15.30% respectively. It could be concluded that knot has the highest occurrence in Lao teak timbers for all wood products, square log and round log, compared to others wood characteristic parameters. This is because teak plantations in Laos were mostly grown by private-smallholders with over 80% of the growers not thinning and pruning their trees (MAF 2001). Knot hole was one of the wood defects that the buyers were seriously concerned about when they buy timber. Similar studies also found that knot, buttress and bend are also the highest occurrence on round log from teak plantation grown in Sri Lanka by approximately 90%, 25% and 20% respectively (Jayawardhane et al. 2015; Kumar 2013).

3.2. Ranking of wood characteristics and properties

Teak wood characteristics and properties were ranked for their importance based on buyers’ requirements. The survey questions included what is the ranking importance of each particular wood
characteristic? what are the most important wood characteristics for buyers’ particular products? what are the wood characteristics and properties that buyers want? Descriptive statistical analysis was implemented by applying the statistical packages of SPSS for Windows.

Each parameter of wood characteristics and properties was ranked for its importance based on buyers’ requirements and preferences. The score of the rankings was statistically designed for 5 ranges (Figure 4). To measure this ranking, a perception index for importance level based on the buyers’ requirements and preferences is developed. Buyers are invited to give their opinion on one of five options: 1) not important, 2) little important, 3) Middle important, 4) very important, and 5) the most important. To have more choices scoring from the buyers, the ranking was separated into two different types of wood characteristics and properties: the first type is not related to wood defects and include heartwood, log diameter, log length, wood colour, wood hardness, wood density, wood shrinkage, wood static bending, compression and shear strength, and the second type is related to wood defects, such as wood decay, pipe, insect hole, bend, knot hole, end split, wane or buttress, knot and end check.

For the first type of wood characteristics and properties which are not classified as wood defects; heartwood obtained the highest total score, followed by log dimensions (diameter and length) as the second most important requirement from the buyers (Figure 4). It means that timber with higher heartwood proportion and large (diameter and length) are in higher demand and priced high. Wood colour is the third rank most important requirement for buyers. The results show that wood properties are not important to buyers. Buyers do not value wood properties when choosing and paying for the timber.

![Figure 4. Ranking of non-defect wood characteristics and properties according to their importance for the buyers.](image-url)
Market Preference of Wood Characteristics and Properties

The other wood characteristics called “wood defects” were ranked for their importance to buyers. Wood decay and pipe are the most important defects with score ranking between 4.2 and 4.5 (Figure 5). It means that when decay and pipe are found on timber, it would be rejected by the buyers. The second most important wood defects are bend and insect hole with ranking between 3.43 and 4.23 (Figure 5). Knot hole, and end-split are the “middle important” wood defects with ranking between 2.62 and 3.42. Log wane/buttress, knot and end check are not important defects for buyers.

![Figure 5. Ranking of defect-wood characteristics according to their importance for teak buyers.](image)

Table 1. Buyers’ acceptance rate and value of wood characteristics, n=100 buyers.

| Wood characteristics | Minimum | Maximum | Mean   | Std. Deviation |
|----------------------|---------|---------|--------|----------------|
| End split (%)        | 5%      | 50%     | 21.89% | 9.95%          |
| Buttress (%)         | 5%      | 30%     | 18.20% | 7.40%          |
| Pipe (%)             | 1%      | 31%     | 13.81% | 9.74%          |
| Bend (%)             | 3%      | 15%     | 6.23%  | 2.76%          |
| Heartwood (%)        | 40%     | 80%     | 59.62% | 10.41%         |
| End-check (mm)       | 5       | 20      | 16.60% | 5.60           |
| Diameter (cm)        | 8       | 20      | 12.14% | 2.48           |
| Log length (m)       | 1       | 2       | 1.48   | 0.38           |
| Knot (No.)           | 3       | 15      | 10.29% | 4.58           |
| Knot-hole (No.)      | 0       | 4       | 2.00   | 1.04           |
| Insect hole (No.)    | 0       | 3       | 0.60   | 0.88           |

3.3. Buyers’ acceptance of wood characteristics and properties

The aforementioned section shows the importance of ranking wood characteristics and properties based on buyers’ preference and requirements. However, the above score ranking could not obviously illustrate the value of wood characteristic and property that are acceptable to buyers. This section further explains the implications of specific values for teak timber grading rules improvement.

To measure the buyers’ acceptance rate, a percentage index for key wood characteristics and properties is used. Buyers are asked to show their opinion how many percentages and defect values they can accept. Almost all 100 teak buyers who participated in the assessment did not realize any specific value of wood properties for their wood products. For wood characteristics, decay is the worst defect considered by the buyers and the timber with wood decay is rejected and not paid for. For other wood characteristics, buyers have different limitations for accepting timber (Table 1).

Maximum log end-split acceptance from the buyers is 50% and the average acceptance is 21.89% of the split length for a minimum timber length of 2.20m. Log buttress unit is in percent by
calculation of the ratio between log diameter and the maximum “distance deep” between a straight line extended between buttress peaks. Maximum log buttress acceptance from the buyers is 30% and 18.20% on average. Log pipe unit is in percent by calculation of the ratio between pipe diameter and log diameter. Maximum pipe acceptance from the buyers is 31% and 13.81% on average. Log bend unit is in percent by calculating the ratio between log diameter and the distance of bend from a straight line extended between log ends. Maximum log bend acceptance from the buyers is 15% and 6.23% on average. However, a log which has more than one bend is not acceptable for the buyers. Heartwood unit is in percent by calculation of the ratio between heartwood and log diameter. Large heartwood log is a higher preference by buyers. In this study, the minimum heartwood acceptance from buyers is 40%. Minimum log dimensions of diameter and length acceptable by buyers are 8cm and 1m respectively. The maximum numbers of knot and knot hole acceptable are 15 and 4 respectively for a minimum log length of 2.20m. Maximum number of log insect holes that are acceptable is only 3 (Table 1).

3.4. Impact of wood characteristics and properties on market price

The relationship between log prices, wood characteristics and properties were tested. The predictor variables of wood properties included different classes of wood hardness, stiffness, density, and unit shrinkage. Twelve wood characteristics used were log diameter, length, bend, pipe, knot, knot hole, end split, end check, decay, insect-hole, buttress and heartwood. The market prices are based on current prices provided by buyers. All calculations of present market prices were based on prices that were prevalent in 2017-2018. The price unit used in the analysis is “US$”. Each particular parameter of wood characteristic was assigned different valued-classes per 2.20m of log length. The valued-classes are based on Lao plantation log grading standards (from grade A to grade D criteria) (Hopewell et al. 2015). Log grading standards in the past have not included wood properties. However, this study offered wood property values for the buyers’ decisions. These particular valued-classes of both wood properties and characteristics were provided to teak buyers for their offer prices. The data obtained from 100 teak buyers was analyzed by applying a Multiple Linear Regression (MLR) model of SPSS Statistical software. The general regression of hedonic price function is formed as

\[ P_i = f(Z_i) + \epsilon_i \]

where \( P_i \) is the \( i^{th} \) log price and \( Z_i \) is a vector of different properties or characteristics of the \( i^{th} \) product (Rosen 1974). Hedonic price function is useful in determining the implicit price for product characteristics that can explain the amount paid for extra product characteristics as a function of the level of provision of that characteristic and the level of provision of other products’ characteristics. The results demonstrate that wood properties have not had any impact on log prices. Almost all teak buyers do not offer a different price for teak timber that provided different valued classes. The study revealed that Lao teak buyers have never considered wood properties in their purchasing price. The buyers pay for logs based on visual inspection of wood characteristics such as log dimensions and visible defects. However, of 12 wood characteristics listed above, only three characteristics (log diameter, log length, heartwood) showed statistically significant coefficients fitted to the Multiple Linear Regression (MLR) on log price at p-value<0.05 level (Table 2) and a coefficient of determination \( R^2=0.40 \). Wood decay is rejected by buyers and do not offer a price. The buyers do not buy log presented decay or rot. The best selected model from this analysis is:

\[ \text{Price} = -78.08 + 25.50 \times \text{Diameter} + 1.16 \times \text{Heartwood} + 30.89 \times \text{Length} \]

The coefficient value of the model demonstrated that log length has a larger impact on log price compared to log diameter and heartwood by 30.89, 25.50 and 1.160 respectively (Table 2). However, it needs to be realized that the log length affects log price only when the log length is shorter than 2.20m. Obviously, the coefficient value indicates that if log length increases from a minimum log length 1m to 2.20m, the price positively increases to 30.89US$/m³. Eq.[2] also confirms that log price increment which was due to an increase of each unit of 5cm log diameter and 10% heartwood proportion are 25.50 US$/m³ and 1.16 USD/m³ respectively.
Table 2. Coefficient values correlated between round log price and wood characteristics.

| Model | Unstandardized Coefficients B | Std. Error | Standardized Coefficients Beta | t-statistics | p-value | Zero-order Correlations | Partial Correlations |
|-------|-------------------------------|------------|--------------------------------|--------------|---------|-----------------------|---------------------|
| 1     | (Constant) 47.209             | 14.529     | 3.249                          | .002         |         | .528                  | .528                |
|       | Log diameter 22.965           | 4.899      | .528                           | 4.688        | .000    | .528                  | .528                |
| 2     | (Constant) -22.219            | 28.089     | -.791                          | .432         |         |                       |                     |
|       | Log diameter 23.438           | 4.625      | .538                           | 5.067        | .000    | .528                  | .561                |
|       | Heartwood 1.176               | 415        | .301                           | 2.832        | .006    | .281                  | .354                |
| 3     | (Constant) -78.086            | 35.069     | -2.227                         | .030         |         |                       |                     |
|       | Diameter 25.500               | 4.504      | .586                           | 5.662        | .000    | .528                  | .607                |
|       | Heartwood 1.160               | 397        | .297                           | 2.918        | .005    | .281                  | .366                |
|       | Log length 30.896             | 12.457     | .256                           | 2.480        | .016    | .155                  | .317                |

Note: * statistically significant at 5% level.

Teak (*Tectona grandis* Linn.F) is one of the most popular and valuable species planted by local smallholders in northern, central and southern regions of the country, with approximately 40,000 ha in production (Midgley et al. 2017). The largest planted area is in the northern part of the country, especially in Luang Prabang Province, with 15,342 ha (Boer and Seneanachak 2016) has increased to 18,211 ha (Boer 2019). This species is increasingly in demand and grown in several regions, including Asia, Africa, and Latin America. It is estimated that 5.9 million ha is planted around the world, although it grows naturally in Myanmar, Laos, Thailand, and India (Midgley et al. 2015). Globally, teak has been accepted for a wide range of purposes from general carpentry and joinery, to furniture and cabinet making, and from veneer to construction applications, including railway and ship building materials (Bhat 1998; Bailleres and Durand 2000; Matumura and Kawasaki 2011). In Togo, teakwood has been extensively used for construction and carpentry purposes (Kokutse et al. 2004). Teak timber is used commercially in the Lao wood processing and manufacturing industries, for furniture products and decorative building components (such as doors, windows frames, wall, ceiling, and flooring), and for both export and domestic markets (Midgley et al. 2015). Currently, the teak timber used in Lao for wood products is of different ages, ranging between 12-25 years of age with broadly variable wood characteristics and values (Boer and Seneanachak 2016; Midgley et al. 2007). Despite the lack of information about market preferences and prices, teak tree harvesting only occurs in accordance with farmers’ personal needs and motivations (Midgley et al. 2007; Midgley et al. 2015). In addition, global market preferences and prices for teak timber also vary broadly based on several factors such as plantation sites, timber dimensions and wood qualities (grades) (Jayawardhane et al. 2015). Wanneng et al. (2021) found that the original Lao trading system of teak plantation timber was complex and confusing including a total of 11 visual wood defects for grading criteria which were time consuming and costly. The existing prices for different log grades were only based on the most limited grading criteria which were not meeting buyers’ requirements for particular end-used products.

This result showed that log sizes (length and diameter) are the most important variables of wood characteristics, which have significant effect on log price. The literature review of this study revealed that in Sri Lanka and India, the length and circumference or girth of log from teak plantation, were recognized as the most important significant variables affecting log price, followed by other variables of wood defects such as knots, bend, insect hole and buttress, etc. (Jayawardhane et al. 2015; Kumar 2013). This is similar to the findings of this study. However, these previous studies did not include buyers’ requirements for wood properties, and the analysis of the relationship between price and wood characteristics for particular wood products.

Some key results of this study were the development of the ranking importance of wood characteristics, and the range of accepted dimensions or the number of these characteristics based on the survey of teak buyers in Laos. This finding information is useful for developing a log grading rules of teak plantation in Laos or in similar tropical countries. This proposed log grading rules can be easily applied to the selection of grades for particular end-use products, and to ensure that log grades are meeting teak buyers’ requirements.

The study also found that there were not any specific limits on the values of wood properties for the acceptance by teak buyers. The reasons provided by the buyers were that both domestic and international markets’ requirements for teak plantation timber and finished wood products were not restricted to any specific values regarding wood properties. Our results showed that wood properties...
were not important for teak buyers. That is, wood properties had no impact on log price. Teak buyers in Laos did not offer a different price for teak timber that has different wood property values. This could suggest that wood properties do not need to be considered in teak timber quality grading.

4. Conclusion

This study investigated the teak buyers’ preferences on wood characteristics and properties of teak plantation grown in Laos. We conducted interview survey on one hundred buyers from wood sawmilling and manufacturing companies in Laos. The results show that knot is a major characteristic appearing on timber from teak plantations for all round, square logs and furniture products. White-sapwood, end split and buttress are the second predominant defects in teak wood products, square log and round log respectively. In addition, the large heartwood proportion, diameter, and longer length logs are from the most preferred by the buyers. On the other hand, decay, pipe, insect hole, bend, and knot hole are the worst wood defects that the buyers are seriously concerned of when they buy timber. Wood properties are not important for the buyers. The price-quality model in this study indicated that log length, log diameter and heartwood proportion are the only significant wood characteristics affecting the price of logs from teak plantation in Laos. The results of this study provide information to improve plantation logs grading rules, particularly in Laos and similar developing countries. This study results will also be beneficial to teak growers on the best market opportunities for their products so that they will be able to adapt optimal silvicultural regimes including tree harvest timing, log scaling, pruning and thinning, to maximize return on investment considering product quality. Wood processors and manufacturers will be able to have a clear understanding of the value of timber they are buying; based on the specific qualities and quantities, while ensuring resource supply could meet market demands.

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