1 Introduction:
This report responds to project activity 3.7 ‘Explore value adding opportunities for community timber in local sawmills in Lae.’ The methods intended for this activity were;

‘In collaboration with the Timber and Forestry Training College (TFTC) and Hamea Enterprises1, identify local timber processors and their production, products and markets in the Lae/Madang area who would benefit from a revised timber authority (TA) harvest permit and reduced impact logging (RIL) guidelines for small-holders involved in eco-forestry. Undertake a series of harvesting and processing trials, using timber from eco-forestry operations, to facilitate access to value-adding opportunities for the participating communities. Monitor the costs and benefits of these trials.’

Background information on the TA harvest permit
Identifying the key constraints of the TA harvest permit and suggesting opportunities to improve the TA process was the objective for activities 3.1 and 3.2. One of our findings from these research activities was that there is a large informal timber market in PNG made up of forest resource owners (FROs) and small-scale timber producers that chose to operate outside the purview and regulations of the government. Participants of the informal market chose to operate there due to constraints of the TA process, and other challenges that exist in the formal timber market. These other challenges include a declining real value of timber royalties and mis-management of the royalty payments. These findings are discussed in detail in our report ‘Constraints of the Timber Authority Harvest Permit and Options for Improvement.’

Background information on eco-forestry
Eco-forestry is defined as an ecologically sustainable and economically viable alternative to conventional logging. The key principles of eco-forestry were derived from the ‘Sustainable Forest Management’ and ‘Ecosystem Approach’ to forest management principles, which were promulgated from the outputs of the United Nations conference on Environment and Development in Rio de Janeiro in 1992. Beginning in the 1990s, the eco-forestry management model was introduced in PNG by multiple non-government organizations (NGOs). The premise of this management model was that NGOs trained FROs to fell trees on their own land and produce rough-sawn lumber with portable sawmills that was to be exported. To meet the eco-forestry principles, the timber harvests were to be evenly distributed across all species present at the site to maintain the composition and structure of the forest. Research by Scudder et al. (2018) found that the eco-forestry management model ultimately failed at all of the NGO facilitation sites. The leading causes of the failure were that despite the trainings provided by the NGOs, the human capacities of the FROs never reached a level that allowed for the

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1 Hamea Enterprises is a small-scale wood product manufacturer located in the city of Lae. The founder of Hamea Enterprises is Dr. Eddie Nir, who agreed to assist us with our research.
production quality and quantity of lumber desired by the market buyers. In addition, it was found that only four of the tree species (Dracontomelon dao, Intsia bijuga, Pometia pinnata, and Pterocarpis indicus) had a rough-sawn lumber sales value per m³ that was greater than the mean cost of milling per m³ (i.e. cash outflows from sawmill operations and sawmill labour) (Scudder et al. 2019). The implication of this finding is that the eco-forestry model of an even harvest distribution across all species is not financially viable. If only the most profitable species are harvested there is a risk of ‘high-grading’ or ‘creaming’ of the forest. A review of one of the NGO’s lumber export shipping manifests revealed that almost all the shipments were solely comprised of Intsia bijuga, indicating that the true intent of eco-forestry may not have been put into practice.

**Background information on the Central Processing Unit (CPU)**

There has been an ongoing interest among the PNGFA and ACIAR FST/2012/092 (Enhancing Value Added Wood Processing in Papua New Guinea) in identifying a functioning model for a Central Processing Unit (CPU). The essential role of the proposed CPU is the creation of value-added wood products derived from small-scale timber harvest on FRO lands. One of the objectives of the proposed CPU was that the CPU would undertake the TA application requirements to mitigate the human and financial capital constraints experienced by FROs. At the time of this writing, the CPU is still a research concept in progress. Two of the ACIAR Project - FST/2012/092 project outputs were a market analysis report for the proposed CPU by Smith (2018) and the creation of a business plan for the proposed CPU, which was produced by Yakuma (2017).

The market analysis by Smith (2018), recommends that the CPU focus should be on the housing sector and other small buildings for the PNG market. An additional recommendation by Smith (2018), was to assess the possibility of the CPU manufacturing rotary peeled veneer and/or plywood. Demand for plywood in PNG is increasing within the housing sector. A report on enhancing value added wood product processing in PNG recognized that a shift toward a greater use of engineered wood products and prefabricated housing in PNG could be an opportunity for small-holder new product development (Jeremiah et al. 2019). However, veneer, plywood, and prefabricated housing is currently not a core competency of TFTC, and an assessment has not been made on if TFTC could feasibly manufacture these types of wood products. The business plan by Yakuma (2017), recommends that the CPU manufacture sawn wood products using logs harvested from a timber authority (TA) harvest permit possessed by TFTC and from rejected export logs from industrial harvest sites. Manufacturing sawn wood products is a core competency that TFTC already possesses, as portable sawmill training is part of their college curriculum. Both the market analysis by Smith (2018) and the business plan by Yakuma (2017), do not identify specific wood products that the CPU should manufacture or the target market to be focused on.

**Implications of previous research findings**

One of the intended activities for this research was to facilitate value-adding operations with FRO communities. We found that the previous attempts by NGOs to facilitate FRO value-add operations with portable sawmills resulted in financial expenditures in excess of $28 million (2018 USD) over two decades with no lasting outcomes (Scudder et al. 2018). Since these previous attempts at value-add capacity development were not successful, we determined that it would be more prudent to focus our research on identifying opportunities for improving the financial return that FROs receive from selling their timber. We also found that there are multiple value-add wood product businesses operating in the informal market. This finding indicated that these businesses have already identified a successful operating model. We
determined that it would be beneficial to gain an understanding of this existing model and focus our research on opportunities for making improvements to this model. Due to these findings, we revised our intended methods for this research activity.

Our revised methods have been separated into three sub-activities. For the first sub-activity we undertook a value-chain analysis of the informal timber market sector. The objective of this analysis was to gain an understanding of the change in product values at each step of the value-chain and determine if changes could be made to improve financial returns to FROs. The second sub-activity was a production cost analysis of multiple value-add wood products to identify the products with the largest gross profit margins. The intent of this sub-activity was to assist the proposed CPU and other small-scale manufacturing businesses in identifying options for improving profitability. The third sub-activity was a market situation analysis for the products identified in sub-activity two. The purpose of this sub-activity was to assist the proposed CPU and other small-scale manufacturing businesses in identifying strategic market options for the proposed products.

2 Methods:
The methods used to conduct our three sub-activities are described below.

2.1 Value chain analysis of the informal timber market sector
We used a case study methodology to investigate the value chain of the informal market sector\(^2\). Our data collection included interviews of FROs and small-scale timber producers. We categorized the small-scale timber producers as: sawmill owner only; small-scale manufacturer with no mills; and small-scale manufacturer with mills. The term ‘manufacturer’ refers to the small-scale timber producer owning wood machining equipment that allowed them to produce value-add wood products; dressed structural lumber; mouldings; and tongue & groove (T&G) flooring. We interviewed a total of 19 informal market sector participants that comprised 23 interviewees (see table 1). These participants were located in and near the cities of Lae and Madang (see figure one). The names of the 19 informal market participants and associated interviewees have been omitted to ensure confidentiality. The questions asked were; where was the timber/wood products sold and to whom; the type of equipment used to harvest the trees and process the timber; the cost of production; and prices received from sales. The interview format was similar for all interviewees. The interviews were primarily conducted by the first author, with participation also provided by the third author and a former research forester of the Tropical Forestry and People Research Centre. Hand-written notes were taken by the three interviewers during all interviews. The length of the interviews varied between 30 minutes and one hour. At least one staff member of PNGFA or TFTC was present at all the interviews to provide their post-interview perspective to the interviewers.

We compiled the interview data into tables with Microsoft Excel software. For each stage of the value chain we organized the sale prices by species/products. We then averaged the sales prices to identify the change in product values at each step of the value chain. The value chain stages that we used were; log standing on the stump; rough-sawn lumber at the harvest site; rough-sawn lumber delivered to a manufacturing business; and finished value-add product for sale at the mill. We selected four wood products to assess at each value chain stage, which were; T&G flooring (\textit{Intsia bijuga} 95 x 20 mm); treated architrave moulding (mixed hardwoods 70

\(^2\) The value chain analysis of the informal market sector was a sub-set of a larger case study on the informal market sector (Scudder et al. 2019a).
x 20 mm); treated structural lumber house post (*Vitex cofassus* 150 x 150 mm); and treated weatherboard (mixed softwoods\(^3\) 145 x 20 mm). These products were selected because we were told that they were commonly produced by small-scale manufacturers in the informal market.

Table 1: Descriptions and number of interviewees

<table>
<thead>
<tr>
<th>Informal market participants</th>
<th>Participants</th>
<th>Interviewees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest Resource Owner (No mills)</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Forest Resource Owner (With mills)</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Sawmill owner only</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Small-scale manufacturing business (No mills)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Small-scale manufacturing business (With mills)</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>23</td>
</tr>
</tbody>
</table>

Figure 1: Location of research sites

2.2 Production cost analysis of value-add wood products

We conducted in depth interviews with identified experts of small-scale wood product processing in Lae. The interviewees were comprised of seven professors/teachers from TFTC

\(^3\) We were told that these species were mixed tropical deciduous species that had softer wood than most tropical hardwoods. They were not conifers.
and two small-scale wood product manufacturer business owners. The interviews were conducted by the first author and a PNGFA employee. Hand-written notes were taken by both interviewers during all interviews. The length of the interviews varied between 30 minutes and 2 hours. Production cost data from interviewees of the value chain analysis activity was included when available. The purpose of these interviews was to identify the average production costs and gross profit margins for a series of value-add wood products at each stage of the value chain. The value-add wood products we selected were; treated D-mould (mixed hardwoods 20 x 10 mm); treated architrave moulding (mixed hardwoods 70 x 20 mm); T&G wood flooring (Intsia bijuga 95 x 20 mm); treated weatherboard (mixed softwoods 145 x 20 mm); and six dimensions of treated dressed mixed hardwood structural lumber. The dimensions of the dressed structural lumber were 50 x 50 mm, 75 x 50 mm, 100 x 50 mm, 150 x 25 mm, 150 x 50 mm, and 150 x 150 mm. The value-chain stages that we assessed the production costs were; milling of rough-sawn lumber with portable sawmill in forest; transporting the lumber to a manufacturing business; grading and sorting the lumber to be air-dried; machining the lumber; and chemical treatment if applicable.

We compiled our interview data into tables with Microsoft Excel software. For each stage of production, we organized the production costs by species/products. We then averaged the costs for each category to derive an average cost for each production stage. For each product, we calculated an expected gross profit per m$^3$ of finished product and the associated gross profit margin.

### 2.3 Market situation analysis

A market situation analysis is comprised of four steps (Marshall and Johnston 2009); an analysis of the macro-external environment; an analysis of the competitive environment; an analysis of the internal environment of the organization; and a SWOT (strengths, weaknesses, opportunities, and threats) analysis, which summarizes the findings of the first three steps. The purpose of the macro-external environment and competitive environment analysis is to identify the existing opportunities and threats of the market. The purpose of the internal environment analysis is to identify the strengths and weaknesses of the organization that would be operating the proposed CPU.

The macro-external environment analysis includes five sub-steps. These are; the political and legal rules, laws, and norms that impact operating behaviour; demographic trends among consumers; technologies used in the industry; overall economic conditions and the impact that they will have on an industry; and the natural environment which includes sustainability issues (Marshall and Johnston 2009). We assessed these five sub-steps through a review of the available technical reports on these subjects and informal interviews with PNGFA and TFTC staff. In addition, we forecasted new housing construction for the Morobe and Eastern Highlands Provinces to estimate the potential size of the geographic market. This forecast was developed with data collected from the PNG 2011 census report by the PNG National Statistical Office (PNGNSO) (2013b), which provided data on population by district, annual population growth rates by province, and average number of people per dwelling by province. Additional data used for the forecast was sourced from a household and income expenditure
survey by PNGNSO (2013a), which indicated that only 20.8% of homes in the Morobe Province and 24% of homes in the Eastern Highlands provinces are non-traditional dwelling.

The analysis of the competitive environment includes five sub-steps. These are; the threat of new entrants (assessment of barriers to entry); rivalry among existing firms; the threat of substitute products; the bargaining power of buyers; and the bargaining power of suppliers. These sub-steps were assessed through informal interviews with PNGFA and TFTC staff, as well as additional field interview research conducted by project partners at PNGFA and TFTC.

The internal environment analysis includes four sub-steps. These are; analysis of the firm structure and systems; the culture of the organization; the current leadership; and the organization’s resources. The purpose of this analysis is to assess how these sub-categories include a customer-centric focus as a core value of the organization. At the time of this report there is no existing CPU organization. It is currently unknown who would operate the CPU, with potential suggestions being TFTC, the PNGFA, and a private business. This report has assumed that TFTC will be the operator of the CPU, and the strengths and weaknesses section of the SWOT analysis are based on TFTC’s capabilities.

Figure 2: SWOT analysis template

<table>
<thead>
<tr>
<th>Opportunities (external, positive)</th>
<th>Threats (external, negative)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strengths</strong> (internal, positive)</td>
<td>Strength-Opportunity strategies</td>
</tr>
<tr>
<td>Which of the company’s strengths can be used to maximize the opportunities you identified?</td>
<td>How can you use the company’s strengths to minimize the threats you identified?</td>
</tr>
<tr>
<td><strong>Weaknesses</strong> (internal, negative)</td>
<td>Weakness-Opportunity strategies</td>
</tr>
<tr>
<td>What action(s) can you take to minimize the company’s weaknesses using the opportunities you identified?</td>
<td>How can you minimize the company’s weaknesses to avoid the threats you identified?</td>
</tr>
</tbody>
</table>

3 Results:

3.1 Value chain analysis

Our estimates of the values for our four selected wood products at the four value chain stages of the value chain are discussed below.

Stumpage value is typically defined as the residual value of the logs after subtracting logging costs and transportation costs from the price paid for the logs by a sawmill. The stumpage value is typically the payment that a landowner can expect to receive for their timber. When we conducted our interviews with FROs and the small-scale timber producers we found that payments to FROs for their timber are typically not calculated on a log volume basis. The most common payment arrangement was referred to as the ‘2 for 1 agreement.’ The 2 for 1

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4 The term permanent housing refers to homes that are constructed from lumber, concrete, steel, and other materials. Most of homes in PNG are traditional homes, which are constructed from bush materials. While some of the traditional homes may incorporate manufactured wood products in their design, these materials are typically recycled from some other previous use.
agreement allocated two thirds of the milled lumber to the portable mill owner and one third of the milled lumber to the FRO, who typically was given the option of selling their portion of the lumber to the sawmill owner at an agreed rate. From the average of these set rates and assuming a lumber recovery rate of 50%, we estimated the value of the ‘logs standing on the stump’ for our four selected wood products. In some cases, the FROs owned or had access to a portable sawmill but were not able to transport the milled lumber to a manufacturing business. In these situations, the manufacturer would arrange the transportation but would provide a different payment price than if the lumber had been delivered by the FRO. The finished product price refers to the sales prices per m$^3$ of product. These products are typically sold at rates per lineal meter, which we have converted back to m$^3$ for ease of comparison. These product values by value chain stage are presented in table 2.

Table 2: Value of wood products are various value chain stages (Kina per m$^3$ of log/lumber)

<table>
<thead>
<tr>
<th>Value-chain stage</th>
<th>T&amp;G flooring</th>
<th>Architrave moulding</th>
<th>Structural lumber house post</th>
<th>Weatherboard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log standing on the stump$^1$</td>
<td>77</td>
<td>63</td>
<td>63</td>
<td>30</td>
</tr>
<tr>
<td>Rough-sawn lumber at harvest site$^2$</td>
<td>500</td>
<td>450</td>
<td>450</td>
<td>450</td>
</tr>
<tr>
<td>Rough-sawn lumber delivered to mill$^2$</td>
<td>1,058</td>
<td>750</td>
<td>750</td>
<td>750</td>
</tr>
<tr>
<td>Finished product located at mill$^2$</td>
<td>4,702</td>
<td>3,352</td>
<td>2,133</td>
<td>2,667</td>
</tr>
</tbody>
</table>

$^1$ refers to log value (Kina per m$^3$).
$^2$ refers to lumber value (Kina per m$^3$).

3.2 Production cost analysis

Our estimates of the average production costs for our 10 selected products at the selected production stages are presented in table 3. We found that the value-add wood products with the highest expected profit margins to be: D-mould (88%); T&G flooring (82%); weatherboard (72%) and architrave (71%). While D-mould had the largest profit margin, this product has the smallest dimensions of the products assessed (20 x 10 mm) and is typically manufactured from the leftover scrap of larger products. All the structural lumber products assessed had a gross profit margin of 62%.
Table 3: Average value-add production costs and gross profit margins for selected products (Kina per m$^3$ of lumber product)

<table>
<thead>
<tr>
<th>Value-add products</th>
<th>Timber and sawmilling cost</th>
<th>Transport cost</th>
<th>Value-add manufacturing cost</th>
<th>Gross profit analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Payment to FROs</td>
<td>Labour</td>
<td>Oil/Fuel</td>
<td>Total cost</td>
</tr>
<tr>
<td>D-mould$^1$</td>
<td>126</td>
<td>488</td>
<td>290$^6$</td>
<td>758</td>
</tr>
<tr>
<td>Architrave$^2$</td>
<td>126</td>
<td>366$^7$</td>
<td>218$^7$</td>
<td>654</td>
</tr>
<tr>
<td>T&amp;G flooring$^3$</td>
<td>154</td>
<td>244</td>
<td>145</td>
<td>543</td>
</tr>
<tr>
<td>Weatherboard$^4$</td>
<td>60</td>
<td>244</td>
<td>145</td>
<td>449</td>
</tr>
<tr>
<td>Structural lumber$^5$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 x 50</td>
<td>126</td>
<td>244</td>
<td>145</td>
<td>515</td>
</tr>
<tr>
<td>75 x 50</td>
<td>126</td>
<td>244</td>
<td>145</td>
<td>515</td>
</tr>
<tr>
<td>100 x 50</td>
<td>126</td>
<td>244</td>
<td>145</td>
<td>515</td>
</tr>
<tr>
<td>150 x 25</td>
<td>126</td>
<td>244</td>
<td>145</td>
<td>515</td>
</tr>
<tr>
<td>150 x 50</td>
<td>126</td>
<td>244</td>
<td>145</td>
<td>515</td>
</tr>
<tr>
<td>150 x 150</td>
<td>126</td>
<td>244</td>
<td>145</td>
<td>515</td>
</tr>
</tbody>
</table>

$^1$Mixed hardwoods, 20 x 10 mm.  
$^2$Mixed hardwoods, 70 x 20 mm.  
$^3$Intsia bijuga, 95 x 20 mm.  
$^4$Mixed softwoods, 145 x 20 mm.  
$^5$Mixed hardwoods, multiple dimensions mm.  
$^6$We assumed D-mould would be the result of re-sawing and doubled the labour and oil/fuel costs.  
$^7$We assumed that architrave would often be the result of re-sawing and increased the labour and oil/fuel costs by a factor of 1.5.
3.3 Market situation analysis

3.3.1 Macro-external environment
We found that most of the small-scale timber market operators exist in an informal market that operates outside the purview or regulation of the government. The reason this market is referred to as ‘informal’ is because these participants are not applying for and receiving the required TA harvest permit. The PNGFA currently does not have the resources to enforce this regulation and limits their involvement of TA enforcement to lumber exports. The current political environment of the TA results in three potential threats; the export market is not available to non-TA operators; the government could change their policies and begin policing the informal market; and if an organization does pursue a TA, they will have larger operating costs relative to other informal market participants.

Transportation within PNG is difficult and expensive. Most of the roads are in poor condition, which dramatically reduces the speed of transport. Furthermore, there is not a highway system that connects all the cities within PNG. For example, traveling from Lae to Port Moresby is only possible by airplane or boat. The market analysis by Smith (2018), recognized that Lae is PNG’s largest port city and capable of accessing Port Moresby, which is the largest permanent housing market within PNG. However, participating in a market that requires ocean transport will add additional complexity to the CPU business. We suggest that the CPU initially focus on nearby markets that can be reached through road transport. These markets are the city of Lae, the rest of the Morobe Province, and the Eastern Highlands Province.

Our housing forecast identified two geographic markets that have highest potential for new housing demand in the Morobe and Eastern Highlands Provinces (see Table 4 and Figure 3). The geographic market with highest potential demand was in the Eastern Highlands and comprised of the Goroka, Kainantu, Unggai/Benna, Asaro/Watabung, and Lufa districts. The second identified geographic market was made up of the Lae, Bulolo, Huon Gulf, and Menyamya districts in the Morobe Province. We identified four customer categories that purchase value-add wood products within these provinces. The two primary customers are hardware supply retailers and construction companies. The customer categories are independent carpenters and the general public.

The manufacturing technology in use by small-scale manufacturers is predominantly made up of equipment with low economies of scale and outdated machinery. The use of portable sawmills will typically never reach a level of productivity that can be achieved through conventional logging and modern fixed site saw mills. The primary machining equipment that we have viewed are various moulding machines and planers (thicknessers). Almost all the machining equipment we viewed appeared to be several decades old. An implication of using out of date machinery is that it may be difficult to produce products with a level of quality made by competitors using more modern equipment. The industrial-scale wood processing sector in PNG is comprised of 28 saw mills, one plywood mill, one veneer mill, and eight furniture manufacturers (PNGFIA 2010, PNGDL 2015). In 2016, PNG’s wood processing sector produced approximately 82,000 m$^3$ of sawn wood, 29,000 m$^3$ of plywood, and 62,800 m$^3$ of veneer (ITTO 2017).
Table 4: Housing demand forecast for the Morobe and Eastern Highlands Provinces

<table>
<thead>
<tr>
<th>Province</th>
<th>District</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
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<tbody>
<tr>
<td>Morobe</td>
<td>Bulolo</td>
<td>169</td>
<td>174</td>
<td>180</td>
<td>185</td>
<td>191</td>
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<tr>
<td></td>
<td>Huon Gulf</td>
<td>126</td>
<td>129</td>
<td>133</td>
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<td></td>
<td>Menyamya</td>
<td>117</td>
<td>120</td>
<td>123</td>
<td>127</td>
<td>130</td>
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<tr>
<td></td>
<td>Nawae</td>
<td>61</td>
<td>62</td>
<td>64</td>
<td>66</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>Lae (Urban)</td>
<td>35</td>
<td>36</td>
<td>36</td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Lae (Rural)</td>
<td>136</td>
<td>143</td>
<td>150</td>
<td>157</td>
<td>165</td>
</tr>
<tr>
<td></td>
<td>Markham</td>
<td>88</td>
<td>91</td>
<td>93</td>
<td>96</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>732</td>
<td>755</td>
<td>780</td>
<td>805</td>
<td>831</td>
</tr>
<tr>
<td>Eastern Highlands</td>
<td>Kainantu</td>
<td>335</td>
<td>347</td>
<td>361</td>
<td>374</td>
<td>388</td>
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<tr>
<td></td>
<td>Henganofi</td>
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<td>52</td>
<td>53</td>
<td>54</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>Unggai/Benna</td>
<td>252</td>
<td>264</td>
<td>277</td>
<td>291</td>
<td>305</td>
</tr>
<tr>
<td></td>
<td>Goroka</td>
<td>334</td>
<td>349</td>
<td>364</td>
<td>380</td>
<td>397</td>
</tr>
<tr>
<td></td>
<td>Asaro/Watabung</td>
<td>228</td>
<td>239</td>
<td>250</td>
<td>262</td>
<td>275</td>
</tr>
<tr>
<td></td>
<td>Lufa</td>
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<td>157</td>
<td>163</td>
<td>168</td>
<td>174</td>
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<tr>
<td></td>
<td>Okapa</td>
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<td>83</td>
<td>84</td>
<td>86</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1,434</td>
<td>1,492</td>
<td>1,552</td>
<td>1,615</td>
<td>1,680</td>
</tr>
<tr>
<td>Grand total</td>
<td></td>
<td>2,166</td>
<td>2,247</td>
<td>2,332</td>
<td>2,419</td>
<td>2,511</td>
</tr>
</tbody>
</table>

Figure 3: Comparison of housing demand by district in the Morobe and Eastern Highlands

Note: Greatest demand is in the red coloured districts, followed by the dark orange, light orange, and yellow coloured districts.
The primary macro-economic factor we identified that could have an impact on the proposed CPU is a government proposed log export ban. Currently, approximately 90% of logs harvested in the formal market are exported. There is an interest within the PNG government in reducing the volume of log exports and increasing the downstream processing of wood products. To facilitate this, a log export ban has been proposed to occur in 2020. If the proposed ban did occur, it is possible that the small-scale wood product market would be flooded with cheap logs and wood products, making it difficult for the proposed CPU to compete. We were told that this is not the first time a log export ban has been proposed by the government, with past proposals occurring in 2000 and 2010. Multiple interviewees told us that the proposed 2020 log export ban is unlikely to happen for two reasons. The first reason is that the timber concession given to the logging industry are multi-year contracts with the government, which would be violated by the ban. The second reason is the government is currently struggling to source enough revenue to cover its operating costs and is dependent on the revenues generated from log export duties.

Environmental sustainability is always a consideration that must be assessed within the forest products industry. We found that the species Intsia bijuga is one of the most highly sought-after timber species in both the formal and informal markets. Its primary uses are for house posts, beams, structural lumber and furniture. The popularity of this species is due to extremely dense heartwood (641-961 kg/m3), limited shrinkage insect repellent properties, and the rich dark colour of the heartwood (Thaman et al. 2006). Due to its high popularity, Intsia bijuga has been recognized as being seriously threatened from overexploitation in the South Pacific (Thaman et al. 2006). This species is also a shade-tolerant and slow growing species that can take 75 to 80 years to reach maturity (Thaman et al. 2006). If this species continues to be over-harvested in PNG, it is likely to be replaced by less valuable early successional pioneer species. We were told by several small-scale manufacturers that sourcing Intsia bijuga timber is getting harder and they continually have to travel greater distances to find it.

3.3.2 Competitive environment
An analysis of the threat of new entrants is primarily an assessment of how strong the barriers of entry are to an industry sector. In the small-scale wood product manufacturing sector, the primary barrier is the access to capital for the purchase of machining equipment. While the cost of this equipment is small relative to many types of modern manufacturing equipment, it is beyond the financial reach of most small-scale forest industry participants. Furthermore, since most participants operate within the informal market, they are often viewed as illegal operations and not able to qualify for bank financing.

Currently, we have not been able to assess the extent of rivalry among the existing small-scale wood product manufacturers. Since many of these businesses operate within the informal market, they are not readily identifiable through online searches. Further research by in-country project partners is needed before a thorough assessment can be completed.

We found that there is a threat of substitutes to value-add wood products. Several of the interviewees told us that there is a growing interest in substitutes to wood products such as steel, cement, and plastics. The tropical climate in PNG can result in wood products quickly deteriorating if they are not properly treated. We were told that the interest in substitutes is due to some manufacturers not properly treating their products, or not treating them at all.
Currently, we have not been able to assess the bargaining power of the value-add wood product buyers (hardware supply retailers and construction companies). Further research by in-country project partners is needed before a thorough assessment can be completed.

We have determined that the bargaining power of the timber suppliers (FROs) is minimal. The FROs are primarily ‘price takers’ that have limited knowledge of market demand or the market value of timber species at the various stages of the value chain. We found this also to be true of the majority of saw millers that act as middlemen between FROs and the manufacturing businesses. The small-scale manufacturing businesses currently have bargaining stronghold over the other small-scale market participants.

3.3.3 Internal environment
The internal environment assessment will need to be completed by the future entrepreneurial team of the proposed CPU. The assessment should include: analysis of the firm structure and systems; the culture of the organization; the current leadership; and the organization’s resources. The purpose of this analysis is to assess how these sub-categories include a customer-centric focus as a core value of the organization.

3.3.4 SWOT analysis
We have identified the strengths, weaknesses, opportunities and threats, which are listed below.

Strengths
- TFTC owns all or most of the equipment needed to implement the proposed CPU. This equipment includes: portable sawmills, chain saws, dump truck, chemical-pressure-treatment facility, and wood working machines/tools; moulding machine, table saw, planer/thicknesser, sanders, and basic carpentry tools.
- TFTC has an existing manufacturing site, allowing them to conduct milling, lumber drying processes, value-add processing, and finished product storage.
- The faculty at TFTC train students in the use of wood product manufacturing and award ‘Year 1’ certificates in solid wood processing. Thus, they have expert level experience themselves.
- TFTC already manufactures value-add wood products for sale, thus giving them experience in conducting business transactions.

Weaknesses
- TFTC is first and foremost, a school/training facility. There is not enough equipment to operate a full-time business and to continue to use the equipment for educational purposes.
- Most of the equipment is greater than 40 years old, with much wear. There is a need for replacing this equipment with modern machinery with advanced technologies.
- The faculty at TFTC are the expert equipment operators, but they are first and foremost teachers. Using the faculty to operate the equipment for the CPU will result in a conflict of interest with TFTC’s current core competency – teaching.
- There is the possibility that the salaries paid to the faculty are higher than a standard wood product manufacturing business would pay its equipment operators. If this is the
case, the CPU’s operating costs would be higher than its competitors, which would result in reduced profits relative to the competitors.

- TFTC has experience in producing value-add wood products for sale, but it has never operated as a private business solely dependent on sales revenues. Conducting business transactions (exchanging wood products for money) does not guarantee that the business management experience necessary for a maintain profitable business currently exists in the organization.

**Opportunities**

- Improving chemical treatment procedures for wood products, combined with an appropriate marketing campaign to educate customers about the benefits of the treated products. In addition, changes in the chemicals used can be done to fall in line with the international wood treatment and preservation standards.
- Improving the quality of wood products by sourcing modern machining equipment.
- Improving the quality of wood products by improving the air-drying procedures and/or researching options for low-cost kiln drying (solar kilns).
- Improving the quality of wood products by introducing more stringent grading procedures.
- Utilizing timber species that are easier to source for specific products, combined with an appropriate marketing campaign to educate customers. For example, *Pometia pinnata* is a timber species that is a suitable replacement for *Intsia bijuga* for T&G flooring, it is prevalent throughout PNG forests, and an earlier successional tree species that is more likely to experience natural regeneration.

**Threats**

- Permanent housing demand is low due to most people not having the financial means to purchase/build a permanent home.
- Industrial-scale sawmills can produce lower-cost products due to economies of scale.
- Shipping costs in PNG are high.

4 **Discussion:**

We found that in the current small-scale timber sector, the manufacturing businesses are capturing most of the timber values. Our analysis of the production costs and gross profit margins revealed that there is an opportunity for FROs to receive a greater return for their timber. For example, we found that if payments to FROs were doubled for timber used to make architrave, T&G flooring, and weatherboard, the gross profit margins only declined by 2-4%. As the gross profit margins after this adjustment are 66-79%, there appears to be a more than adequate gross profit margin remaining for businesses to make a fair profit. We provide an example of the prices paid and cumulative production costs at each stage of the value chain for *Intsia bijuga* T&G flooring in figure 4.
We recognize that the high gross profit margins are a necessary incentive for entrepreneurs to take the risk of establishing a business and for recovering the costs of capital equipment purchases. However, we believe that these gross profit margins are much higher than similar businesses in other countries and that this is due to the limited availability of market information to all participants. One of the economic principles of the free market system is that market participants will always make rational decisions that are in their best interest when they have complete access to market information. We found that in PNG, the only participants that seem to be aware of the market values are the manufacturing businesses. FROs and most of the saw millers have not made rational decisions that are in their best interest because they do not have access to market information. To mitigate this challenge, we suggest that there be an increase in extension forestry. We have also made this recommendation in our reports for activities 3.1 and 3.2. An increase in the number of extensions foresters will allow for a greater level market information dissemination. This would increase the bargaining power of the FROs and saw millers and likely raise the prices that they receive for their timber.

We determined that the primary niche products that the proposed CPU should focus on are T&G wood flooring (made from *Pometia pinnata*, and *Intsia bijuga*), weatherboard (made from mixed softwoods, and architrave made from mixed hardwoods. We found that these products had the largest profit margins and require a larger volume of use per housing unit relative to D-mould. Structural lumber products that are in demand should still be produced, but we recommend that the cutting patterns for milling the logs focus on producing flooring, weatherboard, and architrave pieces. In addition, focus on these value-add products can act as a hedge against the larger sawmills that are able to produce rough-sawn lumber products at lower costs.

We suggest that the CPU differentiate itself from competitors by striving to produce the highest quality T&G flooring and weatherboard within the target market. Opportunities for improving product quality can be achieved with the purchase of modern machining equipment, improved drying and grading standards, and improved chemical treatment procedures. We recommend that further research be conducted to identify the specific product attributes desired by the target market related to these quality improvement opportunities. We also recommend that further research be conducted to identify the service attributes desired by the target market.
Some examples of service attributes are; installation instructions included with the product; installation training; product delivery; prices; payment options; and sales reps being available.

In addition to the products suggested above, we also suggest that further research be conducted into identifying additional market opportunities for the wood product residues/waste materials. One product option that has been identified for the short-length timbers/offcut materials is foldable, portable and do-it-yourself (DIY) furniture such as student desks small tables and stools (Ozarska et al. 2019). Research by Ozarska et al. (2019), in collaboration with TFTC, completed a DIY furniture pilot project utilizing previously unwanted short-length timbers. Further research should be conducted on the potential market opportunities for these products. Firewood is an additional product that has been identified as an option for utilizing the wood slabs, and lumber offcuts (Yakuma 2017). The residue product options for sawdust and shavings produced by the moulding machine and planer/thicknesser should also be explored. These residues could potentially be used for charcoal production and/or sold to charcoal producers. By identifying product lines for these wood residues, the CPU revenue streams can be increased, and wood product waste can be reduced.

We suggest that the CPU target market be businesses in Lae that are within a close proximity to the CPU. While we were able to identify districts in the Eastern Highlands that have high demand for new permanent housing (Goroka, Kainantu, Unggai/Benna, Asaro/Watabung, and Lufa districts), it is recommended that these be a secondary market focus since these sites will require greater marketing costs. In addition, product shipping costs will also be lower if customers are in the city of Lae or nearby rural areas.

We recommend that an in-depth operational plan be developed for the CPU. The purpose of this plan is to identify strategies for mitigating the weaknesses recognized in the SWOT analysis. This plan would explore the required employees, daily activities, and estimated daily operational costs. The purpose of this assessment would be to identify expected manufacturing outputs and costs at the weekly, monthly, and annual levels. A business plan produced for the proposed CPU by Yakuma (2017) has provided a good initial estimate of operational expenses and outputs. It is also suggested that this operational plan discuss the relationship between the proposed CPU and TFTC to outline several items; who is in charge of management decisions of the CPU, how the CPU finances will be distinct from TFTC’s finances, the role of TFTC faculty, and if/how TFTC’s existing manufacturing equipment and property will be used by the CPU.

It is possible that the CPU may not be operated by TFTC but may be established nearby in Lae. In this case, TFTC would be able to deliver training and collaboration with the CPU operating entity and the PNGFA.

5 Conclusion
We had three research objectives for this analysis; 1) gain an understanding about the change in product values at each step of the value-chain and determine if changes could be made to improve financial returns to FROs; 2) complete a production cost analysis of multiple value-add wood products to identify the products with the largest gross profit margins; and 3) conduct a market situation analysis to assist the proposed CPU and other small-scale manufacturing businesses in identifying strategic market options for the proposed wood products. We found that the small-scale manufacturing businesses have captured the bulk of the timber value with a minimal portion being captured by the FROs. We surmised that this is due to a lack of market
information dissemination and suggest that an increase in extension forestry could assist in improving the education and timber sale bargaining power of FROs. We found that the value-add products that have the largest profit margin potential for the proposed CPU are T&G flooring, weatherboard, and architrave. We suggest that the CPU focus on becoming a manufacturing quality leader with these identified products. Our market situation analysis indicated that the geographic market locations with the best potential for the CPU are in selected districts in the in Lae within close proximity to the CPU. Secondary markets that can be pursued later are in the Eastern Highlands Province.

For further research, we recommend that other geographical markets also be assessed for development of a CPU entity. It may be that there are locations where there is already a strong demand for value-added wood products. Developing multiple CPUs in the various regions of PNG could be helpful in improving small-scale forestry operations throughout the country. In addition, further research is also needed in identifying opportunities for the government to aid in linking the proposed CPUs to landowners interested in selling their timber. This would support CPUs in securing the raw timber required for conducting their value-add operations.
6 References:


