Journal of Forest Products Business Research
Volume No. 6, Article No. 4

A Value Stream Mapping Analysis of Selected Wood Products Companies in Central America

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ABSTRACT

This paper presents a quantification of value-added times for wood products manufacturing companies in Central America. The analysis was performed in three different companies located in Honduras, Costa Rica, and Guatemala by using a case study methodology. The lessons and insights learned from these case studies could be used to better understand how to develop a value stream mapping analysis in other wood products manufacturing industries around the world.

Key findings of this study indicate that raw material inventory is the largest contributor to waste (non-value-added activities) for the three companies used in this study. Value-added time ranged from 8.8 to 12.3 percent of total process time, with kiln-drying operations being the largest value-added time contributor. Other processing operations were found to contribute very little to the total value-added time for all cases (under 0.05%). It was concluded that the companies must reconfigure their inventory policies in order to decrease waste in their production systems. This important lesson can be used to help other wood products manufacturers who wish to start applying lean thinking to their manufacturing processes.

Keywords: value stream mapping, value added, Central America, wood products industry

Introduction

The goal of this study was to quantify value-added time in wood products industries in Central America by applying value stream mapping analysis. The economic impact of the wood products industry, not only in this region but also in South America, needs to be more consistently addressed by researchers. According to Velarde (2002), on average, forests in Latin America make up 44 percent of the total land area, followed by permanent pastures at 30.6 percent. Forested areas are more than 20 percent of the total land area in Chile, Costa Rica, Ecuador, Guatemala, Mexico, and Panama. This figure is less than the new regional indicator (44%) for 2000. **Table 1** shows a comparison of forestry facts for the three countries involved in this research.

Table 1. Forestry facts comparison (Quevedoi 2004, Velarde 2002, McKenzie 2004).

	Forest cover	Annual production	Protected forest	Forestry direct employment	Plantations extension
	(million ha)	(MMBF)	(million ha)	(number of people)	(ha)
Guatemala	4.27	365.5	2.38	36,878	121,000
Costa Rica	2.13	402.6	1.2	18,000	52,038
Honduras	5.60	321.6	2.76	60,000	30,000

From **Table 1**, it can be seen that Honduras has the largest forest cover of the three countries. Despite having the smallest forest cover (2.13 million ha), Costa Rica is the largest producer of forest products, with 402.6 million board feet (MMBF) per year. Additionally, data from **Table 1** show that Honduras has the greatest number of people (60,000) employed in the forest industry, while Costa Rica has 18,000 employees in the sector.

Other important issues impacting the forestry industry in these three countries are related to value-added products and operations. In Guatemala, the sawn lumber is the main forestry export product, but it only makes up 10 percent of total industry production. Most of the local consumption of forest products is in the form of firewood (47%). Information presented by MAGA (2004) states that it is clear that embedding new technologies into the forest products industry will lead to a rebirth of the secondary products sector in Guatemala. For MAGA, investing in new technologies and improving business processes is necessary for increasing the competitiveness of the Guatemalan forest products industry. Therefore, this study also assists in understanding how one of the most important Guatemalan companies is using technology and business improvements to achieve this goal.

In Honduras, the sawmill industry is the most dominant industry, and it is based on the utilization of its more than 2.7 million ha in pine forests. It is estimated that 97 percent of Honduran forest industry activities are related to pine exploitation in the forms of resins and sawn lumber. An interesting fact is that wood fuel consumption is about 3.8 billion BF/year. The total production of the Honduran forest industry was estimated at 321.6 MMBF with an approximate value of US$ 47.8 million in 2001. Pratt and Quijandría (1997) indicate that, during the previous decade, the forest industry in Honduras required an increase in value-added activities in order to level the trade balance between exports and imports. In 1997, the trade deficit was US$ 63 million. Many attempts have been made by local government agencies, with support from non-profit organizations such as the Rainforest Alliance, to improve the competitiveness of the secondary wood products industry in Honduras. This effort, however, is still in its early stages.

In Costa Rica, there are more than 650 primary and secondary wood products companies operating in the country, with an estimated output value of US$ 150 million. It is important to note that 35 of these companies have full vertical integration ranging from forest plantation management to sales and customer support. These leading companies, however, are not technologically comparable to companies from more developed countries.

Literature Review

According to Womack and Jones (2003), lean thinking provides a way to do more with less: less human effort, less equipment, less time, and less space. The main goal of lean thinking is to provide customers with exactly what they want, while reducing waste and creating value at the same time (Jones and Womack 2000). Womack and Jones (2003) state that value can only be defined by the customer. Because of this, and a multitude of other reasons, the mission of producers is to create value, which can also be difficult for them to accurately define.

The most important analytical tool to help producers define value in their production systems is known as Value Stream Mapping (VSM). Contreras and Galindo (2007) define VSM as a representation of both the value-added and non-value-added operations that are required to produce a product from raw material to the customer, with the main focus being on process flow. Wixson (1997) incorporates a similar definition. He says that VSM is a graphical tool used to identify valued-added and non-valued-added processes, helping to reduce the waste of human resources, time, material, and equipment.

In order to successfully apply VSM to a production process, it is necessary to outline a methodology. Lee (2007) established the following steps in order to successfully apply VSM: evaluation of the current state; determination of the future state; identification of future state infrastructure; identification of priorities and precedence; and the development of plans.

Once VSM has been applied, it is very important to use specific indicators in order to define a reference or comparison point for future improvements. Vorne (2007) states that a production system which is trying to embrace lean thinking to generate value-added products through the application of VSM needs to have a system of indicators to ensure that it is achieving its strategic goals and reducing its waste. Seth and Gupta (2005) show results from the application of VSM to a supplier of an automobile manufacturer in India. They used indicators, such as output per person, reduction of work in process, and finished goods inventory, to report gains in productivity. Their research also shows that it is important to establish whether a company that is embracing lean thinking has a positive performance at some measurable level. Vorne (2007) and Quesada and Gazo (2007) conducted research on the impact of lean practices implementation and company performance. In both cases, the authors conclude that lean projects should have the ability to reduce waste, while at the same time help the organization reach its strategic goals

There are many studies on lean thinking, and they all share the common philosophy of reducing waste, while reaching strategic and financial goals. Other studies, such as those by Bamber and Dale (2000) and Adamides et al. (2008), focus on the importance of the alignment of the human resource, while making the transition from a traditional manufacturing system to lean manufacturing system; however, that it is not always easy. For example, Bamber and Dale (2000) found that this transition is less difficult if the human interactions among managers and employees are considered as a determining attribute of lean management. Adamides et al. (2008) conclude that the application of lean tools, such as VSM, must be executed under an overall framework where every employee connected to the value stream needs to work together with others. Overall, as indicated by Seth and Gupta (2005), lean thinking studies are not just about financial goals or waste reduction, but rather more about having the true commitment of an entire organization.

Table 2 shows some examples of specific applications and results of lean thinking and VSM in the wood products industry. Hunter et al. (2004) and Wood and Wood Products (2006) indicate important gains in productivity ranging from 18 to 50 percent. Cumbo et al. (2006) and Gagnon and Michael (2003) found that implementation and results of lean tools are subject to implementation barriers such as performance systems, machinery constraints, and employee alignment with the strategy. Vlosky et al. (2003) proposed a higher order conceptual framework to increase value-added activities in the wood products industry in Honduras.

Table 2. VSM research and applications in the wood products industry.

Authors	Application of VSM	Results
Cumbo et al. (2006)	Investigated the implementation of lean tools in a rough mill manufacturing plant	Barriers for implementation of lean tools have to do with performance measurement, machinery constraints, and inability to control "off-spec" production
Wood and Wood Products (2006)	Reported on lean implementation tools from a cabinet maker	Company achieved a 50% increment in productivity
Hunter et al. (2004)	Designed a manufacturing cell based on lean thinking for a furniture company	Productivity gains amounting to 18%
Gagnon and Michael (2003)	On-site interviews evaluated employee strategic alignment when implementing a lean manufacturing program	Employees with higher levels of knowledge of the new strategy tend to exhibit major levels of commitment, job satisfaction, and trust
Vlosky et al. (2003)	Proposed a conceptual framework to increase value-added in the forest products industry in Honduras. Focused on pine and hardwood forest industry	Guidelines to better utilize forest and all related associated matters

In summary, a company needs to be efficient and effective at the same time. Lean thinking tools, such as VSM, can assist a company in reaching its efficiency goals by reducing waste, while meeting customer and company deadlines. Research in the wood products industry has focused primarily on empirical studies that survey the status of lean thinking applications in companies. But, it is unclear how lean thinking tools, such as VSM, can be used to measure value-added time in order to determine which activities are the ones that contribute the most to waste.

Methodology

The objective of this research was to quantify value-added activities through a multiple case study analysis of secondary wood products companies in Central America by using VSM. According to Ellram (1996, page 115), case studies are "excellent for theory building, for providing detailed explanations of 'best practices,' and providing more understanding of data gathered." Gilgun (1994) states that case studies are not well suited to probabilistic generalization, but they are useful to study problems in depth and gain understanding of certain processes when more detail is needed.

VSM was chosen as the analysis tool because it allows graphical description of a process by breaking down its value-added and non-value-added activities. Also, VSM can be used by top managers to introduce lean thinking concepts to front-line workers and operation managers. The use of VSM as an analysis tool to identify and reduce waste has gained credibility, not only in the manufacturing sector, but in the service sector as well (Hopp and Spearman 2004).

Value-added analyses have previously been performed primarily in North America. Information on value-added activities in the wood products industries in Central America based on lean concepts and tools is almost non-existent. This paper attempts to measure valued-added activities by using VSM in different companies in three different countries within the Central American region.

Table 3. Description of potential firms.

Company location	Products	Number of employees	Market
Costa Rica	Lumber, flooring, wood panels	35	Local, exports
	Lumber, engineered beams	300	Local, exports
	Doors	45	Exports
Guatemala	Flooring and decking	50	Local, exports
	Lumber, flooring, and decking	250	Export
	Flooring, furniture, lumber	75	Local, exports
Honduras	Lumber, furniture, other wood products	7	Local, exports
	Lumber and furniture	20	Local

In order to gather first-hand information that accurately assesses the situation of the secondary wood products manufacturing sector in Central America, three companies were identified in Guatemala, two in Honduras, and three in Costa Rica for a total of eight (**Table 3**). This selection was made based on the fact that these companies had shown some level of innovation at either the product, process, market, or organizational levels. According to OECD (2005), a firm might be considered an innovator if products, processes, markets, and organizational structures experience constant changes that lead to a steady increase of company performance. Considering this, the following factors were accounted for in selecting the case companies:

- Combination of technology: wood products companies need to properly combine new technology with old technology in order to be more cost efficient. The selected companies have a significant technology combination.
- Type of market: selected companies have a combination of domestic and international market activities. The ability to develop new markets was an important factor in selecting a company.
- Product innovation: The selected companies are constantly incorporating new products that require new process improvements. These companies are open to improving their competitiveness by incorporating the concept of innovation, not just to their products and processes, but also to their marketing and organizational structures.

Once the eight companies were identified based on the selection criteria, a modified diagnostic tool previously described by METAFORE (2006) was applied to all of the companies in the study. This diagnostic tool has been used by several wood products consulting firms to evaluate company performance based on the factors described previously. Specifically this tool was used to evaluate every internal business process of the entire value-added chain for each company. Quality control, raw material transformation processes, inventory management, product and process design, technology investment, marketing and sales, strategy and business management, financial issues, and supply chain management issues were the main business processes that were evaluated for each company.

It was also necessary to examine how external variables, such as forestry and market regulations, affected each company within its country. Therefore, in addition to the diagnostic tool, personal interviews were conducted. These interviews were directed to the owner or plant manager and ranged in length from 1 to 3 hours, depending on the detail needed in each case. According to Merriam (1985), this step is necessary in order to increase the reliability and validity of gathered data.

After information concerning each company's business processes was captured using the diagnostic tool, the companies with the highest diagnostic scores were selected, one from each country, to apply the VSM analysis. The main parameters of the VSM analysis were lead time, value-added (VA) time, non-value-added (NVA) time, and takt time. An explanation of how these values were calculated follows:

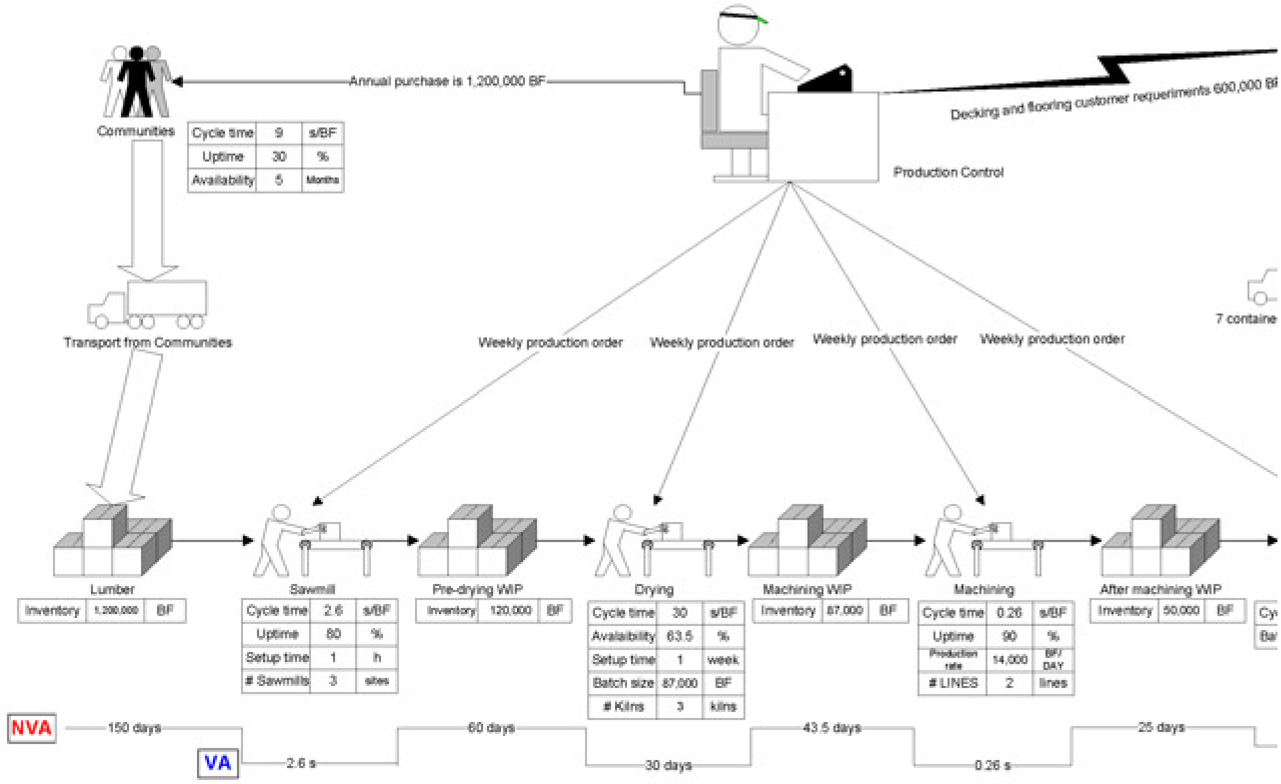
- Lead time (total process time) is the sum of all times, VA and NVA times, from the moment the supplier sends the raw material to the manufacturing site until the customer receives the order.
- VA time is the sum of all value-added activities. In this case a value-added activity is considered an activity that transforms the raw material or work in process inventory into a product that has some value from the customer perspective.
- NVA time is the sum of all activities that do not add value to the product. Waiting times, waste, overproduction, transportation, and moving activities are considered NVA.
- Takt time is calculated as the division of the daily demand by the daily available production time.

Results

VSM Analysis in Guatemala

Figure 1 shows the current value stream map for the selected secondary wood products company in Guatemala. For this case, working time is 5 hours/day, 6 days/week, and 25 days/month.

Figure 1. Current value stream map for the flooring and decking company in Guatemala. (**Full size figure**.)



VSM was developed for flooring and decking products produced from a local species known as Pucte (*Bucida buceras*). Marketing and production information showed that the demand for this product was estimated at 600,000 board feet per year (BF/year) with a 50 percent process yield estimate, meaning that a total of 1,200,000 Doyle BF are required in order to meet demand. Logs can be harvested for only a maximum of 5 months due to weather and road access conditions. Once the logs are transported to the yards, they wait an estimated 150 days before sawmilling. Capacity of sawmilling operation is not considered a problem as there are three available sawmills.

Figure 1 shows that the bottleneck operation is kiln-drying. For this operation, 1 month is required to dry 87,000 BF using three kilns at a 63 percent of full capacity. The setup time for this operation takes 1 week (loading and unloading the lumber). Further analysis shows that there are two moulding lines installed that can run up to 7,000 BF/day each, which sums to a total of 14,000 BF/day.

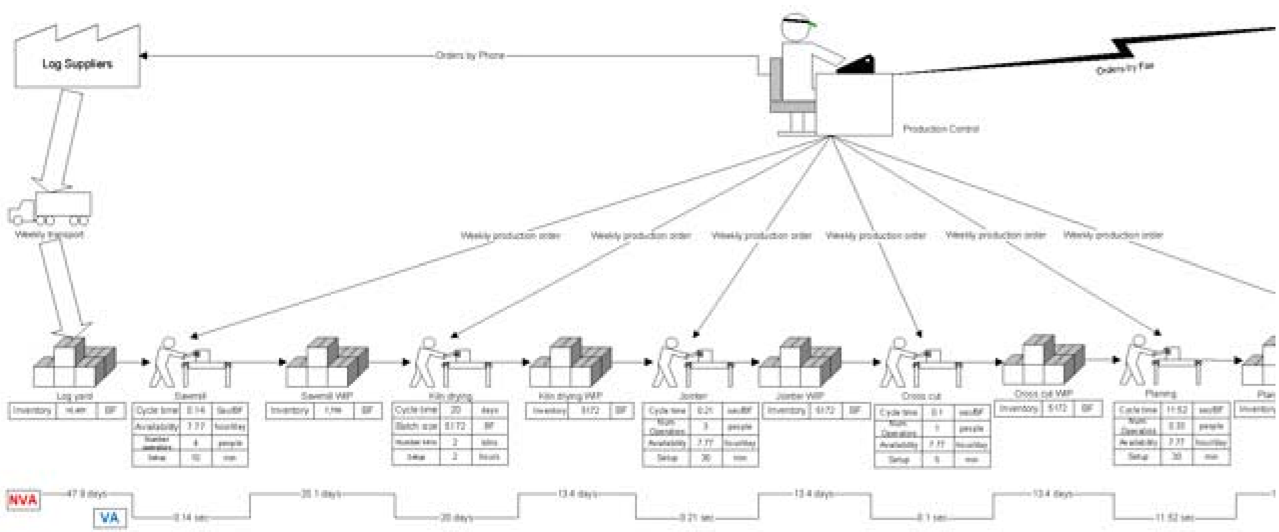
Finally, the packaging process in **Figure 1** shows that one container can hold up to 7,000 BF of finished product. Based on customer demand, it is necessary to export an average of seven containers each month (600,000 BF/year).

In summary, it can be seen from **Figure 1** that value-added time sums to approximately 30 days, while lead time sums to 338 days, meaning that only 8.8 percent of total lead time is considered value-added time.

VSM Analysis in Costa Rica

Figure 2 shows the value stream map for the secondary wood products company located in Costa Rica. For this company, value-added analysis was performed for its most common product, wood flooring. It can be seen in the map that the total process time is 168.4 days from the moment the company obtains logs from the supplier until the customer receives the product. Takt time was measured at 386 BF/day, considering an 8.5 hour/shift and 5 working days/week. Monthly demand for this product was estimated at 8,478 BF/month. One other important note is related to the work-in-process (WIP) inventory for each machining process. Based on the batch size from the two kilns, the WIP for the jointer, planing, moulding, and cross-cutting operations equals 5,172 BF. The WIP for the kilns was estimated at 7,758 BF, corresponding to an approximate 20.1 days of inventory for this process. From the total lead time, only 20 days correspond to the value-added time, or 11.9 percent of total lead time.

Figure 2. Value stream map for the wood flooring company in Costa Rica. (Full size figure.)



VSM Analysis in Honduras

Table 4 shows business statistics for the selected Honduran company. This company was created as a cooperative to help indigenous communities produce higher value wood products. With the help of non-profit groups, an initial capital investment was made to acquire the building and equipment and to train employees. The non-profit groups also helped to develop a new market in Europe for products made of lesser known species. During 2003, the second year of operation, sales reached $US 86,416.

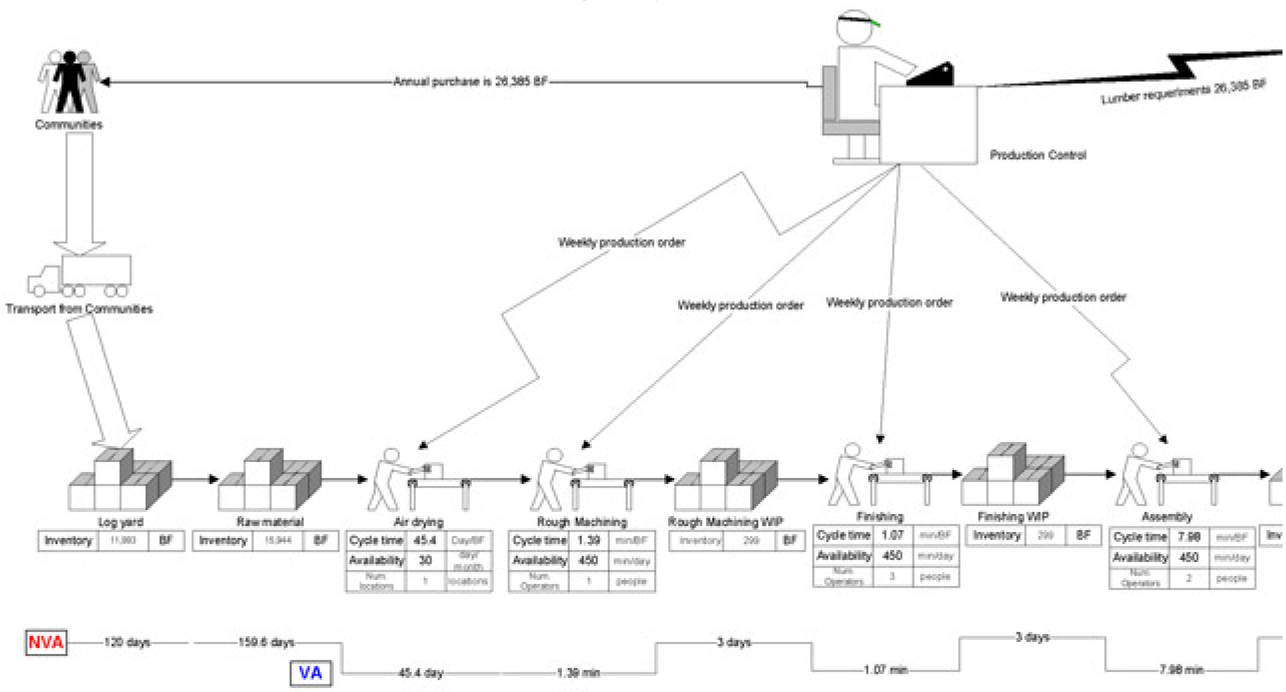
Table 4. Summary of Honduran company operations.

Item	Amount and unit
Available daily time for each operation	7.50 hours/day
Available days per week	5.50 days/week
Total value-added time	45.02 days

Total processing time	365.56 days
Total non-value-added time	320.54 days
Value-added time as a percentage of total processing time	12.4%
Non-value-added time as a percentage of total processing time	87.6%
Takt time	99.64 BF/day
Suppliers of lumber	7 suppliers
Supplier lumber capacity	1,000,00 BF/week
Monthly total demand	2,198.75 BF/month
Lumber demand as a percentage of total demand	46.60%
Furniture demand as a percentage of total demand	53.40 %

Table 4 shows the main production indicators and VSM results for this Honduran firm, while **Figure 3** shows the value stream map. The results indicate that value-added time sums to 12.4 percent of total cycle time (365.6 days) and the takt time is 99.64 BF/day. Weekly processing capacity is 1,000 BF and the company operates with 7 employees, 7.5 hours/day, 5.5 days/week. For this company, monthly demand is composed of lumber (46.6%) and furniture and other wood products (53.4%). Furniture and related value-added wood products from this firm are primarily exported to Europe (90% of total sales) and the United States.

Figure 3. Value stream map for the wood products company in Honduras. (**Full size figure**.)



Discussion

By applying lean thinking tools, such as VSM, a manufacturing process can be analyzed in order to identify those activities or processes that generate value and those that do not. VSM diagrams are a visual means of conceptualizing the raw material transformation process differently than other process analysis tools. The VSM analysis helps to identify activities or processes that are considered waste or muda (a Japanese term for waste) at several stages throughout the value-added chain in the manufacturing process.

In order to distinguish value-added operations from non-value-added, it is necessary to recognize the various types of waste that are present in a manufacturing environment. There are several types of waste including overproduction, delays, transportation, inventories, over-capacity, and human resource underutilization. Companies need to learn how to recognize and reduce waste in order to be more cost effective and increase the value of their products.

In this paper, VSM was used to quantify value-added and to separate it from non-value-added. As stated previously, waste in the manufacturing environment has many forms. In today's global economy, modern firms need to synchronize their supply chains so that inventory waste can be minimized to the point where customers are consistently receiving what they want.

In many companies, lead time and customer satisfaction have become, perhaps, the most important performance indicators. Reduction of waste enables enterprises to achieve internal efficiency and competitiveness. This study only reflects the present-day situation, and it does not develop a future VSM state for the three analyzed companies.

Table 5 summarizes the results of analyzing the three manufacturing operations using the VSM tool. One of the main differences that can be seen from **Table 5** is the total cycle time or total production time. In the case of Honduras and Guatemala, weather conditions are very difficult. From May to January, it is impractical to harvest timber due to persistent rainfall that affect roads and collection site conditions. For this reason, logging operations in these two countries can only be performed from February to May, allowing for just over 4 months to accumulate log inventories for sawmill operations. This situation considerably affects total cycle time and customer lead time.

Though difficult, climate conditions in the Costa Rican case are not as challenging as in the other two countries. Log harvesting sites are accessible from January to August. The longer harvesting season makes the average inventory in the Costa Rican case lower than the other two cases.

Table 5. Value-added comparison for three cases.

Case	VA as % of total cycle time	Total cycle time	Waiting time (days)		Annual production	Type of product
			Raw material inventory	WIP and finished inventory		
		(days)			(BF)	
Guatemala	8.8	338	150	159	1,200,000	Flooring and decking
Costa Rica	11.9	168.4	48	87	92,500	Flooring
Honduras	12.32	365.56	280	41	26,395	Lumber and furniture

After VSM was applied to the three selected companies, the ratio of value-added time and non-value-added time to the total cycle time was calculated. These ratios can be interpreted as a measure of how well a company is using its resources in order to transform raw materials into value-added products. According to Raymond (2002), a ratio of 5 percent of value-added time is considered respectable for any manufacturing company. In all three cases, the VA time was superior to this benchmark. One possible explanation is that, in this analysis, lumber drying, the most time-intensive task, was considered to be a value-adding process. In all three cases, the drying operations comprise over 98 percent of VA time. As such, the managers in this study should be mindful of the fact that total VA may be high when compared to benchmarks of other wood products industries.

The most important negative factors that affect VA come from firms which have to rely on large inventories (raw material, WIP, and finished products) to meet demand. In general, large inventories increase waiting times (Hopp and Spearman 2004). For two of the companies in the study (Guatemala and Honduras), the harvesting time window is only 4 months due to weather conditions. Raw materials must be stored for long periods to supply operations for the remainder of the year when harvesting is suspended. This condition alone adds 120 days to total process time for the Honduran case and 150 days for the Guatemalan case. In contrast, the Costa Rican log inventory was only 47.8 days.

Given these weather conditions, it is very difficult to reduce waste in the form of raw material inventory for companies whose situation is similar to the Guatemalan and Honduran case studies. It seems that this is necessary in order to ensure a log supply for the months that weather conditions prohibit harvesting. In fact, these companies focus much of their energies in filling their log inventories so that production does not cease when log harvesting is not possible. It is known that log inventories are costly to maintain, and depending on the log yard conditions, much damage could be sustained by rain or excessive sunlight exposure. Therefore, a company that comes up with a creative solution to this problem may substantially increase its competitiveness.

It is important to consider the NVA time added by the work in process inventory. Different from harvesting and logging conditions that lead to excessive raw material inventory accumulation, WIP inventory is a variable that the firms in the analysis could study and improve as needed. By looking for specific actions to decrease the amount of WIP inventory in all three cases, the total NVA time can be considerably decreased to benefit the firms and their final customers. For instance, **Table 5** shows the waiting times for raw material, WIP, and finished inventories. The contribution of waiting times for WIP and finished inventories to total processing time were calculated as 47.0 percent, 51.6 percent, and 11.2 percent for Guatemala, Costa Rica, and Honduras, respectively. These statistics support the belief that companies can decrease their total process time, lead time, and NVA time by focusing on WIP and finished inventory reductions.

Conclusions and Future Research

This research is presented with the goal of helping researchers and practitioners understand how to apply VSM to wood products firms. Most results of lean thinking studies focus on value-added analysis for large wood products firms, mostly located in North America. In this case, the application of VSM allowed for the quantification of value-added times for three firms located in Guatemala, Costa Rica, and Honduras. This study confirmed, especially in the Guatemala and Honduras cases, the findings of previous research showing that waiting times and inventories are perhaps the most important contributors to non-value-added time. The contribution of drying operation time is also important in that comprises more than 98 percent of total value-added time in all of the cases. No previous attempts in the literature were found to calculate value-added time including drying operations, because lean thinking research has been mostly applied to the secondary wood products industry rather than the primary wood products industry. This implies that primary wood products industries might show larger value-added times than secondary wood products companies. Therefore, future research on the calculation of VA time should focus on considering a specific set of benchmarks for each sector of the wood products industry so that comparisons can be conducted more consistently.

Acknowledgments

This research was partially funded by the TREE Program of Rainforest Alliance. Special thanks to Dr. Frank Judd, Director of the TREE Program.

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