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Green productivity: waste reduction with green value stream mapping. A case study of leather production

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Abstract: This study aims to identify and reduce waste in PT Rajapaksi Adya Perkasa manufacturing company. The analysis uses the concept of green productivity with Green Value Stream Mapping as the analysis model. Through the GVSM current state, this study calculates the amount of green waste in the production line including seven green waste. The result of this study shows an improvement to minimize the waste that occurs through the GVSM future state. GVSM technique increases the green productivity value from 1.12 to 1.81.

Key words: green productivity, green waste, green value stream mapping, economic indicator, environmental indicators.

1. Introduction

Globalization has an impact on the development of the world economy. An open economy has created a competitive atmosphere among industries not only at the national level but also at the international level (Saxena et al., 2007). The industry must be able to survive and have a strategy in winning the global competition. Increasing production is one of the right steps. Manufacturers face continuous demand so producers need to pay attention to the environment as a rule that is enforced throughout the world (Gungor & Gupta, 1999).

Environmental problems from the impact of products that are continuously rarely noticed by companies. Indonesia, especially East Java, which is one of the largest leather material industries in Indonesia, has problems with poor environmental management. Many production processes are not based on environmentally friendly concepts. The remainder of the skin cutting is not used properly, besides being sold, it is also disposed of freely into the environment. Disposal of raw materials is detrimental to the company in terms of the economy and can cause landfill. More directed environmental management is needed to reduce its impact on the environment.

Overcoming environmental problems, Elkington (1997) presents a challenge to achieving sustainability as an unprecedented source of commercial opportunities for competitive companies, one of which is through increasing environmental efficiency. The underlying assumption is that financial success can be made consistent with the compliance of ethics, environment, and society (Dobers & Wolff, 2000; Mohanty & Deshmukh, 1998; Stead & Stead, 2000).

In the concept of environmental efficiency, green productivity is one part of this effectiveness. Green productivity is an effort to protect and improve the quality of the environment (Hur, 2004). Green productivity is an alternative solution in evaluating and improving the environment by adjusting financial analysis (Singgih et al., 2010). Green productivity is

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a strategy that is not only a commitment to protect the future of the environment, preserving natural resources, but also building a future factory towards sustainable development (Sheng et al., 2005).

Green productivity must be increasingly important and quick to do (Brandt, 2007; Corbett & Klassen, 2006; Dills & Stone, 2007; Stead & Stead, 2000) given that as population increases, and the economy develops, ecosystems and resources of the planet experience external challenges usual (de Burgos & Cespedes, 2001; Esty & Winston, 2009; Hart, 1995; Kleindorfer et al., 2005; Mohanty & Deshmukh, 1998). The production system, which supplies increasing demand for goods, is associated with adverse environmental impacts (Frosch & Gallopoulos, 1989).

Gaur et al., research (2011) shows that green productivity can know the development of declining productivity and neglect the environment. This can be used as a reference to find alternative solutions for future improvements. By setting standards for assessment to be ratified by the government. In addition, providing solutions by renewing environmentally friendly technology. With the green productivity approach, companies benefit from minimizing the use of energy resources so that production processes are more effective and increase profits.

Increasing productivity alone will not continue if you do not pay attention to environmental security issues. Integrating productivity improvements by paying attention to the environment is a challenge in the current industrial era. Even though such things are needed to survive in increasing global competition. while productivity provides a framework for continuous improvement, environmental protection provides the basis for sustainable development. Based on the description of the above problems, the purpose of this research is to increase productivity by paying attention to the environment through green productivity, as well as providing alternative solutions to solve economic and environmental problems so that it can improve and develop sustainable industries.

2. Literature Review

2.1. Green productivity

Green Productivity is an understanding that a healthy environment and a strong economy can foster an interdependent competitive business climate. The potential for using Green Productivity integrates environmental protection into business operations as a platform of increasing productivity (Asia Productivity Organization, 2008).

Green productivity measurement is a measurement tool used to measure the performance of green productivity implementation. It could be said as a strategy to increase productivity and environmental protection, by analyzing productivity and environmental performance separately (Findiastuti, et al., 2011).

Asia Productivity Organization (2008) explain that life cycle cost is the entire product life cycle starting from extraction, use and disposal of products by evaluating the environmental burden of a product. This approach comes from Europe and is considered as the development of environmental friendly products. Conventionally, the increased in productivity is focused on cost effectiveness through cost reduction. With the emergence of the "quality" impulse, productivity is measured by comparing the benefits obtained from the program (output) with the quality of the resources used in the program (input).

$$\text{Green Productivity Index} = \frac{\text{Selling Price/Life Cycle Cost}}{\text{Environmental Impact}}$$

Adopting GP ratio, Gandhi (Findiastuti, et al., 2011) justify 'Environmental Impact' by weighting the environmental indicators of Solid Waste Generation (SWG), Gas Waste Generation (GWG), Water Consumption (WC) as the following:

$$\text{Green Productivity Index} = \frac{\text{Selling Price/Life Cycle Cost}}{\text{w1SWG+w2GWG+w3WC}}$$

2.2. Green waste

Besides Lean Waste, Breet Wills (Balinski & Grantham, 2013) states that the presence of green waste that can be measured and systematic. Green waste is categorized into seven namely energy, water, material, waste, transportation, emissions, and biodiversity. Wills explained in detail every green waste on the following:

1. Energy refers to the source of electricity generation and production. Energy is believed to be a waste when it is overused and it becomes a dirty source.

2. Water as a limited source. Excessive use of water is said to be wasteful, in financial terms it is seen from the cost of water consumption and contaminated water.
3. Material waste that comes from defect products.
4. waste that comes from green waste disposal.
5. Emissions that are formed from waste dumps, recycling, and combustion.
6. Transportation waste, namely how much transportation is used for people, materials, supplies, and finished products.
7. Biodiversity waste includes disruption to the surrounding environment such as tree logging or garbage accumulation.

2.3. Environmental indicators

Findastuti (2011) says that eco-efficiency of production is related to the ability to produce goods and services by minimizing the causes of environmental damage. There are two indicators to find environmental efficiency, namely economic indicators and environmental indicators. Environmental indicators are the denominator of eco-efficiency ratios. Environmental indicators at all levels are related to the environmental themes of each unit depending on the product, process, or service.

Marizkaa et al. (2015) explains that the Green productivity index is calculated by the environmental impact formula, a model of increasing green productivity to ensure the quality of production and reduce environmental impacts simultaneously.

According to Asia Productivity Organization says that the environmental impact from the production. The process is defined as the accumulation of the production process of leather material, which is the three environmental variables including Solid Waste Generation (SWG), Gas Waste Generator (GW) and Water Consumption (WC) as described in the equation:

$$EI = A(SWG) + B(GWG) + C(WC) + D(LC)$$

$$EI = (0.375 \times GWG) + (0.25 \times WC) + \\ + (0.125 \times SWG) + (0.25 \times LC)$$

Note: EI: Environmental Impact, GWG: Gas Waste Generator, WC: Water Consumption, SWG: Solid Waste Generator, LC: Soil Pollution.

2.4. Economic indicator

Findastuti (2011) sais that eco-efficiency of production is related to the ability to produce goods and services by minimizing the causes of environmental damage. There are two indicators in finding efficient environments, which are economic indicator and environmental indicator. Economic indicator is numerator in environmental efficiency ratio. Micro level economic indicators are about the value of products or services, such as: net sales, production per year, gross added value.

3. Methodology

This research is a qualitative study with a case study approach. This research was conducted on the small and medium scale leather industry (IKM), namely PT. Rajapaksi Adyaperkasa East Java, Indonesia. Data collection is used by the method of observation, interviews and documentation. This study focuses on knowing the green productivity process (green productivity). The measurement of green productivity comes from the comparison of economic indicators and environmental indicators. Economic indicators derived from productivity and environmental indicators are obtained from the green value stream mapping.

Green value stream mapping as a model minimizes economic impacts by maintaining indicators of economic growth (Marizkaa et al., 2015).

Breet Wills (Balinski & Grantham, 2013) said the green value streaming mapping procedure is very similar to value streaming mapping, namely the initial structure of supplier diagrams, customers, value stream activities, and information flow are identical. But the difference lies in green waste, namely energy, water, materials, waste emissions, transportation, and biodiversity.

Breet Wills (Balinski & Grantham, 2013) continues that there are several steps in the green flow map, namely: 1. Identification of inputs and outputs, 2. Measuring recycling, 3. Classification of each input and output as biological or technical, 4. Assessing the effect of the material on environment and society, and 5. Elimination of materials that have a negative impact on the environment.

4. Result And Discussion

This study focuses on knowing the green productivity process at PT. Rajapaksi Adyaperkasa. The measurement of green productivity comes from the comparison between economic indicators and environmental indicators. Economic indicators derived from productivity, while environmental indicators are obtained from the green value stream mapping.

4.1. Current state maps

Current state maps is one of the bases of continuous improvement. All information about the current state map is now collected based on the method suggested by Rother and Shook (1999). In current state maps, economic indicators and environmental indicators are explained. Economic indicators for analyzing circumstances about process inputs, production processes, and output processes and the initial productivity of industry in this case leather industry and the use of resources that will be counted as environmental indicators.

4.1.1. Input

Input is obtained from the labor force, production process, product, and inventory. The production process consists of cutting, preparation, stitching, and assembling. The workforce is 3,000 employees and 250 office staffs. There are 3 product categories namely woman, man, baby, and unisex under the brands of Santica, Airmax, Disney, Hasbro, Cars, Pokemon, and Marvel. The company produces 54,000 pairs of shoes per month. The production process can be described in the following sections:

1.1.1. **Production process**

The production process starts by receiving pre-orders from consumers, choosing the desired shoe model. Then from the company offers about certain models as additional shoes, if it does not agree, the model is kept as a database, and if agreed, the development division works on the model desired by the customer. This division uses sophisticated machines so that the process can be guaranteed. The next process is making shoes, and when the shoes are ready, the company sends shoes to the customer. The order flow diagram can be seen in Figure 1.

The process of production unit consists of 4 stages, namely cutting, preparation, stitching, and assembling. First, cutting process is trimming shoe materials into certain shapes which are divided into upper side (outer hood), lining (inside of shoe), insole (instock, EVA, Texon), strap (replacement strap), famp (front part of shoe), quarter (middle body), back counter (the back side of shoe consisting of back tabs and variations), outer and inner tongue, and toe cap. The cutting process uses trimming machines.

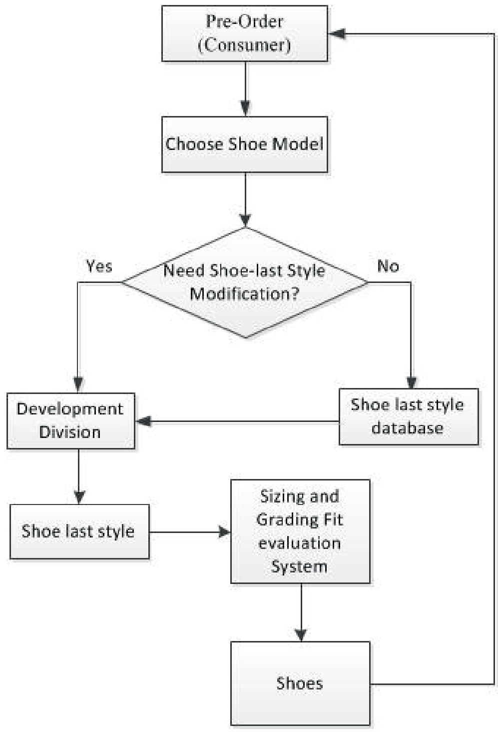

Figure 1. Order scheme of Shoes.

The second process is preparation, this process only consists of two times namely Interlining and Lining using a sewing machine. The goal is to provide a coating so that the feet don't get scratched and feel warm. After that, matching each shoe-making component makes it easier for the assembling stage to assemble each shoe. This division prepares 20-40 components that must be paired into a pair of shoes.

The third stage is the stitching stage that contains shoe components sewing process. The process begins with skiving/scrapping which aims to smoothen the component. Each component is sewn in a zigzag pattern, then the variations are placed to order. The sewing process uses 1 needle or 2 needles. Next, the shoes are returned to the foam collar section and trimmed by the stitches. Next, the strap insertion process is done to attach the rope by sewing "tongue" part. After the stitches meet the standard required, there is a shoe cleaning process. Before entering the final stage, there is a quality control team and molding process to make sure that the shoe shape is firm.

The last step is assembling, which is the stage of assembling the shoes. This stage consists of three parts. The first stage, shoes must be checked first by quality control to prevent damaged items. Shoes enter texon, upper, and shoe lase preparations process that contains applying laxes taxon and upper layers to the shoes, then the goods are put into the oven. The next process is using the Tupap machine to make the shoes supple and firm. Shoes are drawn sampling by the "workers" to sew upper sampling and use a cutting machine to form the back of the foot.

The second assembling stage consists of a vacuum heater (leather), there is a front-part grinding process and the side-part grinding process. Next, scrapping the upper and bottom part of the shoes. Shoes are given adhesive material for upper (subordinate shoes) and outsole (rubber shoes). Then the shoes are put into the oven again and applying the adhesive material to the upper and outsole. Shoes are put in the oven and apply the second adhesive material to the upper and outsole to be assembled together. The shoe enters the universal press machine to press the shoes so that it can be more adhesive and the shoes are inserted into the excessive glue removal machine and heating machine.

The final assembling stage is a finishing process consisting of shoes inserted into a cooling machine. Then the shoe lasts releasing process and cleaning the rope, insock, as a whole. Before being packaged, goods are controlled in advance by a quality control team. The goal is to ensure the goods are in good quality and avoid defective items. If the item is defective, it will be repaired immediately. If the damage is severe then it needs to be returned to pre-order items. When the item is perfect, the item is ready to be packaged through the packaging process. The production process chart of PT. Rajapaksi Adyaperkasa as follow (Figure 2).

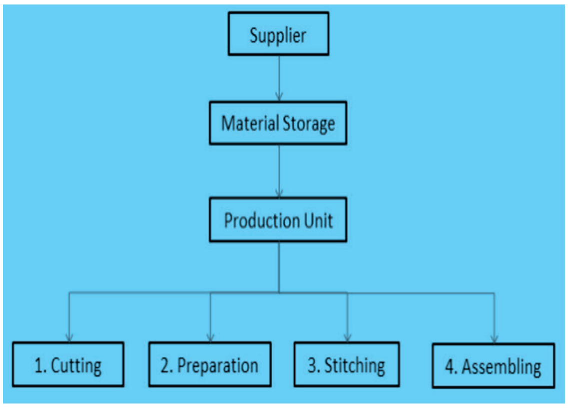

Figure 2. Production Process.

This production process requires costs in the process. The total production cost for 79,370 unit per month is Rp. 9,741,228,000, that consists of:

Table 1. Cost of Production Process Current State Maps.

No	Cost of	Total (in Rupiah)
1	Worker salary	6,816,500,000
	1573 workers (@3,580,000)	6,056,050,000
	152 office staff (@5,000,000)	760,000,000
2	Material	1,157,000,000
3	Raw-Material	1,237,000,000
4	Electricity	530,728,000

4.1.2. Output

Output of each stage has different targets. Cutting target consists of 10-12 pairs/hour (leather), 2000 pairs/day (upper), 300 pairs/hour, while preparation is 70 pairs/hour (all component), for Stitching consists of 33 people produce locally 23 pairs/hour and expert 85 pairs/hour and assembling stages which are 30 pairs/hour. From the entire process, the total number of shoes produced was 79,370 consisting of standard products and defects of 2920 pairs. Total sales of shoes for 77,950×Rp. 300,000 is Rp. 23,385,000,000.

4.1.3. Productivity

To get the high productivity level, it is necessary to compare inputs and outputs in each production process. Calculations are calculated as the ratio of product sales revenue /total production cost. The total production cost for 79,370 units per month is Rp. 9,741,228,000. Total sales of shoes for 77,950×Rp. 300,000 is Rp. 23,385,000,000

$$\frac{\text{Rp. } 23{,}385{,}000{,}000}{\text{Rp. } 9{,}741{,}228{,}000} = 2.40$$

Productivity level below 50% indicates low productivity. Santica brand shoes at the lowest productivity level, because the productivity percentage is only 40% of the total sales of Santica shoes. Meanwhile, the productivity level included in the high productivity category should have the percentage of 50% above. The highest productivity level is 80%, namely Airmax shoes.

4.1.4. Environmental impact indicator

According to the Asia Productivity Organization, the environmental impact of production is the process of accumulation of the production process of leather material, among others, the three weights of environmental variables including Solid Waste Generator (SWG), Gas Waste Generator (GWG) and Water Consumption (WC) as described in the equation:

Table 2. Waste Production of Current State Maps.

Green Waste	Rajapaksi Adyaperkasa Company
Energy	1503 kwh
Water	3843.5 liter
Material	4571.5 kg
Garbage	230.5 kg
Transport	95 km
Emission	21.81 kg
Bioversity	1,001 ha

Total Production of leather shoes is 54,000 pairs of shoes. The assumption is that producer produces 700 per one lead. So that for a production base of 1 ton of shoes at least 80 times the lead.

Gas Waste Generator (GWG) is 21.81 kg per machine. Land Consumption (LC) 4571.5 kg. Water Consumption is 3843.5 liters because the density of water reaches 1 kg/liter. Solid Waste Generator (SWG) 230.5 kg is waste originating from dirty leather material and material that is not in accordance with the standard. From the data generated from the process, the environmental impact can be calculated in part as follows:

$$EI=(0.375\times21.81)+(0.25\times3843.5)+(0.125\times230.50)+(0.25\times4571.5)=8.17875+960.875+28.8125+1142.875=2140.74125 \text{ kg or } 2.14 \text{ ton}$$

Based on the results of the impact of economic indicators and environmental indicators, then calculated with green waste in accordance with current conditions (current stage), then the following comparison is obtained:

$$GPI = 2.40 : 2.14 = 1.12$$

Based on the data described above, current state maps can be seen in Figure 3 below as follows:

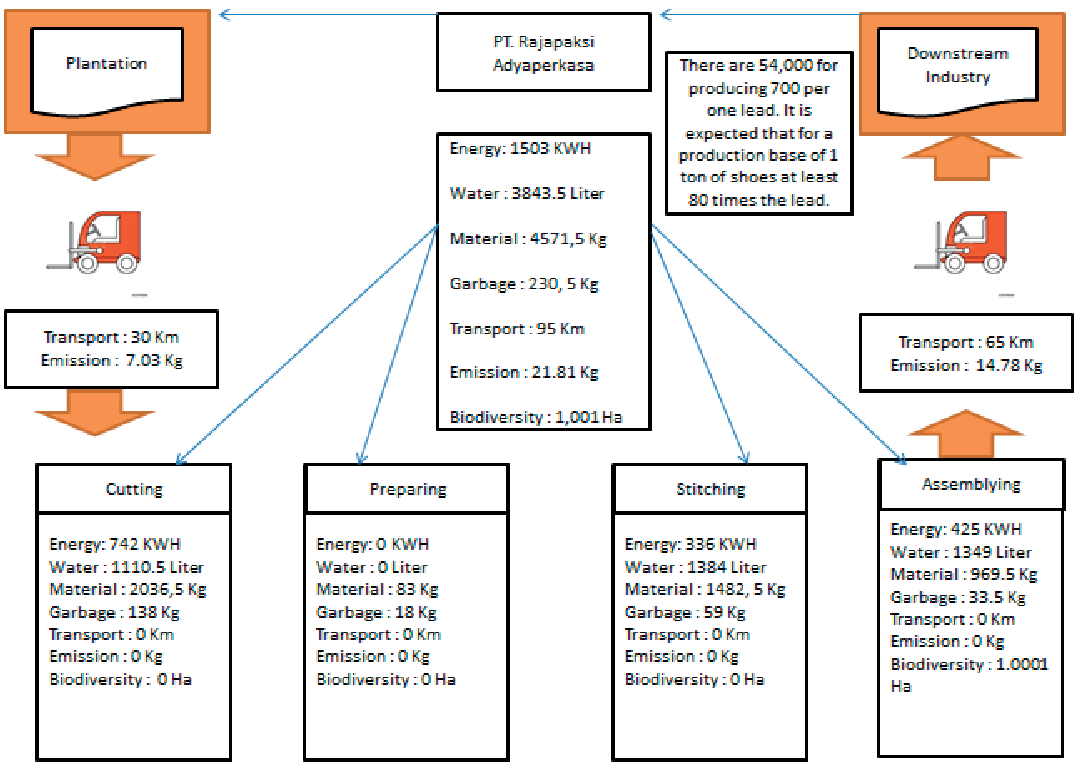

Figure 3. Current State Maps.

4.2. Future State Maps

Future state maps situation is nothing more than an implementation plan that describes the tools needed in the lean process to eliminate waste and where (in what process) the tool is needed in the value flow of a product. The process of mapping future conditions develops productivity and reduces the amount of waste that can affect the level of productivity of the company. Meanwhile, a complete value stream to map perfect future conditions must try to define lean equipment to reduce both. This, of course, follows an efficient procedure in which it tries to answer a set of questions that have been prepared, therefore, produces a mapping of future conditions that will facilitate the reduction or at least eliminate various types of waste in the current manufacturing structure. The application of future state maps illustrates an improvement in every production in manufacturing. explanation of future state maps is a change in economic and environmental indicators.

4.2.1. Input

The total production cost of 79,370 unit per month is Rp. 7,357,228,000, consists of:

Table 3. Cost of Production Process Future State Maps.

no	Cost of	Total (in Rupiah)
	Worker salary	4,692,500,000
1	1145 workers (@3,580,000)	4,099,100,000
	118 office staff (@5,000,000)	592,900,000
2	Material	997,000,000
3	Raw-Material	1,237,000,000
4	Electricity	430,728,000

Based on the table data above, there was a reduction in workforce of 428 people for workers and 34 people for office staff. The use of materials and electricity also has a reduction so that high productivity occurs in the production process.

4.2.2. Output

The total number of shoes produced is 79,370 consisting of standard products and defects of 2920 pairs. Total sales of shoes for 77,950×Rp. 300,000 is Rp. 23,385,000.

4.2.3. Productivity

To get the high productivity level, it is necessary to compare inputs and outputs in each production process. Calculations are calculated as the ratio of product sales revenue/total production cost. The total production cost for 79,370 units per month is Rp. 7,357,228,000. Total sales of shoes for 77,950×Rp. 300,000 is Rp. 23,385,000,000.

$$\frac{\text{Rp. } 23{,}385{,}000{,}000}{\text{Rp. } 7{,}357{,}228{,}000} = 3.17$$

4.2.4. Environmental impact indicator

Meanwhile, economic impact indicators are described as follows:

Table 4. Waste Production of Future State Maps.

Green Waste	PT.Rajapaksi Adyaperkasa
Energy	1089 kwh
Water	3527.5 liter
Material	3407 kg
Garbage	206 kg
Transport	80 km
Emisi	12.38 kg
Bioversity	1,001 ha

Total Production of leather shoes is 54,000 pairs of shoes. The assumption is that producer produces 700 per one lead. So that for a production base of 1 ton of shoes at least 80 times the lead. Gas Waste Generator (GWG) is 12.38 kg per machine. Land Consumption (LC) 3407 kg. The use of water in production is 3527,5 liters because the density of the water reaches 1 kg/liter. Solid Waste Generators (SWG) 206 kg is a waste originated from the dirty leather material and material that is not in accordance with the standard. From the data generated from the process, the environmental impact can be calculated in part as follows:

EI=(0.375×12.38) + (0.25×3527,5) + (0.125×206) + (0.25×3407) = 4.6425 + 881.875 + 25.75 + 851.75 = 1765.0175 = 1.75 ton

GPI = 3.17: 1.75 = 1.81

Based on the data described above, future state maps can be seen in Figure 4 below as follows:

5. Conclusion

This study analyzes green productivity based on economic indicators and environmental indicators. The economic indicator is obtained based on the input and the result of the output ratio is 2.40. While environmental indicators are calculated by

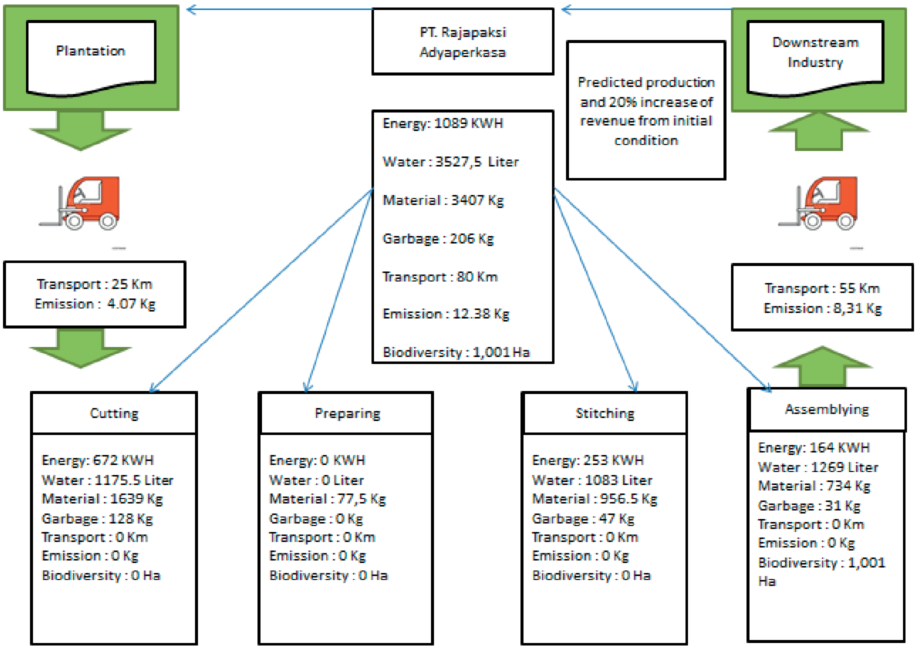

Figure 4. Future State Maps of Pre Processed Rubber.

the environment index formula is 2.14. So, green productivity index produces 1.12. Green productivity techniques are able to provide solutions to improve pollution (Balist, 2016).

This study uses the green value streaming mapping technique to evaluate alternatives to improve green productivity. The current state of green value streaming mapping is based on the results of green productivity. The researchers give suggestions through the future state green value streaming mapping table. The GVSM technique can increase the value of green productivity from 1.12 to 1.81. Increasing in value of green productivity is a good sign of the value of green productivity. The same idea with Primary research (2015) that the greater the EPI value, the better the environmental performance that has been applied in the company. Deviation (Pi) can be said to be good if the percentage is positive and bigger.

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