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Green Supply Chain Management with Life Cycle Assessment Approach for Degraded Forest Management: A Strategic-Fit Framework

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Abstract. Unsustainable forest management is considered as one of activities that leads to forest degradation. Together with deforestation, degraded forests are contributors to the greenhouse gas emissions from the forestry sector, so it needs to be controlled. Furthermore, degradation affects the forest's productivity, and thus will affect the performance of the company which owns the licence for the utilization of its timber forest products. The objective of this research was to be able to identify aspects in Green Supply Chain Management and Life Cycle Assessment which are considered the most relevant to be applied in the management of degraded forest, and further to be structured in form of framework. The method used in this research is a qualitative approach with a case study PT XYZ as the holder of a Business License for the Utilization of Timber Forest Products in Natural Forest, in East Kalimantan. Research data obtained through literature studies, field observations, and interviews with key personnel in the company. Data is then analyzed through reduction and concluded. The results showed that internal supply chain activities, namely forest planning, forest development, log production, and marketing, play a significant role in the process of greening the supply chain. The proposed GSCM-LCA Framework includes Green Planning, Green Operations, Green Distributions, and Green Marketing with LCA observations focusing on evaluating and analysing environmental impacts caused by their harvesting and transportation activities. The design of the framework in this study emphasizes strategic-fit, as an effort to adjust the company resources and abilities towards the opportunities in the external environment.

Keywords. Green Supply Chain Management, Life Cycle Assessment, degraded forest, strategic-fit

1. Introduction

Forests play an important role as an environmental buffer. Besides its function in carbon sequestration, forests are also potential in providing sustainable alternative fuels (biofuels). However, forestry sector activities are considered as one of the sectors that contribute significantly to emissions. (Wibowo, Handayani, & Mustikasari, 2018)

The great potential to convert the biomass in the forests as a renewable energy source must go along with the ability of forestry sector organizations to pay more attention to environmental impacts in carrying out their production activities. Indonesia was in the highlight because of the emissions resulting from its forest management activities.

Based on 2014 data, Indonesia is the largest emitter producing country from its logging activities, with a total emission of 50,7 TC/Ha per harvest (Table 1), where the total of emissions is calculated from extracted log emissions (ELE), logging damage factor (LDF) and logging infrastructure factor (LIF). (Pearson, Brown, & Casarim, 2014).

Table 1. Total Emission of Logging Activities per harvest in several countries

Country	Timber extraction rate (m ³ ha ⁻¹)	ELE (Mg C ha ⁻¹ harvest ⁻¹)	LDF (Mg C ha ⁻¹ harvest ⁻¹)	LIF (Mg C ha ⁻¹ harvest ⁻¹)	Total logging emissions per harvest (Mg C ha ⁻¹)
RO Congo	9	2.3	4.5	2.2	8.9
Indonesia	34	8.5	19.4	22.8	50.7
Bolivia	5	1.5	6.2	1.4 ^a	9.0
Brazil	5	1.9	3.6	1.4 ^a	6.8
Guyana	13	4.7	12.9	12.7	30.3

Besides the forest fires, unsustainable forest management and logging practices were identified as one of the activities that caused forest degradation. In production forest (HP), the state of being degraded lowering the production capacity and the overall productivity of the forest itself. Therefore that the utilization of the timber forest products in such condition can be considered no longer profitable, especially associated with the cost's imposition by the government on timber forest products which contributes to the high cost of production.

The world market demands for environmentally friendly products from the forest, as well the terms and regulations that underlie it, affect how companies owning Business License for the Utilization of Timber Forest Products in Natural Forests (IUPHHK-HA) run their businesses and make plans in order to compete globally while maintaining the sustainability of their resources.

With the complexity in running the forestry business, companies are required to implement an integrated management strategy, which can solve environmental issues and in the same time improving their performance.

In the forestry sector many planning problems arise along the chain, so coordinating wood flow is an important stage for many companies. (Carlsson & Rönnqvist, 2005). The supply chain activities in wood production activities begin with trees standing in the forest and continue with planning, harvesting, scaling, grading, transportation, wood processing, and ending in selling to various customers.

The case study in this research is PT. XYZ, in East Kalimantan, the company that holds a Business License for the Utilization of Timber Forest Product in Natural Forest (IUPHHK-HA). In 1997/1998, PT XYZ's concession experienced severe forest fires towards $\pm 65\%$ of its area, turning the most production forest area, including the logged-over area, into degraded forest.

The limited quantity and quality of raw materials, degradation, stagnant prices of forest products and the broad awareness of global warming, makes the company facing two things at the same time, challenges and opportunities.

Challenge, because to be able to run the business sustainably, the company need to change the pattern to a new one by optimizing the utilization of available resources into a product that has competitive advantages. Challenges also comprise how these conditions will change the way how the business should be managed, including putting together procedures that did not exist before. Opportunity, because the world market demand for renewable energy sources provides an opportunity for companies to develop biofuel products such as bioethanol, woodchips, and wood pellets.

In line with the company's vision and mission to develop and implement a sustainable production forest management system and in the same time gain profitability, the management has obtained a Pilot Project permit putting in to practice a silvicultural system of Clear Cutting With Planting (THPB) with renewable energy-based on the part of its degraded forest area, which is an area of 30,852 hectares. This, in some measure, is part of an effort to optimizing the area potential with different types of wood-energy that consist of various cycles, including Arenga Pinata (Aren), to ensure the sustainable supply of raw materials for the bio-coal / wood pellet and bioethanol industries, as well as to increase productivity and profitability while still maintaining biodiversity as a whole in non-forest areas. (Suplemen RKUPHHK-HA PT XYZ, 2016).

With the objective that the company needs to have tools for managing and controlling its supply chain activities more effectively and efficiently also by including an approach to calculating environmental impacts within a certain boundary, it is necessary to design a Green Supply Chain Management framework with a Life Cycle Assessment approach based on strategic fit to be applied to forest management in the THPB area.

2. Literature Review

2.1. Supply Chain Management (SCM)

SCM or Supply Chain Management enables organizations around the world to improve their performance by reviewing and redesigning their supplier networks, processes, and customers (Vahid et al., 2014).

In order to meet the needs of their final consumers, every manufacturing or service industry has a specific supply chain design. The supply chain of forest products can be categorized as a divergent supply chain, where the number of products multiplies along the chain. (Vahid et al., 2014). Logs harvested from the forest are sent to a variety of primary wood processing facilities after they are sorted in the sortyard, commonly based on diameter, quality and species. Furthermore, there are secondary wood processing facilities that use products or by-products from primary facilities (e.g. wood chips or sawdust) to produce final products (e.g. value-added wood products or bio-energy) which will be distributed to retail units or directly to end consumers, as in Figure 1. Each unit in the supply chain can act as an independent unit or be part of integrated forest company.

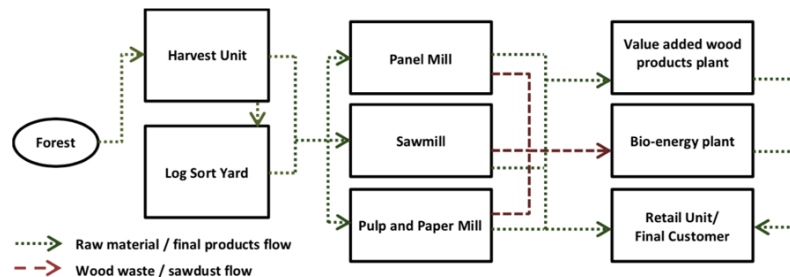


Figure 1. Overview of common supply chain in forestry production

2.2. Green Supply Chain Management (GSCM)

GSCM or Green Supply Chain Management is a concept that has been developed from Supply Chain Management, which includes elements of environment concerns at each point of its activities. GSCM requires companies to continuously improve their production performance by complying with the regulations regarding environment, with the intention to increase competitiveness as well as to improve company's brand image. (Ahmad H Sutawidjaya, Lenny Ch Nawangsari, & Suharno, 2017). GSCM is a concept to integrate supply chain management with environmental considerations and a goal to reduce waste, emissions, energy, and solid waste. (Wisner, Tan, & Leong, 2015).

2.3. Principles of GSCM

Srivastava (2007) differentiated GSCM main activities into Green Design and Green Operations, where Green Design emphasizes the environmentally conscious design (ECD) and life-cycle assessment/analysis (LCA) of a product. According to Ninlawan, Seksan, Tossapol, & Pilada (2010) and Chin, Tat, & Sulaiman (2015) GSCM principles include, among others, Green Procurement, Green Manufacturing, Green Distribution, Reverse Logistics. Hervani, Helms, & Sarkis (2005) define GSCM as Green Purchasing and Green Manufacturing / Materials Management and Green Distribution / Marketing and Reverse Logistics, altogether.

a) Green Procurement

Green procurement is related to the activities of minimizing the use of materials, prioritizing the reuse and recycling of materials, as well as reducing the use of materials which are harmful to the environment, and involving environmentally conscious supplier partners.

b) Green Manufacturing / Productions

Green manufacturing / productions is defined as a production process that uses inputs with relatively low environmental impact, which are very efficient, and which produce little or no waste or pollution. The principles of GSCM can lead to a lower raw material cost, profit from efficiency in production, a reduction in environment and work safety costs, and in the same time improve the image of the company applying it. (Atlas & Florida, 1998).

c) Green Distributions

Activities in green distribution include the selection and saving in packaging usage, including the use of environmentally friendly materials. Logistics are also the main determinant in green

distribution, covering the direct delivery to customers and the choice of environmentally friendly vehicles.

d) Green Marketing

Green marketing involves marketing products that have been assumed to be environmentally safe. It means that this aspect of marketing also pays attention to the elements of product modification, changes in the production process, changes in packaging, and changes in advertising. (Syahbandi, 2012).

e) Reverse Logistic

Reverse logistics is the activity of planning and controlling efficiently towards the supplies, raw materials, and finished goods, in order to gain the value that still exists in a product or to properly dispose it. (Rogers & Tibben-Lembke, 1998).

2.4. Life Cycle Assessment (LCA)

LCA is a technique of assessing environmental inputs and outputs that occur at each stage of the product life cycle and process. (Morris, 2009). In other words, LCA focuses on environmental aspects and potential environmental impacts throughout the product life cycle, starting from the acquisition of raw materials, transportation of raw materials, processing of raw materials, product distribution, consumer use of the product, recycling, recovery, and final disposal.

2.5. Forest Products LCA

In principle, LCA observations can be carried out partially or for the whole life cycle of a product, depending on the goal and scope of the assessment. This also applies for forest products, because activities in the forestry sector can be seen as an independent or integrated unit. The life cycle assessment system can be set in the limited scope of the forest biomass supply chain, as seen in Figure 2.

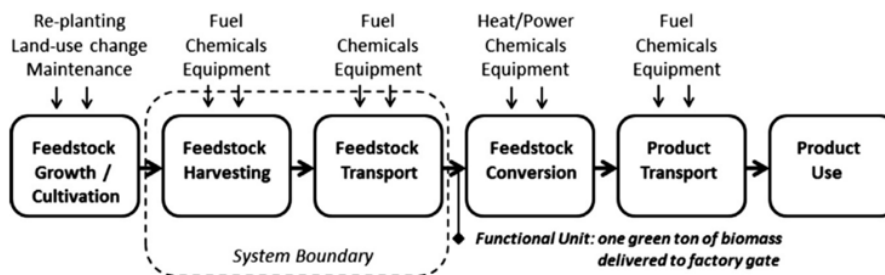


Figure 2. The schematic life cycle of a wood product.

2.6. Phases on LCA implementation

Based on ISO 14040 (2006) of “Environmental Management - Life Cycle Assessment - Principles and Framework”, LCA consists of 4 phases:

- Goal and scope definition, which determining the purpose and scope of the discussion. This stage describes the product, process, or activity.

- Life-cycle Inventory Analysis (LCI) involving data collection and calculation procedures, i.e., making an inventory of inputs and outputs from each process unit, identification and measurement of the use of energy, water, and raw material requirements and release to the environment (air emissions, disposal of solid waste, liquid waste, etc.) at the specified system limit.
- Life cycle impact assessment (LCIA), that is, a further assessment after the LCI stage, to identify the extent and significance of the environmental impacts associated with inputs that have been inventoried in the previous stage.
- Life Cycle Interpretation, namely the interpretation phase of the results from the previous stage, to arrange corrective steps.

3. Research Methods

The method used in this research is a qualitative descriptive approach with case studies in the company as a holder of IUPHHK-HA, where most of its production forest area is categorized as degraded forest. Data collection techniques are through in-depth interviews with 10 key informants, observation and literature review on published documents that are related containing research topics of Supply Chain Management, Green Supply Chain Management, and Life Cycle Assessment, preferably in the forestry and/or wood industry sectors.

The documents that have been obtained are then analyzed, compared, and synthesis. Interviews and field observations were conducted to obtain information about timber production flows, including sales, and identify the use of raw materials and energy. This information helps to determine which aspects of GSCM and LCA are relevant to be applied.

4. Results and Discussion

4.1. Proposed GSCM-LCA Framework

The proposed framework is based on extensive literature review, data collection, and information in the form of interviews and observations to achieve a strategic-fit framework that can help companies adjust between their resources and capabilities with opportunities in the external environment.

4.1.1. GSCM Framework. The main roles of the company as case study in this research are forest management, reforestation through replanting, land use, and maintenance (including forest protection). The company's business work plan is outlined in a Business Work Plan (RKUPHHK-HA) which has gained approval from the Director-General of Sustainable Production Forest Management, Ministry of Environment and Forestry of the Republic of Indonesia.

Based on the result of this research, the relevant aspects of GSCM to be put into the framework, according to the objective of this research, are as follows:

- Green Planning, covers the aspects of Green Design and Green Purchasing;
- Green Operations, represents the activities of planting and maintaining plants, harvesting and transportation, and wood processing;
- Green Marketing & Distribution;
- Reverse Logistics includes the reuse and remanufacturing of waste logging and wood processing activities.

Illustration of those aspects, and how the relationship between concepts and entities of the aspects are as presented in Figure 3.a.

The application of these GSCM aspects is expected to help companies to convert inputs in the form of natural resources, human resources, machinery, and equipment as well as investment and working capital, into outputs in the form of sustainable products, competitive advantage, efficiency and profitability.

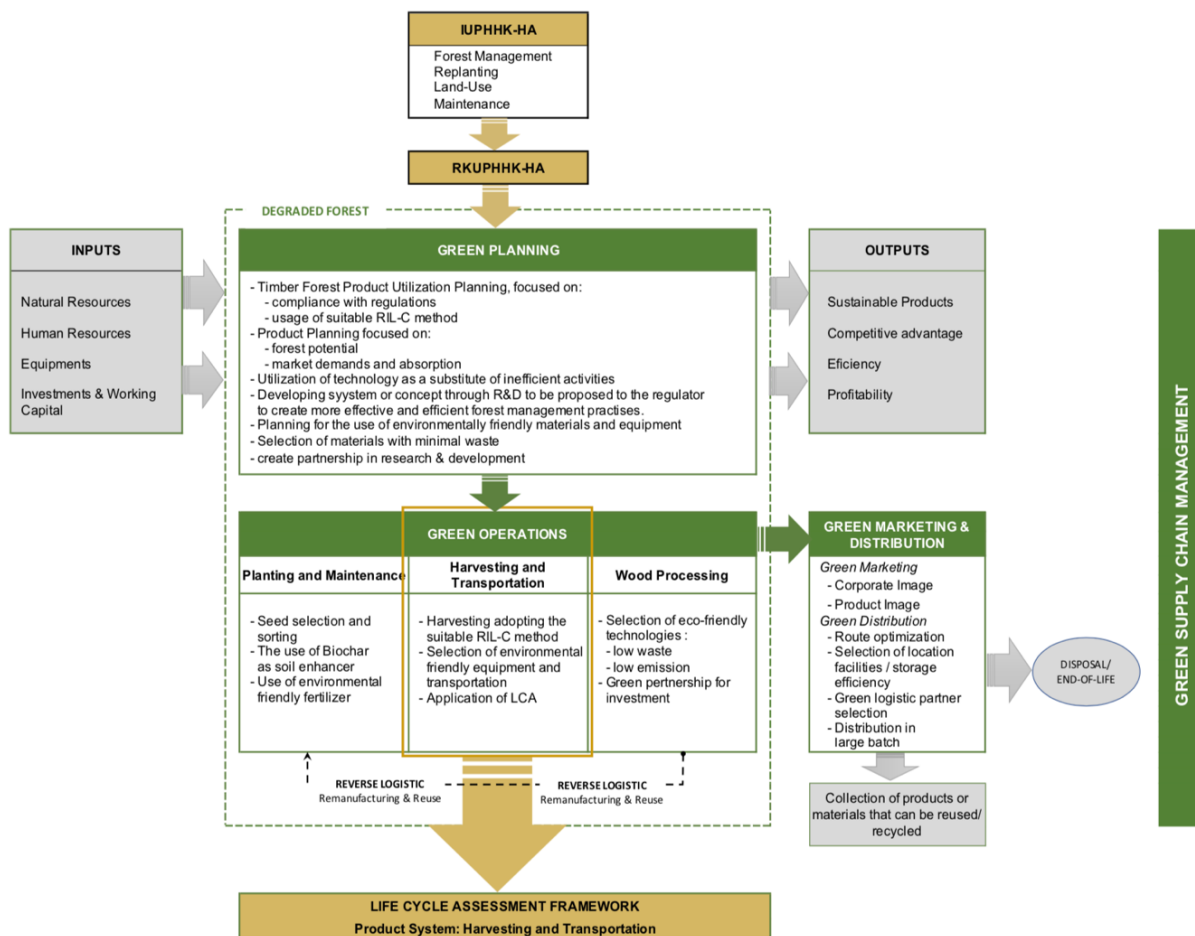


Figure 3.a. Proposed GSCM-LCA Framework (GSCM-Part)

4.1.2. *LCA Framework.* In companies utilizing timber forest products in natural forests, the following stage in the production system, after forest planning, is the harvesting activity. According to the THPB Silviculture-System, the harvesting system to applied in the field is clear-cutting, to be then replaced with a new crop. The concept of implementing LCA is as presented in Figure 3.b., which includes the following phases:

Goal and Scope. The goal and scope of the proposed LCA in this framework are:

- to identify hotspots of activities that produce the highest emissions, to be able to determine corrective measures;

- to help structure the GSCM, through designing and planning the process sequence based on the lowest emission impact, including the selection of equipment and materials that are more environmentally friendly;
- the system boundary of the LCA is limited to the activities involving the timber flow, starting from the extraction of the raw material during harvesting until transporting them to factory gate (cradle-to-gate).

Inventory Analysis. Based on field observations and interviews, mass and energy flow to produce 1 Ton of biomass within the proposed system boundary, include : fossil fuel (diesel fuel and gasoline), transportation (dump trucks, logging trucks), equipment (chainsaw, excavators, loaders, grapple, grader), material (barcode sheet, S-hook). While the inventory of output includes products (biomass) and emissions (greenhouse gas emissions: CO₂, CH₄, N₂O).

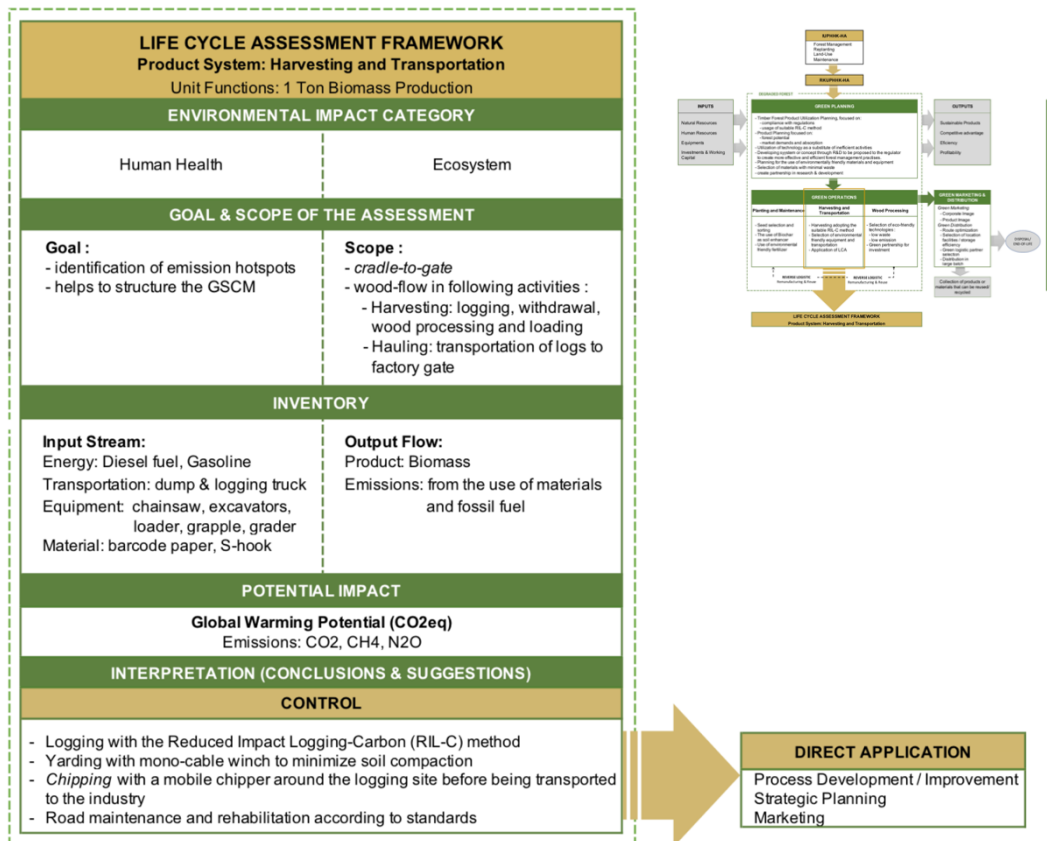


Figure 3.a. Proposed GSCM-LCA Framework (LCA-Part)

Impact Assessment. The impact assessment should be done to determine the impact of the production activities to produce 1 Ton of biomass, in the form of GHG emissions (kg Co₂-eq), where the activities including harvesting / logging, delimiting, extracting, scaling, and transporting the biomass to industrial sites. The estimated amount of GHG emissions per ton of biomass refers to the equation listed in the IPCC guidelines (2006), by calculating the inventory volume and fuel emission factors. The value of energy needs in each production of

1 Ton of biomass is obtained by multiplying the inventory volume by the calorific value. Emission factors and heat values used in the calculations refer to those applied in Indonesia, or in other words using a Tier 2 level of accuracy,

Interpretation. Process improvement scenarios can be proposed if the calculation is already obtained from the previous stage. However, based on a literature review of the previous research, the application of GSCM is able to help reduce carbon emissions and in the same time improve environmental. (Wyawahare & Udawatta, 2017). Several methods in RIL-C can also be adopted as an effort to reduce emissions from logging activities, including the use of mono winch cables (TNC, 2018). Road maintenance and rehabilitation can also help in reducing emissions. Chipping wood that will be converted into wood pellets near the felling site can also reduce carbon emissions during transportation.

4.2. Discussion

A strategic fit framework of GSCM-LCA, as the result of this research, is to be applied to logging areas with renewable energy-based THPB silvicultural system, where clear-cutting is carried out over the entire area. In this system, all aboveground biomass contained therein is extracted to optimize the fulfilment of alternative raw material needs.

By knowing the potential tree stands in the cutting block area, forest product planning can be designed accordingly to meet the market needs and still be able to pay attention to the impact to the environment and comply with regulations. Technology and innovation can be utilized to carry out an effective and efficient timber cruising and to design eco-friendly products within the life cycle.

Logging system and work sequences are important factors in forest planning because they affect the amount of emissions release into the air. The selection of only prime seedlings to be planted also plays an important role in minimizing waste, since they survive better.

Based on past research, the traditional mechanization and logs delimiting before extracting them by cable logging, is the method with the lowest carbon emission. (Mirabella, Castellani, & Sala, 2014). This shows that the choice of method, work order and tool is crucial when it comes to emissions, including choosing the right vehicle capacity and saving fuel as well as the application of eco-drive driving. Location determination of nursery to supply seedlings, of sort and stock yard, and of other facilities to support the operations, also affects the efficiency of activities. In environmentally friendly production process, the more materials can be utilized the better, because it means minimizing waste.

The aspect that needs to be considered in green marketing is the compliance with customer needs, such as environmental certification of products and of the production processes. This is essential to build an environmentally friendly corporate image. Having logistic partners who share concern about the environmental impacts also needs to be considered.

In this research, the reverse logistics already occurs in the relatively early stage of the whole process, which is when harvesting waste is processed into biochar and returned to the environment as a soil enhancer.

In the framework, Green Partnership is not presented in a single frame, because in principle the partnership to achieve the same environmental goals can be applied to almost all aspects of GSCM.

The direct application of this entire approach is the development and / or improvement of processes, strategic planning and also marketing, by having a self-declared claims that

emissions are controlled in the process of harvesting and transportation of timber.

There are various environmental impacts that have the potential to be assessed in forestry activities, including the measurement of the environmental impact of land use where the reforestation process involves the use of chemicals such as fertilizers, pest control, and other materials that cause environmental problems. Also, in the advanced wood production process that requires large amounts of water and also produces liquid waste that contains lots of organic substances. However, in this research, the assessment of the environmental impact was only limited to the measurement of GHG emissions (CO₂, CH₄ and N₂O), which are produced from the use of fossil fuel in logging, extracting, delimiting, bucking and transporting activities.

5. Conclusion

The framework of Green Supply Chain Management - Life Cycle Assessment which can be applied to utilization of timber forest products in degraded forests, emphasizes on Green Planning, include Green Design and Green Procurement; Green Operations, since extraction of raw materials until the wood processing; Green Marketing, including sales and distribution; and Reverse Logistics. The LCA approach used in this framework aims to identify the emissions released to produce 1 Ton of biomass, which is primarily caused by timber harvesting activities and transportation of biomass to industry. Based on previous research on RIL-C method, the change in the application of RIL to RIL-C has the potential to reduce emissions by 41-66 tons Ha, while the application of mono cable winch technology can reduce carbon emissions by 30-40 tons / ha. (Ruslandi, 2013)

Considering to what seems to be the identification of research problems in the first place, that harvesting and transportation activity in forestry sector contribute significantly to the release of greenhouse gas (GHG) emissions, the application of Life Cycle Assessment (LCA) serves to help measuring the environmental impact on the application of GSCM, focusing on the operational short supply chain from timber harvesting to transportation to the wood processing location. With the measurement of GHG emissions, management can identify the points of activity that produce large emissions (hotspots) in order to plan and implement corrective actions and process improvement, so that the LCA can help determine the structure of the GSCM.

6. Limitations

In contrast to previous studies by Pearson et al., (2014), which the measurements of carbon emissions are based on the emissions produced from the felled timber, factors of damage caused by logging and infrastructure factors on logging, in this research the proposed calculation approach is based on the usage of fossil fuel in the process.

The proposed framework is to serve as prelude to the adoption of GSCM-LCA for degraded forest management. They are some issue need to be considered, as such:

- This framework still needs to be tested for its application in the field, and it needs to be followed up with performance measurement of GSCM implementation. A total commitment from management is needed to carry out the GSCM-LCA practice, especially coordination from cross sections and joint awareness of the importance of improving environmental conditions, including instilling Lean's thinking, which is thought to minimize waste in every aspect of the company.
- The application of LCA will need to expand its system boundary of observation to be able to evaluate all stages in the supply chain, from the extraction of raw materials to

the final stages of product use (disposal). Likewise, the observation of inputs and outputs should be carried out on all activities that contribute to the environmental impact. LCA can be a tool for decision making in terms of process planning and selection of technology and products to be developed.

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