Fulfilling Eucalyptus raw materials for pulp and paper production plants

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Abstract. Eucalyptus is one of the major species used for pulp and paper industry. As industries develop, the need for Eucalyptus supply increases. However, there are challenges plantation companies must specifically determining eucalyptus market price potential risks in eucalyptus plantation and how eucalyptus plantation impacts the surrounding environment. Stakeholders on eucalyptus supply chain have risks which have to be mitigated. The eucalyptus seedling and developer and the supplier hold crucial role in providing good quality eucalyptus raw material for pulp and paper production plants. This research is conducted to explore on ways to mitigate each stakeholders risk, challenges plantation companies face in fulfilling eucalyptus raw material for pulp and paper production plants. There are four stakeholders in eucalyptus supply chain: eucalyptus seedling developer and seller, supplier, distribution centre and pulp and paper production plants. Some of the major risk stakeholders are facing in eucalyptus supply chain are: early cut of eucalyptus trees, farmers’ lack of understanding on growing eucalyptus properly, small stem size, fluctuating eucalyptus wood price and low stock quantity. Some of the minor risk stakeholders are facing: earthquake, over fertilization, overwatering, cold climate, and plant setting. There are four methods used to determine eucalyptus pricing: cost-based pricing, customer-based pricing, competition-based pricing, and statutory pricing. Eucalyptus consume high amount of water which can cause dry areas around eucalyptus plantation area and low groundwater reservoir.

1. Introduction
Eucalyptus is an essential raw material in paper making industries. The most common species used for commercials are E. grandis and E. tereticornis. Many of these industries have developed their own eucalyptus plantation for production purpose. However, eucalyptus is a controversial plant due to high water consumption, nutrient depletion and its allopathic effects [1].

As new pulp and paper factories are emerging, the demand for raw material is going to increase. This means the demand for eucalyptus will increase proportionally to the number of pulp and paper factories. Thailand, for instance, has reached a growth in paper mills as much as 18.13% in 2016. New eucalyptus plantation will be made by these new factories [2].

Plantations are usually developed at high commodity price. Plantation take years to develop. For eucalyptus to mature, it needs around 6-7 years. However, commodity prices tend to change over time. By the time, the plantations become productive, the commodity price has gone low which could make company stakeholders lose capital [3].

In summary, this research is conducted to understand the needs and challenges in fulfilling eucalyptus as raw material for paper making factories specifically methods used in determining
eucalyptus market price, potential risks in eucalyptus plantation and how eucalyptus plantation impacts the surrounding environment.

2. Materials and Methods
The materials used for this research are 27 published articles within 2017-2021, a thesis, and a book from Brazil, China, Ethiopia, Germany, India, Malaysia, New Zealand, Portugal, Thailand, and United States of America. These materials are found by searching on Google Scholar with the keyword eucalyptus, pulp and paper production raw material, and eucalyptus environment impact. The search criteria for this paper is articles published in the last five years.

The method used for this research is analysing articles from previous research on eucalyptus plantation. The articles used for this research is analysed thoroughly for the relevance and requirement of this research objectives. There are five stages in this method which can be seen in figure 1.

![Research Methodology Flowchart](image)

2.1. Selection of Subjects
The initial stage is to determine the theme to be discussed. The research will discuss challenges in fulfilling eucalyptus raw material for paper production plant. The theme was chosen to see problems and challenges in eucalyptus plantation and pricing scheme.

2.2. Collect Relevant Research Articles
The second stage is collecting papers. Collected papers are taken from diverse publishers. Papers in this research are papers which are published in the last five years.

2.3. Selection of Articles by Abstract and Research Criteria
The third stage is to select papers out of the collected papers. The selection is done by reading the article abstract. Out of the 29 collected materials, 18 articles, a thesis and a book are selected based on the relevance of the paper’s title and abstract with this research objectives.

2.4. Analysis of the Selected Articles
The selected papers are then analysed on the fourth stage based on the introduction, methods, results, discussions and conclusions. Each chapter is analysed thoroughly as a guide for this review article.

2.5. Evaluation and Discussion
Papers from the fourth stage are evaluated based on the conclusions of each research and discussed as a reference in answering this research objectives.
3. Results and Discussion

Eucalyptus is a plant species native to Australia, Asia, and South America. It has a quick growth and adaptable with environment which makes it a choice for reforestation [4]. Some countries in the world such as Portugal, Brazil, Indonesia, and China have transitioned using eucalyptus as raw material for paper productions [5,6]. This leads to new plantation areas within the countries and dominance of eucalyptus as the most commercially used species for pulp and paper productions.

Eucalyptus plantation has reached more than 20 million hm² worldwide in total and they make 33% of the available plantation in the world [7]. Eucalyptus has a high-water consumption and reduces soil fertility over time. This could reduce land productivity and it has an influence over the surrounding water quality. It is possible to maintain soil fertility by retaining residues after logging. The residues have an abundance of organic matters which could help improving eucalyptus production when it’s dissolved back into the soil [7]. One method for boosting eucalyptus production is by increasing eucalyptus seedlings salt tolerance. This method has beneficial effect such as: deforestation reduction, limiting and reducing salinity effect, and raw material for pulp and paper factories [8].

Eucalyptus plantations are facing both social and natural challenges such as: price and market pressure, conflicts with local villagers and activists, management difficulties, lack of government support, environmental issues such as black water occurrences, pest and disease problem, soil erosion, biodiversity impact, etc [3,6,9]. Labour problem is also a problem which plantation companies are facing, but there are instances where the companies need both labour and land for plantation development [10].

There are four stakeholders in eucalyptus supply chain: eucalyptus seedling developer and seller, supplier, distribution centre and pulp and paper production plants. Eucalyptus seedling developer and seller is responsible for researching and selecting suitable eucalyptus seedling for supplier. Supplier is responsible for planting, maintaining, and harvesting eucalyptus trees. Distribution centre is responsible for buying and checking eucalyptus wood from the supplier before delivering it to pulp and paper production plants. Pulp and paper production plant is responsible for producing chemical pulp for paper production [11].

Some of the major risk stakeholders are facing in eucalyptus supply chain are: early cut of eucalyptus trees, farmers’ lack of understanding on growing eucalyptus properly, small stem size, fluctuating eucalyptus wood price and low stock quantity. Some of the minor risk stakeholders are facing: earthquake, over fertilization, overwatering, cold climate, and plant setting [11]. These risks could become a potential problem in fulfilling eucalyptus supply for pulp and paper factories.

There are tendencies from companies to open a new plantation when the commodity prices are going up. However, eucalyptus plantation takes 6-7 years to become productive. By that time, the commodity prices would have declined which lead to company financial losses [3]. During the period of 6-7 years, most company suffer financial loss due to this decision. Therefore, a proper planning is needed before plantation companies develop a plantation area including the projected cost and risk.

The pricing for eucalyptus product can be done in 4 methods: cost-based pricing, customer-based pricing, competition-based pricing, and statutory pricing. Cost-based pricing is pricing based on current and projected future cost. Customer-based pricing is a pricing method based on customer price demand. Competition-based pricing is a pricing method based on competitor’s price for similar products. Statutory pricing is a hybrid approach of cost-based, competition-based, and customer-based pricing [12].

Different methods for cultivating eucalyptus, in this case pulpwod and short rotation, gives different impact on environment. A study shows pulpwod eucalyptus production has more benefits than short rotation eucalyptus, except in climate change (more than 20% lower emissions) [13]. Basic density is an indicator to determine fibre and solid wood products quality. Wood with low density results in smooth, dense sheet with high tensile strength. However, wood with high density results in bulkier, stiffer, and more porous sheets [14]. Higher fibre length in wood leads to better pulp and paper making qualities. Basic densities around 460 and 480 kg m⁻³ is preferred for paper manufacturer [15]. Wood with lower density tend to be consumed more [16]. Eucalyptus had the least value in fibre
length, lower fibre lumen diameter and fibre diameter compared with acacias [14]. However, paper sheets produced from eucalyptus has better mechanical properties than merit paper sheets [17]. A physiological disorder in eucalyptus did not affect wood properties related to pulp production, however a physiological disorder has shown an effect on eucalyptus wood volume [18]. Eucalyptus consumes high amount of water and cause soil erosion. Eucalyptus leaves are highly resilient, thick and tough yet it has low specific leaf area. These thick leaves cause more evaporation than normal leaves which leads to high water consumption. Eucalyptus trees produce massive amount of litter and a study found these litters constitute lower sediment yield which may have caused soil erosion [4].

Eucalyptus litters have caused the occurrences of black water resulting with fish death near the plantation area. This black coloured water is caused by high temperature and rainfall condition which fastens eucalyptus residues and litter. The mineral within the residue reacts with iron cations (Fe$^{2+}$) and intoxicate the water [19].

A paper can be recycled up to 3.6 times [20]. In the process of productions, pulp and paper production plants could recycle failed paper products up to 3.6 times before the cellulose fibres on papers are degraded as an alternative to decrease waste production.

4. Conclusion
There are four methods used to determine eucalyptus pricing: cost-based pricing, customer-based pricing, competition-based pricing, and statutory pricing. These pricing methods can be used on its own or in combination for accurate market pricing. Some of the major risk stakeholders are facing in eucalyptus supply chain are: early cut of eucalyptus trees, farmers’ lack of understanding on growing eucalyptus properly, small stem size, fluctuating eucalyptus wood price and low stock quantity. Some of the minor risk stakeholders are facing: earthquake, over fertilization, overwatering, cold climate, and plant setting. These risks have an impact on eucalyptus supply in the market. Therefore, it is important for stakeholders to mitigate these risks. There are studies showing eucalyptus produce massive amounts of leaf litters. These litters have caused environmental issue which led to fish death. Eucalyptus consume high amount of water which can cause dry areas around eucalyptus plantation area and low groundwater reservoir.

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