Research Review on Implementation of Intensive Silviculture Techniques

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Abstract. National timber demand tends to increase, meanwhile natural forest timber production tends to decrease. Aside from the natural growth of the tree tend to be slow, the current forest management were not able to increase the productivity of the timber forest product. In this latest development, Intensive Silviculture Technique (SILIN), is expected play important role in increasing timber productivity. The objective of this research was to review the implementation of SILIN toward sustainable forest management and to develop SILIN database system. Hopefully, the database can be a reference in obtaining information of SILIN. The summary of each research and study is categorized into some categories: (i) ecology; (ii) silviculture; (iii) genetics; (iv) integrated pest management; and (v) economy. The result of the study showed there are 68 researches and studies of Intensive Silviculture, the category is dominated by silviculture aspect (31 researches), the ecology aspect are 23 researches, the genetics aspect are 2 researches, integrated pest management aspect are 3 researches and economy aspect are 9 researches. The amount of the result likely to increase and the summary of the research and study will periodically upload on our website that can be accessed on kajiansilin.com.

1. Introduction
The importance of timber production for national development are for the benefit of public consumption, industrial and export. National wood production decrease significantly from 26,05 million m$^3$ in 1992 to 5.90 million m$^3$ in 2018 [1]. Nowadays, the logged over area is fragmented by the variation of forest condition both in terms of stand density and stand structure [2]. Due to condition of logged over area and growth speed variation, the ability of the stand recovery process is various and need more than 200 years to reach climax condition, or 50 to 70 years to reach next rotation [3].

The dynamic of forest management in Indonesia moves from sustain yield management to ecosystem-based management. The basic system of natural forest management in Indonesia started with the application of Indonesian Selective Cutting System (TPI). For the better management, the TPI System has improved to be Indonesian Selective Cutting and Planting (TPTI). Because of the low productivity, tenure conflict, and illegal logging, it needed a new system to overcome those problems. In 1997, Selective Cutting with Line Planting (TPTJ) was introduced to improve the land productivity, boost stand potential and strengthen the regional tenure. On its development system was perfected by tree breeding approaches, environmental manipulation and integrated pest management into Intensive Silviculture or known as SILIN. The main reason why we should change to SILIN because we would like to manage the forest more productive, efficient, competitive and sustainable. SILIN have been implemented since 2004 and followed by Decree of Director General of Forestry Production Development Number SK.226/VI-BPHA/2005.
Almost whole management unit (IUPHHK) have fragmented forest area or the area are divided into several clusters with different forest condition and typology [4]. Utilizing fragmented area with a homogeneity silviculture system produces low benefit. The increasing of the benefits can be obtained by the implementation of multisystem of silviculture in each cluster area. Each silviculture system needs efficient and effective technique to increase forest productivity. SILIN is expected to be a breakthrough the glory of forest management in Indonesia.

SILIN is a silviculture technique which combines three main elements of silviculture, that is: target species, environment manipulation, and integrated pest control. SILIN can increase wood productivity and non-timber forest product (NTFP) also environment services [5]. The benefit of SILIN is ecologically, economically and socially profitable. The benefit in ecology is the composition of the forest that is built remains like origin forest. The benefit in economy is the guarantee of production in the next rotation without allocating development fund because it can be covered by the harvesting in preparation is. The benefit of social is enhancing the job vacancy for the society [6].

Nowadays, SILIN research may have been done a lot, but in fact the results of those studies and researches have not organized well. Therefore, it needs to retrieve the research results of SILIN that have been done. The objective of this research was to review the implementation of SILIN toward sustainable forest management and to develop SILIN database system.

2. Method

2.1. Materials
The materials that used in this study are the results of researches and studies about SILIN that have been implemented in Indonesia. Data retrieval have been conducted by online and offline systems. In addition, literature study already did in some libraries: IPB Faculty of Forestry Library, IPB Central Library, and Forest Research and Development Library.

2.2. Procedure
To review the SILIN need a comprehensive understanding about the SILIN philosophy, design, and its implementation in the field. Therefore, data retrieval was done by collecting publications, journal, proceedings, thesis, dissertation, as well as ongoing researches. Data was systemized and classified into different aspects, among them ecology, silviculture, genetics, integrated pest management, and economy.

Database managed using MySQL and also build a website using Wordpress CMS to show, add, edit, and delete the data. This website can be accessed on kajiansilin.com. The database will be modified by the website. For each interaction in the website that has been done, the website will send a query message to MySQL to modify the data. In general, there are two types of role in the website consisted of guest and admin. For the guest role, it can be accessed by everyone. They can access homepage, list categories and searching feature. The information that can be obtained in each data consisted of the title, the writer/researcher, year, institution and the summary of the research. If it is available, the URL address of the research will be included in the summary. For the admin role, admin needs to authenticate by input the username and password. The admin can modify the database whether to edit, add and delete the data using form in the dashboard page.

3. Result and discussion
In data collection, the internet search result with Intensive Silviculture as the keyword produce a lot of search results. It takes a lot of time to get the appropriate result of Intensive Silviculture research because the information come from so many unfiltered sources. The result of the inventory is as follow and the data obtained was sourced from repositories at several campuses, such as IPB University, Gadjah Mada University, Lambung Mangkurat University, and Cendrawasih University and supported by offline source that can be accessed.
Based on the table above, there are 68 researches and studies about Intensive Silviculture that can be accessed. Those researches and studies are consisted of 54 researches from online sources and 14 researches from offline source. The category is dominated by silviculture aspect as much as 31 researches, ecology aspect as much as 23 researches, genetics aspect 2 researches, integrated pest management aspect as much as 3 researches and economy aspect as much as 9 researches (Table 1).

| Aspect                        | Total |
|-------------------------------|-------|
| Ecology                       | 23    |
| Silviculture                  | 31    |
| Genetics                      | 2     |
| Integrated Pest Management    | 3     |
| Economy                       | 9     |

The ecological aspect mostly explained about the stand composition and structure. The result of the researches showed that the stand condition in the logged-over Area still complies as the productive forest, hence there are still standing stock for the next rotation. However, the implementation of Intensive Silviculture in primary forest tends to change the stand composition and structure. The stand still normal is indicated by the curve of the number of individuals per diameter class resembles the inverse “J” curve.

The composition of the vegetation in the TPTII area after 5 years harvested consisted of 24 species in seedling level, 29 species in sapling level, 15 species in poles level and 32 species in tree level while in the area before harvested consisted of 22 species in seedling level, 38 species in sapling level, 35 species in poles level and 61 species in tree level [7]. The land openness because of the commercial species harvesting reached 45.21-64.51% and caused the damage reached 30.26% from the total stand individual [8].

Changes in the composition and structure of stands in the application of SILIN are an inevitability. To overcome this problem, Reduce Impact Logging (RIL) can be applied with the following criteria: (1) does not exceed production capacity, i.e. the volume of timber harvesting does not exceed the volume of forest footprint production capacity; (2) does not exceed the recovery capacity of the forest ecosystem, i.e. forest damage that occurs does not exceed the capacity to restore the forest ecosystem; (3) forest ecological balance and species diversity, i.e. wood harvesting does not cause scarcity of certain commercial types [9].

Silviculture aspect that should be considered to implement SILIN consisted of site planning, procuring seedlings or nurseries, land preparation and hole planting making, planting, maintenance, integrated pest management, and harvesting technique. Quantitative planning for Dipeterocarp plantation forest management has been carried out. Various aspects are needed to prepare quantitative planning for Shorea sp. stand consisted of young tree growth (Shorea sp. plantation in logged-over area and Shorea sp. plantation in critical forest or shrub), the dynamics of Dipeterocarp plant, adult plant growth and thinning on Dipeterocarp plant, monitoring of potential stand, as well as site quality. In logged-over forests, maintenance of natural regeneration needs to be done 4 to 5 years after logging. For critical forests or shrubs, research results showed that Dipeterocarp can grow well as long as the silvicultural techniques are used appropriately and maintenance is carried out intensively. In normal conditions the maintenance of plants is to eliminate the disturbances of vine or wild animal. In dry conditions there must be activities aimed at avoiding the danger of fire. Field observation showed that fast-growing Dipeterocarp species are susceptible to drought [10]. This research showed that, scrub forest or degraded land can still be utilized with appropriate silvicultural treatment. Plant maintenance also needs to be considered, one of plant maintenance techniques can be done by using litter mulch and black silver plastic mulch. Both of these techniques are expected to increase plant growth and reduce maintenance costs [11].
For the procurement seedlings and nurseries, in one trial of Shorea spp. seedlings found that the height increment and diameter of Shorea leprosula species are higher than that of other Shorea species, namely 149.2 cm and 1.6 cm at PT SBK, at 88.2 cm and 0.8 cm at PT IKANI, and at 172.4 cm and 1.7 cm in PT Ema Djuliaawati after one year of planting in the field [12]. The result of the other research showed that diameter increment of S. leprosula is higher than other types, which is equal to 1.6 cm. In addition, the height increment of S. leprosula was also higher compared to other species, which equal with 149.2 cm with a life percentage of 77.8% [13]. Procurement seedlings and nurseries are still focus on several species of Shorea spp, whereas the number of species in Dipterocarp plants is more than 200 species. The further research about growth, diameter increment, height increment of the other species of Dipterocarp are still needed to find out which species has the best growing increment.

One of researches suggested that the recommended silvicultural system for the management of logged-over area from the inverted J-shaped diameter distribution and from the similarity between communities that similar is the individual selective cutting silviculture system. The recommended silvicultural system for the management of logged-over area from the inverted J-shaped diameter distribution and the similarity between the different communities that different is the group selective felling silvicultural system [14]. With these information, hopefully the failure of silvicultural implementation and forest damage can be reduced.

The success of implementation of Intensive Silviculture is also related to harvesting techniques. The productivity of conventional logging techniques ranges from 33.4 - 39.7 m³/hour with an average of 36.4 m³/hour, higher than low impact logging techniques that range between 28.3 - 36.23 m³/hour with an average average 32.8 m³/hour. The cost of cutting conventional logging techniques varies between Rp 1,712 - Rp 2,023 m³ with an average of Rp 1,893/m³, lower than low impact logging techniques which range from Rp 1,884 - Rp 2,412/m³ with an average of Rp 2,104/m³. Logging techniques with a low impact on the TPTII system requires additional costs and lower productivity, but can improve logging efficiency [15]. Seeing from the researches that have been done, information related to silviculture aspect is sufficient to meet the information needed. However, further research must be done so that the recommendations for the Intensive Silviculture development can be in accordance with what is targeted. For example, research on: (a) the potential and growth of secondary types of forest plants; (b) intensity of disturbance of vine, their impact and handling; (c) techniques for removing secondary tree species and their effects on plant growth; and (d) efforts to make the plants more resistant to weather conditions that are too dry [10].

There are two researches about genetic aspect that has been found. The first study was an analysis of the genetic diversity of Paraserianthes falcatoria L. Nielsen. The results of analysis of variance in total height and stem diameter growth in sengon seedlings showed that location and family variables had a significant effect [16]. Based on the results of genetic material collection activities at PT Balikpapan Forest Industries East Kalimantan, the results of analysis of variance of S. leprosula at the age of 12 months, individual heritability values for height parameters and stem diameter are included in the "low" category, while for family heritability values for high parameters include the category of "medium" and diameter included in the "high" category [17]. The research about the genetic aspect still hard to find, whereas genetic aspect in one of the principal components of SILIN.

In the development of SILIN technique, it is inseparable from organism disorder. Coptotermes sp. have found and attacked S. leprosula at four plantation area in PT Suka Kaya Makmur West Kalimantan. This termite attacked about 4.37% until 27.02% part of the tree [18]. The other field observation showed that Doumitus ceramicus attacked teak tree which planted used Intensive Silviculture technique. The result showed that the area that has been attacked was about 8.3%-46.64% part of the tree and the intensity of the damage was about 3.61%-19.87% [19]. However, information regarding integrated pest control methods is not yet available.

The average of productivity of operational scale in PT Sarmiento Parakanca Timber East Kalimantan reached 31.931 m³/hour and it was higher than trial scale that only 15.520 m³/hour. The average of skidding cost of operational scale was Rp 21,142.75/m³ was cheaper than trial scale that reached Rp 34,156.70/m³ [20]. The result of financial aspect analysis at PT Suka Jaya Makmur West Kalimantan
for the first rotation (25 years) showed that the Net Present Value (NPV) was Rp 3,991,548,550 with Benefit Cost Ratio (BCR) 1.016 and Internal Rate of Return (IRR) 15.83% and for the two rotations the NPV was Rp 13,412,215,740 with BCR 1.044 and IRR 18.19% it means that TPTJ Intensive Silviculture technique in this management unit deserves to be implemented [21]. The two results of research related to economic aspect that have been mentioned come from different research sources. However, when referring to the results of financial analysis at PT Suka Jaya Makmur, the Intensive Silviculture technique is feasible to implement because it has positive NVP, BCR more than 1 and IRR higher than discounted rate used.

4. Conclusion

According the ecological aspect, the application of intensive silviculture can change the structure and composition of the stand. To prevent excessive damage, the implementation of Reduce Impact Logging is expected to reduce forest damage and land openness. Information about silviculture aspect which available is sufficient, but for the procurement of seedlings and nurseries is still focus on several species of Shorea sp., whereas the species of Dipterocarp plant are more than 200 species. Continued research on silvicultural aspects is still very much needed, such as research related to the potential and growth of secondary plant, the intensity of disturbance of vine, the technique of removing secondary tree species and efforts to make plant more resistant to weather that are too dry. Research on genetic aspect is still little done, whereas the genetic aspect is one of the principal components in the implementation of Intensive Silviculture. Regarding on the economic aspect, Intensive Silviculture is feasible because it has NVP and BCR> 1 and IRR higher than discounted rate used.

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