Potential impact of beekeeping activity on bioenergy supply in West Java, Indonesia

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Abstract. Beekeeping activity has been integrally well arranged by the people of West Java area. Many bee-based products are already well developed and become a part of people activities. Most of beekeeping activity considered as an activity to gain income only from bee products. In fact, this activity has a high potential impact to bioenergy resources, especially biomass and biogas. Kaliandra (Calliandra calothyrsus) is one of potential bee forage that also has a good performance to be used as biomass source. On the other hand, this along year flowering plant, also provide their leaves as proteins source for cattle. Through sustainable beekeeping activity, which is involving bee forages planting and pruning, bioenergy sources also will automatically increase in availability. As a part of Java Island, West Java was well known for its green and flowering landscape. Though honey also produced by outer area of Java Island, but beekeeping activity was majority well arranged by Java Island people. The calculation shows that the beekeeping activity with new 450 beehive result in the potential addition of biomass and biogas supply in West Java. The potential addition calculated was 0.043 – 900.732 TJ for biomass and 0.039 TJ for biogas supply.

Keywords: Beekeeping, Bioenergy, Biomass, Biogas.

1. Introduction

World renewable energy consumption is increased annually. In 2000, total renewable energy consumed was 47.4 EJ (17.6% of world energy consumption), and grew annually to 65.9 EJ (17.9% of world energy consumption). With about 13% share in the global energy, biomass is the most consumed renewable energy sources compared to the other (solar, wind, etc.) [1]. As one of tropical country in the world, Indonesia has huge potential commodities to be developed as bioenergy sources. Most of bioenergy product in Indonesia is available and produced in the forms of bioethanol, biodiesel, biogas and biomass.

Ethanol is the second most popular bioenergy in Indonesia that used to be produced from cassava and molasses. While biodiesel as the most used bioenergy in Indonesia mostly came from the transesterification of palm oil. Biodiesel already used in Indonesian diesel transportation and distributed by Pertamina, a stated owned petroleum company, with the concentration of biodiesel in
final product called Biosolar is about 15%. Biogas was developed in variable scale of production. The production of biogas mostly integrated with the waste treatment plant of cattle farm. Only certain companies developed biogas, even though some of big companies that have thousand of cattle still let the manure without converted into biogas and waste it into open yard. Biomass in Indonesia is still need to be developed since it is not intensively used for daily activities. Actually, some area of Indonesia still practices traditional cooking which uses biomass (firewood), but not in the forms of modified and modern such as bio-pellets, biomass briquettes, or as a conversion product of biomass like bio-oil, bio-char and others.

Bioenergy development in Indonesia tends to be up and down due to the fluctuation of oil world price. For example, in 2011, biodiesel production in Indonesia reached 1.6 billion liters and significantly increased to 3.6 billion liters. In 2015, the production capacity of biodiesel in Indonesia was lower down due to the increase of its production price [2].

Beekeeping activity is still considered to be a small business and does not have significant effect on economy and environment. The production of honey is still predicted to be lower than 10 million tons per year. This amount is relatively smaller than other countries, for example Taiwan with more than 11 thousand tons per year and Ethiopia with 53 thousand tons per year. Since the bee needs forage for their life, they should be supported by adequate amount of flower within two km away from their hives. Planning the plantation of bee forage flower is the first thing to do before keeping the bee. Once the bee could not find their forages, bee will be absconded.

Smart Apiculture Monitoring Service (SAMS) is a research program funded by European Union (EU) under Horizon 2020 which targeted on two bee species which are Apiscerana and Apismelifera. The research is conducted in High-Income Country (Europe), Middle-Income Country (Indonesia) and Low-Income Country (Ethiopia). The program was designed to accurately recognize natural signal of bee and their activities which then can be interpreted as human understandable language. About 450 new controllable beehives was targeted to be achieved after research project finished. Measurement of another impact of this research was conducted to find out more implications of beekeeping activities especially on bioenergy resources availability. Kaliandra is one of popular bee forages that also has a good potential to be utilized as bioenergy sources.

Kaliandra (Calliandra calothyrsus) is a small leguminous plant from Fabaceae family. In Indonesia, especially in Java Island, Kaliandra can be easily found in forest area. There are two main types of Kaliandra that available in large number, white flower Kaliandra and the red one. Kaliandra has many functions beside only as bee forage. The root of Kaliandra can well hold the land to prevent erosion, the leaves also favored by cattle, while the trees and brunches also can be used as firewood and biomass sources. As Kaliandra also need to be pruned at least once a year, then Kaliandra provide their tree, brunches and also leaves to be used as bioenergy resources availability. This study aimed to analyze the impact of beekeeping activities on the additional availability of bioenergy resources. The study of Kaliandra, especially in relationship with beekeeping activity is never been arranged. Kaliandra data and information itself is not publicly available and easy to be accessed. In addition, this study will also provide more public accessible information of Kaliandra.

2. Methods

The potential impact of beekeeping activity will be limited to the impact of Kaliandra as bee forage on bioenergy resources. In order to do the analysis, primary data was collected through intensive interview with stakeholders including bee experts, academician, some beekeepers in West Java, bee marketers, state owned forestry company (Perhutani) and Indonesian Apiculture Association. Academician that actively involved during the research was from two universities (Universitas Padjadjaran and IPB University) that have expertise in bee research for more than 5 years. Beekeepers that were interviewed came from the representative elevation of West Java areas.
including lowland (below 300 meters above sea level), medium (300 - 900 meters above sea level) and highland (above 900 meters above sea level).

To support the primary data, some of statistical data was used mainly about the current population of Kaliandra in West Java forestry area. The data was then calculated to obtain how much energy could be restored from the beekeeping activities.

3. Results and Discussion

3.1 Impact on the availability of Biomass resources

Recent research activities defined the calorie value of Kaliandra. Kaliandra was identified to have a relative high calorie content in their trees. The calorie content of Kaliandra woods is about 4600 kcal/kg, while for its char, the calorie content can be up to 7200 kcal/kg [3]. This calorie value is quite competitive to be compared to other biomass resources.

Kaliandra can be planted with minimum land characteristics requirement. Kaliandra also can be found growth in marginal land. Therefore, Kaliandra can be chosen to support both bioenergy and also local cattle farm. Kaliandra can be used as biomass sources both directly in its original form and in the form of bio-pellet and bio-briquette. Unfortunately, Kaliandra is still not optimally utilized as biomass source. The data about Kaliandra plantation itself is very difficult to be obtained. There is no current database about Kaliandra plantation. Though the Kaliandra plantation area was reported up to 30,000 ha in 1970’s, but the utilization effort is very limited. In 2019, some of governmental office is reported to have a plan to increase the area of Kaliandra plantation, together with other biomass producer plant.

The amount of biomass produced was varied due to the age of Kaliandra plants and the pruning methods. As planned through SAMS scheme, it was programmed that the amount of Kaliandra tree will be increased to provide bee forages. Although other plants option also possible to be utilized as bee forages, but as Kaliandra is able to flowering along the year, then Kaliandra is considered as most suitable plant for bee forage. The total energy conserved was calculated using the equation as follow:

\[ TE = TA \times P \times DB \times E \] (I)

Where:

- \( TE \) = Total Energy Conserved (Joule)
- \( TA \) = Total Area of Kaliandra plantation (ha)
- \( P \) = The productivity of each hectare of Kaliandra (m³)
- \( DB \) = Dry biomass (kg/m³)
- \( E \) = Energy content of each kg of dry biomass (Joule/kg)

Based on the intensive discussion with experienced beekeepers, it was calculated that at least two hectares of new Kaliandra plantation should be planted to support forage for a hive. With the planting 1x2 m², then for each beehive, it required about 5,000 Kaliandra plants. The calculation result of the total Kaliandra for 450 beehives it will be 2,250,000 new Kaliandra plants. If one hectares of 3 years old Kaliandra generates 35-65 m³, the total biomass generated will reach up to 58,500 m³ dry biomass. This calculation is for three years old high quality Kaliandra trees. In the first year, it was said that the yields of Kaliandra is only 5-20 m³ per hectares and produce only 4,500 – 18,000 m³ dry biomass. To be able to convert this Kaliandra based biomass volume to its weight, the density of Kaliandra of 500 – 800 kg/m³ was used. The final result of this calculation was varied due to the range of its calculation component which almost all of them came in variations number. The minimum of energy that could be reserved from Kaliandra biomass was about 69.287 Tera Joule (TJ), while the maximum value
reached 900.732 TJ and the averages was 216.657 TJ. The detailed calculation results are presented in Table 1.

| Total planted area (ha) | Obtained Dry Biomass (m³) | Obtained Dry Biomass (tons) | Conserved Energy (Tera Joule) |
|-------------------------|---------------------------|-----------------------------|------------------------------|
| 900 (1st year)          | 4,500 – 18,000            | 3.6 – 14.4                  | 69.287 – 277.148             |
| 900 (3rd year)          | 31,500 – 58,500           | 25.2 – 46.8                 | 485.009 – 900.732            |

3.2 Impact on Biogas availability

Integrated cattle farming system in Indonesia is successfully applied mostly by big companies. In fact, small and medium cattle farms can also arrange the integration between cattle farm and bioenergy production facilities. While the woods and brunch of Kaliandra can be utilized as biomass source, its fresh leaves are favored by cattle as their feed. In a huge plantation, one-year pruning schedule will be perfectly done by take turns one area another.

Biogas is produced through the digestion of cattle manure. Ideally, Kaliandra leaves able to substitute 30% (maximum) of total cattle feed. With the total addition area of 900 hectares, this Kaliandra plantation will have the capability to feed up to 62,500 cows. When assumed that each cattle produce 10 to 35 kg of manure and 0.023 to 0.080 m³ of biogas, then the total biogas generated should reach 1,437.5 m³ or equivalent with 9.343.750 kcal (0.039 TJ).

3.3 Discussion

Calliandra calothyrsus has many functions for peoples and ecosystem. It is still debatable between bee experts and beekeepers whether Kaliandra is the best choice or only an alternative to other plants as bee forages. For example, though Kaliandra has a lot of nectar contained in their flower, but the amount of pollen is very limited. Bee even has to spend extra effort to gain the pollen from Kaliandra because it lies in the top of the flower and often mobilized by wind then fall down. Some people also do not allow Kaliandra to reach their maturity time and flowering. Once Kaliandra have abundant leaves, the people will prune the brunch and let the Kaliandra leaves as cattle feed.

Deforestation is another issue that might be the most threatening factor to Kaliandra plantation. Many people do not recognize the benefit of Kaliandra plant and want to utilize the forest land to be planted with other commodities like coffee and horticultural plants. Currently, the state-owned forestry company of Indonesia (Perum Perhutani) is allowing the people or a company to rent their forestry land and use it commercially as long as it does not destruct the main forestry trees that cultivated in those lands.

4. Conclusion

The SAMS program which encourages peoples to start do beekeeping activities a have significant impact on bioenergy sources. Biomass and biogas are two forms of bioenergy which will be impacted by beekeeping activities. About 0.043 TJ in biomass form and 0.039 TJ in biogas form can be some additional input to current bioenergy resources as impact of new beekeeping activities promoted by the SAMS program.
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