Intensity of Teak Wood Production in Central Java Using Point Process by Counting Measure Approach

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Abstract. Teak is known as a tree that has a high quality wood and economic value. Teak forests have important role as supporting ecosystems, preventing erosion, and have social functions for research facilities. Central Java has the largest teak forest area on Java. The number of districts that teak wood production in units of time in can be assumed as a counting process. The counting process that considers the events in surrounding area which also has teak forests is called the point process. In this research, we determine the intensity of teak wood production in Central Java with a point process by counting measure approach. There are some steps to reach the research’s aim: 1). Mapping the Forest Management Unit (FMU) of the Central Java Regional Division, 2). Divide the FMUs area of the Central Java Regional Division into 3 sub-regions with the same area, 3). Classify FMUs according to their respective sub regions, 4). Calculate the number of FMUs scattered in each sub-region, 5). Determine the intensity of teak wood production with the counting measure approach based on step (4). We obtained that the production of teak in the Central Java Regional Division dominated by type AIII (large round wood). Overall sub region I is the largest teak production area in Central Java, especially at FMU Randublatung.

1. Introduction

Teak (\textit{Tectona grandis Linn F}) is a high quality wood that has many demands by the public even though the selling price is high. Teak is classified as fancy wood and has a high durability class last up to 500 years [1]. It is resistant to termites and fungi. Besides the very useful wood, teak leaves are also used for food wrapping, especially in traditional markets. Among the teak trees, there are usually planted with some secondary crops [2]. Teak forests also have very important non-economic values, such as supporting ecosystems, preventing erosion, and have social functions for research facilities.

Java Island is the region that has the most extensive teak forest in Indonesia. It reaches 600,000 ha and 409,700 ha of which is located in Central Java Province [3]. So, Central Java is the largest province that has teak forests area. The teak forests are managed by PT. Perhutani. It has about 2.6 million ha of teak forest which consists of 54 Forest Management Unit (FMU). There are 20 FMUs in Central Java Regional Division [4]. The number of FMU that produce teak wood in units of time in a region can be assumed as a counting process. The counting process that considers the surrounding events in this case the surrounding area which also has teak forests is called the point process. This research will be determined by the intensity of teak production in Central Java.

The forming of a point process can be carried out through 4 (four) approaches, namely the counting measure approach, ladder function, point sequence, and interval sequence. In this paper, the counting measure approach will be discussed more deeply, because the counting measure approach is
the most systematic approach if the process dimension space is expanded [5]. Mathematically, the Poisson process is a trivial example of a point process. Therefore, the Poisson process is defined as a simple point process, where the number of events in a set follows a Poisson distribution and the number of events in a set that is mutually independent is mutually [6].

To explain the steps of forming a point process, a process is defined in $R^2$ with some conditions, including: 1) the results of counting process in a closed and limited set are nonnegative and finite and 2) the counting process fulfill the independent increment property [7].

2. Stochastic Process

According to Ross [8], a stochastic process $\{N(A), A \subseteq \mathbb{R}^d, d \geq 1\}$ is defined as a collection of random variables $N$, where $A$ represents the parameter index. If the process is defined in a 1-dimensional space, then generally the index of parameter $A$ is time and it is denoted by $t$. Furthermore, if the process is defined in 2 or 3 spaces, then $A$ can be a set in $R^2$ and $R^3$. The stochastic process is a random event, or is mathematically a set of random variables $\{N(t)| t \in T \}$, where $T$ is the set of time indices (Mingola [9]). The stochastic process is the set of random variables $\{N(t; s)|t \in T, s \in S\}$. $T$ is time set and $S$ is sample space (Allen [10]). According to Ross [8], the stochastic process with $T$ is an uncountable set, is called the discrete time stochastic process, whereas when $T$ is interval of the real number, it is called the continuous time stochastic process.

The stochastic process has two properties: independent increments and stationary increments. If the random variable $N$ is independent of any given set of $A$, then the stochastic process is independent increment. If the distribution of the random variable $N$ for any set $A$ depends only on the size of the set $A$, then the stochastic process has a stationary increment property.

3. Counting Process

The stochastic process $\{N(A), A \subseteq \mathbb{R}^d, d \geq 1\}$ is called the counting process if $N(A)$ states the number of events occur in any set $A$. It can be a time interval for dimension 1, in $R^2$ for two dimensions and set in $R^3$ for three dimensions, Cahyandari [7].

According to Ross [8], the counting process is a stochastic process in which the random variable $N(t)$ denotes the number of occurrences to time $t$. The counting process $\{N(t), t \geq 0\}$ follows:

a. The number of events is an integer.

b. If $s < t$ then $N(s) \leq N(t)$.

c. If $s < t$ then $N(t) - N(s)$ is the number of events in intervals ($s, t$).

The independent increments properties of the stochastic process are fulfilled by $N(t) - N(s)$, which are the number of events in disjoint sets are independent. Mathematically, the disjoint sets are represented as partitions.

4. Point Process

The process of a point is a random collection of points that lie on a particular region [6]. According to Cahyandari [7], based on the area of definition, the process of the point is divided into two, namely:

1. Point process point on one dimension space

   Generally, the process parameter index is time, where the point denotes the time of an event. This process is known as the temporal point processes. Point process is usually used on queue issues.

2. Point process point on more than one dimension space

   Spatial point processes (spatial point processes). In general, this process is observed by location, where the point indicates the location of an event. This process is commonly used in forestry issues, such as the location of burned trees, on earthquake problems, e.g. epicenter of the earthquake and so forth. For example, in the earthquake problems, the point of the process is expressed by pairs ($x, y$) where $x$ denotes longitude and $y$ denotes latitude.
5. Set Partition
Consider a set \( A \subseteq R^d \) for \( d = 1, 2, 3 \). Then \( \mathcal{A} \) is finite partition of \( A \), \( \mathcal{A} = \{ A_i \mid i = 1, 2, ..., n \} \) is called collection of set partition \( A \) if:

a. \( A_i \neq \emptyset \)

b. \( \bigcup_{i=1}^{n} A_i = A \)

c. For \( \forall i, j, i = 1, 2, ..., n \), if \( A_i \neq A_j \) then \( A_i \cap A_j = \emptyset \). [7].

The counting process of events in set \( A \) can be determined by summing the counting process of events results for each sub set \( A_i \). It means,

\[
N(A) = N(\bigcup_{i=1}^{n} A_i) = \sum_{i=1}^{n} N(A_i)
\]

(5.1)

where are \( N(A) \) and \( N(A_i) \) for \( i = 1, 2, ..., n \) nonnegative integer [8].

5.1 Set Partition in \( R \) (time parameter index)
Set \( A = [0, t] \) is defined. The interval partitions of \( A \) are sub intervals \( A_i \) which are mutually independent for \( i = 1, 2, 3 \). Furthermore, the number of events on interval partitions of \( A \) is \( N(A_i) \). So, the number of events on interval \( A \) is sum of events in each interval partition of \( A \). It can be written as \( N(A) = N(A_1) + N(A_2) + N(A_3) \).

5.2 Set Partition in \( R^2 \) (field parameter index)
Set \( A \) is defined as quadrilateral, triangle circle and ellipse. The partition of set \( A \) is a congruent set with shorter side length. Furthermore, the number of events in set \( A \) is the sum of the number of events on each congruent set partition.

6. Result and Discussion

6.1 Point Process by Counting Measure
There is the explanation about point process forming [9]. If a set \( A \subseteq R^d \), \( d = 1, 2, 3 \) is given and \( N(A) \) states the number of events in set \( A \). If set \( A \) fulfilled the partition definition on sub section 4, then \( N(A) \) can be noted as (4.1). If it is assumed that set \( A \subseteq R^d \) with \( d = 1, 2, 3 \) and \( N(A) \) finite. Simplify, when \( A = [0, T] \) as union of \( n \) disjoint sub interval \( T_i, i = 1, 2, ..., n \) then

\[
T = \bigcup_{i=1}^{n} T_i \text{ and } T_i \cap T_j = \emptyset \text{ for } i \neq j, i, j = 1, 2, ..., n.
\]

(6.1)

If equation (6.1) is substituted in (4.1) then we obtain,

\[
N(\bigcup_{i=1}^{n} T_i) = \sum_{i=1}^{n} N(T_i)
\]

(6.2)

where is \( N(T) \) non negative integer and finite on interval \([0, T]\) (Daley and Vere-Jones [5]). In practice, the interval \([0, T]\) can be short, so \( T_i \) for \( i = 1, 2, ..., n \) are very short subintervals and have same length. The selection of equal subinterval length makes the calculation of average events in interval \([0, T]\) simpler. It is based on counting result of events in each sub interval \( T_i, i = 1, 2, ..., n \).

6.2 Application
In this study, the data used is data on 2014 teak wood production in Central Java [11]. There are 20 Forest Management Units (FMU) in the Central Java Regional Division namely FMU Cepu, FMU Randublatung, FMU Gundih, FMU Purwodadi, FMU Telawa, FMU Blora, Mantingan FMU, FMU Kebonharjo, FMU Pati, FMU Semarang, FMU Kendal, Pekalongan Timur FMU, West Pekalongan FMU, Pemalang FMU, Balapulang FMU, West Banyumas FMU, East Banyumas FMU, South Kedu FMU, North Kedu FMU, Surakarta FMU.

Based on the Company Class (CC), woods are divided into Teak CC (53.66%), Pinus CC (37.61%), Damar CC (4.43%), Mahoni CC (1.77%), and Mangrove CC (2.53%). The production of teak in the FMU Central Java Regional Division is divided into three types, namely small round wood (AI), medium round wood (AII), and large round wood (AIII). Based on BPS data [11], the highest AI, AII
and AIII teak wood production was Randublatung FMU, amount to 13547.68 m$^3$, 7964.23 m$^3$, and 21814.34 m$^3$. The FMU that does not produce teak wood, are West Pekalongan FMU and East Pekalongan FMU. The average production of AI, AII and AIII teak is 3305.38 m$^3$, 1853.53 m$^3$ and 4281.90 m$^3$ respectively. Map of FMU in the Central Java Regional Division is shown in Figure 1.

![Figure 1. Map of the FMUs in the Central Java Regional Division.](image)

There are only 18 FMUs from 20 FMUs that produce teak wood, so we only choose the appropriate FMU. Then we assign the counting measure for 18 FMU that produce teak wood. Therefore, the analysis was carried out to determine the intensity of AI, AII, and AIII teak production in the Central Java Regional Division. The Central Java Regional Division FMU Association can form a point process. These points are the FMUs that produce teak AI, AII, and AIII. It is shown in Figure 2.

![Figure 2. The FMUs of Central Java Regional Division which produces teak AI, AII and AIII](image)

There are the steps of counting measure for a number of Central Java Regional Division FMUs that produce AI, AII and AIII teak wood.

1) Partitioning the FMUs area into three sub-regions with the concept of congruence, namely each sub-region which has an area of 26,666.66 km$^2$.

2) Classify the FMUs according to their respective sub regions.

3) Determine the intensity of production of AI, AII, and AIII teak based on the previous steps.

Based on the previous steps, a partition form and classification of the FMUs Regional Division of Central Java were obtained. The partitions and classifications are carried out by converting the degree of South Latitude and East Longitude into units of kilometers, which is 1 degree longitude / latitude = 111,322 km. Then the results of the partition and classification of the FMUs are shown in Figure 3. There are 5 FMUs in Region I, namely Kebonharjo FMU, Cepu FMU, Blora FMU, Randublatung FMU and Mantingan FMU. Subregion II contains 9 FMUs, namely FMU Pati, FMU Purwodadi, FMU
Gundih, Surakarta FMU, Telawa FMU, Semarang FMU, Kendal FMU, North Kedu FMU, and South Kedu FMU. Subregion III has 4 FMUs, namely the Pemalang FMU, East Banyumas FMU, West Banyumas FMU, and Balapulang FMU.

Figure 3. Three partitioned sub-regions.

The points in Figure 3 state that the Central Java Regional Division FMUs produces teak. It is defined that set A is the Central Java Regional Division FMU and the event is the FMU that produces AI, AII, and AIII teak. So, the point process is the number of Central Java Regional Division FMUs that produce AI, AII, and AIII teak. The number of FMUs in each sub region that produces AI, AII, and AIII teak is shown in Table 1.

Table 1. The number of Central Java Regional Division FMUs which produce teak AI, AII, and AIII.
The intensity of teak production in the Central Java Regional Division FMUs is determined based on the production of AI, AII, and AIII teak types. The intensity of the teak production in each sub region is the amount of the of AI, AII, and AIII teak type wood produced divided by the area.

Table 2. The intensity of AI, AII, and AIII teak production in each sub-region

| Sub region | The amount of teak production (m³) | Area (km²) | The intensity of teak production (m³/km²) |
|------------|-----------------------------------|------------|-----------------------------------------|
|            | AI      | AII | AIII | AI      | AII | AIII | AI      | AII | AIII |
| I          | 36224.21 | 14364.38 | 51510.53 | 26666.66 | 1.3584084 | 0.5386644 | 1.9316452 |
| II         | 22085 | 12801.9 | 23314.11 | 26666.66 | 0.8281877 | 0.48007137 | 0.8742794 |
| III        | 7798.432 | 9904.304 | 10813.28 | 26666.66 | 0.2924413 | 0.37141149 | 0.4054981 |

Based on Table 2, the intensity of AI, AII, and AIII teak production can be obtained for each sub region. In sub region I, the greatest intensity of teak production was type AIII (large round) which was 1.9316452 m³/km². It means that for each km², sub region I produces large round teak for about 11.9316452 m³. In sub region II, the greatest intensity of teak production was type AIII (large round) which was 0.8742794 m³/km². In sub region III, the greatest intensity of teak wood production was type AIII (large round wood) which was 0.4054981 m³/km². So, it can be concluded that the production of teak in Central Java Regional Division in 2014 was dominated by type AIII (large round wood). Overall, the largest intensity of AI, AII, and AIII teak production is in sub region I, especially in Randublatung.

7. Conclusion

According to the results and discussion above, it can be concluded that:
1. The forming of point process by counting measure approach when the set \( A = [0, T] \) can be written as
\[
N \left( \bigcup_{i=1}^{n} T_i \right) = \sum_{i=1}^{n} N(T_i)
\]
where \( T = \bigcup_{i=1}^{n} T_i \) and \( T_i \cap T_j = \emptyset \) for \( i \neq j \), \( i,j = 1,2, \ldots, n \) and \( N(T) \) are nonnegative integer.
2. There are 18 FMUs that produce the teak wood in Central Java.
3. There are three types of teak: AI, AII and AIII.
4. The teak production in Central Java is dominated by the AIII type.
5. The largest intensity of AI, AII, and AIII teak production is in sub region I, especially in Randublatung.

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