Silviculture and Productivity of *Calamus inops* as an Important Resource toward Self-Financing for Lore Lindu National Park

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**Abstract.** Local communities have been given access to harvest rattan in the traditional zone of Lore Lindu National Park (LLNP) as the conservation incentive. *Calamus inops* is the most valuable rattan in terms of economic value. Therefore, the purpose of the research is to propose conservation strategies of *Calamus inops* and analysis its potential source of self-financing mechanism for LLNP. We conducted the rattan inventory using stratified sampling based on habitat types with 39 strip samplings and 195 plots. The results showed that *Calamus inops* was found in lower montane forest and upper montane forest. The habitat preferences were various such as altitude ranges from 931 m asl to 1753 m als; pH from 6 to 7.5; and climate in C1, D1, and E1 of the Oldeman classification. Whereas, standing stock and productivity of traditional zone in 2018 were 397.23 tons, and 92.7 tons year⁻¹ respectively. LLNP will gain benefits for self-financing through decreasing monitoring operational cost and non-tax state revenue (PNBP) from rattan. Briefly, *Calamus inops* has potential as a financial resource combining with other revenue sources of LLNP. For improvement, restocking with seedlings and implement other silvicultural practices are strongly suggested to increase productivity. Moreover, it is needed supporting regulations to implement the self-financing concept.

1. Introduction

Since 2006 Ministry of Forestry has proposed to develop national park models. Lore Lindu National Park (LLNP) is one of 21 national park models. The aim of designing NP models is expected to be managed in a more optimal, efficient and effective [1]. Increasing numbers of conservation designation have challenged conservation managers to propose self-financing for conservation programs by more creative funding mechanisms. Several national parks attempt to propose their potential resources such as tourism activities. Lore Lindu National Park has several options for gaining revenues form no tax state revenue (PNBP) such as tourism, research and others. Currently, Directorate KSDAE issued regulation No.P.6/KSDAE/SET/Kum.1/6/2018 regarding technical guidance for conservation partnership in conservation in a nature reserve and nature conservation area that allowed local communities to harvest and sell commercial rattan in a traditional zone of a national park. Currently, rattan harvesters should pay a business license for non-timber forest product (IUPHHBK) to Provincial Forestry Office because they collect rattan from forest production under the Provincial Forestry Office management. On one side, giving access to local communities to manage...
rattan in tradition zone of a conservation incentive and sustaining their income from harvesting rattan. It is a new conservation paradigm to involve local communities in national park management. On the other side, it becomes the potential PNBP revenue for the LLNP. Because harvesting location is a national park, there are many prerequisites should be developed to ensure sustainable harvesting and benefit for conservation purposes for instances developing local institution for managing rattan, deciding harvesting quota and improve rattan habitat with silvicultural techniques.

Rattan is one of the high economic value of non-timber forest products as a source of Indonesia foreign exchange and involving farmers in the business. Togisi or tohiti (Calamus inops) is a well-known commercial rattan. Calamus inops is one of the high economic value rattans [2]. Tohiti stems are slightly hard and solid, hence, it is very good to be used for furniture, sand blocking, boat backs, bicycle stem filler, and steel substitute [3]. Calamus inops has high economic value and demand but it has been more threatened than other commercial rattans. Therefore, the purpose of the research is to propose conservation strategies of Calamus inops and analysis its potential source of self-financing mechanism for LLNP.

2. Method

2.1. Material and study area
This research is focused to manage Calamus inops that located in the traditional zone of LLNP. LLNP is a conservation area managed with a zoning system such as the core, wilderness, special, utilization, rehabilitation, and traditional zones. Based on the regulation, local communities have accessed to utilize rattan only in a traditional zone. The allocated area of the traditional zone is 31,156 ha and 25,397 ha of it is rattan habitat. The total area of LLNP is 215,733.70 ha. This research was conducted from October 2017 to March 2018.

2.2. Procedure
Primary data were collected by rattan inventory using 39 strip samplings (20 × 100 m). Each strip sampling was divided into five plots, resulting in a total of 195 plots. Whereas secondary data were collected by questionnaires, interviews and other relevant resources.

2.3. Data analysis

- **Rattan standing stock or increment formula**

  \[ y = \frac{\sum_{i=1}^{n} y_i}{n} \]

  Where \( y \) is the average plot value of standing stock or increment (ton ha\(^{-1}\) year\(^{-1}\)), \( y_i \) is the plot value (ton), \( n \) is the number of sample plots, \( \hat{y} \) is total estimation population value standing stock or increment (ton year\(^{-1}\)), and \( A \) is total area (ha).

  The increment was calculated based on the growth rate, rattan fresh weight, and harvestable rattan area in the traditional zone.

- **The system dynamics model**

  The system dynamics model was proposed to simulate the rattan sustainable harvesting model and its economics aspects. We used Powersim software in simulating the model based on the initial condition (Table 1).
Table 1. Initial conditions for sustainable harvesting and self-financing scenario

| System dynamics variables                              | Value                  |
|--------------------------------------------------------|------------------------|
| Total commercial rattan standing stock                 | 4,814.02 ton           |
| Standing stock of *Calamus inops*                      | 397.23 ton             |
| Harvesting rate                                        | 17.61 % year⁻¹         |
| Increment rate                                         | 11.22 % year⁻¹         |
| Restocking of *Calamus inops*                          | 10 % year⁻¹            |
| Maximum harvesting capacity (Workload)                 | 11.7 ton person⁻¹ year⁻¹ |
| Harvesting cost                                        | 5,025,696 IDR year⁻¹   |
| Harvesting correction factor                           | 0.8                    |

2.4. Research framework

New conservation paradigm tends to involving local communities in a conservation management. Classic conservation, 'fortress conservation' and “fines” approaches, is not effective in attaining conservation purposes [4]. The research framework showed in Figure 1.

Figure 1. Research framework

3. Result and discussion

3.1. Distribution and population of *Calamus inops* in Lore Lindu National Park

Rattan is the most important non-timber forest product for local communities adjacent to LLNP. Based on the rattan inventory in LLNP, *Calamus inops* is only found at lower montane forest and upper montane forest habitat type. Habitat preferences of *Calamus inops* were shown in Table 2.

Table 2. Habitat preferences of *Calamus inops* in Lore Lindu NP

| Habitat attributes | Range               |
|--------------------|---------------------|
| Altitude           | 931 - 1753 m asl    |
| pH                 | 6 - 7.5             |
| Humidity           | 54 - 74 %           |
| Slope              | 33 - 84 %           |
| Climate*           | C1, D2, and E1      |

*Note: 1 Oldeman classification
Calamus inops has a wide range of habitat preferences. These data could be used as references for both in-situ and ex-situ conservation. Conserving rattans needs basic resource information for such as population, distribution, standing stock and others. We estimated the population of Calamus inops as shown in Table 3.

Table 3. Calamus inops population in LLNP

| Unit area             | Seedling | juvenile | Semi mature | Mature | Total     |
|-----------------------|----------|----------|-------------|--------|-----------|
| Total area of LLNP    | 1,958,110| 394,329  | 371,479     | 170,931| 2,894,849 |
| Traditional zone      | 237,433  | 51,866   | 56,765      | 25,357 | 371,421   |
| Total                 | 2,195,542| 446,195  | 428,244     | 196,288| 3,266,270 |

3.2. Regeneration
Successful regeneration will ensure the sustainability of Calamus inops. Mostly, rattans grow in clusters and only several rattan solitary. The total number of seedlings in traditional zone was 2,195,542 seedling or 67.21% from the total population. It was the normal population structure. Calamus inops is solitary rattan, therefore its regeneration only depends on seed production. Calamus inops is zoochoric plant that its seeds are spread by animals. This character makes it more susceptible comparing with clustering rattan.

3.3. Productivities and sustainable harvesting
Sustainable rattan management will be achieved by providing accurate data about resources. Rattan inventory will gain population data including standing stock and productivity. Productivity or increment is growth dimensions that include increasing diameter, height, and weight annually. Renewable resources can be utilized sustainably if growth data are available [5]. Table 4 is the standing stock and increment of Calamus inops.

Table 4. Standing stock and increment of Calamus inops in LLNP

| Unit area          | Standing stock (ton) | Increment (ton year⁻¹) |
|--------------------|----------------------|------------------------|
| Total area of LLNP | 2 902.51             | 586.94                 |
| Traditional zone   | 397.23               | 92.7                   |

Rattan productivity is affected by standing stock amount. In LLNP, rattan harvesters are only permitted to collect rattan in the traditional zone. The current inventory showed that increment of Calamus inops was 3.7 tons. This productivity could be optimized by restocking with seedling.

3.4. Improving sustainable harvesting
The rattan population and production in LLNP has depleted due to over-harvesting [6]. Standing stock and increment will decrease year by year. Referring to the rattan inventory result in Sumatera by ITTO and MOF (2008) that found the standing stock of rattan in natural forest was 0.38 tons ha⁻¹. By 25 397 ha area of the traditional zone, the optimum standing stock is 7 835.77 ton. Whereas total standing stock of all commercial rattan in the traditional zone was 4 814.02 ton (Yulianto, unpublished). Therefore, the standing stock will be increased due to restocking with rattan seedlings as 3 021.75 tons.

3.5. Economic value and its projection values
Rotan Togisi (Calamus inops) is the most valuable rattan compared with other commercial rattans in Lore Lindu National park such as Batang (Calamus zolligeri), Lambang (Calamus ornatus), and Noko (Daeomonorops macroptera). Canes of Calamus inops has outstanding characteristics i.e., weight loss only 27% whereas other rattans more than 50% on average; categories
as large cane rattan with an average diameter over than 18mm; high quality canes for exported commodity. In trading, the middlemen bought rattan from harvesters surrounding LLNP and sold to rattan industries in Palu with "cut weight" based on weight loss. Calamus inops is priced with only cut 25% from fresh weight and other commercial rattans cut 50% from the fresh weight. Besides canes, its shoots called “umbut” has marketable value by selling it as a vegetable even has a bitter taste. The economic valuation of the standing stock based on the current price, 1,200,000 IDR ton⁻¹, was 3,483,012,000 IDR in the total area of TNLL and in the traditional zone was 476,676,000 IDR. Moreover, We developed the system dynamic model to simulate rattan management that concerning Calamus inops restocking (Figure 2).

Figure 2. System dynamics model with concerning restocking of Calamus inops in traditional zone

Note = CI: Calamus inops; OCR: other commercial rattans; SS: standing stock; IUPHHBK: Izin usaha pemanfaatan hasil hutan bukan kayu

The system dynamics model enabled to simulate the rattan harvesting management in the traditional zone of LLNP. The simulation based on the initial condition in 2007 and run for 10 years (Table 5).

Table 5. Sustainable harvesting Projection of Calamus inops and other commercial rattans in traditional zone of LLNP

| Variables                          | Projection from 2018 to 2027          |
|------------------------------------|--------------------------------------|
| Standing stock of Calamus inops    | 397.23 – 936.65 ton                  |
| Standing stock other commercial rattan | 4 416.79 – 4 416.79 ton          |
| Total rattan production            | 436.96 – 485.92 Ton year⁻¹          |
| Harvester income*                  | 9 014 304 - 9 014 304 IDR year⁻¹     |
| Total harvester                    | 37 - 42 Person                      |
| Total IUPHHBK                      | 4 369 590 – 4 859 208 IDR year⁻¹    |

*excluded inflation rate
Rattan population management dealt with controlling standing stock, increment and harvesting. For sustainable harvesting, harvesting should not exceed increment. We proposed to improve the rattan population by restocking of *Calamus inops* with scenario 10% from standing stock. The projection show the rattan production will increase from 436.96 ton per year to 485.92 ton per year. Increasing production will affect number of harvesters and PNBP form IUPHHBK. IUPHHBK is potential revenue for supporting self-financing of LLNP.

3.6. Conservation incentive and self-financing

LLNP was appointed as a national park in 1993. Previously, it used a classic conservation approach to manage the park area with strict regulation and law enforcement approach. However, this approach failed to conserve rattan in LLNP. Siebert [7] found that rattan production in Lore Lindu National Park has depleted annually due to high harvesting rates. Giving access to the local communities surrounding LLNP is form of a conservation incentive. An economic incentive is a conservation strategy in protected area. Fulfilment livelihood of local communities influenced positive attitude towards national park management [8]. By this mechanism, between local communities and LLNP agree to manage rattan sustainably by developing a local institution called Conservation Community Partnership (CCP). CCP will give benefits to both parties. For local communities, CCP could secure their harvesting activities and sustain the livelihood. For LLNP, it will be a potential revenue by receiving PNBP from IUPHHBK of rattan with needed supporting regulation. Furthermore, it will get indirect benefit form reducing the cost of national park monitoring and conflict resolution programs. Therefore, harvesting rattan is one of revenue resources for establishing a concept of self-financing national park. *Calamus inops* has potential as a financial resource combining with other revenue sources of LLNP.

4. Conclusion

Comparing with other commercial rattan in LLNP, *Calamus inops* should be the concern of population management because of its economic value, market demand and distinctive regeneration characters. By proposing harvesters to restocking and silviculture practices, it could improve standing stock, canes production and rattan population that giving benefits for both harvester income and national park conservation. By combining other revenue incomes, improvement *Calamus inops* population by restocking is a potential resource for proposing self-finance national park by two mechanisms. The first is income from IUPHHBK and decreasing the budget for monitoring and conflict resolution cost. However, it is still needed supporting regulations for implementing the concept.

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