Impact of community intervention on grass stock at gunung merapi national park (Southern), Java, Indonesia

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Abstract: Gunung Merapi National Park (GMNP), a new national park, was known its ecological functions and the local community is very much depending on the area. The main objective of this study was to determine the intervention level of the local community on the grass stock and create a scheme to minimize the intervention at GMNP. A line plot sampling method was applied based on the distance between the village (Kaliadem and Jambu) and the national park. Therefore, the sampling area was divided into five zones which are Zone I, II, III, IV and V. The existing stand was analyzed using the biodiversity index while distribution of species was calculated by agglomeration and dispersion index, the similarity in the pattern of the ecosystem was analyzed using hierarchical clustering and the intervention of the local community was determined using the intervention index. The scheme was created using the allometric model. The result showed that the diversity index for trees in GMNP is very low with the number of trees between 1-3 species. Meanwhile, the distribution pattern of the trees at all zones is clumped with Dispersion Index (IE) more than 1.27 or Agglomeration Index (R) less than 2.15. The ecosystem at zones II, III and IV possesses a similarity, whereas zones I and V have a trend in forming the ecosystem which is different from the other zones. Based on intervention index at GMNP area involved on going local community intervention. Three schemes were labelled as scheme 1 (implemented zone system GMNP version), scheme 2 (intensification traditional zone) and scheme 3 (synergistic schemes 1 and 2).

Key words: National park, Diversity, Community, Intervention, Scheme opportunity

Introduction

Mountains have significant reservoirs of biological diversity, water, energy and further ecosystem services (Viviroli and Weingartner, 2004), rural development through grazing and timber production (Buttoud, 2002), crop and livestock productions (Spehn et al., 2002), protection against natural hazards (Price and Butt, 2000) and it is a known fact that protected areas affect the livelihood of the local people living beyond (Lynagh and Utich, 2002). In the world's human population inhabit mountainous regions about 26 % (Meybeck et al., 2001).

Protected area which has grown rapidly in Indonesia is the national park. In the 1980s, the emerging of the national park concept was actually copied from the conservation movement which originated from USA. The first five national parks declared are located in Bali, namely Gunung Leuser, Gede Pangrango, Ujung Kulon, Baluran and Komodo National Park, covering a total area of 1.4 million hectares. How these national parks were managed at that time remains unclear. Ten years later, the newly introduced law of UU No.5 in 1990 required not less than 11 government regulations in order for it to be executed. Later various efforts to organized management conservation areas have been done continuously and this has led to the development of a system for the “national park”. More than 65 % of the conserved areas are national parks (Ministry of Forestry-Indonesia, 2006).

Gunung Merapi National Park (GMNP) was established in 2004 (Ministry of Forestry-Indonesia, 2004). The core value of the GMNP is an ecosystem which is fundamental for the south part of the Yogyakarta Province and the Central Java Province. The ecosystem of the GMNP is still natural, comprising of alpine ecosystem with various species of grass, herbs and shrubs, and mountainous tropical forest ecosystem with many flora and fauna endemics such as Spizaetus bartelsi, Panthera sp., species epitit Vanda tricolor and others available will become the plasma nutfah in the future (Ministry of Forestry-Indonesia, 2002). Another unique characteristic of the GMNP is the active Merapi volcano which erupted in 2006.

One of the cluster relations between the local community and the GMNP is the grazing stock. This is a major or fundamental problem in the development zoning system at the national park, especially on southern of GMNP. Managing protected areas is essentially a social process and it needs conjunction with wider social, historical, economic and cultural influences (Kothari and Lockwood, 2006). Durban Accord 2003 describes that managing protected areas requires an action or effort which can reduce and overcome poverty at the conservation area (IUCN, 2005). The objective of this study was to determine the intervention level of the local community on the national park as a grazing stock, as well as its impact. Based on the information derived from the study, a scheme was therefore designed to develop a proper management system to make GMNP sustainable and prospective in the future.

Materials and Methods

According to Ministry of Forestry-Indonesia (2007) the land use surrounding GMNP was classified into four clusters, namely...
Fig. 1: Location of the study

grazing pattern (Sleman District, Yogyakarta Province), non-wood forest products include rock and sand mining (Magelang District, Central Java), vegetables (Boyolali, Central Java) and the transition between grasses and vegetables (Klaten District, Central Java). The study area was in the district of Sleman, including Kaliadem and Jambu Village, and Cangkringan regency (Fig. 1). GMNP which covers an area of about 6.410 ha, is located on elevation ranging from 600 to 2967 m asl (Purbawinata et al., 1997). The climate of the area is categorized as wet tropic with the climate of C with Q 33.3-66% based on Schmidt and Fergusson classification. The annual rainfall of about 875 mm year" to about 2527 mm year"", with the wet months of November to May, and the dry month of June to October (Sutikno, 2002).
A line plot sampling methods applied in this study was based on the distance between the villages (Kaliadem and Jambu) and the National Park. The study area was divided into five zones, which Zones I, II, III, and IV, with the transect size of 300 m crosswise and following the direction of slope. For Zone V, the transect size of 1200 m following the direction of slope (Fig. 1). The distance 50 m in the line transect of every zone makes a quadrat plot with the size of 20 x 20 m. All the trees in the quadrat plots were identified and measured of their diameter (DBH), height and crown diameter. The categorization of the grasses was based on the percentage of coverage, species, effective areas of grasses and grass productivity per size.

Interviews with the people in the farmer community in Jambu and Kaliadem was applied using the multistage random sampling technique by dividing the population units into several strata and based on the grass area cultivated. The total number of the respondents at Kaliadem was 35 and 16 for Jambu. The size of grazing area own by the farmer were divided into four classes, namely class 1 (0.01-0.1 ha), class 2 (0.11-0.2 ha), class 3 (0.21-0.3 ha) and class 4 (0.31-0.4 ha). This study conducted from November 2008 to March 2009.

The variables for the species diversity include richness, evenness and heterogeneity. These variables were quantified by nominal index 1) species richness index with Jacknife Estimate, Evenness index by Shannon-wiener and heterogeneity index (Magurran, 2004). According to Krebs (1989) the spatial distribution of the species was analyzed using the agglomeration (IE) and dispersion index (R). The pattern of similarity in the ecosystem was analyzed using hierarchical clustering (Waite, 2000) with the following parameter of cluster indicators: Evenness of seedlings, saplings, poles, trees and grass species.

The community’s intervention at the GMNP was determined based on the aspect of land used for cultivating the grass. The parameter intervention approach was the grass ratio cultivated by farmer with the cover crops and the intensity of grass harvesting at every zone. These parameters were model by using a mathematic equation with one value index intervention (0-1). The index of

![Fig. 2: Similarity ecosystem at every zone](image)
intervention with value 1 showed that the level of intervention is high and if the index is close to 0, the level of intervention is therefore low. The formulation of the intervention index used as follows:

\[ I = \frac{\sum_{i=1}^{z} RGT_i \times IGH_i}{\sum_{i=1}^{z} RGT_i + \sum_{i=1}^{z} IGH_i} \]

Where,

- \( I \) = Intervention index (near 1 show the high intervention level)
- \( RGT = \) Ratio grass cultivated by local community and wild cover crop
- \( IGH = \) Intensity grass harvesting (bunch/day)
- \( z \) = Number of zone in the unit research

The final analysis of this research was building the scheme opportunity to minimize the intervention and also increase ecological functions. The scheme was developed based on the relationship analysis between the variable diversity and the community's...
Fig. 5: Intervention diversity index and harvesting productivity at GMNP with various Scheme 1 (a), Scheme 2(b) and Scheme 3(c)
intervention at the GMNP. Thus, a model of functional relation was established using the allometric model between the variables. The model was simulated for several schemes with the opportunity to establish.

Results

Species density at every zone has a similar trend, i.e. it is dominated by trees and sapling level. The percentage of density for the number of trees in Zones I to V was found to significantly decrease, except for Zone IV which has a higher density as compared to the others. Meanwhile, Zone V has the highest and Zone III had the lowest total seedling (Table 1).

The diversity index describes the domination of any species in every zone. The tree species that dominated Zones I, II, and III are *Pinus merkusii*, *Erythrina lithosperma* and *Schima wallichii* for Zones IV and V. Based on the hierarchy clustering analysis, similar ecosystem were discovered in Zones II, III and IV but not in Zones I and V (Fig. 2).

Generally, the trees distribution pattern at all zones is IE more than 1.27 or R less than 2.15 which categorized as clumped. The agglomeration indexes for Zones II, III and V (1.019, 0.848 and 0.835) are higher than Zones I and V (0.715 and 0.589), as compared to the IE at Zones II, III, and IV (1.364, 1.552 and 1.566), which are much lower than Zones I and V (1.661 and 2.097). The spatial parameter for Zones II, III and IV was higher than Zones I and V which mean that the individual trees more distributed. Meanwhile, the land space at Zones II, III and IV have tree distances of 1.961 m, 1.632 m and 1.638 m wider than at Zones I and V, which have 1.523 m and 1.318 m (Table 1), respectively.

The diversity of the grass species at the slope of Mount Merapi in Zone I is higher than the other zones, with an average of eight species. Nevertheless, the number of grass species was found to decrease at Zones II and III, with the average of 5.330 and 4.691 species, respectively. The total number of the grass species at Zones IV and V had increased to 5.275 and 5.988 species, respectively.

Based on the importance value index (IVI) at Zones I-IV, the grass species that were cultivated by farmer, namely *Brazillia bresanta* and *Panicum muticum* have an IVI of 45% much higher than the other species. Meanwhile, the IVI for *Penisetum purpureum* was decreased at Zones I-V, and the IVI for *Brazillia bresanta* increased for Zone I (5.90%) to Zone III (99.46%), but decreased for Zone IV (79.91%) to Zone V (54.19%). The wild grasses at Zones I-IV were dominated by *Imperata cylindrica*, *Nephrolepis exaltata* and *Chrysopogon aciculata*, but the domination was found to decrease from Zones I-V. This situation was different for Zones IV and V, whereby wild grasses were dominated by *Eupatorium inulifolium* with IVI values of 27.19 and 82.83 %, respectively.

Generally, the grass harvesting using 'cut and carry system' is used mostly in the morning (80%) and afternoon (20%) with the size of 1 bunch equal to 50 kg. The rotation of the grass harvesting during raining season at Zone I for the land class 2 productivity was 18.64 tone ha⁻¹, and for class 3, the productivity of 18.92 tone ha⁻¹ was found, with the surplus grass stock and harvesting rotation of 40 and 50 days. As for land class 1, the productivity was found at 24.75 tone ha⁻¹, with the harvesting rotation of only 24 days.

The productivity at Zones II, III and IV for class 2 (17.86 tone ha⁻¹), class 3 (17.95 tone ha⁻¹) and class 4 (14.71 tone ha⁻¹) showed the surplus of grass stock, with the harvesting rotation of 35, 51 and 60 days, respectively. Meanwhile, the productivity at class 1 was 25.86 tone ha⁻¹, with a harvesting rotation of 23 days (deficit). As for the productivity during dry season of class 4 at Zones II, III and IV, they were found to have a surplus grass stock with the harvesting rotation of 33 days (Fig. 3).

The higher intervention index was found at Zones II and III, with the values of 0.558 and 0.476, respectively. Those zones have a percentage of grass cultivated by farmer lower than the other zones. The intensity of the grass cultivation would give a much higher effect on the rotation of grass harvesting than the other zones, with about 1.833 to 1.800 bunch per day (Fig. 4).

The relationship between the community and the management of the National Park has three basic problems, and the matrix opportunity together with its three schemes is given in Table 2. Based on this matrix, three alternative schemes with different levels of constrain were designed. The conservation scheme was arranged based on the analysis of the functional relationship between diversity and intervention index. The model of the conservation scheme has the formula of $\hat{H} = 0.709 - 0.629 I$ (H=diversity index and I=intervention index) and $r^2=0.657$, $p$-value=0.027. The estimation of grass harvesting for every scheme was done based on the allometric model between the variables for intervention and grass harvesting, using the formula, $GH = 2.947 I^{0.482}$ ($GH$=grass harvesting (bunch day⁻¹) and I=intervention index) with $r^2=0.949$, $p$-value=0.005.

In Scheme I, the problem solution with repressive approach, the management of the GMNP established zoning was based on the rule set by Indonesian national park management (Ministry of Forestry-Indonesia, 2006) which could return the national park ecosystem with high diversity. The value of diversity was set above 0.8, with an intervention index of less than 0.007. The local people would have limited access to grass harvesting and the opportunity for harvesting was only about 0.273 bunch per day in Zone I. Nevertheless, this particular scheme has a high conflict resistance because the grass stock available to the local people does not have any alternative solution yet (Fig. 5a).

In Scheme II, the community are given special space allocation (traditional zone) for the grass stock at Zones I and II.
### Table 1: Stand density and dispersion

<table>
<thead>
<tr>
<th>Levels</th>
<th>Zone I</th>
<th>Zone II</th>
<th>Zone III</th>
<th>Zone IV</th>
<th>Zone V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D</td>
<td>P</td>
<td>D</td>
<td>P</td>
<td>D</td>
</tr>
<tr>
<td>Seedling</td>
<td>58.33</td>
<td>9.72</td>
<td>87.50</td>
<td>14.19</td>
<td>37.50</td>
</tr>
<tr>
<td>Sapling</td>
<td>225.00</td>
<td>37.50</td>
<td>258.33</td>
<td>41.89</td>
<td>187.50</td>
</tr>
<tr>
<td>Poles</td>
<td>83.33</td>
<td>13.89</td>
<td>79.17</td>
<td>12.84</td>
<td>145.83</td>
</tr>
<tr>
<td>Trees</td>
<td>233.33</td>
<td>38.89</td>
<td>191.67</td>
<td>31.08</td>
<td>137.50</td>
</tr>
<tr>
<td>Distance average (m)</td>
<td>1.523</td>
<td>1.961</td>
<td>1.632</td>
<td>1.638</td>
<td>1.318</td>
</tr>
<tr>
<td>Agglomeration index (R)</td>
<td>0.715</td>
<td>1.019</td>
<td>0.848</td>
<td>0.835</td>
<td>0.589</td>
</tr>
<tr>
<td>Dispersion index (IE)</td>
<td>1.661</td>
<td>1.364</td>
<td>1.552</td>
<td>1.566</td>
<td>2.097</td>
</tr>
</tbody>
</table>

D = Density (Individual/Ha), P = Percentage of Density (%)

### Table 2: Opportunities and constrains of the scheme models at the GMNP

<table>
<thead>
<tr>
<th>Problems</th>
<th>Opportunities</th>
<th>Description scheme</th>
<th>Constrain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Local community intervention on grass stock</td>
<td>Scheme 1: Maintaining the traditional space by intensifying grass cultivation</td>
<td>- Grass regeneration</td>
<td>- Low ecosystem biodiversity</td>
</tr>
<tr>
<td>2. The low biodiversity of the GMNP</td>
<td>Scheme 2: Implementation of the zoning system version GMNP</td>
<td>- Review traditional intervention</td>
<td>- Low functional ecology</td>
</tr>
<tr>
<td>3. Mismatch zoning system between the GMNP version and the traditional practice</td>
<td>Scheme 3: Transition grass to promising non-wood forest products</td>
<td>- Design traditional limited zone</td>
<td>- Require intervention control for a long period of time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Implementing zone GMNP version</td>
<td>- Ideal national park requires a long time to achieve</td>
</tr>
</tbody>
</table>

- Intensification with grass shading tolerant
- Enrichment species forage non grass
- Low responsibility among the local community
- Conflict of interests
- Alternative forage is not available
- Participatory Planning
- Understanding among stakeholders
- Intervention NWFP
- Vertical space intensively with epifit promising (Vanda tricolor)
- Intensification of cover crops with ornamental plant (Medinella speciosa and Nepenthes alata), herbal (Cinchona ledgeriana, Java Chili, Andrographis paniculata) potential.

### Stakeholders support

- Review grass area at the GMNP
- People still have a desire to utilize space management in GMNP
- Local wisdom in keeping the local community sustainability GMNP
- Based on the P. 56/MenhutII/2006 guidelines on the National Park zone which allow the allocation of land:
- Manage the grass in the traditional zone.
- Manage NWFP with promising rehabilitation zone intensively
- Model national park collaboration
- Encourage the optimization of model GMNP collaborative management with social movement
- Synergetic nature conservation program community based
- Synergetic program for empowerment community
This particular zone implemented the grassing which was designed with intensive cultivation and enrichment for non-grass. The scheme was kept balanced between the aspects of ecology and economy, with an intervention index =0.5 at Zone I and 0.7 at Zone II. Zones III, IV and V focused more on rehabilitation and grass harvesting at these zones have just over two years of early rehabilitation. When rehabilitation causes trees to grow well, harvesting of grasses will be stopped. However, if the situation does not improve, this will be transitioned to the possibility of grass harvesting at Zones III and IV to about 0.423 bunch per day, and the ecosystem will be developed near the natural forest at Zone V (Fig. 5b).

Scheme III is a synergistic between schemes I and II which implements the zoning system for the GMNP and the community is facilitated when managing the national park zone with focus given on the development of the non-wood forest products. The scheme was designed in such a way that the intervention on harvesting grasses at Zones II, III, IV and V was near to zero (nil). The activity of the local people in harvesting grass was only limited to Zone I, with the intensity of grass harvesting as more or less about 0.82 bunch per day and this will be decreasing further (Fig. 5c).

Discussion

**Stand performance:** The strategic functions of Mount Merapi on the aspects of ecology and economy have become a considerable basis for establishing a national park. According to history, the early management of this area involved forest production and this was then changed to function as forest conservation and up to now, this mountain has been developed into a national park (Ministry of Forestry-Indonesia, 2004). Based on this record, the stand performance at the national park is dominated by monoculture. The distribution of the diversity index for every level of tree composition was between 0.139-0.847, with a total number of species at 1-3. This is because the seedling potential is distracted by the grass harvesting activity because almost all of the cover crops or plants with the height similar to the grasses will also be cut following the harvesting of grasses. Thus, this proves disturbance caused by human is an important influencing factor for the distribution of the community structure, species composition and plant diversity (Wiens, 1997). In many cases, the people-park conflicts have caused damages to valuable habitats, ecosystems, flora and fauna (Coggins, 2000).

The high intervention also showed that the grass species cultivated by farmers is higher than wild grasses. This situation is represented by heterogeneity index of less than 1. It showed that any grass can dominate in every zone. Beside that, the high dependency on grass stock from the grass production during rainy season has caused surpluses for Zones I, II, III and IV, with higher rotation of 40-50 days, while during dry season, the rotation has surplus of up to 33 days. The MMNP as a grass stock for the local community done for more than twenty years can give negative effects, particularly the low level of diversity stand because the available of seed bank is disturbed by the grazing activity at all zones. All the GMNP zone has been intervened by the local community for a longer duration. In the native rangelands in the western of China, a similar impact on heavy grazing has reduce the composition of the vegetation species, richness and productivity, as well as the changes of the herbs and shrubs diversity over the past few decades (Wang et al., 2002).

The trend in the index intervention showed that the zone nearest to the village has a low intervention, while those distant away have higher intervention. Based on the level of trees, every zone has dominant species. The loss of diversity such as heterogeneity caused by heavy grassing pressure might increase homogeneity in the vegetation composition (James et al., 1999). Species domination showed that the value of diversity is lower than individual distribution regularly for every species. Thus, it is generally recognized that there is a positive association between species richness and abundance (Denslow, 1995).

**Management regime:** Based on importance value of the local community’s dependency on the national park and in the scheme to encourage an effective management of the national park, some solution alternatives are therefore needed. For this, the aspirations and attitude of the local people living in and around the protected areas should be taken into consideration. The needs, aspirations and attitudes of local communities on surrounding protected area should be considered in the management (Xu et al., 2006). In this study, the scheme of solution alternatives (management regime) were categorized as scheme 1 (implementation of the zoning system version GMNP), scheme 2 (intensification traditional zone) and scheme 3 (synergistic schemes 1 and 2).

**Scheme 1. Implementation of the zoning system GMNP version:** In this scheme, the management of the national park was designed using the master plan GMNP with a complete component zones such us wild zone, core zone, conservation zone and zone others than the ones established by the Ministry of Forestry, based on the need assessment on natural resources and ecosystem (Ministry of Forestry-Indonesia, 2006). The design and zone implementation are emphasized by the manager of GMNP with the aim to minimize the intervention of the local people using the zone borders. This scheme has a top down management which marginalizes the benefit of local people with little attention given on planning, management and decision making. Conservation and development planning in Indonesia has been largely determined by top-down, providing little, if any, voice to resident communities (Ministry of Forestry, 2001). Indonesian political culture moves toward decentralization and devolution of power to the regions greater autonomy, institutional and political legacies tends to determine the conservation and development planning for some time to come (Gustave and Borchers, 2008).

The advantage of scheme I is for all zoning in GMNP can be implemented and the possibility to increase the biodiversity in...
order to improve the landscape ecosystem. Besides that, this scheme also increased the conflict between the local community and the management of the GMNP.

**Scheme 2. Intensification traditional zone:** In this scheme, the local community will facilitate grass intensification with the potential for grass regeneration and enrichment forage of the non-grass planting being focused at Zones I and II. As for Zones III, IV and V, the emphasis is given on the rehabilitation and the non-wood forest products (NWFP). The grassing activity will be stopped in Zone I and II if the NWFP is ready to harvest. However, the limitations include the intervention control and implementation management based on national park model.

The scheme has been introduced in many protected areas including Kakadu National Park and the Great Barrier Reef Marine Park (Australia) which makes provision within the zones allocated for this purpose (Thomas and Julie, 2003). The other national parks in Indonesia, this scheme is implemented at Halimun-Salak National Park with the existing community species as corridor (Supriyanto, 2007).

**Scheme 3. Synergistic Scheme 1 and 2:** The existing local community intervention which GMNP need not to be stop and they should find ways to synergise the power. Forest conservation efforts have been increasingly looking for collaboration or the participation of local communities from various incentives and programs to promote economic activities forest based (Salafsky et al., 2001). According to Straede and Thorsten (2006) the intervention does not automatically caused destruction because it is illegal. This depends on the level of the extracted flora and fauna, as well as the general disturbance in the area.

In scheme 3, combination of scheme 1 and 2 are recommended with the focus given on the implementation of the zoning system version GMNP and on increasing the participation of the local community in the management of the national park with intensified forest rehabilitation. Forest rehabilitation with the NWFP potential includes epift Vanda tricolor and ornamental plant (Medinella speciosa and Nepenthes alata). Beside that, plants/herbs with medicinal properties, such as Cinchona ledgeriana, Andrographis paniculata and Java Chili, will also be planted. The opportunity of diversification of the NWFP is very high because Mount Merapi has many natural diversities which consist of 43 and 76 rare flora and fauna, respectively (PHKA, 2009).

In this scheme, the intervention is controlled and the effort to increase the function of the ecosystem can be implemented by developing the total component of the national park. Using this scheme, the total management of the national park can make it sustainable and promising. Resettlement approach in the developing countries has little reward for social economic consequence and in some cases for long-term access of the park (McElwee, 2001).

**Conclusion**

Based on the existing stand diversity and the level intervention of the local community at GMNP, the third scheme has more opportunities to be implemented in the GMNP and this scheme has become a qualitative reference to encourage the national park model with the synergy between the local community and the management of the national park. The system links the local community and the management of the protected area with site-bases biodiversity conservation approach that offers a realistic prospect of success (McShane and Wells, 2004). Scheme 3 is the most suitable solution to develop a proper management system to make GMNP sustainable and prospective in the future.

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