Priority of The Forestry Extension Officer Distribution Based on Geographic Information System In Environment Problem Solutions

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Abstract. Magelang Regency is one of the regencies in Central Java Province that has forests as much as 32% of its area. The forest area continues to drop along with the many threats to the existence of the forest. Deforestation, critical land and forest fire are a widespread environmental problem in protected areas and cultivation. This will have an impact on the environmental quality that is essential for sustainable living. To minimize the impact, community awareness efforts need to be conducted through extension activities. Therefore, the existence of forestry extension as the forming actors of the environment-caring community becomes very important. The current competence and placement of forestry extension is not ideal compared to environmental issues and community needs. Utilization of Geographic Information System (GIS) through priority distribution modeling can help overcome this.

Keyword : Environmental, Forestry extension, GIS

1. Introduction
Forest is a potential natural resource that should be preserved for its function and its advantages. Forest gives a huge contribution to mankind, either from the ecology side, economy and social side. Forest as the capital of national development, should be managed, preserved, protected and utilized sustainably for the present and the future generation.

In Java, the recent issue happened is the increased amount of critical land, forest fire and also land cover change rate from forest into non-forest land/ deforestation. Statistics from KLHK [1] shows that the wide of critical land in Java on 2013 (critical & very critical category) is about 1.738.800 ha. The wide of forest & land fire in Java on 2015 reaches 11.263,69 ha. Deforestation land either inside or outside forest zone in Java during 2014-2015 is about 20.900 ha [2]. Those three things threatened the sustainability function of the forest.
The forest damage influence on human life. Impact of changes in land cover looks at changes in atmospheric temperature, humidity, clouds, circulation, and precipitation. On a regional scale, changes in land cover caused a decrease in temperature of 1 °C in summer and -0.8 °C in winter [3], has resulted in extreme conditions ie floods and droughts become more frequent with greater volume and wide [4]. Those damaged forest condition becomes a tough job in forest development. Ministry of Environment & Forestry commits an accelerated movement in order to decrease and rehabilitate the damaged forest through the Priority Policy on Forestry and National Development Program of United Indonesia Cabinet, one of them are the empowerment of people living close to the forest [5]. Through the empowerment program, people are encouraged to analyse the potential, the condition and forestry issues that needs to be resolved in order to create sustainable forest. The people empowerment program for forestry development is also executed by conducting a forestry extension.

Forestry extension is a knowledge, behaviour and attitude development process of the target community so they will know, want, understand, execute and manage the forestry business to increase their income and their welfare as well as to let the community active in preserving forest and the environment itself. [6]. The role of forestry extension officer is important yet strategic to persuade and coach the community to contribute into sustainable forest management. Sufficient number of forestry extension officer become a consideration for a successful extension.

Magelang Regency is one of the regencies in Central Java Province which suffer from damaged forest and lands. In Mount Merbabu National Park, the forest land closure only have 30% remaining from the whole area of the National Park with deforestation rate about 3% per year [7]. The wide of the critical land in Magelang Regency is about 24,907,8 ha. Forest fire recorded around 17 times and the width of the damaged area around 62,9 ha [8].

From the human resources itself, Magelang Regency only have 13 Forestry extension officer. This condition is far from ideal amount. The following chart shows the number of forestry extension gaps ideal and existing.

![Figure 1. Proportion of Forestry Extension Officers in Magelang Regency](image)

With the limited staff as well as the complicated issues, it is a must to have an information regarding the work area priority as the policy foundation for staff assignation. The purpose of this research also aim to create a mapping model of Priority Of The Forestry Extension Officer Distribution In Environment Problem Solutions in Magelang Regency according to Geographical System Information.

2. Methods
The approach used on this research is descriptive quantitative. The data being used is the critical land data, land cover data during 2000-2015 and hotspot data during 2012-2017. Method used to measure
each variable is Analytical Hierarchy Process (AHP). AHP is designed to collect the perception from person who is related to specific matters through a procedure to achieve a specific preference scale from various scales [9]. The perception as the main input came from the experts who understood about the matters given, know the effect of the issue or even have certain responsibility with certain issues. In this research, there are 3 respondents from structural officials and forestry extension officer. The AHP Method is needed to measure each indicator in order to decide the priority of the work area of the forestry specialist. AHP is necessary for weighting of each indicator in the determination of priority work areas of forestry extension. Converting data into a GIS database realize the results of AHP weighting and determine a score on a thematic map through the formulation of mathematical models.

Model of Priority Of The Forestry Extension Officer Distribution Based on Environment Problems generated by justification through weighting on each independent variable, that is:

a. Critical land
b. Deforestation
c. Hotspot

The result of weighting is the basic data in making priority map of placement of forestry extension workers. The classification is divided into 3 (three) based on the value of the weighted result, namely:

a. Low Priority.

b. Medium Priority.

c. Main priority.

3. Results & Discussion

The analysis process begins with determining the forest damage indicator, the calculation of indicator weight, and overlay process through GIS to generate priority distribution of forestry extension officer.
From interviews with experts, including variables of forest destruction are critical land, deforestation and forest fires.

### 3.1. Critical Land Distribution

Parameter of critical land is based on Permenhut Nomor P.32/Minhut-II/2009 which including land cover, land slope angle, erosion danger rate, productivity and management. Data distribution of critical land in Magelang Regency obtained from the Institute for Watershed Management Serayu Opak Progo. The classification of critical land for each district is presented in the following table:

| No | District      | Non critical (ha) | Critical potential (ha) | Moderate (ha) | Critical (ha) | Total (ha) |
|----|---------------|-------------------|-------------------------|---------------|--------------|------------|
| 1  | Bandongan    | 1.481             | 3.102                   | 1.981         | 4            | 6.567      |
| 2  | Borobudur    | 2.939             | 176                     | 1.478         | 1.092        | 5.685      |
| 3  | Candimulyo   | 1.193             | 2.904                   | 343           |              | 4.440      |
| 4  | Dukun        | 442               | 2.839                   | 2.351         | 12           | 5.644      |
| 5  | Grabag       | 538               | 5.873                   | 2.518         | 10           | 8.938      |
| 6  | Kajoran      | 1.253             | 2.031                   | 4.792         | 571          | 8.648      |
| 7  | Kaliangkrik  | 1.394             | 2.084                   | 1.888         |              | 5.365      |
| 8  | Mertoyudan   | 4.557             | 45                      |               |              | 4.602      |
| 9  | Mungkid      | 3.773             | 329                     |               |              | 4.102      |
| 10 | Muntilan     | 2.194             | 823                     |               |              | 3.017      |
| 11 | Ngluwar      | 1.223             | 1.012                   | 50            | 1            | 2.287      |
| 12 | Pakis        | 4.586             | 4.732                   | 1.352         |              | 10.670     |
| 13 | Salam        | 1.348             | 1.277                   | 218           |              | 2.843      |
| 14 | Salaman      | 2.809             | 815                     | 2.316         | 914          | 6.854      |
| 15 | Sawangan     | 1.530             | 2.284                   | 2.230         | 504          | 6.548      |
| 16 | Secang       | 4.126             | 617                     | 245           |              | 4.988      |
| 17 | Srumbung     | 1.119             | 3.648                   | 634           | 532          | 5.933      |
| 18 | Tegalrejo    | 3.143             | 1.541                   | 105           |              | 4.789      |
| 19 | Tempuran     | 2.217             | 296                     | 42            |              | 2.556      |
| 20 | Windusari    | 438               | 2.793                   | 2.526         | 1.337        | 7.093      |
|    | **Total**    | **36.323**        | **38.383**              | **28.645**    | **8.218**    | **111.569**|

*Source: Critical Land Map of Magelang Regency (KLHK, 2017).*

Critical lands are included in the class is not critical and potentially critical is 74.615 ha (66.87%). From 21 districts, almost all districts have either critical or potentially critical degraded land. Mertoyudan, Mungkid and Muntilan districts do not have critical land but only potentially critical. These districts are a sub-district in the lowlands with these district is in the lowlands with the land use of settlements and rice fields.

The area of critical land belonging to moderate critical is 28.645 ha (25.67%). Kajoran & Pakis district are the district that have largest area in moderate critical class. Kajoran & Pakis are the districts which located in the upper section of the river, the area with wave topography & steep slope. Land moderate critical category is land that has been eroded mild to moderate, including surface erosion and flow erosion. If it is left without any repair effort then in a relatively short time the land will become critical.
The land area of critical category is 8,218 ha (7.36%). Critical land is a soil that has experienced severe erosion, with a degree of gully erosion. They generally have medium-shallow solum (<60 cm) with a horizon A thickness less than 5 cm, slope 15 to > 30%. This condition illustrates the need for conservation cultivation techniques on lands classified as critical, such as conservation techniques bench terracing, rolls or alley cropping techniques [10].

![Critical Land Distribution Map](image)

**Figure 3. Critical Land Distribution Map**

### 3.2. Deforestation
Deforestation is a condition of forest land cover change to be not forested [11]. Deforestation rate is based from the land cover map (during 2000-2015) which released by BPKH Region XI Java – Madura. Calculations performed on the condition of land cover in the coverage in 2010 was Forest while the coverage of the 2015 has been changed into Areas Non (Non-Forest) is reduced conditions the land cover in coverage in 2010 is not Forested (Non Forests), while the coverage of the 2015 changes to be Forested.

| No | District | Deforestation (Ha) |
|----|----------|--------------------|
| 1  | Dukun    | 49                 |
| 2  | Pakis    | 97                 |
| 3  | Sawangan | 104                |
| 4  | Srumbung | 15                 |
| 5  | Windusari| 5                  |
|    | **Total (Ha)** | **271**            |

*Source: The results of the land cover map analysis from 2000 to 2015, Scale 1: 250,000 (BPKH Region XI Yogyakarta, 2017).*

Of these results, it turns out deforestation occurs only in 5 districts. The highest deforestation occurred in the district of Sawangan. Sawangan is a district located between the upstream and downstream. In this district, the forest turned into rice fields and vegetable land. Sawangan, Dukun and Pakis known as district of vegetable suppliers for Magelang and surrounding districts.
3.3. Hotspot
Hotspot indicated that certain region is vulnerable to fire. The main objective of forestry extension is to inform the community about the danger of forest fire and encourage them to contribute to prevent forest fire. So, by knowing the hotspot distribution, forestry specialist could educate the community about how to deal with forest fire.

| No | District   | 2011 | 2012 | 2013 | 2014 | 2015 | 2017 | Total |
|----|------------|------|------|------|------|------|------|-------|
| 1  | Borobudur  | 2    |      |      | 2    |      |      | 4     |
| 2  | Kajoran    |      |      |      |      | 1    |      | 1     |
| 3  | Kaliangkrik| 1    | 1    |      | 5    | 7    |      | 14    |
| 4  | Mertoyudan |      |      | 2    | 2    | 5    |      | 14    |
| 5  | Pakis      |      |      |      |      | 3    |      | 3     |
| 6  | Salaman    |      |      |      | 1    | 1    |      | 2     |
| 7  | Sawangan   |      |      |      |      |      | 1    | 1     |
| 8  | Secang     | 2    | 1    |      |      |      |      | 3     |
| 9  | Srumbung   |      |      |      | 7    | 7    |      | 14    |
| 10 | Tempurun   |      |      |      |      | 1    |      | 1     |
| 11 | Windusari  |      |      |      |      |      | 3    | 3     |
|    | Total      | 3    | 3    | 3    | 3    | 21   | 1    | 34    |

Source: MODIS C6 NASA FIRMS Fire Archive, start date: 2010-01-01, end date: 2017-08-15, accessed on https://firms.modaps.eosdis.nasa.gov/download/mpl/DL_FIRE_M6_16167.zip, date August, 18, 2017 (NASA, 2017).

The research result shows that minimum hotspot rate is found in Magelang regency. In the last 6 years, only 34 hotspots distribution found in 11 districts. Here are 3 districts (Srumbung, Kaliangkrik, Mertoyudan) with the highest score. This means that forest fires need to be wary of these three districts.
3.4. Priority of the forestry extension officer distribution.
Priority Of The Forestry Extension Officer Map is created from the overlay of critical land map, deforestation map and hotspot map.

Table 4. Score value for each indikator

| Independent Variable | Score |
|----------------------|-------|
| Deforestation from 2000 – 2015/ (Ha) | Critical Land | Number of Hotspot from 2011 - 2017 |
| < 33 | not critical / critical potential | < 3 | 1 |
| 33 s/d 66 | moderate | 3 s/d 5 | 2 |
| > 66 | critical | > 5 | 3 |

*Note: To determine the classification of scores = Max value - Min value.*

The next step is to reclassification based on the scores in table 4. The results of reclassification can be seen in the figure 6, 7 and 8. To determine the importance of each variable, the AHP Method is used. The weighting of each variable of the respondents can be seen from the table 5.

Table 5. Weighting of each variable of the respondents

| Indicator   | Respondent 1 | Respondent 2 | Respondent 3 | Rate |
|-------------|--------------|--------------|--------------|------|
| Critical land | 0,67         | 0,67         | 0,66         | 0,667 |
| Deforestation | 0,26         | 0,26         | 0,25         | 0,257 |
| Hotspot     | 0,07         | 0,07         | 0,09         | 0,077 |
Analysis of respondents' combined opinion shows that critical land indicator (weight value 0.667) is the most important aspect to consider in determining the priority of distribution of forestry extension officer. The following aspects to note are the indicators of deforestation (weighted value 0.257) and the hotspot indicator (weighted value 0.077).

This opinion reflects that the critical land indicator is considered very closely related to the area of forestry extension work. The preference of respondents to prioritize critical land indicators in the determination of forestry extension work area is logical because the role of extension workers as a motivator of farmers in improving the environment.

The resulting AHP rank is then converted into the SIG database for a given value. The weight of each indicator scores through the formulation of the mathematical model.
Figure 9. Weighting result of forest extension officer placement

Table 6. Area of area based on weighted results

| No | Total Value of Weight | Area (Ha)   |
|----|-----------------------|------------|
| 1  | 1.00                  | 51.384,66  |
| 2  | 1.08                  | 12.559,56  |
| 3  | 1.15                  | 10.761,85  |
| 4  | 1.67                  | 18.383,19  |
| 5  | 1.74                  | 7.453,71   |
| 6  | 1.82                  | 2.717,96   |
| 7  | 2.18                  | 40.91      |
| 8  | 2.26                  | 49.44      |
| 9  | 2.33                  | 3.046,12   |
| 10 | 2.41                  | 2.660,34   |
| 11 | 2.49                  | 2.419,88   |
| 12 | 2.85                  | 63,12      |
| 13 | 2.92                  | 28,45      |
|    | Total                 | 111.569,20 |

Note: Maks = 2.92; Min = 1.00; Mean = 1.43; Interval = 0.64

Furthermore, the scores above are grouped into three zones with the following scores: high priority has a score > 2.28, medium priority is having a score range of 1.61 - 2.28, and low priority has score value <1.641
The placement of forestry extension is at the district level, then the weighted value is calculated based on the smallest unit of work unit (district), thus yielding the following weighting values:

**Table 7. Weighted value in each district**

| No | District   | Weighted value | Placement Priority | Area (Ha) |
|----|------------|----------------|--------------------|-----------|
| 1  | Pakis      | 866,30         | Tinggi             | 10,670.09 |
| 2  | Grabag     | 483,55         | Sedang             | 8,938.38  |
| 3  | Srumbung   | 407,44         | Sedang             | 5,932.57  |
| 4  | Salaman    | 385,17         | Sedang             | 6,853.92  |
| 5  | Windusari  | 381,83         | Sedang             | 7,093.02  |
| 6  | Kalianangkrik | 349,31     | Sedang             | 5,365.32  |
| 7  | Kajoran    | 257,57         | Rendah             | 8,647.80  |
| 8  | Dukun      | 239,27         | Rendah             | 5,643.68  |
| 9  | Sawangan   | 211,98         | Rendah             | 6,548.50  |
| 10 | Ngluwar    | 167,99         | Rendah             | 2,287.15  |
| 11 | Borobudur  | 130,95         | Rendah             | 5,684.93  |
| 12 | Salam      | 129,99         | Rendah             | 2,843.49  |
| 13 | Tegarejo   | 129,66         | Rendah             | 4,788.73  |
| 14 | Bandongan  | 111,65         | Rendah             | 6,567.34  |
| 15 | Candimulyo | 93,66          | Rendah             | 4,439.70  |
| 16 | Secang     | 52,87          | Rendah             | 4,988.39  |
| 17 | Muntilan   | 40,00          | Rendah             | 3,017.02  |
| 18 | Mertoyudan | 39,24          | Rendah             | 4,601.80  |
| 19 | Mungkid    | 33,00          | Rendah             | 4,101.83  |
| 20 | Tempuran   | 25,00          | Rendah             | 2,555.53  |

Note: Maks = 866; Min = 25; Median = 149; Mean = 227; Interval = 280
Priority of the forestry extension officer distribution in environment problem solutions are grouped into 3 (three) according to the weighting result, that is:
1. Low Priority (Value <305);
2. Medium Priority (305 ≤ Value ≤ 586);
3. Main Priority (Value> 586)

**Figure 11. Priority Of The Forestry Extension Officer Distribution**

Based on environmental problems that occurred in Magelang regency, there is 1 district which become the main priority of extension activity that is Pakis district, while Salaman, Srumbung, Grabag, Windusari, Kaliangkrik are districts with medium priority. Other districts are included in low priority. With a limited number of extension workers, the placement of extension workers is preferred to district with priority and medium priority. Other extension workers can be placed in districts with low priority with work area of 2-3 districts.

4. Conclusion
Priority of the forestry extension officer distribution could be created by a decisive system using AHP & GIS method. The distribution of the forestry specialist up until now is based with the principle of balance in each district. The result shows that the distribution of the forestry extension officer is not in accordance with the environmental issues occurred in Magelang regency. Work area priority is limited only to the environment condition. From the literature review and field observation, social condition could be enlisted as a parameter because the object of the extension activity is human itself.

References
[1] Kementrian Lingkungan Hidup dan Kehutanan 2015 Statistik Kementrian Lingkungan Hidup dan Kehutanan Tahun 2015 Jakarta
[2] Kementrian Lingkungan Hidup dan Kehutanan 2016 Deforestasi Indonesia Tahun 2014-2015. Jakarta : Direktorat Inventarisasi dan Pemantauan Sumber Daya Hutan
[3] Cao Q, Yu D, Georgescu M, Han Z and Wu J 2015 Impacts of land use and land cover change on regional climate: a case study in the agro-pastoral transitional zone of China. *Environ Res Lett.* **10**

[4] Pawitan H 2014 Perubahan Penggunaan Lahan Dan Pengaruhnya Terhadap Hidrologi Daerah Aliran Sungai. Researchgate

[5] Peraturan Menteri Kehutanan Republik Indonesia No 10 Tahun 2011 Tentang 6 (enam) Kebijakan Prioritas Bidang Kehutanan dalam Program Pembangunan Nasional Kabinet Indonesia bersatu II.

[6] Peraturan Menteri Kehutanan Lingkungan Hidup dan Kehutanan Republik Indonesia No 36 Tahun 2015 Tentang Petunjuk Teknis Fungsional Penyuluh Kehutanan dan Angka Kreditnya.

[7] Alkaf M, Munibah K and Rusdiana O 2014 Model Spasial Perubahan Penggunaan Lahan Di Taman Nasional Gunung Merbabu dan Daerah Penyangganya. *Majalah Ilmiah Globe.* **16**(1):43–50.

[8] Dinas Pertanian Tanaman Pangan Peternakan dan Kehutanan 2015 Laporan Akhir : Penyusunan Rencana Kehutanan Tingkat Kabupaten (RKTK) Kabupaten Magelang Tahun 2015. Magelang

[9] Oktariadi O 2009 Penentuan Peringkat Bahaya Tsunami Dengan Metode Analytical Hierarchy Process. *J. Geologi Ind.* **4**(2) 103-16

[10] Anasiru R H 2016 Analisis Spasial Dalam Klasifikasi Lahan Kritis Di Kawasan Sub-Das Langge Gorontalo. *Informatika Pertanian* **25**(2) 261-72

[11] Kementrian Lingkungan Hidup dan Kehutanan 2015 Statistik Kementrian Lingkungan Hidup dan Kehutanan Tahun 2015 Jakarta