The Encroachment Dynamics in Mount Gede Pangrango National Park

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Abstract. Mount Gede Pangrango National Park is the example of a protected area in which land conflict happens. The surrounding communities run their cultivation activities inside the national park which are actually illegal according to the law. This research aims to capture the progress of conservation efforts vis-a-vis such an encroachment issue as well as to explore the characteristics of the surrounding villages that can explain the encroachment level. To this end, this research performed spatial analysis and stepwise multiple regression using Landsat imagery, Google Earth images and village potential data. The result shows that the area of plantation, dry-agriculture land and bare land were declining. The encroachment level could be associated with the distance of settlement to the number of farm laborers around and the land slope of the national park. Meanwhile, the existence of large land occupied by the private company could restrain the tendency of local people to encroach the land of national park.

Keywords: national park, spatial analysis, landuse change, land occupied

1. Introduction
The establishment of protected area through state regulation is one of the existing tools in conserving regions having native ecosystem and biodiversity. In the populous developing countries such as Indonesia, enforcing such policy may face serious challenges. It is often found that some parts of conservation-designated area have been already occupied by local people before and after the stipulation. In addition, in many cases, there have been conflicts among interested parties, mainly between the related governmental bodies and the surrounding society [1]. The government is obligated to carry out the conservation mandate. On the other hand, the surrounding communities, mostly low economic class, have dependency on the resource within the protected area. Even, some people have resided within the area. These situations have then generated legal and social problems [2,3].

Mount Gede Pangrango National Park (MGPNP), conserving tropical forest, is an example of protected area in which land conflict happens. The common types of human-induced disturbance in the forest conservation area are timber theft, wild animal hunting, uncontrolled farming, and illegal logging [4]. In general, such behaviors resonate the common practices of illegal land utilization in Indonesia [3].

Since its first legal establishment, MGPNP has been expanded two times, merging production forest and other protected areas into national park under one official management. There were differences in
management concept and rules before and after the land was designated as a national park. For instance, Perhutani (a state-owned company dealing with forest products) allowed the community to utilize some lands through community forest management (CFM) concept - not only for harvesting forest product but also dry-land agricultural activities. After the land status has been transformed into a national park, such practice has become prohibited by the state law. However, this prohibition does not directly encourage the local people to stop their activities as the utilization of this land can generate income for them.

According to Arshanti [5], 75% of people around MGPNP are working in the agricultural sector. Carolyn [6] adds that 40% of the farmers are farm laborers who do not own agricultural land, therefore access to land resource is crucial with regards to their income source. In difficult economic situations, farmers especially those without land around forest region tend to penetrate and utilize the forest [7]. This can potentially increase land clearing activities in the forest area [7].

Considering that MGPNP is surrounded by densely populated area, the encroachment phenomena will possibly continue to occur. Efforts to conserve this area may thus become challenging. In this research, we aims to paint a picture of the conservation progress amidst the encroachment practices by paying attention to land cover change of MGPNP (research objective 1; RO1), especially before and after the expansion. We also inspected the relation between the characteristics of the surrounding villages with the encroachment level (RO2).

2. Literature Review

2.1. National Park
National park according to Law 5/1990 on Conservation of Biological Natural Resources and their Ecosystems is defined as natural conservation areas with native ecosystems, managed through zoning systems and used for research, science, education, cultivation, tourism and recreation purposes. Based on management concept, the national park is surrounded by a buffer area. This area provides an additional layer of protection for the national park. Buffer zone should ideally be in the forms of forest, free-state land or land encumbered with rights, and they are needed to maintain the ecosystem of the national park [8]. Buffer zone has two main functions. The first is as additional area for flora and fauna habitat and the second is as social buffer. To strengthen its function as social buffer, buffer zone should be able to produce valuable products for the community [9]. However, maintaining buffer zone is difficult since most lands have become private property.

Conservation and research activities in MGPNP area began in 1830 through the establishment of a small botanical garden near the palace of the Governor General of Dutch East Indies in Cipanas. In 1889 the Dutch East Indies Government designated a plot of mountain forest (covering 240 hectares: the botanical garden, hot water, and surrounding areas) as a nature reserve - the first nature reserve and biodiversity conservation area established in Indonesia. After Indonesian independence, the government raised the legal status of the nature reserve and other adjacent area to be national park covering 15,196 hectares. This area had continued to expand. In 2003 Minister of Forestry determined the first expansion to 21,975 hectares. The new lands came from natural reserve, natural tourism parks, production forests, and limited production forests that were located around MGPNP [10]. Perhutani handed over some of its lands to national park in 2009, so the area had increased to 22,851 hectares (known as second expansion). In 2014, to correct the lands belonging to MGPNP, the boundary line of GGPNP were remeasured by comparing the boundaries based on written documents, boundaries in the field, as well as existing maps. This activity eventually expanded the area known as part of the national park to 24,270 hectares.

2.2. Conflict of Interest in National Park
According to Law 5/1990, several activities are allowed to be conducted within the national park: research, science, education, supporting cultivation, tourism, and recreation. The duty of related
government body, i.e. Center of MGPNP, is to maintain the conservation function of the national park in accordance with the mandate of the law. The center began to face serious encroachment problems since the expansion of the MGPNP area in 2003 (enacted through Forestry Minister’s Decree Number 174/Kpts-II of 2003). The problem source was that residents had been already conducting agricultural activities in some parts of the new MGPNP land.

The existing human activities had thus threatened the main function of the national park [11]. Although land utilization is also mentioned in the law, this activity is particularly for environmental services that have little or no physical change or intervention [12]. Adding to the conflict, the local community claimed to be the owner of land after it had been determined as part of the national park [13].

The local people often do illegal hunting, timber theft, rattan and bamboo theft, land grabbing, and fruit harvesting in MGPNP [14]. The use of forest land without right permit, known as illegal occupation, is basically due to people’s strong need on land, mainly as their source of income [15]. For rural community, land is the main resources of welfare [16,17]. Pakpahan and Erwidodo [18] argue that rural communities around forest in Java Island experience difficulties in obtaining employment because of lack of employment opportunities, lack of skills to work other than in agricultural sector, and low mobility.

3. Methodology

3.1. Study Area

The study area of this research is Mount Gede Pangrango National Park (Figure 1), located in West Java Province, Indonesia. This national park preserves 2 peaks of twin volcanoes, i.e. Mount Gede and Mount Pangrango, as well as the forest covering it. The forest ecosystems consist of montane, upper montane and subalpine forests. Administratively, MGPNP is located in 3 regencies - Bogor, Cianjur, Sukabumi Regency. The national park is surrounded by 61 villages (desa) from 18 districts (kecamatan). Based on PODES 2011 database, people from the 52 villages depend strongly on agriculture producing staple, horticulture and plantation goods. Meanwhile, most people from the 9 villages work in non-agricultural sectors: processing industry (4 villages); transportation, warehousing and communication (3 villages); trading and restaurants (1 village); and tourism-based services (1 village).

Figure 1. Research location.
3.2. Methods

This study used relevant secondary data: Landsat imagery from USGS, village survey data (PODES) from Statistics Agency and village boundaries from Geospatial Information Agency. Additionally, to understand the result of statistical analysis we interviewed 7 government officers. In general, our approaches consisted of land cover change, zoning consistency and encroachment determinant analysis.

3.2.1. Land Cover Analysis. The land covers data were built by interpreting (on-screen digitizing) Landsat imagery and Google Earth images using ArGIS 9.5 (ESRI, Redlands, CA, USA). Three points of year reference were selected: 1999, 2005 and 2011. The first refers to the state before the first expansion of MGPNP, while the second one refers to the state after the second expansion. 2011 represents several periods after expansion.

Land covers were grouped into 9 classes: primary dryland forest (Fp), secondary dryland forest (Fs), shrub (S), plantation (Pl), dry-agriculture land (Da), build-up land (Bu), rice field (Rf), water body (W), and bare land (Bl). Land cover definition follows document of National Standardization Agency, SNI 7645-2010. In all procedures, we used the latest border of MGPNP, established in 2014, which was obtained from the Center of MGPNP.

\[
LCC = 100 \left\{ \left( \frac{x_n}{x_0} \right)^\frac{1}{n} - 1 \right\}
\]

The rate of land cover change was calculated using Equation 1. LCC is the change rate of land cover in percent per year, \(x_0\) is the land cover area of 0th year, \(x_n\) is the land cover area of nth year, and \(n\) is the number of years. Logic matrix producing six categories of LCC status was developed to grouping variations in land change based on inter-year spatial overlay (see Table 1).

LCCs were differentiated into new encroached land, abandoned land, constant encroachment, stable non-encroachment, changed non-encroach land, and stable shrubs. New encroached land (a) is land previously free from human disturbance, but then changing in a certain period into cover that is unnatural, disturbed, or intensively utilized for agriculture. Meanwhile, abandoned land (b) is the land formerly used for intensive agricultural activities inside the national park in which encroachers stopped cultivating it. It could be marked by the change from plantation, dry-agriculture land, or paddy field into bare land, shrub, or secondary forest.

Table 1. Status of land cover change.

| Land cover change status | Land cover of nth year |
|-------------------------|------------------------|
|                         | Fp  | Fs | S  | Pl | Da | Bu | Rf | W  | Bl |
| Land cover of 0th year  |     |    |    |    |    |    |    |    |    |
| Fp                      | d   | a  | a  | a  | a  | a  | a  | -  | a  |
| Fs                      |    | d  | a  | a  | a  | a  | a  | -  | a  |
| S                       |    | e  | f  | a  | a  | a  | a  | -  | a  |
| Pl                      |    | b  | b  | c  | a  | a  | a  | -  | b  |
| Da                      |    | b  | b  | a  | c  | a  | a  | -  | b  |
| Bu                      |    |   |   |   |   |   | c  | -  | -  |
| Rf                      |    | b  | b  | a  | a  | a  | c  | -  | b  |
| W                       |    |   |   |   |   |   | -  | d  | -  |
| Bl                      |    | e  | e  | a  | a  | a  | a  | -  | d  |

\(^{Fp}\) primary dryland forest, \(^{Fs}\) secondary dryland forest, \(^{S}\) shrub, \(^{Pl}\) plantation, \(^{Da}\) dry-agriculture land, \(^{Bu}\) build-up land, \(^{Rf}\) rice field, \(^{W}\) water body, \(^{Bl}\) bare land; \(^{a}\) new encroached land, \(^{b}\) abandoned land, \(^{c}\) constant encroachment, \(^{d}\) stable non-encroachment, \(^{e}\) changed non-encroach land, \(^{f}\) stable shrub, and \(^{g}\) irrelevant change
Then, constant encroachment (c) is land with intensive agricultural activity or built-up area within the national park area that has not changed during a certain period. Meanwhile, stable non-encroachment (d) is land with cover that does not represent encroachment activities within the national park and has not changed in a certain period and changed non-encroachment land (e) is non-encroached land that changes naturally to become greener. Lastly, stable shrub (f) is shrub-covered land that remains constant in a certain period. Shrub is not deemed as either encroached or non-encroached land since it has both possibilities. Nevertheless, we judge it as the expected condition of national park.

3.2.2. Encroachment Determinants. Multiple regression analysis was employed to identify which embedded characteristics of villages have a significant effect on encroachment. This analysis used stepwise multiple regression. There were 2 dependent variables and 13 independent variables tested (Table 3). Dependent variables were encroached land \( Y_1 \) and agricultural land \( Y_2 \) inside MGPNP. The value of first variable was from the results of LCC analysis in 2005-2011 period, especially lands categorized as new encroachment and stable encroachment. While that of second variable was encroached land in the form of agricultural activities recorded in 2011. Then, the independent variables were grouped into continuous data \( X \) and dummy data \( D \). \( X \) consisted of 8 variables and \( D \) contained 5 variables. We tried to analyse whether there was a connection between the existence of a village in a regency against encroachment activity through variables \( D_1, D_2 \) and \( D_3 \). Then, \( D_4 \) and \( D_5 \) are for whether land policies that has been or was being carried out affect the encroachment level.

**Table 2.** Variables employed in stepwise multiple regression.

| Code | Variables* | Unit |
|------|-------------|------|
| \( Y_1 \) | Encroached land | ha |
| \( Y_2 \) | Agricultural land | ha |
| \( X_1 \) | Village development index | |
| \( X_2 \) | Number of farm laborers | |
| \( X_3 \) | Number of small industries | |
| \( X_4 \) | Percentage of farming family | % |
| \( X_5 \) | Distance between nearest settlement and MGPNP | km |
| \( X_6 \) | Percentage of pre-prosperous family plus prosperous family | % |
| \( X_7 \) | Population density | people/ha |
| \( X_8 \) | Area with 0-25% slope within 1 km inside the boundary | ha |
| \( D_1 \) | Village is located in Bogor (1) or not (0) | |
| \( D_2 \) | Village is located in Cianjur (1) or not (0) | |
| \( D_3 \) | Village is located in Sukabumi (1) or not (0) | |
| \( D_4 \) | Buffer zone occupied by legal enterprises or government (1) or not (0) | |
| \( D_5 \) | There was of CFM in the past (1) or not (0) | |

*value at village level converted into natural logarithm, \( Y \) dependent variable, \( X \) independent variable (continuous data), \( D \) independent variable (dummy data)

4. Results and Discussion

4.1. The State of Land Cover

Primary dryland forest was the most extensive land cover in MGPNP and tends to be centrally located in the middle of the region. This type of land cover had decreased from 1999 to 2011 (Figure 2). Such cover has tight criteria in that it only allows natural and undisturbed cover. If there were an interruption by human, the class would change into ecologically lower category. Yet, secondary dryland forest, spread around the edge of MGPNP, had a rising trend from 1999 to 2011. The constant increase of this cover was caused by rehabilitation result on formerly encroached lands and disturbed primary dryland
forest. According to our interviewees, most secondary forests came from the lands originally managed by Perhutani. There were logging and tree replanting on the land, which were carried out with a rotating block system.

Lands covered by shrub, like secondary forest, spread on the edge of MGPNP and gradually arose. The upward trend of shrub area happened because of 3 things. First, there was interference on the primary dryland and secondary dry land forest, followed by the conversion into shrub. Nevertheless, this was not in remarkable amount. Then the second one was the ex-encroached land left behind by the squatters. Thirdly, the rehabilitation results by the government on non-forest lands.

![Figure 2. MGPNP’s land cover in percentage.](image)

Encroachment-related land covers - paddy field, plantation, and dry-agriculture land seemed to dwindle during 1999-2011. Paddy field covers were generally in the area around the river and dominantly spread on the west and northwest side of the national park. In MGPNP, paddy fields were not too large due slope obstacle. Water accumulation could occur only around the small rivers. Then the plantation area inside MGPNP border was relatively narrow as well, in the range of 0.07%-0.08%, mostly in the form of tea plantation. It spread in the north side and the south side of national park. In Cianjur Regency, there were plantations especially in Cirumput and Padaluyu village which slightly crossed the line of national park. Limitation of boundary signs of the national park caused differences in perception, both for the Center of MGPNP and plantation company.

Dry-agriculture land was the largest kind of encroachment in MGPNP. Such lands concentrated on two poles i.e. the southwest and northeast side of MGPNP. Those lands close to Cipanas and Pacet District, based on our interviewees, were occupied to plan horticultural crops. While farmers around Pawenang Village mainly plant corn, cassava, vegetables and nuts in the MGPNP field [19]. However, the declined agricultural land indicated that people gradually left agricultural activities inside MGPNP. Hence, the land previously used for farming became abandoned and changed into shrub or bare land.

The number of bare lands in MGPNP in 1999 was quite large, 537.45 hectares or 2.21%. This came from GGPNP crater, mountain meadow, ex-fire land, abandoned encroachment, and land that has not been rehabilitated after the trees had been felled. In 2005, the percentage of bare lands reduced to 1.32% but later went up to 1.50% in 2011. This increase did not mean that there was land clearing, but it was caused by the large amount of encroached land left by the local community. Many lands had been abandoned without any or thin vegetation cover.

Built-up land in MGPNP only amounts to 0.03%. It came mainly from tourism-related buildings: (1) Situ Gunung, located in the south side of the MGPNP especially in Sukamanis Village; and (2) Telaga Biru in Cimacan Village - water body, 0.04% in total, was only from these 2 tourisms as well. The Center of MGPNP was also responsible for the existence of the buildings inside the national park. According to our respondents, such usages were tolerable since those were used for official purposes, directed to perform conservation activities e.g. for nature tourism and management office. Yet, attention should be necessarily paid for buildings, in some locations, that surpassed MGPNP boundary due to border vagueness (see Appendix 6).
4.2. Land Cover Change (ROI)

In the period of 1999-2005, we found that there were 11 encroachment-related LCCs (see Table 4). 53.45 hectares of primary forest and 121.98 hectares of secondary forest had changed into shrub, dry agriculture, and bare lands. While 82.98 hectares lands previously covered by shrub became dry agriculture, built-up and bare lands. Few areas of bare lands, 3.06 hectares, had also been converted into plantation and dry agriculture lands. Most of these covers had considerably became dry agriculture lands, 231.45 hectares, which were from primary forest, secondary forest, shrub, and bare lands - 44.64, 114.78, 69.85, and 2.18 hectares respectively.

Then, LCCs during 2005-2011 were more varied. 14 cases, based on cover change analysis, had been found. Primary forest (17.10 hectares) was disturbed and became secondary forest, shrub, plantation, dry agriculture, and bare lands. Secondary forest (14.75 hectares) and shrub (55.85 hectares) turned into plantation, dry agriculture and bare lands. Since the strict limitations of agricultural activities had been implemented, the encroachment risk had significantly declined. There were only 54.65 hectares of new dry agriculture lands during this period. The interesting one is that there were higher plantation activities surpassing MGPNP border (7.07 hectares) comparing to that in 1999-2005.

| Origin land cover in 1999 (ha) | Encroachment-increasing changes in 2005 (ha) | Sum |
|-------------------------------|---------------------------------------------|-----|
|                                | Fp  | Fs  | S   | Pl  | Da  | Bu  | Rf  | Bl  |
| Fp                            | 7.34 | 1.27 | 0.87 | -   | -   | -   | -   | -   |
| Fs                            | -   | 0.98 | -   | 0.42 | 2.34 | 2.15 | -   | -   |
| S                             | -   | -   | 0.27 | -   | -   | -   | -   | -   |
| Pl                            | -   | 0.27 | 2.15 | 40.99 | 0.28 | 69.85 | -   | -   |
| Da                            | -   | -   | -   | -   | -   | -   | -   | -   |
| Bl                            | -   | -   | -   | -   | -   | -   | 1.89 | 1.12 |

| Origin land cover in 2005 (ha) | Encroachment-increasing changes in 2011 (ha) | Sum |
|-------------------------------|---------------------------------------------|-----|
|                                | Fp  | Fs  | S   | Pl  | Da  | Bu  | Rf  | Bl  |
| Fp                            | 8.59 | -   | 0.98 | -   | 3.10 | 44.64 | -   | -   |
| Fs                            | -   | 7.07 | 9.44 | -   | -   | -   | 3.97 | 17.10 |
| S                             | -   | 54.65 | -   | 1.12 | -   | -   | 1.89 | 19.66 |
| Pl                            | -   | -   | -   | -   | -   | -   | -   | 261.16 |

Few areas of bare lands, 3.06 hectares, had also been converted into plantation and dry agriculture lands. Most of these covers had considerably became dry agriculture lands, 231.45 hectares, which were from primary forest, secondary forest, shrub, and bare lands - 44.64, 114.78, 69.85, and 2.18 hectares respectively.

However, even though some lands had been turned into new encroachment lands, the number of abandoned lands were higher (Figure 3). During 1999-2005, new encroached lands was smaller than abandoned encroached lands, which were 261.16 hectares and 271.42 hectares respectively. This difference was not too significant: there was only a slight decline of encroachment area. While in 2005-2011, new encroachment was only 90.96 hectares and abandoned encroached land reached 481.12 hectares. Large stable encroached land during 1999-2005 came from those managed by Perhutan. Then the land was converted into a national park in 2003. Socializations by government in charge regarding
land use restrictions on national park were still limited from 2003 to 2005. Thus, many people remained occupying the lands inside national park. But during the next period, the Center of MGPNP had done more rehabilitation efforts.

Figure 3. Encroachment-related LCCs in MGPNP.

The change rate of primary dryland forest was negative, but the value was small, -0.03% per year from 1999 to 2011 (Table 6). However, this downward trend was counterbalanced by a growth rate of secondary forest, 2.55% per year from 1999 to 2011. Therefore, forest cover constantly increased. While change rates of encroachment-related land covers - plantation, dry agriculture land, rice fields and bare land, rates - were negative as well. Although the built-up land’s growth was positive, this addition only occurred during 1999-2005. This in general showed that the surrounding community tended to abandon the illegal activities inside MGPNP from 1999 to 2011.

Table 5. Average annual land cover change rates in GGPNP.

| Class of land cover         | Average of change (%/year) |
|-----------------------------|----------------------------|
|                             | 1999-2005  | 2005-2011  | 1999-2011 |
| Primary dryland forest      | -0.05      | -0.01      | -0.03     |
| Secondary dryland forest    | 2.81       | 2.30       | 2.55      |
| Shrub                       | 0.50       | 1.33       | 0.91      |
| Plantation                  | 0.80       | -2.22      | -0.72     |
| Dry-agriculture land        | -0.08      | -6.37      | -3.28     |
| Built-up land               | 0.70       | 0.00       | 0.35      |
| Rice field                  | -5.69      | -13.27     | -9.56     |
| Water body                  | -          | -          | -         |
| Bare land                   | -8.24      | 2.12       | -3.20     |

4.3. Determinants of Encroachment (RO2)

Regression results (Table 8) show that the area of encroached land ($Y_1$; encroachment in all forms) was significantly related to 4 variables: the number of farm laborers ($X_2$), the distance between the nearest settlement and MGPNP ($X_5$), land with 0-25% slope within 1 kilometer inside the MGPNP’s boundary ($X_8$), and the existence of a village in Cianjur Regency ($D_2$). The regression result was quite good. It contained a very low probability value, and each $p$-value was below 0.05. These four variables could be considered to explain 47.4% of encroachment issue in MGPNP.

Table 6. Result of stepwise multiple regression.

| Model Indicators | Coef | Std err | t       | p>|t| | Root MSE | Summary |
|------------------|------|---------|---------|------|---------|---------|
| $Y_1$            |      |         |         |      |         |         |
| Cons             | -9.90| 3.09    | -3.20   | 0.00 | -0.90   | -9.90   |
| Independent variables | $X_2$ | $X_5$ | $X_8$ | $D_2$ | $D_4$ | $R^2$ |
|                  | 1.14 | -1.01   | 0.66    | 1.50 | -7.14   | 0.51 |
| $Y_2$            |      |         |         |      |         |         |
| Cons             | -7.14| 2.72    | -2.63   | 0.01 | -7.14   | -7.14   |
| Independent variables | $X_2$ | $X_5$ | $X_8$ | $D_2$ | $D_4$ | $R^2$ |
|                  | 1.14 | -1.04   | 0.00    | 0.00 | -7.14   | 0.49 |

* Only significant variables included, ** Variable names are listed in Table 3
The area of agricultural lands, performed illegally in MGPNP ($Y_1$), had a significant relationship with 3 factors. The first two factors were the same as $Y_1$, i.e., the number of farm laborers ($X_2$) and the distance between MGPNP’s boundary and the nearest residential area in a village ($X_3$). Then, the third factor related to who was given the right to manage the land ($D_x$). Model accuracy for the second dependent variable was also quite good whereas the probability value was very low. In addition, the p-value of the three independent variables was also below 0.05. However, this model is only able to explain the phenomenon of the existence of agricultural land inside MGPNP by 46.5%.

The number of agricultural laborers in closest villages affects encroachment activities, with positive relationship, in the national park. This shows that the more the number of farm laborers from the closest village was, the more illegal encroachment and agricultural lands inside MGPNP would be. Farm laborers did not have their own land and were in urgent need of land to meet their economic needs. Sawitri and Bismark [19] also mentioned that the income of farm laborers around MGPNP ranged from 20,000 rupiah to 25,000 rupiah per day. People who live around forest areas in difficult economic conditions have a tendency to increase dependence on forest products, moreover, there is also a tendency to carry out activities to clear forest areas [7].

Both $Y_1$ and $Y_1$ had negative relationship to the distance of settlement of a village to the GGPNP area in which the closer the distances were, the greater encroachment areas would be. The number of encroachment and agricultural lands inside MGPNP on Bogor’s side is smaller than that of Sukabumi’s and Cianjur’s side. According to Sawitri and Bismark [19] this was due to the fact that the distance of villages in Bogor Regency to the GGPNP area was very far and the direct interest of the community towards the MGPNP land was low. Conditions of land slope become physical obstacle as well for the community to access the MGPNP land. This is certainly reasonable because the higher the slope was, the higher the production costs would become. The MGPNP lands with slope less than 25%, were at greater risk for being penetrated by local people. This was corroborated by the $X_1$’s coefficient whereas the land area with 0-25% slopes had positive relationship with encroachment.

Land tenure by certain parties was also a determining factor. In this study, we observed land licensing surrounding the national park. Lands managed by medium or big enterprises, all for plantation, were distinguished from lands directly managed by the community. This concept was then included as a dummy variable in the regression analysis. The result was significant that land ownership affected the extent of illegal agricultural activities inside MGPNP. Buffer zones that were managed directly by the community tend to increase the risk of encroachment, vice versa. It implies lands around MGPNP utilized by private sectors, especially plantation in this case, tended to be ‘a fence’ for preventing encroachment. It was like an obstacle of mobility.

4.4. Recommendations

In order to facilitate the handling of the encroachment problem, we tried to group villages based on the extent of encroachment and the special characteristics inherent on these villages. This grouping was done without statistical analysis, but rather by using data analysis generated directly by the author. We divided all villages into 5 treatment areas (see Table 9). Villages without any encroachment are in Group 1. Group 2 is grouped according to the fact that there was no encroachment in the form of intensive agricultural activities. Generally, local people only take forest products. Villages that penetrated TNGGP narrowly, only ranged from 0.1 to 4.2 hectares, are then included in Group 3.

**Table 7. Village group recommendation for handling encroachment.**

| Group | Village |
|-------|---------|
| Group 1 | Lemah Duhur, Citapen, Benda, Cikahu ripan, Cipetir, Undrus Binangung, Babakan Panjang, Sukamaju¹, Cisarua, Langensari, and Margaluyu. |
| Group 2 | Kebonpeuteuy, Tegallega, Gede Pangrango, Sukamanis, Cibeureum, Tugu Selatan, Cirumpit, Padaluyu, Sarampad, Bunikasih, Mekarwangi, Karawang, Sudajaya Girang, and Sukalarang. |
Group 3  Citeko, Kuta, Girijaya, Cileungsri, Cibedug, Cikembang, Cimande, Sukamulya2, Bojong Mumi, Purwasari, Gekbrong, Sukatani, Sukamulya3, Seuseupan, Sukaesmi, Cingagara, Nanggerang, Sukagali, Tangkil, and Wates Jaya.

Group 4  Kalaparea, Ciharaeng, Pasir Buncir, Pancawati, Ciloto, Cimacan, and Nagrak Utara.

Group 5  Sukamulya4, Ciputri, Cipendawa, Galudra, Sindangjaya, Pawenang, and Wangunjaya.

Group 6  Ginanjar and Cihanyawar.

1 Sukalarang District; 2 Kadudampit District; 3 Caringin District; 4 Cugenang District

Group 4 covers villages owning land encroachment in the range of 7 to 20 hectares. This region certainly has greater handling needs than cluster 3. Some villages have serious problems whereas they have vast area of encroachment, 25-65 hectares, and have a tendency to increase. Villages with such conditions are included in Group 5. The last group, Group 6, contains regions with serious problems: more than 100 hectares of disturbed national park land. There are only 2 villages with these conditions. However, the extent of encroachment land of both villages tends to decrease year by year.

The results of the regression analysis show that the existence of a company that manages buffer zones has a good impact on the conservation of national parks. It seems to be a fence between national park and local community so that they were hindered from entering the national park land easily. Handing over the lands in the buffer zone to the private sector, if it is still possible, can be one good long-term solution. But it should keep in mind that the company must be engaged in agricultural sector. This at least has 2 advantages: conservation in national park could be well maintained and the community can make money from the company.

5. Conclusion
The land cover areas that were identical to encroachment, i.e. plantation, dry-agriculture land, rice fields and bare land, tended to constantly decrease. Meanwhile, built-up area and water body were relatively consistent. Although primary dryland forests declined, shrub and secondary dryland forest went up with the larger aggregate area. This shows that the forest cover in the MGPNP increased as time go by, particularly during 1999-2011.

The encroachment area and illegal agricultural activities in MGPNP was significantly influenced by the distance of the village settlement to GGPNP, the number of farm laborers, the lands with 0-25% slopes within 1 kilometer inside the national park border, and the land licensing in the buffer zone. The distance of settlement to GGPNP has a negative effect to the illegal activities inside MGPNP. Meanwhile, the lands with 0-25% slope and the number of farm workers were positively correlated to encroachment phenomena. Lands in buffer zones managed by private companies had a lower risk of encroachment than those managed by the community.

6. Appendices
Appendix 1. Appearance of land cover in imagery.

| Name                  | Institution                        | Position                      |
|-----------------------|------------------------------------|-------------------------------|
| Rohmadin, SIP         | Government of Caringin District     | Section Chief of Economy      |
| Dra Tetih Sutia Sumila| Government of Megamendung District  | Section Chief of Economy      |
| Isur Surwati, SE, MM  | Government of Cisarua District      | Section Chief of Economy      |
| Teguh Iriyanto, SP MSi| Government of Ciai District         | Chief of Agricultural Service |
| Ardi Andono, STP MSc | Center of MGPNP                    | Section Chief of Cianjur Area |
| Sumiyanto             | Government of Cipanas District      | Section Chief of Governance   |
| AE Haenudin SIP       | Government of Pacet District        | Section Chief of Governance   |
Appendix 2. Government officers interviewed in the study.

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