

Park Buffer Zone Reforestation Initiative

Batang Gadis National Park in Sumatra, Indonesia

by

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Masters project submitted in partial fulfillment of the
requirements for the Master of Environmental Management degree in
the Nicholas School of the Environment and Earth Sciences of

Duke University

2007

Abstract

Sumatra holds extremely high biodiversity, yet its biodiversity is some of the most endangered on Earth, threatened by rapid deforestation. Despite their protected status, some national parks in Indonesia are under severe threat of deforestation due to lack of support from local governments and communities. Batang Gadis National Park (BGNP) is one of the first national parks established through a “bottom-up” process by local communities and local government officials. The buffer zone of BGNP is established to extend 10km outside the national park to reduce the impact of humans on species inside the park. However, the buffer zone is densely populated and the population pressure has caused illegal logging and forest clearing for agriculture and human settlement. The reforestation project is designed to achieve forest rehabilitation and also socio-economic reform of local communities by providing economic alternative income sources and resources. This study suggests priority sites for reforestation projects by analyzing the ecological impacts and socio-economic factors. GIS analysis was employed to examine ecological impacts and to select priority sites. Social survey was used to understand the attitudes and expectations of local communities toward reforestation projects and conservation. This study also provides some suggestions for the effective implementation to achieve conservation goals and enhance both the participation of local communities and their conservation awareness.

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Introduction

Sumatra

Sumatra is the third largest island in Indonesia, 1,800 kilometers long and 400 kilometers wide, with an area of 47.6 million hectares. It holds the highest levels of biodiversity and conservation threats on Earth. Sumatra has the most mammals (210 species) of any Indonesian island. Sixteen species of mammals are endemic to Sumatra and eight of them are listed in the IUCN *Red List of Threatened Species* (CEPF 2004). This island is also unique in supporting populations of most of Asia's large mammals, including the elephant (*Elephas maximus sumatranus*), Sumatran tiger (*Panthera tigris sumatrae*), Sumatran rhinoceros (*Didermocerus sumatrensis*), and Sumatran orangutan (*Pongo abelii*) (Kinnaird 2003).

However, the rapid decrease of lowland forest is now a serious threat to this exceptional biodiversity. According to the World Resources Institute, forest cover in 1997 was about 16.6 million hectares, representing a 45 percent decline from 1950. Especially, the loss of lowland forest is extremely high, and Holmes (2002) predicted that Sumatra's non-swamp lowland forest would be gone by 2005. The variety of factors, including logging (legal and illegal), development of estate crops (mainly oil palm), conversion to agriculture, and forest fires are attributed to this dramatic loss of Sumatra's forest cover (Kinnaird 2003).

During the 1990s, many of the action plan priorities were implemented, including the expansion of the Protected Area system and the creation of national parks (WRI 2002). Despite these positive activities, some national parks in Indonesia remain under severe threats of deforestation. Because national parks in Indonesia have been declared through a top-down process by the national government, there is a lack of support from the local governments and communities which results in the current deforestation issue (van Beukering et al. 2003).

Batang Gadis National Park

A massive flash flood killed more than 140 people in the villages of North Sumatra in 2003. Environmental organizations have attributed this flash flood to deforestation from illegal logging in the area, which has weakened the landscape's ability to absorb water (*Jakarta Post*, October 25, 2004). This catastrophe triggered the creation of a national park in the neighboring Mandailing Natal regency. The communities and local government united to establish 108,000 hectares for the Batang Gadis National Park (BGNP) in October 2004. It is one of the first national parks established by local government officials, and it is a model for the "bottom-up" process of national park creation and collaborative management. However, illegal logging, expanding agriculture, and encroachment continue to cause deforestation in BGNP as well as in other parts of the Sumatran lowland forest.

Reforestation Project in Park Buffer Zone

Indonesia's Ministry of Forestry (2003) estimated that 96.3 million hectares of the country's land area was degraded, including 54.6 million hectares of degraded forest in need of rehabilitation. Rehabilitation can increase the area of forest as well as conserve remaining primary forests and environmental quality. In addition to its biological function, socio-economic reform is important to focus on local community participation and acceptance (Kobayashi 2004). The reforestation project in the park buffer zone is one of the initiatives in BGNP which the local government and NGOs are currently working on. This particular project is in the planning stage by Conservation International Indonesia (CI-I). The objectives of this reforestation project are:

1. To reduce pressures from cultivation areas on the Batang Gadis National Park
2. To decrease the possibility of disasters resulting from conversion of the conservation area

In order to achieve these objectives, the participation and awareness of conservation objectives by the local community are necessary. Lawrence (1996) implied that the

consensus among policy makers, government officials, academics, and NGOs is that achieving conservation goals can only complement advances in rural development if people living on the edge of primary rainforest are actively involved in the planning and implementation of projects designed to slow deforestation. Along with this consensus, the following strategies are taken in this project:

1. Create an alternative income for the local communities who rely on resources in the national park.
2. Provide alternative resources in the buffer zone, such as fuel wood, food crops, and medicinal plants that are currently taken within the national park.
3. Increase environmental and conservation awareness, also on laws and regulations in regard to conservation area and its flora and fauna.
4. Improve the form of participation of local communities in the planning and development of the buffer zone through a reforestation program.
5. Establish physical and habitat barriers to halt the expansion of exotic species, domestic animals, fire, pollution materials or other destructive elements to cross from the buffer zone area into the national park.

Objectives of this study

Given the limited budget and resources, it is important to understand the priority sites by examining the ecological impact and socio-economic condition of local communities for project success. The specific objective of this research is to propose priority sites by examining several factors such as deforestation threats caused by human activities, possibility of disasters, and the acceptance of local communities for project participation. In addition, this study assesses the requirements of project implementation to have a full appreciation of the impact of rehabilitation. The outcome of this study is a model of the site selection and the implementation plan for future reforestation projects in the buffer zone of the BGNP.

Study Area: Batang Gadis National Park

1. Geographical location and Biodiversity

Batang Gadis National Park (BGNP) is located in Mandailing Natal District, North Sumatra, Indonesia (Fig.1). Geographically, this national park is located between 99°12'45" to 99°47'10" E and 0°27'15" to 1°01'57" N. The BGNP ecosystem is one of the richest remaining examples of tropical rainforest in the world. Covering an area of approximately 108,000 hectares, it stretches from Panyabungan graben to the peak of Mt. Sorik Merapi (2,145 meters above sea level), and is composed of lowland forest, limestone forest, freshwater ecosystem, submontane and montane forest with the Sorik Merapi volcanoes as the highest point. 77 percent of vegetation cover in BGNP is from primary dry forest, 16 percent from secondary dry forest, and others are from farming and shrub land. A biodiversity study conducted by Conservation International Indonesia in 2004 found forty-two species of mammals including the Sumatran tiger (*Panthera tigris sumatrae*), serow (*Capricornis sumatrensis*), Malayan tapir (*Tapirus indicus*), Malayan sun bear (*Helarctos malayanus*), sambar deer (*Cervus unicolor*), clouded leopard (*Neofelis nebulosa*). This survey also discovered high avifauna and plant diversity; 247 bird species were recorded and 225 species of plants were found in 200 square meters including rarely found endemic species, i.e. Rafflesia (*Rafflesia sp.*)(CI 2004).

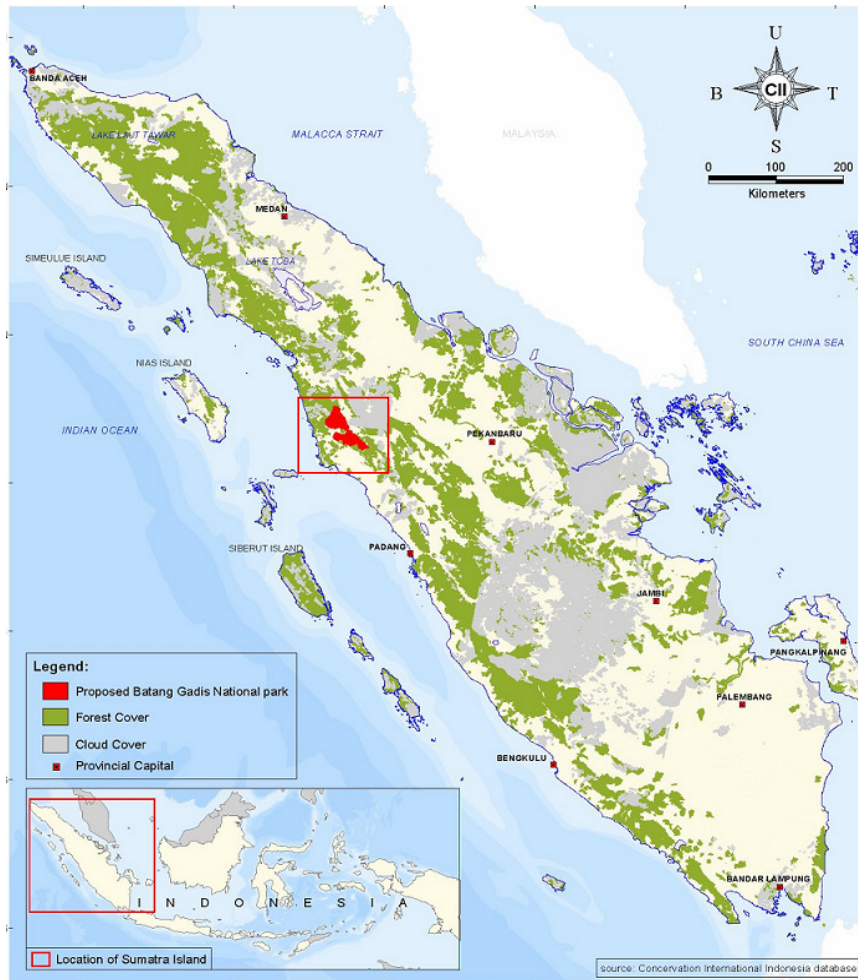


Fig.1. Study Area: Batang Gadis National Park

2. Conservation Threats

BGNP has experienced a lot of conservation threats. Salafsky and Margoulis (1999) categorized conservation threats as *indirect threats*, *internal direct threats*, and *external direct threats*. Internal direct threats are caused by the stakeholders living at the project site, and external direct threats are caused by outsiders. These proximate direct threats are in turn affected by ultimate indirect threats that lie behind the direct threats. The conservation threats in the BGNP are categorized as follows:

- *Indirect Threats*: Population growth and need for cash in villages in BGNP. Timber concessions around BGNP and mining companies may change the social culture of local communities towards more exploitation and materialism.

- *Internal Direct Threats:* Illegal logging, forest clearing for agriculture (rubber, coffee, cinnamon), inhabitant settlement, irresponsible exploiting of timber and wildlife. These threats are caused by local communities.
- *External Direct Threats:* Migrants, especially the Nias Tribe, clear forest for settlement, subsistence and commercial agriculture. Also, mining companies which are located adjacent to BGNP clear the forest for gold mining. This mining activity brings further threats by providing access for illegal logging and illegal wildlife trade.

3. Decentralization and Collaborative Management

Deforestation caused by illegal logging is a complex issue in Indonesia because illegal loggers have been backed many times by the military and key officials in local government working in collusion (Jepson 2001). Jepson mentioned that the most promising approach for sustainable forest management was to foster initiatives that encourage joint management between concessionaries, communities, and district governments for the long term. In addition, Indonesia's current trend towards decentralization has prompted the government to promote collaborative management in national parks and protected areas. The Forestry Office of the Madina District is aiming to use collaborative management as a management model, which will create balanced control between the community and government on natural resources in BGNP.

4. Park Buffer Zone

Buffer zones are frequently established to reduce the impact of people on the biodiversity inside reserves in order to maintain the integrity of the fauna and flora within core protected areas (Sayer 1991). Buffer zones extend the available habitat for plants and animals (extension buffering) and provide resources and services to people (socio-buffering) (MacKinnon et al. 1986). Indonesian Federal Law No.5/1990 regarding Conservation of Living Natural Resources and its Ecosystems defines buffer zones as areas outside conservation and as forestlands, state lands, or lands where its ownership is maintained. The buffer zone of BGNP was created to extend 10km outside the national park border to support conservation and ecosystem integrity (Fig. 2). There are seventy-two villages located in the buffer zone including two villages within the park boundary.

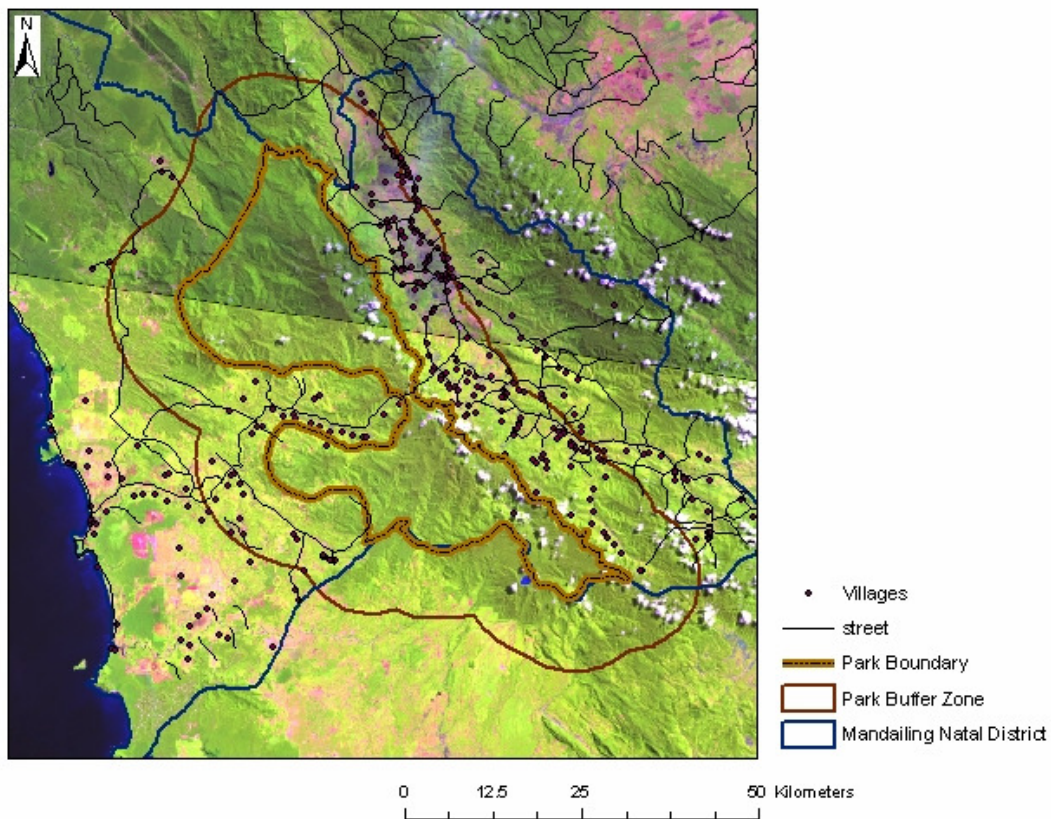


Fig.2. Park buffer zone and villages

5. Socio Economic Conditions

The total population of Madina is 380,546 people which translate to 82,563 households. Population density in the district is 56 people/km². The population growth reached 1.61% between 1990 and 2000 and slightly declined to 0.96% from 2000 to 2003 (BPS Madina 2003). Total regional GDP of Madina District has been growing gradually during the period of 1999 to 2002. In 1999, total GDP was Rp 1.1 trillion (Indonesian rupiah, annual exchange rates of 1999: \$1=Rp7,811 (Asean statistics 2004)) and in 2002 increased to Rp 1.6 trillion (annual exchange rates of 2003: \$1=Rp 8,564) (BPS Madina 2003). The agriculture sector has been contributing the largest proportion of total regional GDP, equaling about 57% of total GDP. A local NGO, Bitra Consortium, conducted a study on socio-economic conditions in ten villages located in the park buffer zone in 2005. Their study stated that the community livelihood in this area heavily depended on the agriculture sector, such as the cultivation of rice, coffee, and rubber. Most of the people work as farmers, but only few of them work their own land. Most work on rented lands and share the harvesting products with the land owners (Fig. 3) (CI 2006).

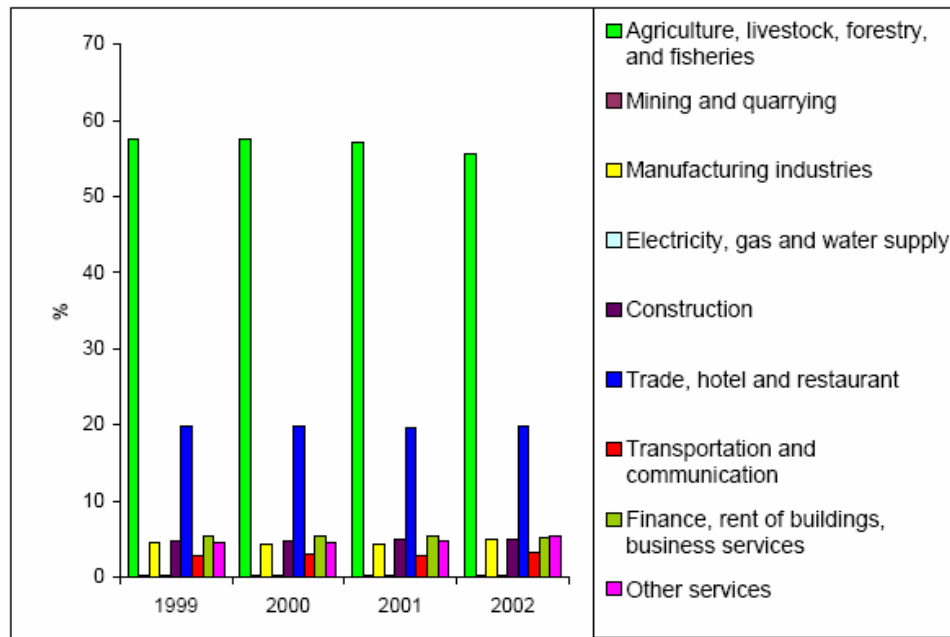


Fig.3. Contribution of Each Economic Sector to Regional GDP of Madina District (1999-2002)

Source: processed from BPS Madina District (2003)

Methods

This study is made up of two components: a GIS analysis, and a social survey. GIS was used to find the sites which currently experience high pressure from cultivation in National Park lands and also have the possibility of experiencing disasters resulting from such land conversion. GIS analysis is important because it allows us to integrate different environmental factors with geographical information. In addition, I conducted a social survey to understand the socio-economic condition, potential threats to conservation area conversion, and attitudes towards project participation of local communities.

1. GIS Analysis

I conducted site prioritization by examining ecological factors, expected threat of human activities, and project feasibility. I used five criteria for this analysis: landcover, erosion level, distance to villages, population change, and distance to the park boundary. The rationale behind each criteria selection is explained, as well as the description and preparation of the data.

1-1. Materials

I used five criteria: landcover, erosion level, distance to villages, population change, and distance to park boundary for site selection. The reasons why I selected these criteria are shown respectively with descriptions and data sources. Each data set was converted into raster data with 28.5×28.5 meter cell size. Values of each data set were classified from one to ten based on threats or priority level. Fig. 4-1 and 4-2 show each criterion graphically with a table of the priority levels.

1. Landcover

The reforestation project should be carried out at sites where forests have been cleared. Therefore, in order to select appropriate sites for this project, I used landcover data from the Global Land Cover 2000 as one of the criteria. Sixteen different landcover types were found in BGNP. The priority levels were assigned considering the project feasibility and threats level. Several types of intact forest had the lowest priority of one. Grasslands, which were thought to be cleared by illegal logging and for human settlements and agriculture, have a high priority of nine or ten depending on the level of clearing. I assigned a high priority of eight for some secondary growth forest used for agriculture because these areas are threatened by its expansion. On the other hand, paddy fields and human settlement have a relatively low priority because these sites were already used for agriculture. If we propose reforestation on existing agricultural lands, we may cause conflicts with the local communities.

2. Erosion Level

Soil erosion was seen in and around the national park. In order to halt the destruction of the conservation area, it is important to mitigate the impacts of erosion by stabilizing the soil. The erosion level is shown by the Erosion Level Risk that consists of very low, low, moderate, high, and very high (Mandailing Natal Regency Forest Office). I reclassified this data into corresponding threat levels. The data were available only for the range of Madina district.

3. Distance to Villages

Opening the forest for human settlement and agricultural expansion is one of the major causes of deforestation in this area. The distance to villages was determined by calculating the Euclidean distance from each village within 10km of the park buffer zone using Arc GIS. Pixels near villages were assigned a higher threat level.

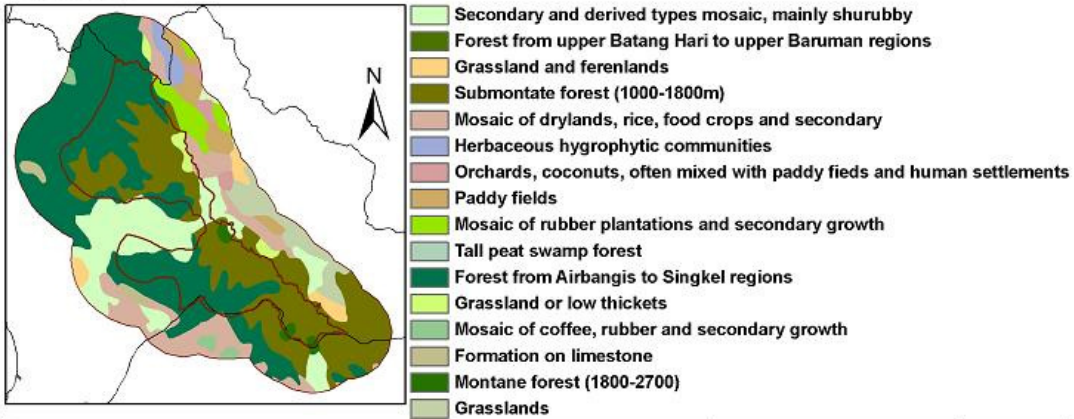
4. Population Change

Population increase serves to create pressure to open the forest and expand agricultural areas as well as human settlements. Data were available for the number of households for each sub-district in the Madina district (Mandailing Natal in Figures 2005). I calculated the percent change of the number of households from 2002 to 2005. Higher changes in population equaled higher threat levels.

5. Distance to Park Boundary

The Euclidean distance was calculated from the park boundary within the 10km buffer zone. The areas closer to the national park borders have a higher value in terms of protecting the conservation area. Therefore, distances closer to the park boundary were assigned higher priorities. However, distances less than zero meaning inside the national park, were assigned the lowest priority as the project is to be implemented in the park buffer zone.

1. Landcover



Landcover_Subclass	Classification	Level
Secondary and derived types mosaic, mainly shrubby	Shrubby/Forest	9
Forest from upper Batang Hari to upper Barumun regions	Forest	1
Grassland and ferenlands	Grassland	9
Submontane forest (1000-1.800 m)	Forest	1
Mosaic of drylands rice, food crops (shifting cultivation) and secondary	Secondary/Agriculture	8
Herbaceous hygrophytic communities	Other	2
Orchards, coconuts, often mixed with paddy fields and human settlements	Rice/Human Settlements	4
Paddy fields (irrigated or rainted)	Agriculture(Rice)	4
Mosaic of rubber plantataions (small holders) and secondary growth	Secondary/Agriculture	8
Tall peat swamp forest	Forest	1
Forest from Airbangis to Singkel regions	Forest	1
Grassland or low thickets	Grassland	10
Mosaic of coffee, rubber and secondary growth	Secondary/Agriculture	8
Formation on limestone	Other	1
Montane forest (1800-2700)	Forest	1
Garsslands	Grassland	10

2. Erosion Level

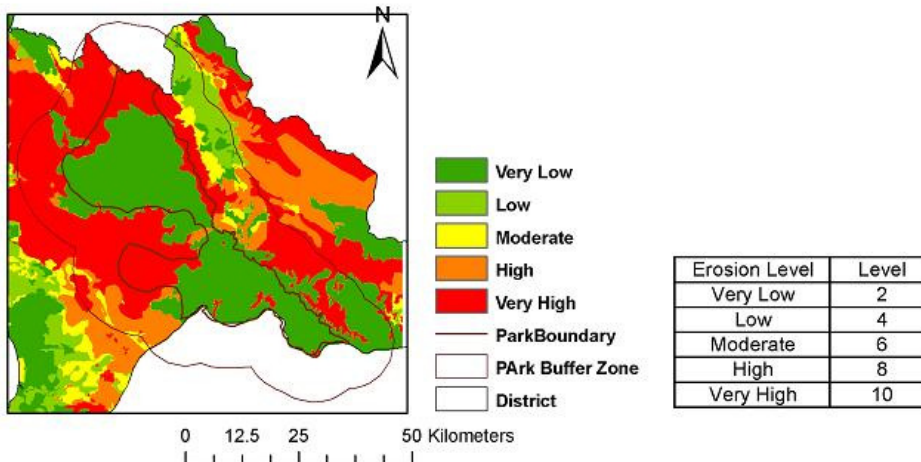
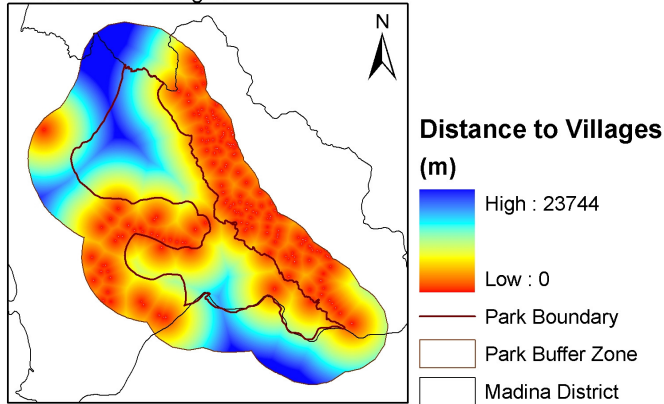


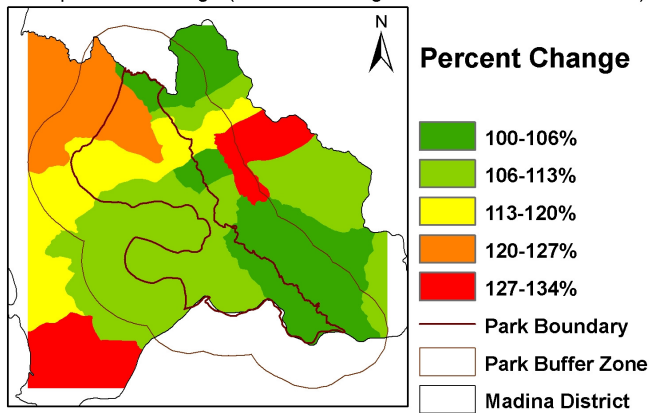
Fig.4-1. Factors for site prioritization: Landcover and Erosion Level.

3. Distance to Villages



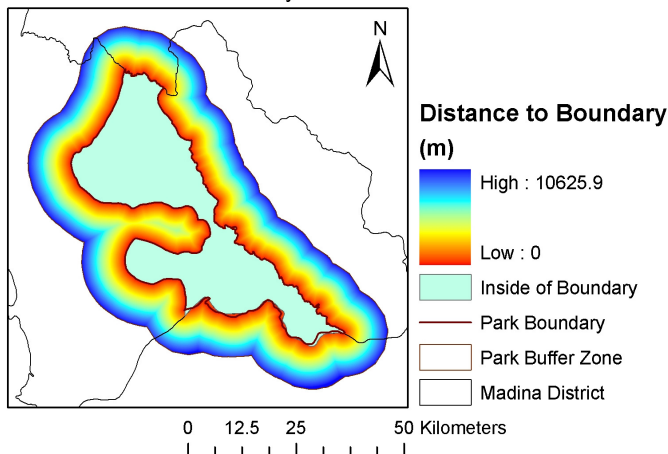
Distance to villages (m)	Level
0-1,955	10
1,955-3,910	9
3,910-5,959	8
5,959-8,007	7
8,007-10,056	6
10,056-12,011	5
12,011-14,060	4
14,060-16,295	3
16,295-19,181	2
19,181-23,744	1

4. Population Change (Percent Change in number of house hold)



Population Change (%)	Level
100-106	2
106-113	4
113-120	6
120-127	8
127-134	10

5. Distance to Park Boundary



Distance to boundary (m)	Level
<0 (inside park)	1
0-1,000	10
1,000-2,000	9
2,000-3,000	8
3,000-4,000	7
4,000-5,000	6
5,000-6,000	5
6,000-7,000	4
7,000-8,000	3
8,000-9,000	2
9,000-10,626	1

Fig.4-2. Factors for site prioritization: Distance to villages, population change, and distance to park boundary.

1-2. Method

After preparing raster data for each criterion, I used a “weighted overlay tool” in ArcGIS to calculate the overall threat level by assigning each a particular weight. Weighted Overlay is a technique for applying a common measurement scale of values to diverse inputs to create an integrated analysis. Each raster can be assigned a different influence level. The cell values were multiplied by their percentage influence, and the results were added together to create the output raster (ESRI). In some site prioritization studies, the influence level for each criterion is arbitrarily decided despite the fact that it affects the study results. In order to conduct the site prioritization fairly and to see the trend in different weight patterns, I examined sixty different scenarios to acquire an overall threat level of each raster cell. The sixty scenarios had three different patterns: 1. all criteria had equal weight, 2. one criterion had twice as great a weight as the others, 3. two criteria had twice as great a weight as the others. All scenarios are shown in Table 1. I used Python scripting to change the weights to calculate the overall threat each time because changing the weight for each scenario would require repeating steps of the weighted overlay. The script I used for this analysis is shown in Appendix1. Finally, I added all the scenarios to see the overall result.

	Weight of each criterion															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Landcover	20	32	17	17	17	17	28	28	28	28	15	15	15	15	15	15
Erosion Level	20	17	32	17	17	17	28	15	15	15	28	28	28	15	15	15
Distance to Villages	20	17	17	32	17	17	15	28	15	15	28	15	15	28	28	14
Population Change	20	17	17	17	32	17	15	15	28	14	15	28	14	28	14	28
Distance to park boundary	20	17	17	17	17	32	14	14	14	28	14	14	28	14	28	28

Table 1. Sixty different scenarios with different weight levels of criteria.

2. Social Survey

I conducted two rounds of interviews. The first one was a preliminary study to understand the socioeconomic conditions of the villages in and around the national park. In addition, I expected to understand the awareness of BGNP and the perception toward collaborative management of BGNP. The objective of the second interview was to understand the opportunity of the reforestation project.

2-1. Preliminary study

First, I conducted the preliminary study to understand the attitudes and expectations of the local communities to BGNP and the general perception of whether or not they were involved in park management, as well as their socio-economic conditions. There are 72 villages in and around the national park. I visited three villages (Simpanggor Jule, Sopotinjak, and Batahan) and interviewed sixteen farmers including the heads of the villages and farmers' groups. These three villages were selected for their respective uniquenesses.

- Simpanggor Jule: The forestry office assigned this village as a priority site for eco-tourism.
- Sopotinjak: Assigned as an eco-tourism site as well as an agro-forestry initiative site.
- Batahan: This village is located within the national park.

Interview questions focused on the following topics.

- The current livelihoods and agricultural activities of the villages.
- The awareness of BGNP.
- Their attitude towards the forest. The reason for and level of importance of the forest for them.
- Any perceived changes before and after BGNP declaration.
- Expectations and concerns toward BGNP.
- Their involvement in BGNP management.

2-2. Interview about Reforestation Project

I interviewed fifteen people who live in six different villages CI-I originally proposed as focuses for this project (Fig. 5). I interviewed heads of the villages and heads of the farmers' groups, as well as farmers in each main village of six different sites. The following topics were asked about in these interviews:

- The current livelihoods and agricultural activities of their villages.
- Any problem or concern related to the forest.
- Their attitude towards the forest. The reason for and level of importance of forest.
- The reason why they cleared the forest.
- The motivation of participation in the reforestation project.
- The species they want to plant.
- Their interest in agro-forestry.
- Any expectation or concern about the reforestation project.

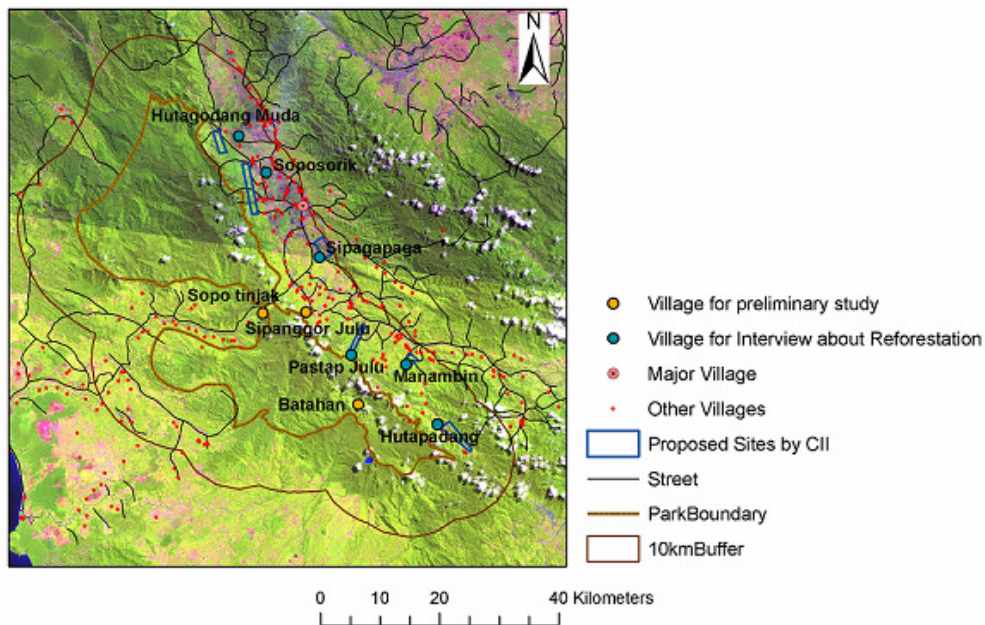


Fig.5. CI-I proposed sites and villages visited for survey.

Results

1. Preliminary study

Farmers in the three villages grow a combination of two or three crops, such as rice, rubber, cinnamon, coffee, cacao, and other vegetables. All farmers mentioned that the forest is important for them and that the importance of protecting the forest has long been taught in their villages, although the reasons for this importance were different. Four farmers mentioned that the forest was important as a water resource. One mentioned that it was important for fuel wood. Four farmers in Batahan mentioned that the forest was important for providing land for agriculture.

All farmers knew about BGNP. They were informed by the Bitra Consortium (local NGO), or a local conservation organization which consists of thirty five villages in and around the national park. However, they claimed that the forestry office had not involved villagers in BGNP management. Their concern over park boundaries which was under the marking process by the forestry office could be the reason for this negative response. Regarding the park boundaries, farmers mentioned that they expected alternative economic income if they lose their community forest. One farmer who was a representative of the village in the local conservation organization mentioned that 30% of the people in his village did not support the national park because they depended on the forest for their livelihood and did not want their access to the forest be prohibited.

2. GIS analysis

The results of site prioritization for 16 different scenarios are shown in Fig. 6-1 and Fig. 6-2. Fig. 6-1 presents scenarios where one or none of the five factors was weighted. Fig. 6-2 shows scenarios when two of the five factors were weighted. Priority levels are shown in levels two to nine. The overall high priority sites which are derived from the combination of all 16 scenarios are shown in Fig. 7. The highest priority sites based on this GIS analysis are shown as an enlarged map in Fig. 7.

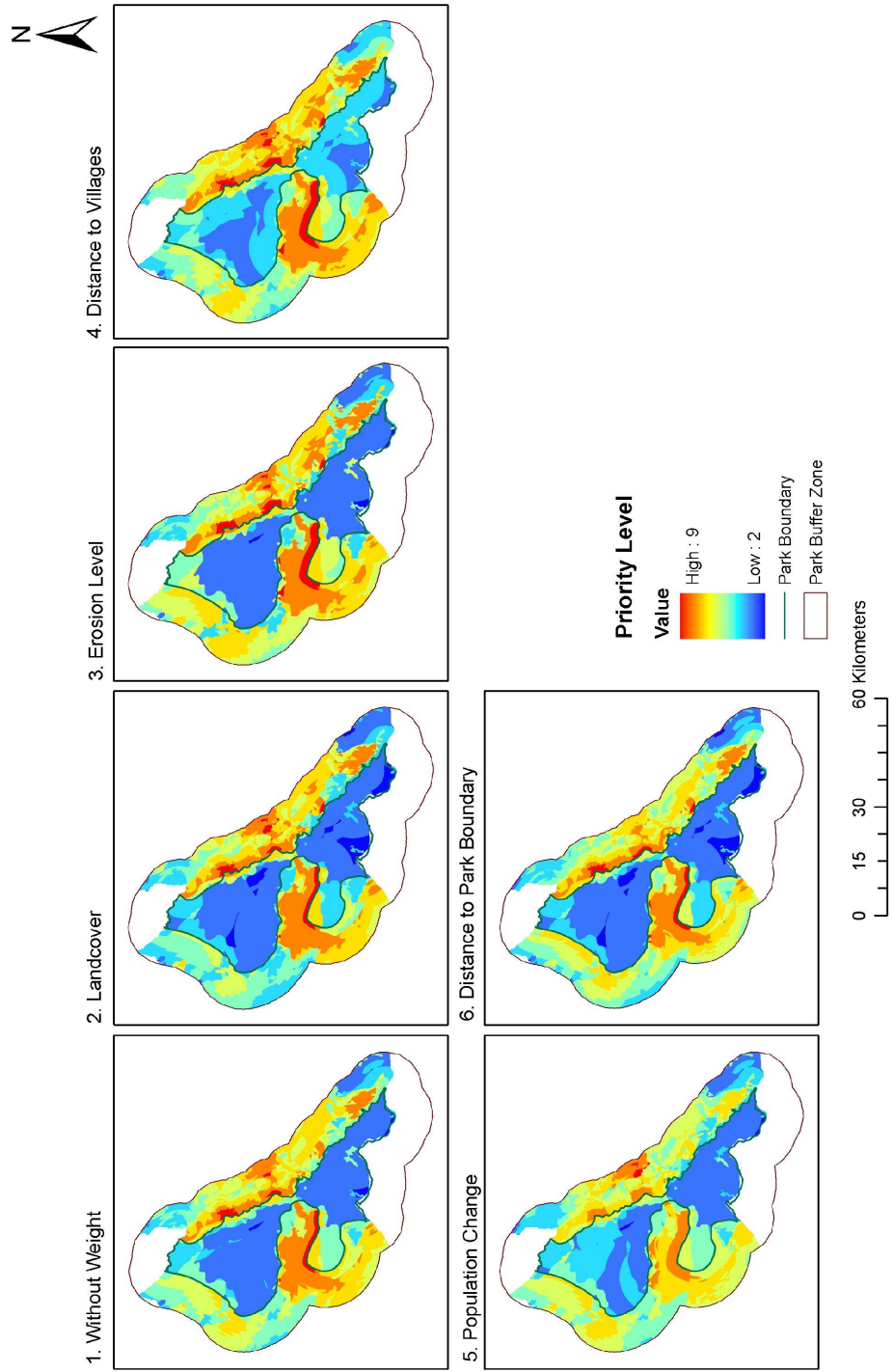


Fig-6-1. Results of site prioritization for scenarios one to six which weighted one or none of five criteria.

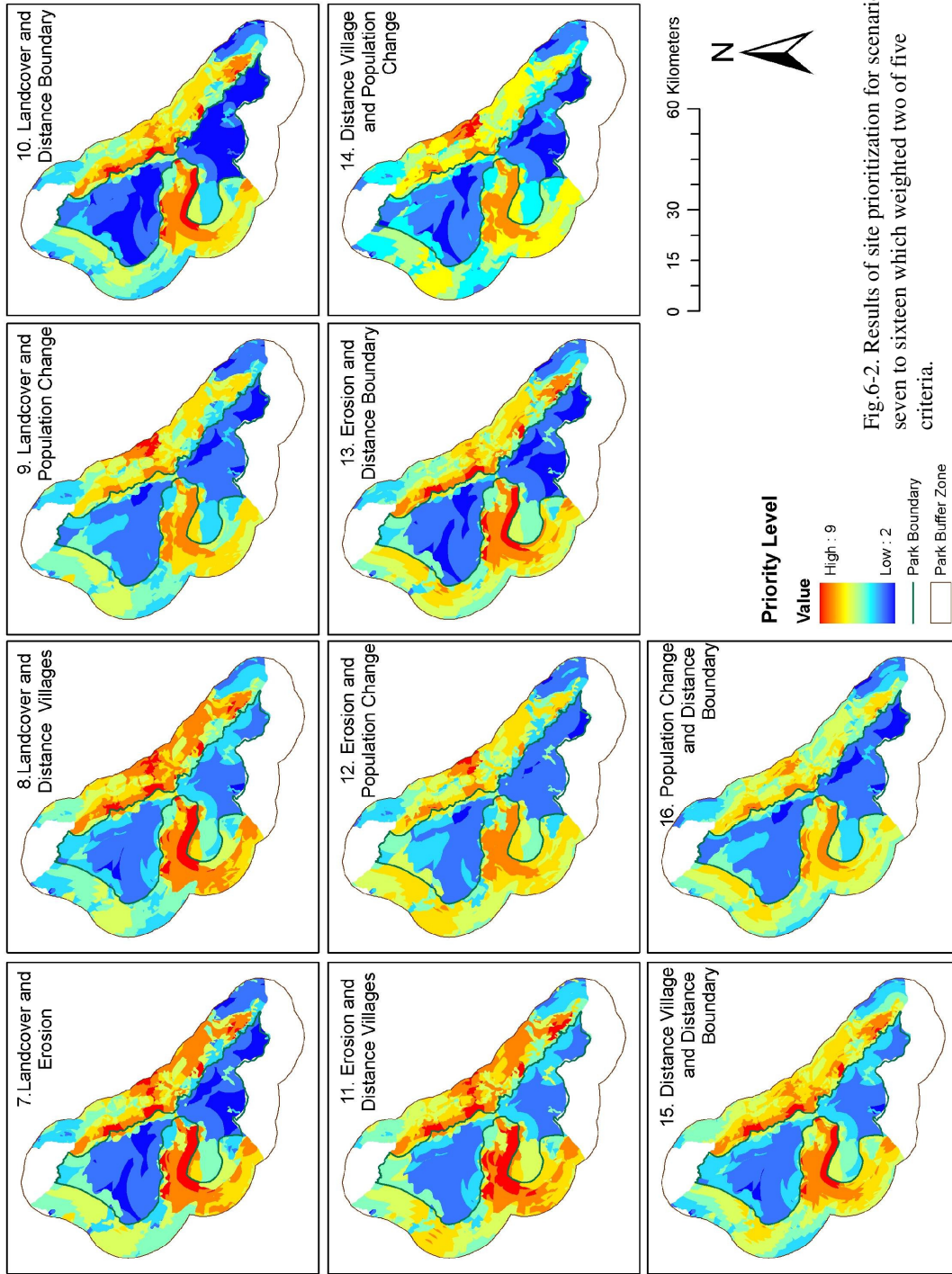


Fig.6-2. Results of site prioritization for scenario seven to sixteen which weighted two of five criteria.

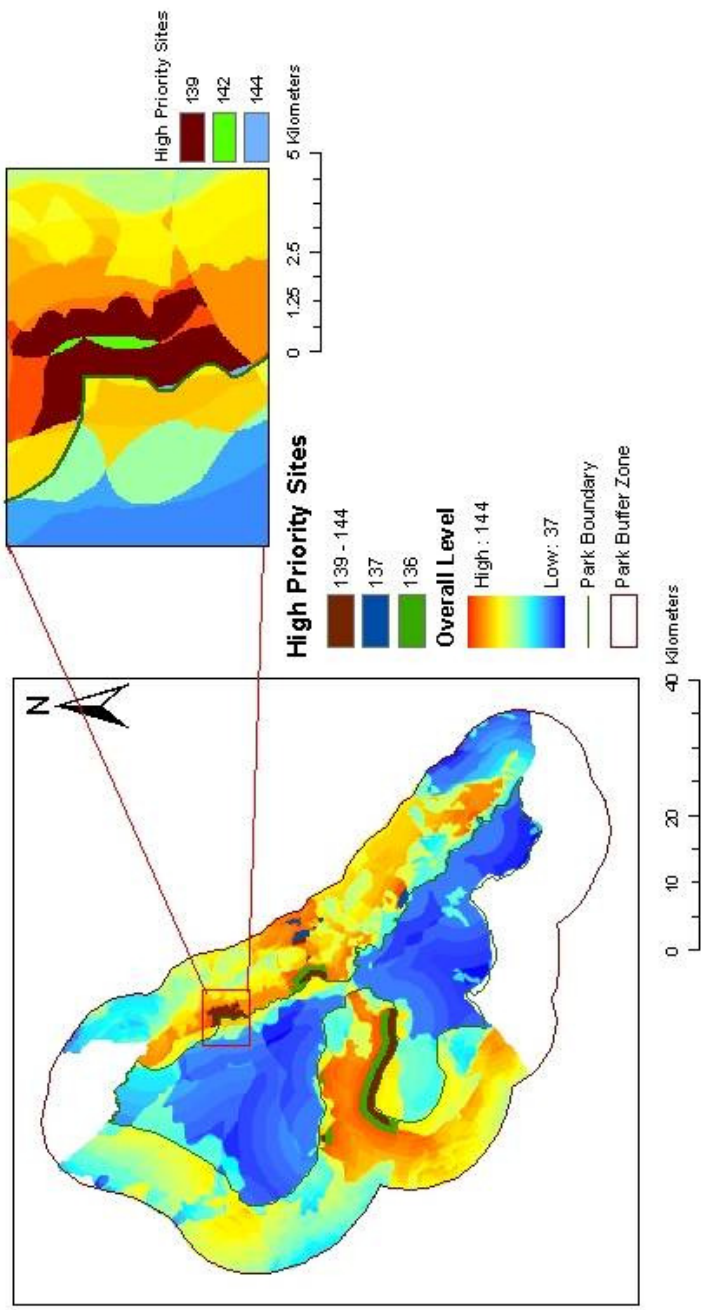


Fig.7. Overall result which was derived from the combination of sixteen different criteria. Enlarged map shows the area of highest priority.

3. Social Survey

Although six sites I visited for interviews were proposed as potential sites by CI-I, the extent of cleared area, and the reasons why forests were cleared were different from site to site as shown below based on the comments from local farmers.

- Hutagodang Muda: About 500 hectares of land was cleared. The communities in this area cleared the forest for plantations in the 1980s but they were not created because local communities could not obtain seedlings from the forestry office as they had expected. In addition, immigrants from Nias Island, which is located to the west of Sumatra and severely damaged by the tsunami in 2004, keep clearing the forest for shifting cultivation of short-term crops.
- Soposorik: 500 to 700 hectare land in total was cleared. Within that, 300-400 hectares was cleared because of illegal logging before the declaration of national park. The other areas were cleared for plantations by local communities.
- Sipagapaga: Local communities cleared the forest for agriculture but they did not plant because of lack of money and seedlings. The open area was about 300 hectares.
- Other sites (Pastap Julu, Manambin, and Hutapadang): 100 to 250 hectares of open area existed in total but its distribution was very patchy. Local communities cleared the forest to plant rubber, coffee, and fruit trees.

The motivation to participate in a reforestation project was very high. All farmers mentioned that they were willing to participate in the reforestation project. They expected alternative income from the plantations. All farmers I asked mentioned that the species they wanted to plant were mainly rubber along with candle nut and fruit trees, such as durian and mango. Two farmers mentioned that mahogany was expensive timber but could not be sold in the market near their villages.

Three farmers in Hutagodang Muda commented on their concerns about the reforestation project implemented by the forestry office. The forestry office provided 36,000 to 40,000 timber seedlings such as mahogany, and 20,000 rubber seedlings. However, farmers mentioned that what they wanted was more rubber than the other species. They did not understand why the forestry office brought more timber species. Also, they had been waiting rain to plant seedlings for three weeks after the seedlings were provided.

Two farmers in Hutagodang Muda and Soposorik talked about a mining company, which was located between these two villages (Fig. 8). They mentioned that they did not agree with mining in this area because it destroys the forest. One farmer mentioned that the

establishment of a stable commodity and income source from rubber would help to stop people from his village from working for the mining company.

Discussion and Conclusions

Opportunity of the reforestation project

From the preliminary study, it can be concluded that the communities did not perceive to be involved in the decision-making process regarding BGNP. Some farmers mentioned that collaborative management was necessary for BGNP management. In addition, they claimed the importance of having alternative income sources. The objective and strategy of the reforestation project could meet these local communities' needs by enhancing the participatory nature of buffer zone management and providing alternative sources of income.

Priority sites for the project

The results of the priority site selection were different based on which factor was weighted. For instance, there was a clear difference of result when population change and distance to park boundary were prioritized. However, a similar trend can be seen through all sixteen scenarios for high priority areas. The correlation between each factor might cause this similarity. Based on the overall results derived from the GIS analysis (Fig. 7), the highest priority sites were located at the north eastern part of the national park, which is close to one of the sites originally proposed by CI-I near Soposorik village (Fig. 8). According to the interviews of farmers in Soposorik village, the proposed site contains a previously illegal logging site and is also located close to a mining concession site. Due to mining and illegal logging activities, there were major roads found inside the park in this area (Fig. 8). The existence of these threats was in line with the result of the GIS analysis and would support the prioritization of this area.

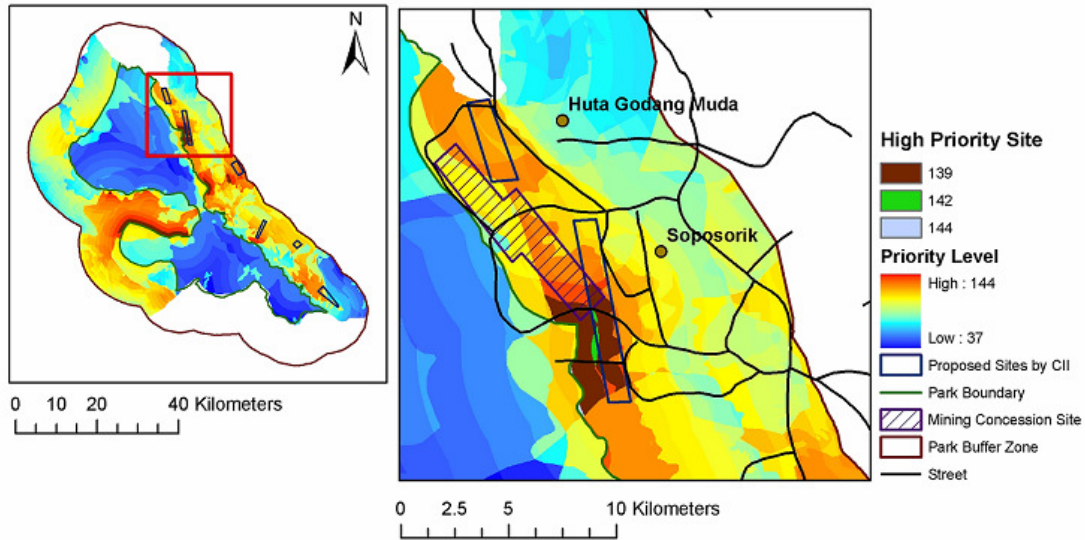


Fig.8. The highest priority area selected by GIS Analysis.

Although the results of the GIS analysis relatively matched with originally proposed sites by CI-I, this analysis indicated that there were also high priority sites located in the center and western part of the national park which were not included in the CI-I proposed sites. This result indicates that we should visit these areas and examine the current landuse, project feasibility, socio-economic condition, and motivation of local communities in order to decide project implementation. Furthermore, we should consider the project budget, political will, and project feasibility by examining such factors as, slope, soil fertility, and water resources in order to select suitable sites for project implementation.

Species Selection

It is important to examine both the role of forest rehabilitation, and economic contribution when deciding which species to be planted. The communities' overall preference was rubber because of its relatively high and stable market price. However, there are trade-offs between diversity and rubber production (Lawrence 1996). Gouyon's study (1993) showed the comparison of net income from jungle rubber and selected rubber plantations (Table 2). Although a jungle rubber plantation is a balanced, diversified system and its structure is similar to that of a secondary forest (Gouyon 1993), the contribution to net income is much lower than selected rubber plantation and requires more land to maintain the same level of income. Given the purpose of this project, the balance between forest rehabilitation and contribution to income would be important to decide upon which species is

best. One of the solutions to increase income without losing a significant level of diversity would be to increase income from non-rubber species. Because non-rubber species are mostly for household consumption, there would be an opportunity to increase income by developing transportation and marketing of these species, such as timber and fruits.

	Jungle rubber ^a		Selected rubber (clones) ^b
	A	B	
Net income/ha/year, '000Rp (%)	431 (100)	606 (100)	810 (100)
Of which:			
Rubber ^c	363 (84)	364 (60)	787 (97)
Rice	9 (2)	11 (2)	12 (1.5)
Other annual crops	9 (2)	10 (2)	11 (1.5)
Fruit trees	22 (5)	100 (16)	0 (0)
Fuel wood	6 (2)	51 (8)	0 (0)
Timber(non rubber)	22 (5)	70 (12)	0 (0)
Total man-days per ha/year	107	126	129
Net income per man-day, Rp	4030	4800	6280
Net income available ^d /ha/year,'000Rp	270	417	617
Area needed per household ^e , ha	2.8	2	1.5

Source: Field Surveys, except for fuel wood needs and prices which were found in a survey by the Directorate General of Forest Utilization and the FAO

a Two hypotheses for the contribution of non-rubber components:

A: minimal: low prices and output, all output for self-consumption;

B: maximal: high prices and output, part of the output sold

b Based on costs and credit schedule of Smallholder Rubber Development Project, assuming an average yield of 1300 kg/ha/year throughout the tapping period.

c Rubber sold at Rp 1000/dry kg, farm gate.

d After deducting the reproduction cost of family work force:

(number of family man-days/ha x basic consumption needs/person/day, i.e., 1500 Rp).

e Total area needed to meet the basic needs of a household of five, i.e., 1,200,000 Rp per year.

Table 2. Farmer's income from jungle rubber and selected rubber plantations (average net income computed throughout the economic life of a plantation) (Gouyon 1993)

Project Implementation Plan

Comments from some local farmers revealed concerns about the current reforestation project implemented by the forestry office.

- **Timing of the project:** The seedlings were provided to local communities in the dry season because of the timing of budget allocation to the local government. Therefore, some local communities were not able to plant seedlings provided by the forestry office due to lack of water and refrained from planting for several weeks.
- **Lack of communication:** The purpose of forest rehabilitation was not communicated well to local communities as seen in comments of farmers who did not understand the reasons why the forestry office provided more native species than rubber seedlings.

This would cause a gap in expectations between the forestry office and communities who expect alternative income from reforestation rather than forest rehabilitation. Addressing these issues is important to provide better outcomes from future reforestation projects. I would suggest the following activities for an improvement of the current situation.

1. Developing Nursery

One possible solution to address timing issues would be developing a nursery in this area instead of transporting seedlings from a major market outside BGNP. This would provide greater flexibility of timing to plant seedlings and also avoid damaging seedlings due to transportation. Although the initial cost and resources need to be examined, a nursery system would provide long-term benefit and sustainable reforestation schemes in this area.

2. Education and Training Program

Given the trade-offs between conservation and income contribution, species selection is a challenging part of this project. Because local communities expect more mono-culture rubber plantation because of its greater income contribution in the short-term, they will not plant diverse species without understanding the importance of diversity. It is necessary to communicate the importance of planting diverse species to local communities from ecological and economic standpoints: for instance the effect of native species on soil erosion control and water run-off control, species habitats, and also the long-term income contribution from timber species. Therefore, an education program to increase environmental and conservation awareness should be associated with reforestation projects. Furthermore, training in agro-forestry methods is also necessary in order to maintain diversity and provide substantial income to the communities.

3. Evaluation and Monitoring Systems

Finally, we need to develop monitoring and evaluation standards for future reforestation projects. The evaluation criteria of reforestation projects should consist of factors to assess both ecological impact and socio-economic conditions. The possible evaluation criteria would be as follows:

- Ecological impact: forest coverage, species composition, erosion level, and key species population in the conservation area

- Socio-economic impact: income contribution to local communities from reforestation areas, conservation awareness of local communities

In order to ensure that lessons learned from this reforestation project inform future projects, the development of an information system is also important.

Furthermore, the involvement of local communities to planning, acting, and monitoring cycle is crucial for this project. As one of the first national parks established through a “bottom-up” process and focused on collaborative management, the reforestation project in BGNP can be an important model of participatory buffer zone management for the other national parks in Indonesia.

Acknowledgements

This project was funded by the Kuzmier-Lee-Nikitine (KLN) Internship Fund and Whitney Lawson Chamberlin Memorial Endowment Fund, and I gratefully acknowledge this support.

I would like to thank Dr. Stuart L. Pimm and Dr. Norman L. Christensen Jr. for their input and support of this project. I also would like to thank Dr. Erwin S. Widodo, Abu Hanifah Lubis, Lelyana Midora, and staff of Conservation International Indonesia for their generous support in Indonesia.

Appendices

Appendix 1

Python script

```
# -----  
# WeightedOverlay_3.py  
# Created on: Tue Feb 20 2007 01:33:02 PM  
# (generated by ArcGIS/ModelBuilder)  
# -----  
  
# Import system modules  
import sys, string, os, win32com.client  
  
# Create the Geoprocessor object  
gp = win32com.client.Dispatch("esriGeoprocessing.GpDispatch.1")  
  
# Check out any necessary licenses  
gp.CheckOutExtension("3D")  
gp.CheckOutExtension("spatial")  
  
# Load required toolboxes...  
gp.AddToolbox("C:/Program Files/ArcGIS/ArcToolbox/Toolboxes/Spatial Analyst  
Tools.tbx")  
gp.AddToolbox("C:/Program Files/ArcGIS/ArcToolbox/Toolboxes/Conversion  
Tools.tbx")  
gp.AddToolbox("C:/Program Files/ArcGIS/ArcToolbox/Toolboxes/3D Analyst  
Tools.tbx")  
  
# Set the Geoprocessing environment...  
gp.scratchWorkspace = "Y:\\research\\student\\ai7\\MP\\MP\\Result"  
gp.outputCoordinateSystem =  
"PROJCS['WGS_1984_UTM_Zone_47N',GEOGCS['GCS_WGS_1984',DATUM['D_WGS_1984',SP  
HEROID['WGS_1984',6378137.0,298.257223563]],PRIMEM['Greenwich',0.0],UNIT['D  
egree',0.0174532925199433]],PROJECTION['Transverse_Mercator'],PARAMETER['Fa  
lse_Easting',500000.0],PARAMETER['False_Northing',0.0],PARAMETER['Central_M  
eridian',99.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Orig  
in',0.0],UNIT['Meter',1.0]]"  
gp.outputZFlag = "Same As Input"  
gp.clusterTolerance = ""  
gp.extent = "514687.863591118 39797.9358388313 598044.535018543  
123971.761355363"  
gp.cellSize = "28.5"  
gp.outputZValue = ""  
gp.outputMFlag = "Same As Input"  
gp.mask = "buffer_10km"  
gp.workspace = "Y:\\research\\student\\ai7\\MP\\MP\\Result"  
  
gp.OverwriteOutput = 1  
  
# Local variables...  
Erosion_ras = "Y:\\research\\student\\ai7\\MP\\MP\\Result\\erosion_ras"  
reclass_pop = "Y:\\research\\student\\ai7\\MP\\MP\\Result\\reclass_pop"  
Pop_Ch_ras = "Y:\\research\\student\\ai7\\MP\\MP\\Result\\pop_ch_ras"  
Rec_dis_vi_10 = "Y:\\research\\student\\ai7\\MP\\MP\\Result\\rec_dis_vi_10"  
  
Re_out_bound = "Y:\\research\\student\\ai7\\MP\\MP\\Result\\Re_out_bound"  
recl_lc_16= "Y:\\research\\student\\ai7\\MP\\MP\\Result\\recl_lc_16"  
  
# Process: Weighted Overlay  
#wo_3_1 = "Y:\\research\\student\\ai7\\MP\\MP\\Result\\Py_output3\\wo_3_1"
```

```

#gp.WeightedOverlay_sa("('Erosion_ras' 20 'VALUE' (1 2; 2 4; 3 6; 4 8; 5
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5; 7 4; 8 3; 9 2; 10 1;NODATA NODATA); 'Re_out_bound' 20 'VALUE' (1 1; 2 2;
3 3; 4 4; 5 5; 6 6; 7 7; 8 8; 9 9; 10 10;NODATA NODATA); 'recl_lc_16' 20
'VALUE' (1 1; 2 2; 4 4; 8 8; 9 9; 10 10;NODATA NODATA));1 10 1", wo_3_1)
#print "finished1"

# Process: Weighted Overlay
#wo_3_2 = "Y:\\research\\student\\ai7\\MP\\MP\\Result\\Py_output3\\wo_3_2"
#gp.WeightedOverlay_sa("('Erosion_ras' 17 'VALUE' (1 2; 2 4; 3 6; 4 8; 5
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10;NODATA NODATA); 'rec_dis_vi_10' 17 'VALUE' (1 10; 2 9; 3 8; 4 7; 5 6; 6
5; 7 4; 8 3; 9 2; 10 1;NODATA NODATA); 'Re_out_bound' 17 'VALUE' (1 1; 2 2;
3 3; 4 4; 5 5; 6 6; 7 7; 8 8; 9 9; 10 10;NODATA NODATA); 'recl_lc_16' 32
'VALUE' (1 1; 2 2; 4 4; 8 8; 9 9; 10 10;NODATA NODATA));1 10 1", wo_3_2)
#print "finished2"

# Process: Weighted Overlay
#wo_3_3 = "Y:\\research\\student\\ai7\\MP\\MP\\Result\\Py_output3\\wo_3_3"
#gp.WeightedOverlay_sa("('Erosion_ras' 32 'VALUE' (1 2; 2 4; 3 6; 4 8; 5
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10;NODATA NODATA); 'rec_dis_vi_10' 17 'VALUE' (1 10; 2 9; 3 8; 4 7; 5 6; 6
5; 7 4; 8 3; 9 2; 10 1;NODATA NODATA); 'Re_out_bound' 17 'VALUE' (1 1; 2 2;
3 3; 4 4; 5 5; 6 6; 7 7; 8 8; 9 9; 10 10;NODATA NODATA); 'recl_lc_16' 17
'VALUE' (1 1; 2 2; 4 4; 8 8; 9 9; 10 10;NODATA NODATA));1 10 1", wo_3_3)
#print "finished3"

# Process: Weighted Overlay
#wo_3_4 = "Y:\\research\\student\\ai7\\MP\\MP\\Result\\Py_output3\\wo_3_4"
#gp.WeightedOverlay_sa("('Erosion_ras' 17 'VALUE' (1 2; 2 4; 3 6; 4 8; 5
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10;NODATA NODATA); 'rec_dis_vi_10' 32 'VALUE' (1 10; 2 9; 3 8; 4 7; 5 6; 6
5; 7 4; 8 3; 9 2; 10 1;NODATA NODATA); 'Re_out_bound' 17 'VALUE' (1 1; 2 2;
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'VALUE' (1 1; 2 2; 4 4; 8 8; 9 9; 10 10;NODATA NODATA));1 10 1", wo_3_4)
#print "finished4"

# Process: Weighted Overlay
#wo_3_5 = "Y:\\research\\student\\ai7\\MP\\MP\\Result\\Py_output3\\wo_3_5"
#gp.WeightedOverlay_sa("('Erosion_ras' 17 'VALUE' (1 2; 2 4; 3 6; 4 8; 5
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10;NODATA NODATA); 'rec_dis_vi_10' 17 'VALUE' (1 10; 2 9; 3 8; 4 7; 5 6; 6
5; 7 4; 8 3; 9 2; 10 1;NODATA NODATA); 'Re_out_bound' 17 'VALUE' (1 1; 2 2;
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'VALUE' (1 1; 2 2; 4 4; 8 8; 9 9; 10 10;NODATA NODATA));1 10 1", wo_3_5)
#print "finished5"

# Process: Weighted Overlay
#wo_3_6 = "Y:\\research\\student\\ai7\\MP\\MP\\Result\\Py_output3\\wo_3_6"
#gp.WeightedOverlay_sa("('Erosion_ras' 17 'VALUE' (1 2; 2 4; 3 6; 4 8; 5
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10;NODATA NODATA); 'rec_dis_vi_10' 17 'VALUE' (1 10; 2 9; 3 8; 4 7; 5 6; 6
5; 7 4; 8 3; 9 2; 10 1;NODATA NODATA); 'Re_out_bound' 32 'VALUE' (1 1; 2 2;
3 3; 4 4; 5 5; 6 6; 7 7; 8 8; 9 9; 10 10;NODATA NODATA); 'recl_lc_16' 17
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#print "finished6"

# Process: Weighted Overlay
#wo_3_7 = "Y:\\research\\student\\ai7\\MP\\MP\\Result\\Py_output3\\wo_3_7"

```

```

#gp.WeightedOverlay_sa("('Erosion_ras' 28 'VALUE' (1 2; 2 4; 3 6; 4 8; 5
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5; 7 4; 8 3; 9 2; 10 1;NODATA NODATA); 'Re_out_bound' 14 'VALUE' (1 1; 2 2;
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'VALUE' (1 1; 2 2; 4 4; 8 8; 9 9; 10 10;NODATA NODATA));1 10 1", wo_3_7)
#print "finished7"

# Process: Weighted Overlay
#wo_3_8 = "Y:\\research\\student\\ai7\\MP\\MP\\Result\\Py_output3\\wo_3_8"
#gp.WeightedOverlay_sa("('Erosion_ras' 15 'VALUE' (1 2; 2 4; 3 6; 4 8; 5
10;NODATA NODATA); 'reclass_pop' 15 'VALUE' (1 2; 2 4; 3 6; 4 8; 5
10;NODATA NODATA); 'rec_dis_vi_10' 28 'VALUE' (1 10; 2 9; 3 8; 4 7; 5 6; 6
5; 7 4; 8 3; 9 2; 10 1;NODATA NODATA); 'Re_out_bound' 14 'VALUE' (1 1; 2 2;
3 3; 4 4; 5 5; 6 6; 7 7; 8 8; 9 9; 10 10;NODATA NODATA); 'recl_lc_16' 28
'VALUE' (1 1; 2 2; 4 4; 8 8; 9 9; 10 10;NODATA NODATA));1 10 1", wo_3_8)
#print "finished8"

# Process: Weighted Overlay
#wo_3_9 = "Y:\\research\\student\\ai7\\MP\\MP\\Result\\Py_output3\\wo_3_9"
#gp.WeightedOverlay_sa("('Erosion_ras' 15 'VALUE' (1 2; 2 4; 3 6; 4 8; 5
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10;NODATA NODATA); 'rec_dis_vi_10' 15 'VALUE' (1 10; 2 9; 3 8; 4 7; 5 6; 6
5; 7 4; 8 3; 9 2; 10 1;NODATA NODATA); 'Re_out_bound' 14 'VALUE' (1 1; 2 2;
3 3; 4 4; 5 5; 6 6; 7 7; 8 8; 9 9; 10 10;NODATA NODATA); 'recl_lc_16' 28
'VALUE' (1 1; 2 2; 4 4; 8 8; 9 9; 10 10;NODATA NODATA));1 10 1", wo_3_9)
#print "finished9"

# Process: Weighted Overlay
wo_3_10 = "Y:\\research\\student\\ai7\\MP\\MP\\Result\\Py_output3\\wo_3_10"
gp.WeightedOverlay_sa("('Erosion_ras' 15 'VALUE' (1 2; 2 4; 3 6; 4 8; 5
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10;NODATA NODATA); 'rec_dis_vi_10' 15 'VALUE' (1 10; 2 9; 3 8; 4 7; 5 6; 6
5; 7 4; 8 3; 9 2; 10 1;NODATA NODATA); 'Re_out_bound' 28 'VALUE' (1 1; 2 2;
3 3; 4 4; 5 5; 6 6; 7 7; 8 8; 9 9; 10 10;NODATA NODATA); 'recl_lc_16' 28
'VALUE' (1 1; 2 2; 4 4; 8 8; 9 9; 10 10;NODATA NODATA));1 10 1", wo_3_10)
print "finished10"

# Process: Weighted Overlay
wo_3_11 = "Y:\\research\\student\\ai7\\MP\\MP\\Result\\Py_output3\\wo_3_11"
gp.WeightedOverlay_sa("('Erosion_ras' 28 'VALUE' (1 2; 2 4; 3 6; 4 8; 5
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10;NODATA NODATA); 'rec_dis_vi_10' 28 'VALUE' (1 10; 2 9; 3 8; 4 7; 5 6; 6
5; 7 4; 8 3; 9 2; 10 1;NODATA NODATA); 'Re_out_bound' 14 'VALUE' (1 1; 2 2;
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print "finished11"

# Process: Weighted Overlay
wo_3_12 = "Y:\\research\\student\\ai7\\MP\\MP\\Result\\Py_output3\\wo_3_12"
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10;NODATA NODATA); 'rec_dis_vi_10' 15 'VALUE' (1 10; 2 9; 3 8; 4 7; 5 6; 6
5; 7 4; 8 3; 9 2; 10 1;NODATA NODATA); 'Re_out_bound' 14 'VALUE' (1 1; 2 2;
3 3; 4 4; 5 5; 6 6; 7 7; 8 8; 9 9; 10 10;NODATA NODATA); 'recl_lc_16' 15
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print "finished12"

# Process: Weighted Overlay
wo_3_13 = "Y:\\research\\student\\ai7\\MP\\MP\\Result\\Py_output3\\wo_3_13"

```

```

gp.WeightedOverlay_sa("('Erosion_ras' 28 'VALUE' (1 2; 2 4; 3 6; 4 8; 5
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5; 7 4; 8 3; 9 2; 10 1;NODATA NODATA); 'Re_out_bound' 28 'VALUE' (1 1; 2 2;
3 3; 4 4; 5 5; 6 6; 7 7; 8 8; 9 9; 10 10;NODATA NODATA); 'recl_lc_16' 15
'VALUE' (1 1; 2 2; 4 4; 8 8; 9 9; 10 10;NODATA NODATA));1 10 1", wo_3_13)
print "finished13"

```

```

# Process: Weighted Overlay
wo_3_14 = "Y:\\research\\student\\ai7\\MP\\MP\\Result\\Py_output3\\wo_3_14"
gp.WeightedOverlay_sa("('Erosion_ras' 15 'VALUE' (1 2; 2 4; 3 6; 4 8; 5
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3 3; 4 4; 5 5; 6 6; 7 7; 8 8; 9 9; 10 10;NODATA NODATA); 'recl_lc_16' 15
'VALUE' (1 1; 2 2; 4 4; 8 8; 9 9; 10 10;NODATA NODATA));1 10 1", wo_3_14)
print "finished14"

```

```

# Process: Weighted Overlay
wo_3_15 = "Y:\\research\\student\\ai7\\MP\\MP\\Result\\Py_output3\\wo_3_15"
gp.WeightedOverlay_sa("('Erosion_ras' 15 'VALUE' (1 2; 2 4; 3 6; 4 8; 5
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10;NODATA NODATA); 'rec_dis_vi_10' 28 'VALUE' (1 10; 2 9; 3 8; 4 7; 5 6; 6
5; 7 4; 8 3; 9 2; 10 1;NODATA NODATA); 'Re_out_bound' 28 'VALUE' (1 1; 2 2;
3 3; 4 4; 5 5; 6 6; 7 7; 8 8; 9 9; 10 10;NODATA NODATA); 'recl_lc_16' 15
'VALUE' (1 1; 2 2; 4 4; 8 8; 9 9; 10 10;NODATA NODATA));1 10 1", wo_3_15)
print "finished15"

```

```

# Process: Weighted Overlay
wo_3_16 = "Y:\\research\\student\\ai7\\MP\\MP\\Result\\Py_output3\\wo_3_16"
gp.WeightedOverlay_sa("('Erosion_ras' 15 'VALUE' (1 2; 2 4; 3 6; 4 8; 5
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3 3; 4 4; 5 5; 6 6; 7 7; 8 8; 9 9; 10 10;NODATA NODATA); 'recl_lc_16' 15
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print "finished16"

```

Appendix 2

Interview Questionnaires

Preliminary Study:

1. How old are you?
2. What is your main commodity?
What types of crops do you grow?
3. (If they have several crops) Which is the most important for your life?
4. Do you know the Batang Gadis National Park?
5. Who told you about Batang Gadis National Park?
6. Has the BGNP establishment affected your life or agriculture?
7. Is the forest important for you?
8. Why is it (or isn't it) important for you?
9. Do you think the BGNP works to protect forest?
10. What do you expect from BGNP?
11. Do you think you and villagers are involved in BGNP management?
If yes, how are you involved in BGNP management?
If not, why do you think you are not involved in BGNP management?
12. Do you have any expectation or opinion for BGNP management?

Interview for reforestation project:

In addition to questions 1 to 12, following questions were asked.

13. Do you know why these area are open?
14. Are you or the other villagers using this open area?
 - If yes, how are you or other villagers using this area?
 - If not, why aren't you and other villagers using this area?
15. If there is the project to replant trees in open area, do you agree?
16. Why do/ don't you agree this plan?
17. Do you want to participate in this project to plant trees?
 - If you agree, what types of trees or crops do you want to plant and why do you want to plant these species?
 - If you don't agree, why don't you agree?
18. Are you interested in agro-forestry?
 - Agro-forestry was explained as the sustainable use of land by planting several trees which crops, such as coffee, rubber, cacao.
19. Do you have any expectation or concern for this reforestation project if we have a project in your village?

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