Assessing land rehabilitation in Indonesia: A case study in Karanganyar District, Central Java Province

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Dedicated to my father, abah, who instilled me
with honesty, kindness and discipline.
He instantiated treatment and care of
other people and the environment.
He also convinced me that I can reach all
goals as long as it has no harm to others;
He always reminded me that
I will be happy if people around me are happy too

ABSTRACT

The Ministry of Forestry (MoF) has established hundreds rehabilitation projects to improve productivity of degraded land under the National Movement of Forest and Land Rehabilitation (GN-RHL/*Gerhan*) scheme. In Karanganyar Regency, Java, MoF's two-year assessments of these projects have shown high seedling survival rates and detailed the extent of the rehabilitated area but there is no subsequent information on tree growth and the maintenance of rehabilitated areas.

This research assessed the longer term success of the *Gerhan* projects. Stand density, stem diameter and height of timber species: teak (*Tectona grandis*), mahogany (*Swietenia macrophylla*), red cedar/*suryan* (*Toona sureni*) were measured. The productivity of Multi Purposes Tree Species (MPTS) in three sub-districts (10 villages) and area planted-maintained were also observed and estimated. At each village four 0.04 ha circular plots were established. Species, stem diameter and height of all trees in each plot were recorded. Mean height and diameter for the main timber species in each sub-district were compared with growth model (Harbagung, 2010; Orwa et al., 2009) predictions, while MPTS productivity was compared to Ministry of Agriculture (MoA)'s guidelines. The extent of the area maintained was also compared to the MoF standard of 55%. All projects below this standard were considered unsuccessful.

Stand density ranged from 575-2,488 stems/ha in different districts, higher than the MoF minimum (400 stems/ha), a result of supplementary planting by farmers. Albizia (*Paraserianthes falcataria*) was the most commonly planted supplementary species. Comparison of mean stem diameter and height for each district revealed that stem diameter for teak and mahogany, 11.5–12.7 cm and 9.8-11.3 cm respectively, generally exceeded the diameters predicted by the growth models, 10.4 cm and 10.0 cm respectively. In contrast, heights, 7.8-11.8 m and 6.7-7.8 m for teak and mahogany respectively, were lower than those predicted by the models, 13.4 m and 11.4 m respectively while diameter (10.0-11.3 cm) and height (6.9–8.9 m) for *suryan* were similar to those predicted by the growth model (11.2 cm and 7.2 m respectively). The area maintained varied; 3 villages in Tawangmangu ranged from 61-91%, while those in Jumantono and Matesih ranged from 21% to 34%.

In terms of tree growth, the projects can be categorised as successful, especially for teak and mahogany suggesting that species selection was appropriate. For MPTS productivity, all No villages achieved success with MPTS projects mostly because of poor management. Using the criteria of planted area maintained, the *Gerhan* was unsuccessful in Jumantono and Matesih but that in Tawangmangu was categorised as successful.

Keywords: GN-RHL/*Gerhan*, Karanganyar District, stand density, diameter, height, teak, mahogany, *suryan*, Multi Purposes Tree Species

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amsl	:	above mean sea level
Badan Litbanghut	:	*Badan Penelitian dan Pengembangan Kehutanan* (Forestry Research and Development Agency)
Baplan	:	*Badan Planologi Kehutanan* (Forestry Planning Agency)
BKSDA	:	*Balai Konservasi Sumber Daya Alam* (Institute for Natural Resources Conservation)
BPDAS	:	*Balai Pengelolaan Daerah Aliran Sungai* (Watershed Management Centre)
BPK	:	*Badan Pemeriksa Keuangan* (Audit Board)
BPTH	:	*Balai Perbenihan Tanaman Hutan* (Forest Tree Nursery Centre)
BTN	:	*Balai Taman Nasional* (Institute for National Park)
CIFOR	:	Center for Internetional Forestry Research
Dirjen RRL	:	*Direktur Jenderal Reboisasi dan Rehabiitasi Lahan (The Directorate General for Reforestation and Land Rehabilitation)*
Ditjen BPK	:	*Direktorat Jenderal Bina Produksi Kehutanan* (Directorate General of Forestry Production Management)
Ditjen PHKA	:	*Direktorat Jenderal Perlindungan Hutan dan Konservasi Alam* (Directorate General of Forest Protection and Nature Conservation)
Ditjen RLPS	:	*Direktorat Jenderal Rehabilitasi Lahan dan Perhutanan Sosial* (The Directorate General for Land Rehabilitation and Social Forestry)
DR	:	*Dana Reboisasi* (Reforestation Fund)
FWI/GTZ	:	Forest Watch Indonesia/
GN-RHL/Gerhan	:	*Gerakan Nasional Rehabilitasi Hutan dan Lahan* (National Movement on Forest and Land Rehabilitation)
GoI	:	The Government of Indonesia
GPS	:	Global Positioning System
Itjen	:	*Inspektorat Jenderal* (Inspectorate General)
MoA	:	Ministry of Agriculture
MoF	:	Ministry of Forestry

MoW	:	Ministry of Welfare
MPTS	:	Multi Purposes Tree Species
NGO	:	Non Government Organisation
OBIT	:	One Billion Indonesian Trees
OMOT	:	One Man One Tree
Puslitanak	:	*Pusat Penelitian Tanah dan Agroklimat* (The Centre for Soil and Agro-climate Research)
Sekjen	:	*Sekretaris Jenderal* (The Secretary General)
TNI	:	*Tentara Nasional Indonesia* (Indonesian National Army)

CHAPTER 1: INTRODUCTION

1.1 Background and problem statement

Forest and land rehabilitation are important agendas in countries that have widespread deforestation and land degradation. In Indonesia degraded land has increased from 43 million hectare (ha) in 2003 (MoF, 2009b) to 82 million ha in 2010 (MoF, 2011a). Degraded land as called as critical land is a piece of land which has lost its functions as water retention, erosion control, nutrient cycling, microclimate regulator and carbon retention (MoF, 2012a). Floods, landslides and droughts have been attributed to this environmental destruction. In response, the Ministry of Forestry (MoF) on behalf of the Government of Indonesia (GoI) has established hundreds of on forest and land rehabilitation projects with the main goal of environmental improvement through ensuring forest and land functions in protecting the environment and conserving water resources, and providing benefits to the community (MoW, 2003).

From 2003, these projects have been collectively labelled as *Gerakan Rehabilitasi Hutan dan Lahan* (*GN-RHL/Gerhan*). *Gerhan* consists of reforestation of state forest areas and re-greening of private land.Indonesia has three main types of state forests: production forests, protected forests, and conservation forests. The *Gerhan* has the following objectives for each forest type respectively: increasing forest cover, productivity and preventing forest fire; improving forest ecological functions; and conserving biodiversity and water resources (Nawir et al., 2007). Outside the state forest area, the objectives are generating income, improving land productivity and conserving soil and water resources (MoF, 2004b; Nawir, et al., 2007).

Nawir, et al. (2007) claimed that approximately 85% of the MoF's budget has been spent on *Gerhan*. Despite this, many projects have been ineffective, indicated by an increase in critical land area rather than a decrease, along with such as failure to plant, incomplete work, and not maintaining the planted site (BPK, 2008). However, while there have been many failures, some areas including Central Java Province have shown good commitment to *Gerhan.*

To illustrate the success of *Gerhan* in Central Java Province, there has been a decrease in critical land area of approximately 23% (MoF, 2011a). In addition, the province has also had a significant decrease in watersheds with a high priority for forest and land rehabilitation, from 31 in 1999 (MoF, 1999) to 21 in 2009 (MoF, 2009c). Since 2003, Central Java has reforested approximately 86,000 ha of state forests, 70% of which was done in 2004 and rehabilitated 354,000 ha of private land, almost 50% of which was done in 2007 and 2010 (MoF, 2009b, 2011a). According to BPK's report (BPK, 2008), there is no evidence of project failure in terms of tree survival compared to those in the other provinces. For example, in 2004, some regencies such as Karanganyar had seedling survival rates of 91.6 % after rehabilitation planting on private land and almost halved their critical land area between 2004 and 2009 (BPDAS Solo, 2008). The district is included in Bengawan Solo watershed, the biggest river system in Java, consequently the success of rehabilitation in this district could play an important role in river service improvement.

To assess the success of forest and land rehabilitation efforts, short and long term assessments which include both physical and non-physical indicators are needed. This has been achieved in developing countries (Chokkalingam et al., 2006a; Nawir, et al., 2007; Zhou & Chokkalingam, 2010). Recently, Le, et al. (2012) reviewed these and other assessments and proposed a conceptual model for assessing reforestation success. Le, et al. (2012) divided success into four stages: establishment, forest growth, environmental and socio-economic. The first stage influences all other stages, the second influences the third and fourth stages which interact with each other.

Different indicators can be used to measure each stage (Le, et al., 2012). Survival rates and area planted compared to target area indicate the establishment success. Tree growth performance, stand density, actual production and area remaining intact or maintained long-term are indicators of forest growth. Environmental success has more indicators with three main ecosystem attributes: vegetation structure, species diversity and ecosystem functions. Socio-economic success can be measured by increased income, local employment and other livelihood opportunities, food and fibre supplies, markets for produced commodities and local empowerment and capacity building. However, while these indicators offer units of measurements, they do not provide a benchmark of what is considered successful.

The MoF, as the leader of *Gerhan*, has set up guidelines to assess the projects, however the focus on the short term indicators, measuring survival rates and area planted compared to target area in the first two years. According to Le, et al. (2012), this assessment only covers the establishment stage without indicating future performance. Aside from the socio-economic goal, other *Gerhan* goals are long term. These include increasing forest cover both in state and private land and enhancing environmental services from the rehabilitated areas; they still need to be measured. Therefore the long term success of these projects is still questionable.

Nawir, et al. (2007) assessed rehabilitation projects in Indonesia over three decades. This study encompassed several aspects of rehabilitation including the impacts of ten selected case studies on land productivity and the environment. The productions of timber, fruit, fuel wood and food crops or vegetables as well as tree growth to determine land productivity were investigated. In relation to the ecological impacts, the following ten indicators were used: water quality, water quantity, water table depth (dry season), water table depth (rainy season), frequency of landslides, floral diversity, fauna diversity, carbon stocks, soil fertility, and soil erosion. However, apart from measuring tree growth, their assessments were qualitative through interviews with projects stakeholders such as project managers or staff and participating and non-participating community and covered projects up to 2003 only. More recent data is needed to assess the success of current projects. The use of quantitative assessment will provide more reliable data and complement the qualitative ones. Some of Le, et al.'s (2012) indicators can be used to do this.

Problem statement

The Indonesian government has conducted hundreds of *Gerhan* projects to counterbalance deforestation and land degradation. Short and long term goals include conserving soil and water, improving forest and land productivity and increasing income of local people. Many of these projects have failed, indicated by an increase in the critical land area. However, in Central Java province, in particular Karanganyar District, there appears to be a good level of success. However, according to Le, et al. (2012), these measurements only cover the establishment stage. There is no data on planted seedlings performance beyond two years. Therefore the long term success of the projects remains unresolved.

1.2 Research aim, questions and objectives

The aim of the research is to examine the success of 2004 re-greening project in Samin sub-watershed, Karanganyar District.

The research will address the following questions:

1. How the planted trees, both timber tree species and Multi Purposes Tree Species (MPTS), have performed (height and diameter) after the MoF's year two assessments?
2. Has the area of the identified project been maintained beyond the project?
3. What factors have influenced the overall success of these projects?

The research has four objectives:

1. To determine the stand density, average diameter, and height for timber tree species of *Gerhan*
2. To identify the stand density and productivity of MPTS
3. To investigate the extent of revegetated area maintained beyond the project
4. To determine the degree of success of the identified projects and the factors influencing success.

1.3 Outline of the thesis

Chapter 1: this chapter introduces background problem on the research topic. It also describes the aim, research questions and objectives.

Chapter 2: this chapter provides a literature review on land degradation, causes and effects, and effort in reducing the degradation in Indonesia. Projects assessments were also reviewed.

Chapter 3: a general description of the study area is presented in this chapter. This chapter also describes material and methodology used in this study including data analysis processes.

Chapter 4: tree species composition, stand density, tree growth and proximate area maintained up to the research undertaken are reported in this chapter.

Chapter 5: the results in Chapter 4 are discussed in the light of the literature review in Chapter 2.

Chapter 6: this chapter presents the conclusions that are drawn from this study.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter provides a literature review on land degradation, causes and effects, and effort in reducing the degradation in Indonesia. The chapter is structured into six sections. The first section contains general description of degraded/critical land, its spread throughout Asian countries, and categorising systems in Indonesia. Section two outlines causes and effects of degraded land in Indonesia. The third section reviews the Government of Indonesia's effort in reducing land degradation through various rehabilitation projects. Sections four and five focus on a national rehabilitation project (*Gerakan Nasional Rehabilitasi Hutan dan Lahan/GNRHL-Gerhan*) and its assessment respectively.

2.2 Land degradation

"Land degradation is defined as a long-term decline in ecosystem function and measured in terms of net primary productivity" (Bai et al., 2008, p.i). In 1991, 15% of Earth land surface was degraded but by 2008, this increased to 24%. Degraded land severely affected considerable areas in Africa, Asia and some parts of Australia. Africa has the largest area degraded land, for example Angola, which has 66.4% of its land area being degraded. Figures are similar for other African countries. In Asia, particularly Southeast Asian countries, approximately 40%-60% of land has been degraded (Table 2.1). More than 20% and 40% of cropland and forest respectively are categorised as degraded.

Table 2.1

Land Degradation in Southeast Asia 1981-2003 (adapted from Bai, et al. (2008))

No	Country	Degrading area (km2)	% territory	affected people	% total population
1	Indonesia	1,028,942	53.6	86,656,550	40.5
2	Thailand	309,245	60.2	36,991,080	56.7
3	Philippines	1,322,275	44.1	33,064,628	42.8
4	Vietnam	134,026	40.7	28,085,074	35.3
5	Myanmar	358,887	52.9	23,608,512	47.9
6	Malaysia	175,817	53.3	10,401,113	46.4
7	Cambodia	77,958	43.1	3,583,464	24.0
8	Laos	133,395	56.3	3,304,253	55.1
9	Brunei	2,663	46.2	264,401	85.0
	Total	**3,543,208**		**225,959,075**	

The government of Indonesia specified degraded land as critical land that has lost its functions for water retention, erosion control, nutrient cycling, microclimate regulator and carbon retention (MoF, 2012a). *Direktur Jenderal Reboisasi dan Rehabiitasi Lahan*/*Dirjen RRL* (The Directorate General for Reforestation and Land Rehabilitation) divided critical land into very critical, critical, rather critical, potentially critical and not critical (Dirjen RRL, 1998). Before classifying the critical levels, land status is differentiated into: protection forest, cultivated farmland and protected areas outside state forests. For protection forest and protected areas outside state forests, *Dirjen RRL* employs permanent vegetation cover, slopes, erosion, and land management as criteria; while for farmland, land productivity and parent material are additional attributes. Within each criterion, the values are classified and scored. The smaller the total score, the more severe the critical level (Table 2.2).

Table 2.2

Critical Level based on Land Status (adapted from Dirjen RRL (1998))

Critical level	**Protection forests**	**Cultivated farmland**	**Protection areas outside state forests**
	Total score	Total score	Total score
Very critical	120-180	115-200	110-200
Critical	181-270	201-275	201-275
Rather critical	271-360	276-350	276-351
Potentially critical	361-450	351-425	351-426
Not critical	451-500	426-500	426-501

Pusat Penelitian Tanah dan Agroklimat/Puslitanak (The Centre for Soil and Agro-climate Research) (Puslitanak, 1997) also divided critical land into the same categories but excluded land which was not critical, with some different attributes (Table 2.3). Potentially critical land has vegetation cover of more than 75%; normal production and hydrology functions; and natural vulnerability to erosion. This land also still has an A horizon of more than 15 cm. However, once it is opened or there are no conservation efforts, the result is erosion. Rather critical land suffers from sheet erosion and rill erosion, and vegetation cover between 50% and 75%; and decrease in productivity, fertility, and hydrological function. Soil depth of this land is 60-90 cm and the A horizon is less than 15 cm. Critical land suffers large erosion events (gully erosion), shallow soil depth up to 60 cm with the A horizon being less than 5 cm, vegetation cover from 15% to 30 %, slopes between 15%-30% and low fertility. Very critical land has very severe erosion including landslide occurrences, 0-30 cm soil depth, without A horizon and sometimes eroded B horizon, vegetation cover of less than 25%, and usually more than 45% slopes.

Table 2.3

Description of Critical Land Catergorised in Indonesia (adapted from Puslitanak (1997))

Attributes/Critical level	Potentially critical	Rather critical	Critical	Very critical
Permanent vegetation cover (%)	>75	50-75	25-50	<25
Production function	good	decreasing	lost	lost
Hydrological function	good	decreasing	lost	lost
Soil depth (cm)		60-90	<60	≤30
A horison depth (cm)	>15	<15	<5	nil
Erosion level	vulnerable	slight-medium	bad	very bad
Slopes (%)	sometimes >45		15-30	>45

Increasing critical land area is becoming a serious concern for the government of Indonesia. The degradation has happened not only inside state forests, but also outside state forests which is mostly privately owned (MoF, 2009b). Based on vegetation cover, the MoF focuses mainly on very critical and critical land. Although there was a slight decrease in critical land since 2006, more than 27 million ha of land still needs remedial treatment (Table 2.4) (MoF, 2009b, 2012a). The extent of critical land continues to increase in some provinces. For example, in Central Kalimantan Province critical land area more than double from 1,758,833 ha in 2000 (MoF, 2009b) to 4,636,890 ha in 2011 (MoF, 2012a). Alarmingly, land degradation also occurs in the other provinces in outer islands such as Sumatra, Moluccas, Sulawesi, and Papua. However, in some provinces including Central Java, there is a significant decrease in critical land. This province reduced critical land area, from 360,827 ha in 2000 (MoF, 2009b) to 159,853 ha in 2011 (MoF, 2012a), a 56% decrease.

Table 2.4

Critical and Very Critical Land in Indonesia 2000-2011(MoF, 2009b, 2012a)

No	Province	2000	2006	2011
1	Aceh	351,015	463,023	744,954
2	North Sumatra	469,143	1,961,726	1,135,341
3	Riau and Riau Archipelago	334,868	2,415,014	1,095,407
4	West Sumatra	131,155	409,031	509,977
5	Jambi	716,147	618,891	1,420,602
6	Bengkulu	578,543	708,949	642,587
7	South Sumatra and Bangka Belitung	3,461,840	3,401,307	4,000,898
8	Lampung	299,157	525,463	589,229
9	Jakarta	-	-	-
10	Banten and West Java	368,794	160,382	551,446
11	Central Java	360,827	261,526	159,853
12	Special Region of Yogyakarta	34,667	44,659	33,559
13	East Java	1,302,379	780,956	608,913
14	West Kalimantan	3,065,728	1,856,305	3,169,491
15	Central Kalimantan	1,758,833	3,206,887	4,636,890
16	East Kalimantan	1,778,782	1,053,690	318,836
17	South Kalimantan	575,383	566,592	786,911
18	North Sulawesi and Gorontalo	235,092	523,044	533,232
19	Central Sulawesi	413,221	216,488	317,769
20	Southeast Sulawesi	241,811	1,284,601	885,463
21	South and West Sulawesi	1,032,802	576,256	1,034,412
22	Bali	33,425	55,921	48,052
23	West Nusa Tenggara	278,698	305,732	91,859
24	East Nusa Tenggara	1,356,757	3,219,811	1,041,688
25	North and Maluku	694,911	1,162,970	1,373,430
26	Papua and West Papua	3,368,903	4,275,170	1,564,042
	Total	**23,242,881**	**30,054,394**	**27,294,841**

Critical land is spread throughout 52 main watersheds in all provinces (MoF, 2003a). These watersheds are managed by31 *Balai Pengelolaan Daerah Aliran Sungai/BPDAS* (Watershed Management Centre) responsible for rehabilitating critical land in their management areas regardless of the ownership status, not only inside but also outside the state forest. In 2000, almost two thirds of the critical land area was private land. Some major watersheds may consist of hundreds of smaller watersheds (MoF, 2009b). Based on the area of critical land, MoF prioritised 472 watersheds in 1999 for rehabilitation and classified them into the first, the second and the third priority (MoF, 1999). Among them, 62 watersheds were categorised as first priority. In 2009, MoF published a shorter list of 108 watersheds classified as first priority for rehabilitation (MoF, 2009c).

2.3 Causes and effects of degraded/critical land

Natural and anthropogenic factors have caused deteriorating land quality leading to its lower production and services (Nachtergaele et al., 2012). Climate, slope and soil vulnerability to water and wind erosion are some of the natural factors influencing land degradation. Whereas, human-induced causes are dominated by land use, economic and social factors. For example, in the Central Rift Valley of Ethiopia, land degradation was attributed to population and livestock growth, unsustainable farming techniques, land tenure system, and poverty (Meshesha et al., 2012). The impacts were tremendous as the decline in agricultural productivity reduced food insecurity and increased poverty in the area. In northeast India, agricultural intensification as a result of a rapid growth of population and increase in demand for agricultural products has eroded soil from cultivated fields (Prokop & Poreba, 2012). This was predicted to cause continuous degradation of the fields into grassland.

The Indonesian climate (e.g. rainfall) together with land attributes (e.g. slope and soil vulnerability) makes land in some areas vulnerable to degradation (Agus, 2011). Most areas have high annual rainfall between 2000-3500 mm. About 45% of Indonesia’s land area is mountainous area with slope ranging from 15% to more than 30% (Puslitanak, 1997). Another 2.5% (5 million ha) are highly vulnerable to erosion because of their structure, parent material and shallowness. These factors together can potentially result in soil erosion, in particular on areas with low or no vegetation cover.

In addition to these natural factors, several anthropogenic factors such as land conversion, and mining are key factors in land degradation in Indonesia (Atmojo, 2006). For example in Citarum watershed, when people converted forests, shrub, and paddy fields into moor and mixed garden, erosion increased dramatically; at least ten times higher than those before conversion (Sutono et al., 2003). Compared to other land uses, mixed garden had the highest erosion level with 30-60 t/ha/year (Sutono, et al.). The impacts of land conversion also occurred in the second largest watershed, Batanghari, where approximately 3 million tonnes sediment enters the river every year (Hidayati, 2005). In addition, the total area for farming tends to decrease as a result of regional development (e.g. settlement) (Efizudin, 2011). On the other hand, demand for agricultural products is increasing. As a consequence, food shortages forced the government to import staple food as much as 2.1 million ton in 2011(Efizudin).

Moreover, unsustainable farming practices such as planting the same crops continuously for a long period without applying soil conservation measures are practised on steep land. For example, Dieng plateau in Wonosobo, Central Java has been cultivated intensively for potatoes (Pikiran Rakyat, 2011). In December 2011, during the rainy season, massive erosion killed 11 villagers and destroyed many houses. In Central Sulawesi, Dechert, Veldkamp and Anas (2004) found that continuous maize cultivation reduced soil fertility to low levels when compared to agro forestry, forest fallow and natural forest land use. Tillage techniques that cross the contour lines potentially increase erosion in the rainy season as can be observed in many orchards in the hillsides of Merapi and Merbabu Mountain in Boyolali District (Riastika, 2011; Suara Merdeka, 2008). In the Special Region of Yogyakarta, although farmers have gradually adapted better farming systems, the efforts have not reduced erosion to the acceptable value for farming systems; 6-8 t/ha/year. Their practices still produced 12-16 t/ha/year (Abas Id et al., 2003).

In some areas, mining has contributed to an increase in critical land (Atmojo, 2006; Dyahwanti, 2007; Hasibuan, 2006; Ismail, 2011; Saba, 2010). Hasibuan investigated the impact of surface mining type C[1] on the environment in Deli Serdang District, North Sumatra Province. The result of the investigation indicated that this type of mining caused soil fertility loss that resulted in unproductive land in the mining area because there were no reclamation efforts after mining. In Java, Dyahwanti found high erosion rate as a result of surface mining in Kledung sub-district, Temangggung. The values ranged from 93-200 t/ha/year, much higher than the acceptable erosion rates. Land degradation may also result from coal mining (included in mining type A) where miners need to open an area to take the resource.

Fire is another factor resulting in critical land in Indonesia (CIFOR, 2003; FWI/GTZ, 2002). Land clearing for oil palm and timber plantations in Sumatra and Kalimantan between 1997 and 1998 burnt 9.7-11.7 million ha of Indonesian forest (CIFOR). This resulted in the loss of many forest services such as soil protection, timber production, and biodiversity. More recently, in Merbabu Mountain, Central Java, almost 3,000 ha of forested area, which produced habitat for primates and other fauna, was left critical as a result of forest fire in 2006 (Kompas, 2011). As a consequence, the area can no longer support primate.

Other impacts of land degradation is a decrease in land productivity and soil fertility and an increase in soil pollution (Atmojo, 2006). Sutono (2008) measured soil erosion of more than 20 t/ha after chilli cultivation. This resulted in the loss of organic matter and nutrients including Nitrogen (N), Phosphates (P) and Potassium (K). As a consequence, farmers have to add more fertilizers to maintain crop yields. Farming intensification also requires higher fertiliser inputs which can cause soil health decline (Mamat, 2008).

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[1]Mining type C is mining for industrial purposes and consisting of nine types of product which are mostly stones (PP.27/1980)

2.4 Efforts in reducing land degradation

To rehabilitate deforested areas and degraded land, the Indonesian government has established a range of replanting programmes (Nawir, et al., 2007). The programmes were divided into six eras: (1) pre-colonial to colonial, (2) colonial to 1960s, (3) 1960s to1970s, (4) 1970s to 1980s, (5) 1980s to 1990s, and (6) 2000s onwards. During the pre-colonial to colonial period, Hindu communities who migrated to Java brought teak seeds and initiated rehabilitation practices. Their faith recognised teak trees as the souls of their ancestors and encouraged them to plant as many trees as possible. This practice has resulted a large area of teak forest in Java, approximately 1-1.5 million ha (Wibowo, 2006) as cited by (Nawir, et al., 2007).

In the Dutch colonial period (1600s-1942), the programmes were continued , one of which resulted in a significant rehabilitation fund, '*Bosfonds'* (Nawir, et al., 2007). The fund was collected from individual/companies who convert forest into farmland and crop estate in downstream areas and used to fund replanting of upstream zones (Ditjen RLPS, 2003) as cited by (Nawir, et al., 2007). However, during the Japanese occupation (1942-1945), these efforts were discontinued (Nawir, et al., 2007). Large forest areas were cleared to produce food for their armies and left 110,000 ha of degraded land (Mursidin et al, 1997) as cited by (Nawir, et al., 2007).

After independence, the Indonesian government has continued rehabilitating land, initiated by the establishment of the Afforestation Committee in 1946, and officially launched in the 1950s (Nawir, et al., 2007). Until the 1960s, these programmes covered only small areas and were applied at irregular intervals. In 1961, Soeharto, (president of the Republic of Indonesia), announced *Pekan Penghijauan Nasional* (National Afforestation Week). This Afforestation Week was subsequently implemented annually until 1995. From the 1950s to 1970s, the programmes were commonly government-based projects using a top-down approach. The project area was still small and the approach was characterised by a mass mobilisation where the government set the planting dates and hundreds of people attended.

The rehabilitation programmes became more serious after flash floods in Solo, Central Java Province at the end of 1970s (Nawir, et al., 2007). Following massive deforestation on Java, the government assigned extension workers to campaign on the importance of preserving forest, soil and water through tree planting, not only in state forests, but also on private land. In this period, floods and other natural disasters were the main reasons for most government rehabilitation initiatives (Nawir, et al., 2007).

The 1980s to 1990s was a transition period from a top-down to a participative approach (Nawir, et al., 2007). Rapid deforestation in Sumatra and Kalimantan was alarming, consequently the government re-formulated rehabilitation programmes to quickly increase forest cover and to fulfil the national demand for timber. Plantation forests were the main form of rehabilitation. Since then, as part of the Reformation Era (1998-present), the government has attempted to be conceptually participative and to accommodate local people's needs, because evaluation of the top-down approach has shown it to be unsuccessful (Nawir, et al., 2007).

As deforestation rates increased, particularly at the end of 1990s, the government put more attention on forest and land rehabilitation (Nawir, et al., 2007). The number of rehabilitation projects and the coverage area increased significantly after the 1980s, as well as the number of institutions involved in the projects; from 29 in the 1980s to 50 in the 1990s-2004. Since the 1980s, Non Government Organisations (NGOs) together with local level government also participated in the project implementations in addition to the central government institutions.

2.5 Gerakan Nasional Rehabilitasi Hutan dan Lahan/GNRHL-*Gerhan* (National Movement on Forest and land Rehabilitation)

The government commitment to rehabilitation programmes has been maintained. In 2003 the government changed the name of these projects to *Gerakan Nasional Rehabilitasi Hutan dan Lahan/GNRHL-Gerhan* (National

Movement on Forest and Land Rehabilitation) (MoF, 2003b). *Gerhan* consists of two main activities: protection of environmental degradation and replanting state forest and private land (MoW, 2003). The first activity mostly focuses on the dissemination of policy on environment protection, community empowerment and law enforcement. The second one include all activities directly connected to planting including providing seedlings, planting, civil engineering for soil and water conservation, planning and designing planting programmes, institutional development and assistance.

Gerhan was an emergency response as many past rehabilitation efforts only covered a small area and the results were disappointing, lagging behind deforestation and land degradation (MoF, 2004c). *Gerhan* encompasses all efforts to restore, maintain, and enhance forest and land functions so that they can maintain their carrying capacity, productivity, and roles in supporting life systems. The MoF divided *Gerhan* into two categories: reforestation in the state forest and re-greening outside the state forest land (MoF, 2003c; The GoI, 2002). Reforestation can be conducted on production, protection, and conservation forest (The GoI, 2002). In production forests, reforestation projects aim to increase forest cover and its commercial value, and to prevent forest fire (MoF, 2003c). In protection forests, the purpose of the project is to improve ecological functions, whereas in conservation forests, the aim is to conserve biodiversity and water resources (MoF, 2003b, 2007). On private land, re-greening is conducted through planting trees and implementing soil conservation practices (The GoI, 2002). Its objectives are to improve land productivity, conserve water resources, and increase local people’s income (MoF, 2003b; Nawir, et al., 2007).

To emphasize the importance and to raise community awareness of *Gerhan*, the Indonesian president, Megawati Soekarno Putri, proclaimed *Gerhan* in the village of Karang Duwet, Wonosari Sub-district, Gunungkidul District, the Special Region of Yogyakarta (MoF, 2004c). Approximately 10,000 people from different backgrounds attended the ceremony. As the village is an important asset for the present and the next generation, it is expected that the presence of the president will encourage the communities both in the village and other villages to participate in succeeding the *Gerhan.* To support this effort, the government also assigned forest extension workers to facilitate, through cooperate with community groups the success of *Gerhan.*

In addition to *Gerhan,* the MoF also initiated One Man, One Tree (OMOT) in 2009 (MoF, 2009a), a response to Presidential Decree No. 24 in 2008 appointing *Hari Menanam Pohon Indonesia* (Indonesian Tree Planting Day)and *Bulan Menanam Pohon Nasional* (National Tree Planting Month) (MoF, 2009a; The GoI, 2008). Furthermore, in 2010 and 2011, a new programme namely One Billion Indonesian Trees (OBIT) was introduced to demonstrate the Indonesian government's commitment to reduce carbon emissions (MoF, 2010, 2011b). One Man, One Tree and OBIT involve all citizen and cover all area including the critical land which have not been planted by *Gerhan* scheme (MoF, 2009a, 2010, 2011b).

2.5.1 Actors involved in *Gerhan*

More involvement from different institutions of different background were needed in the implementation of *Gerhan* (MoF, 2004c). In the *Gerhan* scheme, government and community have their own roles. There have also been clearer roles assigned to all MoF branches involved in the projects. All branches, in Jakarta, have their own roles and responsibilities in the projects. The major role of planning and reporting is held by *Direktorat Jenderal Rehabilitasi Lahan dan Perhutanan Sosial/Ditjen RLPS* (The Directorate General for Land Rehabilitation and Social Forestry). The other branches supported this; *Sekretaris Jenderal/Sekjen* (The Secretary General) of the MoF plan the budget, arrange relevant certain policies and provide training and forestry extension. *Direktorat Jenderal Bina Produksi Kehutanan/Ditjen BPK* (Directorate General of Forestry Production Management) produced guidelines for rehabilitation in production forests; while in conservation forests, the guidelines are arranged by *Direktorat Jenderal Perlindungan Hutan dan Konservasi Alam/Ditjen PHKA* (Directorate General of Forest Protection and Nature Conservation). *Badan Planologi Kehutanan/Baplan* (Forestry Planning Agency) provide databases on forest and land degradation, while *Badan Penelitian dan Pengembangan Kehutanan/Badan Litbanghut* (Forestry Research and Development Agency) provide the technologies, based on scientific research, needed for forest and land rehabilitation. *Inspektorat Jenderal/Itjen* (Inspectorate General) mostly involved in arranging and implementing monitoring guidelines.

At the local level, the MoF has also supporting units (MoF, 2004c) which involve in *Gerhan*: *BPDAS*, *Balai Perbenihan Tanaman Hutan /BPTH* (Forest Tree Nursery Centre), *Balai Konservasi Sumberdaya Alam/BKSDA* (*Institute for* Natural Resources Conservation) and *Balai Taman Nasional/BTN* (Institute for National Park). The first two groups provide seedlings and technical guidelines, coordinating with provincial and regional government, monitoring, evaluating and reporting. The others are responsible for technical guideline and the implementation of forest rehabilitation in conservation forests as well as community empowerment. State companies business interest in the forestry sector are also involved in *Gerhan; Perhutani* is involved in production and protection forest on Java, while *Inhutani* works in the outer islands. In addition to the central government, provincial and regional levels are also mandated to implement *Gerhan.* Provincial governments and forestry-based institutions at this level have duties to report the activity related to *Gerhan* to the MoF and assist institutions at the district level as direct implementer of *Gerhan* in the field.

Community organisation involved in *Gerhan* consist of three elements (MoF, 2004c): farmer groups, NGOs, and private companies. Farmers plant and maintain trees on their land and roadside and help the government to plant trees in the state forests. Farmers also build check dams, retention dams, gully plugs and terraces under guidance from *Dinas Kehutanan* (Provincial and Regional Forestry office). NGOs strengthen farmer group organisation and develop the entrepreneurship of farmers to increase the value of *Gerhan* trees and other products from planted land. Companies provide raw material for planting including fertiliser, pesticides, and insecticides; provide market information and access; and facilitate farmers adopting more productive farming systems. This is expected to build long term cooperation between farmers and private companies for the mutual benefit of both.

2.5.2 Project coverage and site selection

By 2003, more than 400 revegetation projects had been initiated (Nawir, et al., 2007), and more after the *Gerhan* scheme. The Government targeted 18.7 million ha of critical land in both state forests and private land for rehabilitation by 2004, but only 2 million ha was reported. Of the 2 million ha reported to be rehabilitated, the proportion of planted varied between 19% and 93% (Nawir, et al., 2007). From 2003 to 2007, the government targeted 3 million ha of critical land for *Gerhan* (MoW, 2003). Two million ha of which was reported to be replanted (Table 2.5) (MoF, 2009e). More recently, between 2008 and 2009 another 1 million ha was planted (MoF, 2011a). As a result, there has been a slight decrease in very critical land area (300,000 ha) throughout Indonesia, about 2% of the total critical land area (MoF, 2012b). A further 2.5 million ha has been targeted for rehabilitation between 2010 and 2014. This program successfully reduced critical land by 600,000 ha during the first two years (MoF, 2012b), however there is still 27.3 million ha of very critical land in need of rehabilitation (MoF, 2012a).

Table 2.5

Gerhan Development and MoF Assessment (MoF, 2009e, 2011a, 2012a)

Year	target (ha)	planted (ha)	survival rates (%)
2003	300,000	295,445	58.9-86.83
2004	500,000	464,470	40.32-69.2
2005	600,000	447,246	± 70
2006	700,000	454,482	± 70
2007	900,000	754,110	n.a.
2008	500,000	572,807	n.a.
2009	500,000	212,411	n.a.
2010	500,000	1,124,512	n.a.
2011	500,000	567,109	n.a.
2012	500,000	n.a.	n.a

n.a.: not available

The MoF carried out a detailed selection process to identify critical land for rehabilitation (MoF, 2003a). Firstly, the land status was defined as state forest or outside state forest (communities/companies/individual's land). Secondly, the land cover was categorised as less productive or unproductive depending on its sensitivity to erosion, using soil maps. Thirdly, the land was classified into one of classes based on land use. Class 1: consists of bare land, scrubland, and dryland farming in scrubland. Class 2: secondary forests; and class 3: comprises dryland farming, transmigration areas, rice fields, mining, and human settlements. Class 1 requires reforestation or re-greening, class 2 requires enrichment planting, and class 3, soil conservation. Of the 100.6 million ha identified as needing rehabilitation in 2003, 46. 3 million ha was categorised as class 1.

Among the areas targeted to be planted, the government prioritised areas in watersheds with special characteristics: low vegetation cover; vulnerable to natural disasters such as floods, landslides and droughts; important for dam and reservoir protection; and having established community institutions (MoF, 2003b; MoW, 2003). *Gerhan* 2003 was located within 29 priority watersheds in 15 provinces and covering 145 regencies. In 2004, the number of projects increased covering 141 watersheds in 31 provinces and 372 regencies (MoF, 2004c).

2.5.3 Implementation and fund

The government through BPDAS or BPTH utilised outside groups to provide seedlings (except mangrove seedlings) (MoF, 2004c). The species and the number of seedlings needed in the planting project were decided by BPDAS in coordination with the provincial and regional Government directly involved in implementing the project. BPDAS or BPTH then selected a university to assess seedling including assessing the nursery, seedling production methods, species, number, origin, physical and physiological quality and all documents related to the seeds.

Planting of seedlings and soil conservation measures were executed by different groups (MoF, 2004c). Farmer groups, which had *Gerhan* agreements, planted seedlings in state forests (protection and production forests), mangrove forest and private land. They also built soil conservation structures such as dams, terraces and gully plugs. Relevant institutions together with the local community planted trees in conservation forests, road belts, and urban forests. For planting in remote areas where human resources were limited, the government cooperated with *Tentara Nasional Indonesia/TNI* (Indonesian National Army).

Prior to 2004, Nawir, et al. (2007) estimated that 85% of the forestry budget had been spent on various rehabilitation programmes. Between 2003 and 2007, BPK (2008) reported similar spending. Despite this expenditure, some projects failed to plant a single tree (BPK, 2008; Nawir, et al., 2007).

Project fund have come from both Government and private sources (Nawir, et al., 2007). Up to the 1970s funding was primarily from Central Government, while in the 1980s, non-government funds such as international donors and private companies began to contribute (Nawir, et al., 2007). Timber companies which run businesses in state forests contribute to *Dana Reboisasi/DR* (the Reforestation Funds/RF). Central Government receives 60% and Provincial Government receives 40% of the RF. The Central Government distributes funds among projects throughout the country, while the remaining 40% is allocated for local reforestation projects where the timber companies are based (The GoI, 2002). Reforestation Fund can only be used for forest and land rehabilitation activities and some supporting programmes such as research, training, and security. These funds were sufficient to support rehabilitation projects from the 1980s to the first five years of *Gerhan* (2003-2006). Then in 2007, as the available RF decreased, the Central Government added funds for rehabilitation (MoF, 2007). Since 2009, the rehabilitation efforts have been funded by using RF, Central, and Regional Government budgets MoF 2009d (MoF, 2009d).

2.6 Projects assessment

2.6.1 Ministry of Forestry (MoF) assessment

In order to assure that the funding is appropriately used, the Government has been producing annual guidelines, from MoF Decree No. 349 and 369/2003 to the latest MoF Regulation No. 14/2012 (MoF, 2003b, 2012b). The guidelines cover planning, implementation, monitoring and evaluation. However, the focus has been more on implementation including seedling supply, planting techniques, civil structure techniques on soil conservation, and seedling maintenance after planting.

Of the few guidelines covering the evaluation stage, the focus has been on administration and finances (MoF, 2006). The only other evaluations have been on the assessment of seedling survival rates and the comparison of the area planted to targeted area for the first two years of each project. The Government used a minimum seedling survival rate on planted areas of 55% as an indicator of successful plantings for *Gerhan* projects implemented until 2006 (MoF, 2009e). However, since 2007 the standard rate has been increased to a minimum of 60%-70% in the first year. In the second year assessment, the applied standard rate was 80%-90% by accumulating the survival seedling planted during the enrichment planting. The MoF assign internal assessors to conduct a planting assessment at district level. In addition to internal assessors, MoF also appoint independent assessors, *Lembaga Penilai Independen* (LPIs) (e.g. university and consultant) to survey the plantings at the end of each first two years of a project using a sampling technique and report the results (e.g. survival rates of all species) to the MoF (MoF, 2006).

Based on the survival rates assessed by LPIs, the MoF concluded that the programmes in 2003 were relatively successful (59%-87% of survival). However the survival rates of *Gerhan* projects in 2004 were lower, ranging from 40% to 70%. The average survival rates for *Gerhan* projects in 2005 and 2006 were approximately 70% (MoF, 2009e). Since 2007 no information has been available yet for seedling survival rates at first two years (Table 2.5).

The result of that assessment only indicates the short term success of the *Gerhan* projects (Le, et al., 2012). However, it does not guarantee the projects will achieve the long term goals, which are much more important than the short term goals. In addition, the government has been unable to review or to re-assess the projects beyond two years. The long term goals include restoring forest and land resources in *Gerhan* locations, improving the environment and river hydrology and increasing local peoples' livelihood economically, ecologically and socially not only for the people directly involved in the projects but also the other inhabitants (MoF, 2004c).

2.6.2 Impacts assessments other than MoF

Nawir, et al. (2007) recommended that the evaluation should be at least three or four years after project implementation. Nawir, et al. (2007) evaluated 10 examples of rehabilitation projects which represent hundreds of projects during three decades: 2 in Sumatra, 4 in Kalimantan, and 4 in Java. The evaluation was carried out by comparing the impacts of those projects on land productivity, ecology, livelihood, and community rights to forest/land resources between the first and second five years terms. The result indicated that food crops and vegetables were still the dominant products in the first five years; after the fifth year of the projects, timber and non timber forest products (NTFs) from multipurpose trees became the main products

In terms of ecological impacts, Nawir, et al. (2007) found that Watershed Protection Project in Wonogiri, Central Java had the greatest positive impacts. The impacts were assessed using qualitative methods through interviews with local people and project staff. Ten variables were used: water quality, water quantity, water table (dry season), water table (rainy season), frequency of landslides, floral diversity, fauna diversity, carbon stocks, soil fertility and soil erosion. The project showed large positive impacts during both assessment periods (first and second five years after projects) when compared to the other nine projects in Nawir, et al.'s study in 2007. Moreover, only this project was able to reduce water volumes in rivers after long rainfall events to prevent flooding. This was mainly because tree roots, together with other plants, absorbed a large quantity of water in the rainy season. Also increase the rate of water percolation into the soil.

Nawir, et al. (2007) also identified that rehabilitation projects contributed to local people's livelihood. The projects provided short term income to local community through land preparation and tree planting. However, only few of them (Watershed Protection Project and Farm Forestry in Gunungkidul, the Special Region of Yogyakarta) can provide longer term benefits from timber and NTFPs. Both projects were mainly conducted on private land, where replanting activities continued even though fund from the government ended. Moreover, they found that fund for the second replanting/rotation came from revenues from the first harvest of rehabilitation trees.

In term of rights to forest/land resources, Nawir, et al. (2007) found that some projects increased local peoples' rights. For example, rehabilitation of fire affected forests in East Kalimantan and participatory reforestation in West Kalimantan has increased people rights to state forest land and resources. These rights provide local people with more access not only to the trees they planted, but also to various food crops they inserted between the trees. For the participatory reforestation project in West Kalimantan, the local people have consensus on village land uses, consequently they have a better understanding of the status and the utilisation of this land.

2.7 Summary

In Indonesia, a piece of land that has lost its functions for water retention, erosion control, nutrient cycling, microclimate regulator and carbon retention is categorised as critical/degraded land. In 2012, the country had 27 million ha of critical land needs remedial treatment. Land conversion and mining, the main factors of land degradation have cause tremendous decline in agricultural productivity leading to food shortages. Hundred projects have been undertaken to rehabilitate the land since hundreds years ago, one of which is *Gerhan* aiming to improve land productivity, conserve water resources and increase local people's income. Using Reforestation Fund, Central, and Regional Government budgets, the Government, led by MoF, communities and companies have worked together to rehabilitate both state forest and private land throughout the country. Although many projects failed, according to MoF assessment, some others, including project in Karanganyar District was categorised to be successful up to two year. However, this success does not guarantee whether the project achieves its long term goals or not.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

The aim of this research is to examine the success of 2004 re-greening project in Samin sub-watershed, Karanganyar District. This chapter will begin by describing the study site and *Gerhan* project within the site. Then, material and method covering sampling in data collection are highlighted. At the end of the chapter, data analysis used by the researcher is also outlined.

3.2 Site description

This study was carried out to assess the *Gerhan* projects of 2004 in Karanganyar District, Central Java Province, Indonesia. Karanganyar consists of 17 sub-districts (Karanganyar Regency, 2011). Geographically, Karanganyar is located between 110°40' and 110°70' East longitude and 7°28'-7°46' South latitude with an average elevation of 511 m above mean sea level (amsl). The lowest average elevation is found in Jaten sub-district with the value of 90 m amsl, while the highest is in Tawangmangu sub-district (2000 m amsl). The district has a tropical climate with an average temperature ranging from 22° to 31° Celcius and high annual rainfall. In 2011 the annual rainfall was 5,966 mm, with the highest monthly rainfall in March and the lowest in August.

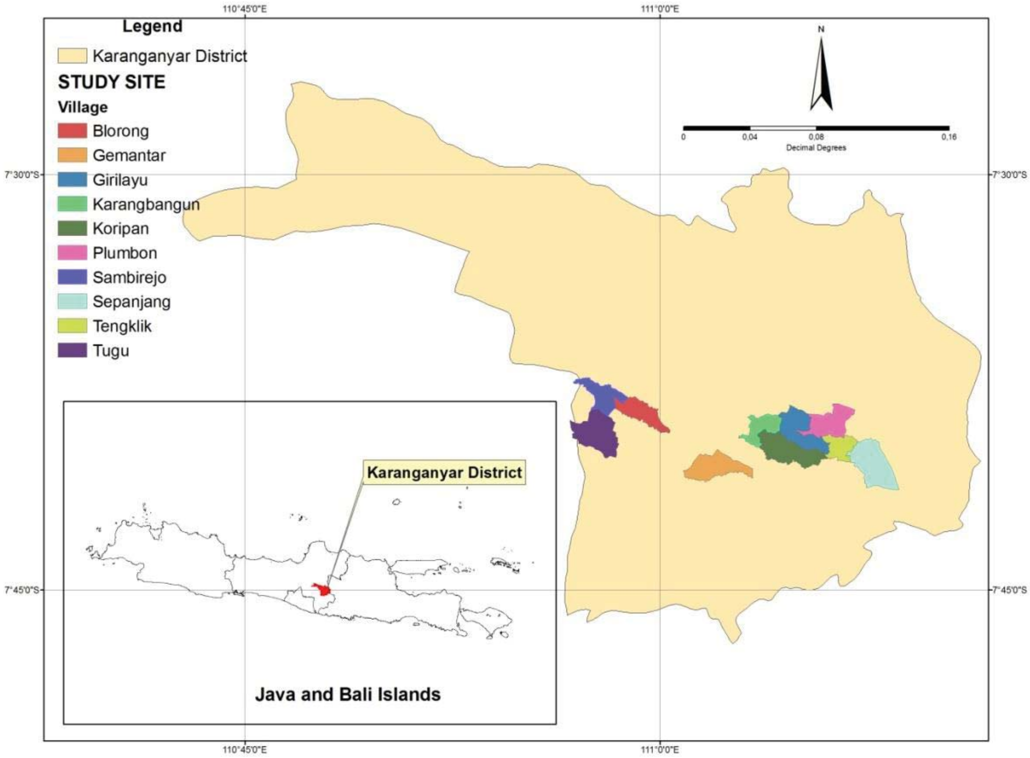

Figure 3.1: Map of study sites in Karanganyar District (adapted from Bakosurtanal, (2001))

The District has a territory of 77,378 ha and consists of several volcanic soil types: ultisols, inceptisols, alfisols, entisols, and vertisols (Karanganyar Regency, 2011). The total population of the District in 2010 was 825,671 people. Karanganyar is an agriculture-based district producing food crops, plantation, forestry, cattle, and fish. Aside from settlements, the main land uses include rice fields, grasslands, and forests. The agriculture sector is the main source of employment; 30.6% of the district's residents work in agriculture while other sectors such as industry, construction and trading employ 14.5%, 6.8%, and 6.2% of residents, respectively.

Bengawan Solo is the longest river in Java with almost 600 km and covers approximately 1.6 million ha of catchment area (BPDAS Solo, 2011). Karanganyar District is located at the upland catchment, namely Solo Hulu watershed which had seven critical sub-watersheds: Walikan, Jlantah, Grompol, Mungkung, Pepe, Kenatan, and Samin (Karanganyar District, 2011). Among these sub-watersheds, Samin constituted the first sub-watershed with the largest area of critical land in 2004, 1,864 ha (BPDAS Solo, 2004). The river flows through six sub-districts, three of which are the main concern of *Gerhan*: Jumantono, Matesih, and Tawangmangu (BPDAS Solo, 2008). Until 2007, there had been many projects in the Samin catchment area in these sub-districts. Therefore, *Gerhan* examples in the areas were used for this research. Study area in Jumantono has inceptisols soil type with 6-10% slope and located at 218-418 m amsl, while Matesih is dominated by entisols soil with 37-46% slope and the elevation of 557-729 m amsl. Tawangmangu has the highest elevation,i.e. 772-953 m amsl, higher slope, i.e. 40-53%, and similar soil type with Jumantono, inceptisols.

Karanganyar District has shown a serious commitment to reforestation and re-greening programmes. Since 2003 the district has conducted planting projects under *Gerhan* schemes throughout all critical sub-watersheds. By 2007, the district rehabilitated 6,150 ha of private land planting 2 million seedlings. The seedlings included timber trees[2] such as teak (*Tectona grandis* L.f.), pines (*Pinus merkusii* Jungh. & De Vr.), mahogany (*Swietenia macrophylla* King), and eucalypt (*Eucalyptus alba* Reinw); and Multipurpose Tree Species (MPTS)[3] such as mango (*Mangifera indica* L.), durian (*Durio zibethinus* Murr), avocado (*Persea americana* P. Mill.), guava (*Psidium guajava* L.), *petai* (*Parkia speciosa* Hassk)*, rambutan* (*Nephelium lappaceum* L.)*, matoa* (*Pometian pinnata* J.R. & G. Forst)*, duku* (*Lansium domesticum* Corr.), and *sukun* (*Artocaprus communis* Forst)*.* Based on MoF measurements in 2007, the efforts were successful, based on a mean seedling survival rate of approximately 81% (BPDAS Solo, 2008).

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[2] tree species which its main product is timber

[3] tree species which has more than one products, i.e. flower, fruit, leaves and/or bark

3.3 Materials and methodology

Data collection was conducted through a stratified sampling method from August to November 2012. Based on the sampling method, the projects were divided into three similar groups based on tree species compositions and the degree of farmer groups' involvement in the projects. These groups are located in Jumantono, Matesih, and Tawangmangu. There are 10 selected sites in total, where 4 are in Jumantono, 3 are in Matesih, and 3 are in Tawangmangu. Each site represents one village and one farmer group. In Jumantono, the main tree species composition is teak, mango and *rambutan;* in Matesih, the main tree species compositions are mahogany and durian. In Tawangmangu, *suren* and durian are the main trees. Farmer groups, according to their preferences, randomly planted the seedlings both in species arrangement and spacing, as long as they fulfil the most important criterion of 400 trees per ha including seedlings regardless the origin of seedlings (MoF, 2004d). The planting is usually in the direction of the contour lines.

Preliminary surveys of revegetation projects were undertaken to select the study sites for plot measurements. Based on these surveys, four areas at each site which were larger than others and dominated by trees from *Gerhan* 2004 were selected and their geographic locations were recorded using a hand-held Global Positioning System (GPS) to ease revisiting the sites.

Plot measurements were conducted to collect stand information, including species, diameter at breast height (DBH), and height, using 0.04 ha circular plots. The circular plot with a-11.8-m radius (corrected to slope) was established using a measuring tape. During the field work, a total of 40 plots were measured. The coordinates of each plot centre was recorded using a hand-held GPS (accurate to approximately 5 m). The border trees that were inside the plot boundary were marked with spray paint. The tree measurement was undertaken following terraces for practical reasons. Within the plots, the tree species was identified by their local names. Their scientific names were determined through online source (Plantamor, 2012). The DBH was measured using a diameter tape at a height of 1.3 m from the ground, where tree height was > 1.5 m. Tree height was measured using a 5-m segmented height-meter for trees less than 5 m and a haga-altimeter for trees of more than 5 m height (Newton, 2007).

In addition to tree data, biophysical indicators (slope, aspect, elevation, soil type) were also collected. Slope and its aspect were measured using a Suunto-clinometer. Elevation was determined using a GPS device. Soil type was determined by referring to the appropriate soil map (RePPProT, 1990).

3.4 Data analysis

Le, et al. (2012) divided reforestation success into four stages: establishment, forest growth, environmental and socio-economic. These first two stages influence the environmental and socio-economic successes. The MoF measured survival rates and area planted compared to target area (MoF, 2004a) which indicate the establishment stage. Two forest growth success indicators proposed by Le, et al. (2012) and represent the same measurements as the MoF's were adopted to assess the success of *Gerhan* 2004. They are tree growth and area remaining intact or maintained beyond the project.

Stand density (S) was estimated from the number of timber trees/MPTS in plots and converted into stems per ha (stems/ha). The growth of timber tree species was assessed by calculating mean diameter and height. For MPTS, the productivity was also identified by direct observation of the presence of flower and fruit, and by interviewing landowners.

To determine the overall success of the project and factors influencing it, two indicator values (tree growth and area planted-maintained) were then compared to the existing benchmarks and/or guidelines from different sources. The equations generated by Suharlan, et al. (1972), and developed by Harbagung (2010) were used to assess tree growth and stand density performance for the main timber species of teak and mahogany, while diameter and height annual increments, and common spacing from a plantation in Vietnam (Orwa, et al., 2009) were used for *suryan*. For MPTS, success was assessed based on survival rates (by referring to MoF guideline) and productivity (MoA guidelines). The MPTS survival rate (in %) was calculated using equation 1. For the area planted-maintained (in %), the same standard as seedling survival rate from the

MoF was used, i.e. 55% as successful indicator. Area planted-maintained was calculated using equation 2. All projects that fell below these benchmarks were considered as unsuccessful.

$$r_m = \left(\frac{S_{fm}}{S_{im}}\right) \times 100\% \quad \text{..........} \quad (1)$$

$$A = \left(\frac{A_p}{A_t}\right) \times 100\% \quad \text{..........} \quad (2)$$

$$A_p = \frac{S_r}{S_i} \quad \text{..........} \quad (3)$$

$$S_i = \frac{S_f}{r_r} \quad \text{..........} \quad (4)$$

where

r_m	:	the survival rate of MPTS (%)
S_{fm}	:	the number of current MPTS (stems/ha)
S_{im}	:	initial MPTS stand density/the number of MPTS planted (stems/ha)
A	:	Area planted-maintained (%)
A_t	:	Area target (ha)
A_p	:	Area planted-maintained (ha)
S_r	:	the number of survived seedlings reported (MPTS + timber trees) (stems/village)
S_i	:	initial stand density/the number of seedlings planted (MPTS + timber trees) (stems/ha)
S_f	:	final stand density/the number of remaining *Gerhan* trees (MPTS + timber trees) (stems/ha)
r_r	:	survival rates reported (MPTS + timber trees) (%)

3.5 Summary

This chapter has provided a description of the research method that was adopted for this research. This research selected only one case study because of time and budget constraints. The case was selected because it represents the success of 2004 *Gerhan* and located in a critical watershed.

CHAPTER 4: RESULTS

4.1 Introduction

The results chapter is divided into 5 sections: stand density, tree growth and area planted-maintained up to the time this research was undertaken. Species composition and stand density of timber tree species and MPTS in three sub-districts is described in section one (Table 4.1-4.3). Section two describes timber tree growth, represented by mean diameter and height (Table 4.1-4.3). Section three highlights productivity of MPTS; the fourth section outlines the area planted-maintained and is described in Table 4.4. The final section describes success level of the *Gerhan* projects (Table 4.5)

4.2 Species composition and stand density for timber tree and MPTS

In all sub-districts, *Gerhan* targeted two to three main species consisting of timber tree species and multipurpose tree species (MPTS) such as fruit and flower tree species. Timber species and MPTS found in this study altogether numbered 31; their local, English and scientific names are provided in Appendix 1. Table 4.1-4.3 shows species which presented at each sub-district and village. The number of different species found at individual villages ranged from 6 to 20 species.

In Jumantono sub-district, consisting Blorong, Gemantar, Sambirejo and Tugu, teak is the main timber tree species with the number of seedlings planted was while mango and rambutan are the main MPTS; however, no mango trees were found in Blorong and rambutan was also absent in Sambirejo (Table 4.1). In this sub-district, only 21 rambutan/ha and 11 mangoes/ha were found in revegetation areas. These densities are much lower than teak (1,300 stems/ha). Mahogany, albizia, and black-wood cassia were also found in this sub-district as the secondary timber tree, as well as cashew nut, jackfruit, stink bean and gnetum (fruit tree species).

Table 4.1

Stand Density, Mean Diameter and Mean Height for Gerhan and Non-GerhanTree Species in Juma
Growth to the Harbagung's Model

No.	Species	Blorong			Gemantar			Sambirejo			Tugu
		S [stems/ha]	mean D [cm]	mean H [m]	S [stems/ha]	mean D [cm]	mean H [m]	S [stems/ha]	mean D [cm]	mean H [m]	S [stems/ha]
1	Jati[a]	1,169	12.7	8.9	1,600	11.8	8.1	1,106	12.5	7.8	1,325
2	Mahoni	44	13.0	7.6	613	5.5	4.6	6	2.5	2.7	108
3	Sengon	25	21.6	11.2	100	19.1	10.0	6	10.0	10.0	33
4	Rambutan[a]	38	8.6	6.3	38	2.6	3.3	0	0.0	0.0	8
5	Mete	6	3.0	3.1	0	0.0	0.0	19	11.8	5.7	33
6	Johar	25	9.1	7.3	0	0.0	0.0	6	5.9	6.0	0
7	Mangga[a]	0	0.0	0.0	25	4.0	2.7	13	21.7	5.4	8
8	Nangka	0	0.0	0.0	25	4.9	4.2	0	0.0	0.0	8
9	Senu	0	0.0	0.0	13	16.8	10.0	0	0.0	0.0	17
10	Pete	0	0.0	0.0	25	3.7	3.7	0	0.0	0.0	0
11	Waru	0	0.0	0.0	25	4.5	4.3	0	0.0	0.0	0
12	Mindi	0	0.0	0.0	13	4.5	4.5	0	0.0	0.0	0
13	Mlinjo	0	0.0	0.0	13	5.5	4.6	0	0.0	0.0	0
	Total	**1,306**			**2,488**			**1,156**			**1,542**

[a]*Gerhan* species. [b]Teak growth obtained from model (Harbagung, 2010)

underlined species indicate MPTS

Standard errors for S, mean D, and mean H of teak were 10, 30, 5, 7 stems/ha (for S); 2.0, 0.7, 1.2, 1.5 cm (m
H) for Blorong, Gemantar, Sambirejo and Tugu respectively.

Table 4.2

Stand Density, Mean Diameter and Mean Height for Gerhan and Non-GerhanTree Species in Matesi
Growth to the Harbagung's Model

No.	Species	Girilayu			Karangbangun			Koripan			Subdistric	
		S [stems/ha]	mean D [cm]	mean H [m]	S [stems/ha]	mean D [cm]	mean H [m]	S [stems/ha]	mean D [cm]	mean H [m]	S [stems/ha]	mean D [cm]
1	Mahoni[a]	1,125	11.3	6.7	913	9.7	7.5	1,113	11.0	7.8	1,050	10.7
2	Jati	50	6.6	6.3	281	7.9	8.3	131	8.0	8.0	154	
3	Sengon	238	13.5	8.5	81	10.8	9.2	50	25.8	13.6	123	
4	Durian[a]	31	5.5	3.8	106	6.0	5.2	6	6.5	6.0	48	6
5	Waru	19	4.6	4.2	50	13.6	13.6	44	12.9	8.0	38	
6	Sono	63	7.4	5.1	0	0.0	0.0	19	0.0	0.0	27	
7	Nangka	13	8.4	5.6	13	4.6	4.8	6	9.0	4.6	10	
8	Mindi	0	0.0	0.0	6	13.0	8.0	19	18.9	11.0	8	
9	Jengkol	6	14.5	5.0	13	19.8	12.5	0	0.0	0.0	6	
10	Rambutan	0	0.0	0.0	19	7.5	6.1	0	0.0	0.0	6	
11	Alpokat	0	0.0	0.0	13	2.9	3.2	0	3.7	3.2	4	
12	Cengkeh	13	13.3	8.5	0	0.0	0.0	0	0.0	0.0	4	
13	Duku	6	1.5	2.1	6	3.7	4.0	0	0.0	0.0	4	
14	Senu	0	0.0	0.0	0	0.0	0.0	13	9.6	7.5	4	
15	Ekaliptus	6	19.6	8.0	0	0.0	0.0	0	0.0	0.0	2	
16	Lamtoro	0	0.0	0.0	0	0.0	0.0	6	3.8	4.1	2	
17	Mlinjo	0	0.0	0.0	6	10.2	8.5	0	0.0	0.0	2	
18	Pete	0	0.0	0.0	6	19.8	18.5	0	0.0	0.0	2	
19	Sirsat	0	0.0	0.0	0	0.0	0.0	6	5.1	5.2	2	
20	Sukun	6	1.4	2.5	0	0.0	0.0	0	0.0	0.0	2	
	Total	**1,575**			**1,513**			**1,413**			**1,475[b]**	**10.0[b]**

Table 4.3

Stand Density, Mean Diameter and Mean Height for Gerhan and Non-GerhanTree Species in Taw Suryan Growth to the Orwa's

No.	Species	Plumbon			Sepanjang			Tengklik			Subdistrict	
		S [stems/ha]	mean D [cm]	mean H [m]	S [stems/ha]	mean D [cm]	mean H [m]	S [stems/ha]	mean D [cm]	mean H [m]	S [stems/ha]	mea D [cr
1	Suryan[a]	313	11.0	8.4	488	11.3	8.9	369	10.0	6.9	390	10
2	Sengon	275	12.3	10.2	113	16.9	12.9	94	8.2	6.0	160	
3	Mahoni	94	11.4	6.9	94	7.9	7.5	63	13.0	6.7	83	
4	Waru	25	26.9	11.5	6	9.0	9.0	19	15.2	10.1	17	
5	Alpokat	13	12.3	12.5	25	7.6	8.2	6	4.2	6.0	15	
6	Durian[a]	19	15.1	7.6	6	6.2	5.0	25	16.8	5.9	17	12
7	Nangka	6	15.0	5.4	6	5.3	2.6	0	0.0	0.0	4	
8	Pinus	19	4.9	5.1	38	11.8	8.9	0	0.0	0.0	19	
9	Agathis	31	10.5	6.2	0	0.0	0.0	0	0.0	0.0	10	
10	Mindi	31	12.8	9.5	0	0.0	0.0	0	0.0	0.0	10	
11	Lamtoro	13	12.0	14.0	0	0.0	0.0	0	0.0	0.0	4	
12	Mangga	6	6.0	3.7	6	4.2	3.5	0	0.0	0.0	4	
13	Kanyere	6	6.0	6.0	0	0.0	0.0	0	0.0	0.0	2	
14	Rambutan	6	10.5	5.0	0	0.0	0.0	0	0.0	0.0	2	
15	Cengkeh	6	14.5	6.0	0	0.0	0.0	0	0.0	0.0	2	
16	Jenetri	6	5.1	5.3	0	0.0	0.0	0	0.0	0.0	2	
17	Kenanga	6	11.0	12.0	0	0.0	0.0	0	0.0	0.0	2	
18	Pete	6	12.0	11.0	0	0.0	0.0	0	0.0	0.0	2	
19	Sirsat	6	8.0	9.0	0	0.0	0.0	0	0.0	0.0	2	
	Total	**888**			**781**			**575**		0	**4,444[b]**	**11**

Similar composition also occurred in Matesih and Tawangmangu sub-districts (Table 4.2 and 4.3). Mahogany (1050 stems/ha) and durian (48 stems/ha) were the main species in Matesih, while *suryan* (390 stems/ha) and durian (17 stems/ha) were the major species in Tawangmangu. Compared to Jumantono and Tawangmangu, Matesih had a greater range of tree species; 9 timber trees including teak, mahogany and largeleaf-rosemallow and 11 MPTS including jackfruit, dogfruit and rambutan. Albizia and teak (Table 4.2 and 4.3) were the most common secondary timber species of *Gerhan*. Slightly different from Matesih, Tawangmangu had 19 species consisting of 9 timber trees such as albizia, mahogany and largeleaf-rosemallow, 9 fruit trees such as avocado, jackfruit and mango, and 1 flower tree, ylang-ylang (Table 4.3).

The stand density of all species ranged from 575-2,488 stems/ha in different sub-districts, with the main species densities were from 313-1,600 stems/ha, higher than the MoF minimum requirement of 400 stems/ha (Table 4.1-4.3). Tawangmangu sub-district had the lowest stand density, i.e. 575-888 stems/ha, while Jumantono and Matesih sub-districts have 1,156-2,488 stems/ha and 1,413-1,575 stems/ha respectively. In Tawangmangu sub-district, Tengklik had the lowest stand density, i.e. 575 stems/ha, consisting of 6 species, but had the largest number of the main MPTS, durian, i.e. 25 stems/ha (Table 4.3). Plumbon had the smallest density of main tree, i.e. 313 stems/ha and Sepanjang had the fewest MPTS, i.e. 6 stems/ha. The main species density, *suryan*, was 390 stems/ha, much lower than reference plantation in Vietnam which had 4,444 stems/ha in initial planting, but approaching the standard from MoF. Albizia and mahogany were the most commonly planted supplementary species with 160 and 83 stems/ha respectively.

On the other hand, the densest planting was found in Jumantono sub-district with the highest stand density of 2,488 stems/ha consisting of 11 species located in Gemantar (Table 4.1). Teak density was at a range of 1,106 and 1,600 stems/ha. This exceeded stand density recommended by the growth model, i.e. 1,079 stems/ha. Mahogany and albizia were the secondary timber trees in the sub-district with 193 and 41 stems/ha respectively. In Matesih sub-district, all villages had similar stand density, ranged from 1,413 to 1,575 with mahogany density were between 913 and 1,125 stems/ha (Tabe 4.2). This was slightly lower than those predicted by the model, i.e. 1,475 stems/ha.

Karangbangun had the lowest density of main tree, mahogany, i.e. 913 stems/ha, but had the largest MPTS density, durian, i.e. 106 stems/ha. The fewest durian was found in Koripan with only 6 stems/ha. Teak and albizia were the other timber trees planted, i.e. 154 and 123 stems/ha respectively. Albizia was the most commonly planted supplementary species at all sub-district and present as the second and the third larger number of tree in all villages, exceeding the number of secondary targeted tree species, i.e. MPTS.

4. 3 Timber tree growth

Comparison of mean stem diameter and height for each sub-district revealed that stem diameter for teak and mahogany, i.e. 11.5–12.7 cm and 9.8-11.3 cm respectively, generally exceeded the diameters predicted by the growth models, i.e. 10.4 cm and 10.0 cm respectively (Table 4.1 and 4.2). Teak plantations in Blorong, Jumantono sub-district with1,169 stems/ha showed the largest mean diameter, i.e. 12.7 cm (Table 4.1). Gemantar had the highest tree density, 1,600 stems/ha (teak), but the mean stem diameter in this village, (11.8 cm), was similar to other villages. In contrast, heights, i.e. 7.8-8.9 m, were lower than those predicted by the models, i.e. 13.4 m (Table 4.1). The tallest teak trees were found in Blorong (8.9 m), while the shortest trees occurred in Sambirejo (7.8 m). Tugu and Gemantar had the same mean teak height (8.1 m).

In Matesih sub-district, the biggest mean diameter of mahogany was found in Girilayu, i.e. 11.3 cm; however, the village had the lowest mean height, i.e. 6.7 m (Table 4.2).Dislike teak and mahogany in Jumantono and Matesih sub-districts, *suryan* in Tawangmangu grow similarly to those in Vietnam (Table 4.3). Hence, diameter (10.0-11.3 cm) and height (6.9–8.9 m) were also similar to those predicted by the model (11.2 cm and 7.2 m respectively). Sepanjang had the highest *suryan* diameter and height, 11.3 cm and 8.9 m. *Suryan* plantation in Tawangmangu is generally undisturbed; dislike mahogany and teak in the other sub-districts where farmers cut the young branch for fodder and teak leaves for food wrapper.

4. 4 MPTS productivity

Rambutan in Blorong, Jumantono, had mean diameter of 8.6 cm, and the owner said that no fruit had been produced (Table 4.1). Likewise, mango in this sub-district which had mean diameter 11.3 cm (Table 4.1) had produced no fruit. In addition, farmers planted other trees before *Gerhan* project; for example, some jackfruits which have diameter of almost 40 cm and have produced fruit.

In Matesih sub-district, durian growth was similar in different villages with diameter and height of 6 cm and 5 m respectively; some trees were flowering during the field survey (Table 4.2). Fruit trees including avocado, langsat and breadfruit were planted three years ago; while stink bean and chinaberry were planted before the projects (2000), with diameter of approximate 20 cm. In Tawangmangu, durian with average diameter of 12.7 cm (Table 4.3) showed better growth than those in Matesih, and some were also flowering. According to landowners, durian in Matesih and Tawangmangu had not fruited. Despite this farmers bought and planted seedlings themselves, however sometimes the seedlings come from projects other than *Gerhan*, for example a project from *Dinas Sosial*/Welfare District Office.

4. 5 Area planted-maintained

The proportion of rehabilitated land that had been planted-maintained[4] was highest in the Tawangmangu sub-district, ranging from 61 to 91% (Table 4.4). In 2004, the Government targeted 175 ha to be planted with *suryan* within the study area in Tawangmangu, was higher than targets for Jumantono and Matesih sub-districts, 100 and 75 ha respectively. Despite smaller rehabilitation programmes, the area planted-maintained in Jumantono and Matesih was also small, ranging from 21 to 34%. The best performed village, Plumbon, achieved the highest proportion of planted-maintained area (91%); the lowest was Gemantar (21%).

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[4]Rehabilitated area that still contained *Gerhan* trees

Table 4.4

Area Planted-Maintained beyond the Project

Sub-district: Village	Area target[5] (ha)	survival rates[6] (%)	survived seedling[7] (stems/village)	current *Gerhan* trees[8] (stems/ha)	initial seedlings planted[9] (stems/ha)
Jumantono:					
Sambirejo	25	93.8	9,379	1,119	1,193
Blorong	25	93.8	9,379	1,206	1,286
Tugu	25	93.8	9,379	1,342	1,431
Gemantar	25	93.8	9,379	1,663	1,773
Matesih:					
Karangbangun	25	93.3	9,327	1,019	1,092
Koripan	25	93.3	9,327	1,119	1,199
Girilayu	25	93.3	9,327	1,156	1,240
Tawangmangu:					
Plumbon	50	86.8	17,358	331	382
Tengklik	50	86.8	17,358	394	454
Sepanjang	75	86.8	26,037	494	569

[5]Source BPDAS Solo (2007)
[6]Source BPDAS Solo (2007)
[7]The number of survived seedlings per village reported by BPDAS Solo (2007)
[8] The number of remaining trees from Gerhan in 2013
[9] The number of seedling planted based on the number of remaining trees from Gerhan divided by survival rates reported

4. 6 Success level

Success level was assessed based on two indicators: tree growth and area maintained (Tables 4.1-4.3 and 4.4 respectively). In Jumantono and Matesih, *Gerhan* was successful, based on tree growth (timber tree) (Table 4.5). However, it was unsuccessful regarding of the MPTS and area planted-maintained. The Tawangmangu project can be categorised as successful, especially for timber tree growth and area maintained.

Table 4.5

The Success Level of Gerhan in Jumantono, Matesih and Tawangmangu Sub-districts

Sub-district	**Tree growth**		**Area planted-maintained**
	Timber tree	MPTS	
Jumantono	successful	unsuccessful	unsuccessful
Matesih	successful	unsuccessful	unsuccessful
Tawangmangu	successful	unsuccessful	successful

4. 7 Summary

The total number of main tree species and MPTS found in this research was 31, with general composition of teak, mahogany and albizia in Jumantono and Matesih; while *suryan*, mahogany and albizia in Tawangmangu. The highest stand density of all main tree and MPTS was in Jumantono, i.e. 1,322 stems/ha, and the lowest was in Tawangmangu with 407 stems/ha. The result also revealed that stand density was higher than the standard from MoF, while tree growth exceeded growth models, especially in term of teak and mahogany diameters. *Suryan* growth was similar to reported results. Rambutan and mango had not produced fruit. Some durians were flowering, but no fruit was observed during the field work. The extent of rehabilitated area which had been maintained varied. Tawangmangu had the highest proportion with 61-91% of the original area still maintained, while villages in Jumantono and Matesih had smaller percentage of area maintained; 21-34%. *Gerhan* projects in Jumantono and Matesih were unsuccessful, while those in Tawangmangu, successful.

CHAPTER 5: DISCUSSION

5. 1 Survival rates

The Indonesia government required a minimum survival rate of 55% for *Gerhan* project to be categorised as successful (MoF, 2009e). In case the survival rate for certain project was below 55% in the second year (final assessment), the project was categorised as unsuccessful. The result was recorded in the *Gerhan* database and considered for the next proposal although the chance was very small. This was because the government ranked areas for *Gerhan* priority.

In this study, the 2004 *Gerhan* projects showed high survival rates which far exceeding the minimum standard of 55%. In the final assessment, the survival rates for main tree species and the MPTS in Jumantono, Matesih and Tawangmangu were reported to be 93.8%, 93.3%, 86.6% respectively (BPDAS Solo, 2008). This study found that survival rates have been maintained in these areas.

The survival rate standards for revegetation projects in China and the Philippines were higher. In China, survival rate of planted trees three years of planting has been used to assess success (Chokkalingam et al., 2006b). Prior to 1985, the Chinese Government required 40% survival rate but has been increased to more than 85% in high rainfall areas and 70% for low rainfall area (< 400 mm/annum). In the Philippines, government funded programmes are required to achieve a minimum of 80% survival rate (Chokkalingam, et al., 2006a). Most projects provided survival rate only up to three years after establishment; these varied between 29-93%.

5. 2 Stand density of timber tree species and MPTS

Average stand density for teak, mahogany and *suryan* resulted from this research were 1,300 stems/ha, 1,050 stems/ha, and 390 stems/ha respectively. The density of MPTS planted with teak, mahogany and *suryan* main trees were 32 stems/ha (21 stems/ha for rambutan and 11 stems /ha for mango) (Table 4.1), 48 stems/ha (durian in Table 4.2) and 17 stems/ha (durian in Table 4.3).

The combined stand density of main trees and MPTS were much higher than the MoF standard of initial planting rates (400 seedlings/ha). Based on the reported survival rate and the MoF standard, the average stand density for teak, mahogany and *suryan* together with the combined MPTS should be 375 stems/ha, 373 stems/ha, and 346 stems/ha respectively.

Due to lack of field checking and monitoring by the Government, the farmers tended to request more seedlings in the subsequent year for the same area. As a consequence, the stand density was very high, even after 8 years of the initial project. In addition, it should be noted that besides the *Gerhan* trees, farmers also planted seedlings from other sources such as farmers' own funds and other projects (e.g. project from Welfare District Office) as also reported by Paimin (2009) especially for border trees (Figure 5.2 a-c). This was indicated by the present of old and young trees at the same project site. The farmers kept the stand density high because they thought that high stand density was linearly correlated to income/revenue. Thus, thinning was not undertaken for the trees, especially for teak and mahogany which were the main commercial timber with high value. Farmers cut the trees only when they need immediate income and generally select the largest tree for harvest (Kurniawan & Roshetko, 2009).

The high stand density in the study site correspond with the findings of Roshetko and Manurung (2009) in Gunungkidul, Yogyakarta and Paimin, Sukresno, and Mashudi (2003) in Grobogan, Central Java. In Gunungkidul, 57% of teak smallholder plantations were not thinned resulting in a high stand density (1,072-1,532 stems/ha). In Grobogan, eight-year-old of state plantation mahogany also had stand density of 1,500stems/ha (Paimin et al., 2003), which is within the range of allowable density, i.e. 1,210-2,078 stems/ha (Perum Perhutani, no date).

5. 3 Timber tree growth

In terms of tree growth, teak and mahogany showed larger average diameter than those predicted by the models, i.e. 12.1 cm and 10.7 cm to 10.4 cm and 10.0 cm respectively (Table 4.1-4.2). The models were generated from teak and mahogany plantations which had similar site condition and stand density as study sites, and applicable throughout Java Island (Harbagung, 2010).However, the average diameter of teak and mahogany found in *Gerhan* sites were still within those interpolated ranges (site index 1-5 for teak and 1-3 for mahogany) in stand tables developed by Suharlan, Sumarna, and Sudiono (1975), i.e. 5.4-17.7 cm and 7.4-13.2 cm respectively. The average diameter for mahogany was also similar to those reported by Paimin,et al. (2003) for 8 year old mahogany in Grobogan, Central Java, i.e. between 9 and 10 cm.

On the other hand, teak and mahogany had average height of 8.2 m and 7.3 m respectively, which were lower than the prediction, i.e. 13.4 m and 11.4 m. The average height of teak was still in the height range found in Suharlan, *et al.*'s stand table (1975), i.e. 7.5-18.2 m. However for mahogany, its average height was below the range (8.7-13.8 m) and lower than those reported by Paimin,et al. (2003), i.e. 9 m. This may because farmers cut the top of the mahogany for fodder.

For *suryan*, the average diameter and height were similar to the reference site in a *suryan* plantation in Vietnam (Orwa, et al., 2009), i.e. 10.7 cm to 11.2 cm and 8.1 m to 7.2 m. However these average values were lower compared to those found in South Sulawesi. Although having the same site characteristics (Karanganyar Regency, 2011; Tana Toraja District, 2012), the *suryan* in South Sulawesi have larger diameter and higher height than those in the study area, i.e. 30 cm to 10.7 cm and 20 m to8.1 m respectively (Putra et al., 2012). However, there is lack of detailed information (on management and planted year) for *suryan* site in South Sulawesi.

5. 4 MPTS survival rate and productivity

MPTS survival rates were low at all sites, i.e. ranging from 10% and 40% (Table 4.1-4.3). The low survival rate of MPTS in the study area contradicts with the finding of Nawir, et al. (2007). They found that the average survival rate of MPTS in ten projects located in West Java (1 project), Riau (2), Kalimantan (4), Central Java (2), East Java (1) and Yogyakarta (1) was just over 75%; this was due to more intensive maintenance from farmers motivated by the potential of the MPTS to provide short-term revenue.

All MPTS in the *Gerhan* 2004 study area which have survived were expected to have produced fruit by 2013. Durian can bear fruit at the age of 8, mango at year 4-5 (MoA, 2001) and rambutan after 4-8 years (Masisworo et al., 1990), but very few of them were producing fruit. More detail on MPTS survival rate and productivity can be found in section 5.6.

5. 5 Area maintained beyond the project

Gerhan trees in the study sites were found in higher densities than those planted/reported by BPDAS Solo (2008), however the rehabilitated areas were much lower than the reported area. This indicates that the initial planting rate was very high (Table 4.4). The high stand density found after 8 year of the project was also supported by the high survival rate (Table 4.4). Regarding this issue, Paimin (2009) suggested that for Indonesian rehabilitation projects there was a need to differentiate between the planted-maintained area and the planted area reported which was often obtained from the number of seedling planted (stems) divided by the MoF standard (400 stems/ha). This was based on his observation that the area reported was calculated by the number of seedlings planted divided by the standard, regardless of spacing in the field. As a consequence, the reported areas were larger than the planted-maintained areas.

Based on ten project sites, the ratio of planted-maintained to target area were varied between 21-91%, where 70% of which were below 35% (Table 4.4). These results contradict with some following examples of rehabilitation projects other than *Gerhan*. Reforestation had successfully been done in an area of 240 ha in Gunung Leuser National Park by cooperating with local people, establishing nurseries, planting and enrichment planting, and maintaining plants in the planted area (Azhari, 2011). In Gunung Gede National Park, the Tree Adoption programme had also succeeded in re-greening 112.5 ha from 2008 to 2010 (Exploitasia, 2011).

Amongst the 10 villages in this study, only villages in Tawangmangu sub-district exceeded the MoF recommended standard of 55% of area planted-maintained to be categorised as successful (Table 4.4). This was because the farmers in

Tawangmangu sub-district rely on vegetable crops as the main income source rather than timber (Paimin et al., 2012). In addition, the required stand density (400 stems/ha) and land spacing (5m x 5m) for *suryan* did not significantly reduce the area for vegetable production. As *suryan* trees grow, the canopy and leaf litter do not greatly harm vegetable production because the canopy is relatively light and the litter decomposes readily. Consequently farmers tend to keep the *suryan* on their land.

In Jumantono and Matesih sub-districts, in the first two years, people planted trees and cash crops (mostly cassava) on their land. As the teak tree grew and the canopies covered the crop area, some farmers stop planting cash crops and focused on maintaining the teak. To meet daily needs for food and other consumables and to maintain the teak, some family members work in town to generate income. However, others continue to plant the cash crop by sweeping and/or burning teak litter (Figure 5.1a, b).

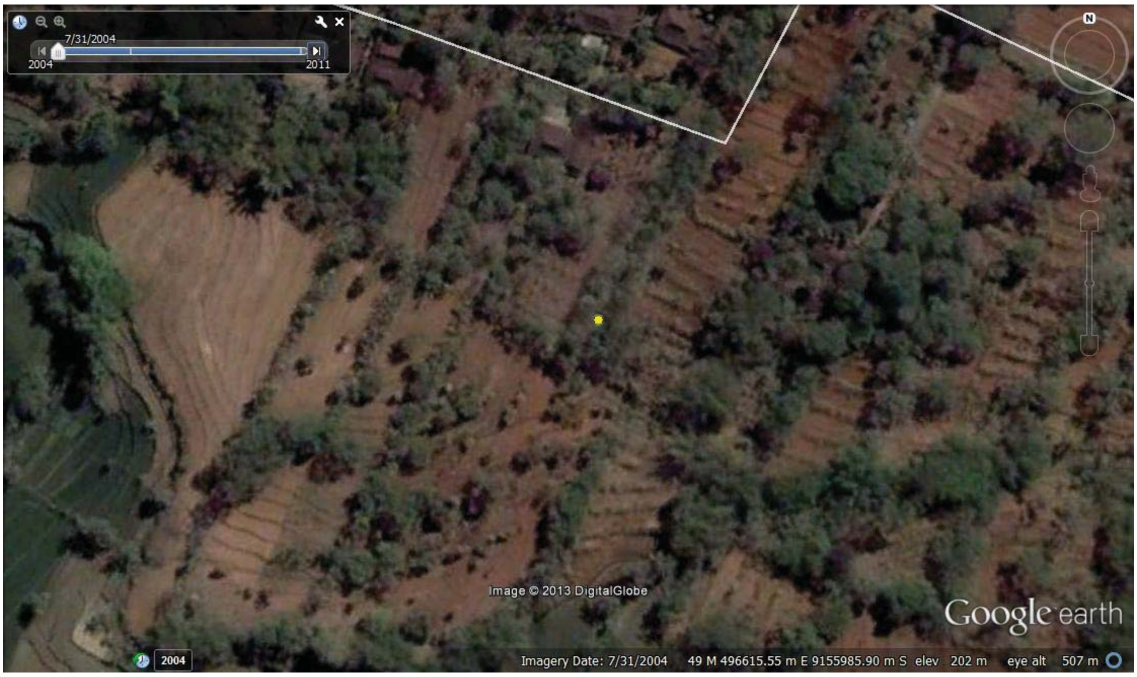
a. sweeping leaf litter

b. Burnt litter

Figure 5.1: Litter treatment for planting cash crops below teak canopy

Maintaining rehabilitated areas beyond the project time frame has been a challenge in a number of countries including China and the Philippines. Although rehabilitation projects in China contributed to income for local people through fuelwood production, business opportunities and jobs (Chokkalingam, et al., 2006b), in some cases the managers faced difficulties in protecting and maintaining the rehabilitated areas. This was because of pseudo participation, incomprehensive justification of local needs, tenure issues, limited funding and incentives. Since 2000, China has rehabilitated approximately 6.7 million ha/year. Until 2003, rehabilitation projects, including planting and aerial seeding of plantation forests had been increasing forest cover by 26 million ha. Although forest cover was maintained on many sites, many revegetation projects lack long-term sustainability (Chokkalingam, et al., 2006b), indicated by repeated rehabilitation projects at the same sites. In the Philippines, Chokkalingam, et al. (2006a) reported that 1.7 million ha of state land were planted between 1960 and 2002, two-thirds of the projects were undertaken by the government sector and the rest were carried out by appointed contractors (company, family).

Although deforestation continues, these rehabilitation projects, as well as farmer and other tree planting initiatives have increased forest cover by 0.7 million ha between 1988 and 2003. However, most projects were struggling with long-term management.



a. 31 July 2004

b. 29 August 2006

c. 8 July 2011

Figure 5.2: Vegetation cover changes in Sambirejo, Jumantono sub-district (Google earth, accessed 5/9/13)

5. 6 Success level and factors influencing the success

In terms of the growth of *Gerhan* timber trees, revegetation projects in three sub-districts can be categorised as successful. Regardless of high stand density which far exceeded those recommended by Ministry of Forestry, teak in Jumantono and mahogany in Matesih have higher mean diameter than those predicted by the growth model from Harbagung (2010) (Table 4.1-4.2). The high mean diameter (as a success indicator) in Jumantono and Matesih was a result of appropriate tree species selection by considering the biophysical characteristics of the selected sites. Soil type in Jumantono was mostly dystropepts, one of inceptisols type, which is very suitable for teak plantation (Riyanto et al., 2013). In addition, the slope (8-15%) was also suitable for the development of teak plantations. Site conditions in Matesih, particularly elevation (500-800 m) and soil type (entisols) were also suitable for mahogany. In addition, the Tawangmangu site was suitable for *suryan*; the soil is well drained and the elevation (770-950 m), is within the suitable range for *suryan* (0-2,100 m) (Lemmens et al., 1995).

On the other hand, the MPTS planted during the 2004 *Gerhan* project was unsuccessful based on the survival rate and productivity. The initial planting of the MPTS was 120 stems/ha (BPDAS, 2007). The survival rates of the MPTS after 8 year of the project were 10-40% (17-48 stems/ha remaining) (Table 4.1-4.3), which were below the standard of MoF, i.e. 55%. Farmers reported that many MPTS seedlings died several days after planting due to damage during transportation (loading and unloading). Although enrichment planting was undertaken after one and two years, in compliance with *Gerhan* guidelines, no information was available on the success of this effort.

The productivity of MPTS was poorer than expected. According to the landowners, none of MPTS in all sub-districts had produced fruits, despite being planted on the suitable sites. Durian were planted in Matesih and Tawangmangu sub-districts, both suitable sites (MoA, 2001) based on soil type (inceptisols) elevation (557-953 m) and rainfall (> 1,500 mm/year). Mango and rambutan were planted in Jumantono which is also suitable for the species as it has good drainage soil, high annual rainfall (>2,000 mm/year), and elevation <500 m amsl (Karanganyar Regency, 2011).

The poor productivity of the MPTS was mainly caused by inadequate management. Rambutan, mango and durian require more intensive maintenance. However, the farmers did not manage the MPTS intensively due to limited resources provided by *Gerhan* project, i.e. fertiliser (when needed until the 2nd year of the project) (MoF, 2004a). To grow well, rambutan seedlings require intensive watering in the first two weeks, i.e. twice a day and once a day until well established, and weeding up to 1-2 m radius from the stem is also recommended (MoA, 2001). At Jumantono, rambutan seedlings were planted during the rainy season, consequently farmers did not need to do intensive watering. However, weeding to reduce competition was not undertaken because of a high density of teak planted on the same area. In this case, farmers only weed 0.5 m around the stem, instead of 1-2 m as suggested. For mango, more frequent fertilising is needed, i.e. in 1-2 months, 1.5-2 years, 2.5-8 years, 9 years, after 10 years, before flowering, in the flowering and after fruit harvesting. In addition, more detailed pruning is required, i.e. once branches are formed, only 3-4 buds/branch are allowed until 1 year, 2-3 buds/branch at year 2 onwards (MoA, 2001). In Jumantono, farmers fertilise mango up to 2 years old, using fertiliser provided by *Gerhan* project. After 2 years, fertiliser was not applied because the farmers considered it unnecessary. Similarly, farmers did not prune mango of the same reason. To produce fruit, durian needs regular fertilising until year 3, and every year subsequently (MoA, 2001). Durian also needs pruning in certain times. At Tawangmangu and Matesih, fertiliser was applied to *Gerhan* trees (*suryan*, mahogany and durian) until 2 years old without clear time intervals but was dependent on the availability of fertiliser from the *Gerhan* project. However, pruning was not undertaken.

Using the planted-maintained area as a criterion (minimum 55% of area maintained), most of the *Gerhan* projects in this study were unsuccessful (Table 4.4). Among 3 sub-districts, Jumantono and Matesih were having area planted-maintained of 21.2-31.5% and 30.1-34.2, which were lower than recommended standard from MoF, i.e 55%. The low percentage of area planted-maintained was mainly caused by the high stand density as a result of high initial planting rate in less area which was supported by high survival rate as described in section 5.2.

CHAPTER 6: CONCLUSIONS

1. To determine the stand density, average diameter, and height for main tree species of *Gerhan*

The average stand density of teak and mahogany were 1,300 and 1,050, far exceeded the MoF standard of 400 stems/ha. The mean diameters for both tree species were 11.5–12.7 cm and 9.8-11.3 cm respectively, generally exceeded the diameters predicted by the growth models, i.e. 10.4 cm and 10.0 cm respectively. In contrast, the average heights of teak and mahogany, 7.8-11.8 m and 6.7-7.8 m respectively, were lower than those predicted by the models, i.e. 13.4 m and 11.4 m respectively. The average stand density of *suryan* was 390 stems/ha which is slightly lower than the standard from MoF. *Suryan* had similar mean diameter (10.7 cm) and height (8.1 m) to those predicted by the model, i.e. 11.2 cm and 7.2 m respectively.

2. To identify the stand density and productivity of MPTS

Stand density of rambutan and mango in Jumantono were 21 and 11 stems/ha respectively, while stand density of durian in Matesih and Tawangmangu were 48 and 17 stems/ha respectively. In term of productivity, none of MPTS fruited after 8 years of *Gerhan* projects, but some durians were flowering during the field work.

3. To investigate the extent of revegetated area maintained beyond the project

The extent of revegetated areas that had been maintained until 8 years varied between 21.2% and 91%.Only villages in Tawangmangu sub-district (61-91%) exceeded the MoF recommended standard of 55%. In Jumantono and Matesih, the *Gerhan* area maintained were only 21.2-31.5% and 30-34% respectively, much lower than the standard.

4. To determine the degree of success of the identified projects and the factors influencing success

In terms of timber tree growth, the project can be categorised as successful as a result of appropriate species selection. However, for MPTS, *Gerhan* projects in all sub-districts were unsuccessful due to inadequate management. Regarding the area maintained, the projects in most sites were unsuccessful because of high stand density resulted from high initial planting rates and high survival rates, lack of field checking, and farmers' thoughts on more trees was equal to more revenue. Only project in Tawangmangu can be categorised as successful.

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APPENDICES

Appendix 1: *Species Found in Gerhan Sites in Jumantono, Matesih and Tawangmangu Sub-district*

No.	Local name	English name	Scientific name
1	Agathis	Damar pine	*Agathis dammara* (Lamb.) Rich.
2	Apokat	Avocado	*Persea americana* P. Mill.
3	Bendo	Terap	*Artocarpus elastica* Reinw
4	Cengkeh	Clove	*Syzygium aromaticum* (L.) Merr. & L.M. Perry
5	Duku	Langsat	*Lansium domesticum* Corr
6	Durian	Durian	*Durio zibethinus* Murr
7	Ekaliptus	Eucalypt	*Eucalyptus alba* Reinw
8	Jati	Teak	*Tectona grandis* L.f.
9	Jenetri	Rudraksh	*Elaeocarpus ganitrus* Roxb.
10	Jengkol	Dogfruit	*Elaeocarpus ganitrus* Roxb.
11	Johar	Black-wood cassia	*Cassia siamea* Lamk
12	Kanyere	-	*Bridelia monoica* Merr.
13	Kenanga	Ylang-ylang	*Cananga odorata* (Lamk.) Hook.
14	Khaya	African mahogany	*Khaya anthotheca (Welw.) C. DC.*
15	Lamtoro	Horse tamarind	*Leucaena leucocephala* (Lam.) de Wit
16	Mahoni	Mahogany	*Swietenia macrophylla* King.
17	Mangga	Mango	*Mangifera indica* L.
18	Mete	Cashew nut	*Anacardium occidentale* L.
19	Mindi	Chinaberry	*Melia azedarach* L.
20	Mlinjo	Gnetum	*Gnetum gnemon* L.
21	Nangka	Jackfruit	*Artocarpus heterophyllus* Lam
22	Pete	Stink bean	*Parkia speciosa* Hassk
23	Pinus	Pine	*Pinus merkusii* Jungh.& De Vr
24	Rambutan	Rambutan	*Nephelium lappaceum* L.
25	Sengon	Albizia	*Paraserianthes falcataria* (L.) Nielsen
26	Senu	-	*Pipturus incanus* (Bl.) Wedd
27	Sirsat	Soursop	*Annona muricata L.*
28	Sono	Palisander	*Dalbergia latifolia* Roxb
29	Sukun	Breadfruit	*Artocarpus communis* Forst
30	*Suryan*	Red cedar	*Toona sureni* Merr.
31	Waru	Largeleaf rosemallow	*Hibiscus macrophyllus* Roxb. ex Hornem

underlined species indicate MPTS