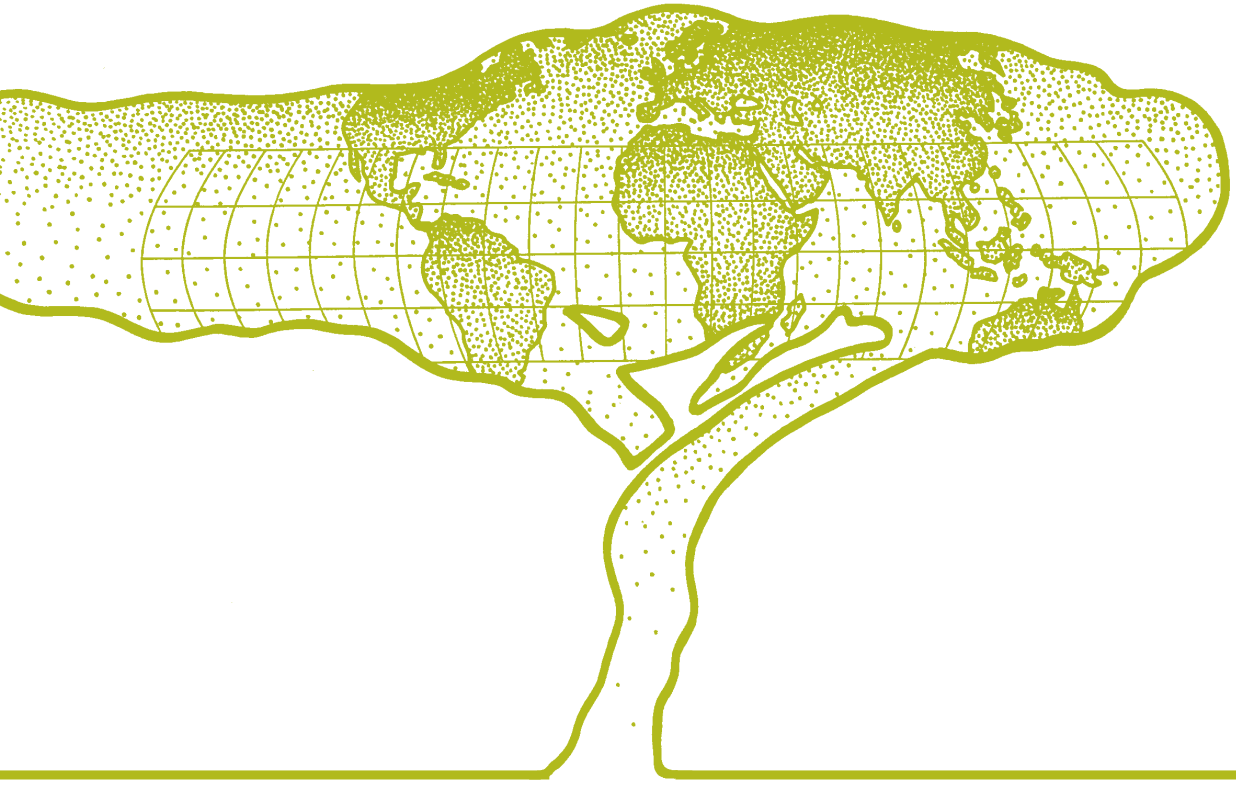
UNIVERSITY OF HELSINKI
Viikki Tropical Resources Institute
VITRI

TROPICAL FORESTRY REPORTS
45



Maarit KALLIO

Factors influencing farmers' tree planting and management activity in four case studies in Indonesia

UNIVERSITY OF HELSINKI
Viikki Tropical Resources Institute
VITRI

TROPICAL FORESTRY REPORTS

TROPICAL FORESTRY REPORTS contains (mainly in English) doctoral dissertations, original research reports, seminar proceedings and research project reviews connected with Finnish-supported international development cooperation in the field of forestry.

Publisher Viikki Tropical Resources Institute (VITRI)
P.O. Box 27, FI-00014 University of Helsinki, Finland
(address for exchange, sale and inquiries)

Editor Markku Kanninen
Telephone +358-9-191 58133
Telefax +358-9-191 58100
E-mail markku.kanninen@helsinki.fi
Website http://www.helsinki.fi/vitri/

Cover Design Lesley Quagraine

Suggested reference abbreviation:
Univ. Helsinki Tropic. Forest. Rep.

Factors influencing farmers' tree planting and management activity in four case studies in Indonesia

Maarit Helena KALLIO

Academic dissertation

for the Dr. Sc. (Agric.&For.) Degree

To be presented, with the permission of the Faculty of Agriculture and Forestry of the University of Helsinki, for public discussion in Auditorium XII, at the University Main Building, Unioninkatu 34, on Saturday 14 December 2013, at 12 o'clock noon.

Helsinki 2013

Supervisor: Professor Markku Kanninen
Viikki Tropical Resources Institute (VITRI)
Department of Forest Sciences, P.O. Box 27
University of Helsinki, FI-00014, Finland

Reviewers: Dr. Martti Varmola
Regional Director, Northern Finland Unit
Finnish Forest Research Institute (Metla)
P.O. Box 16 (Eteläranta 55)
FI-96301, Rovaniemi, Finland

Dr. Markku Simula
Ardot Oy, P.O. Box 1358
FI-00101 Helsinki, Finland

Opponent: PD Dr. Benno Pokorny
Assistant Professor
Chair of Silviculture, University of Freiburg
Tennenbacherstr. 4
79106 Freiburg im Breisgau, Germany

Custos: Professor Markku Kanninen
Viikki Tropical Resources Institute (VITRI)
Department of Forest Sciences, P.O. Box 27
University of Helsinki, FI-00014, Finland

Photos: All photos are credited to Maarit Kallio, except for Figure 3 which is by Supriyadi

ISBN 978-952-10-9551-1 (paperback)
ISBN 978-952-10-9552-8 (PDF)

Unigrafia Oy

Helsinki 2013

Abstract

Indonesia's natural forest, which has traditionally been the main and cheapest source of wood, has been deforested and degraded at an alarming pace. In response to a decreasing wood supply from natural forests and high demand for wood, forest plantations – including smallholder plantations – have been increasingly established by different actors (e.g. government and private industries). These plantations also provide ecosystem services and represent new livelihood options for Indonesia's large population of rural poor. However, the tree planting programs have often failed to take into account the socio-economic and perceptional diversity of the local people involved. The lack of understanding for these issues has contributed to poor levels of success of such initiatives. As a result, the targets set to establish certain areas of plantations have not been reached, and the productivity and quality of the established plantations are generally far from reaching their full potential.

This thesis consists of three papers (published in peer-reviewed journals) based on four case study sites in Indonesia in which 412 households were interviewed and 127 smallholder plantations were measured. The aim was to study the socio-economic, perceptional and motivational factors influencing farmers' current and future tree planting (study I) and management activities (studies II and III). Study I also described how the income received from wood was used and the main disadvantages related to tree planting. Furthermore, studies II and III explored the growth and quality of the tree plantations and how these were influenced by the silvicultural practices performed. The species studied were acacia, kadam, mahogany and teak.

Across the sites trees were planted mainly by the farmers that had more land, higher value of total assets, and more active participation in farmers' groups or other social organizations. The factors influencing silvicultural management activity varied between the sites. When more alternative income earning options were available, and where markets for low quality wood were available, farmers allocated minimum labor to silvicultural management regardless of their socio-economic and perceptional characteristics. In cases where few off-farm income earning options were available, some socio-economic factors were found to be positively correlated with silvicultural management activity; namely larger planted areas, years as a member in farmers group, positive attitudes towards tree planting, and higher numbers of household members contributing to income generation. In the teak sites, stands were mostly of low or medium quality because of the low level of silvicultural management (e.g. poor thinning). Most of the kadam and mahogany planters conducted the recommended silvicultural practices, but only approximately half of these plantations were of high quality. The difference in stand quality in all sites was most likely attributed to the varying seedling or site quality, or the specific methods and timing used in silvicultural practices.

Trees were mainly planted for economic reasons, and were harvested when cash was needed. Long rotation lengths, lack of capital, low wood prices, and poor access to production inputs or markets were found to be the main constraints to current and future smallholder tree planting. In conclusion it is recommended that smallholder tree planting could be enhanced by: a) improving farmers' access to markets and reasonable prices for wood; b) improving farmers' access to high quality planting material; c) improving silvicultural practices; and d) providing more resources to support the farmers while waiting for harvest revenue. Furthermore, it is suggested that baseline information on the socio-economic, environmental and market conditions should be surveyed before implementing new plantation programs.

Keywords: Indonesia, tree planting, farmer, silvicultural management, acacia, mahogany, kadam, teak

Author's address:

Maarit Kallio
Viikki Tropical Resources Institute (VITRI)
Department of Forest Sciences, P.O. Box 27
University of Helsinki, FI-00014, Finland
m.kallio@cgiar.org

Preface

The day to write my acknowledgements has finally come. Thinking back through my PhD journey, it seems that I started ages ago, and I almost feel like a different person today compared to the person at the beginning of the process. There have been so many people involved, without whom this would have never happened. So where to even start?

First, I want to thank Prof. Markku Kanninen, my PhD supervisor at the University of Helsinki, and also my supervisor while I was working at the Center for International Forestry Research (CIFOR) at the beginning of 2006. Markku is my "tropical forestry godfather", who supported me during all the ups and downs related to my PhD research, but who also made my career at CIFOR possible.

Secondly, this thesis uses data collected in the collaborative research project titled "Strengthening Rural Institutions to Support Livelihood Security for Smallholders Involved in Industrial Treeplanting Programs in Vietnam and Indonesia". I would like to acknowledge the generous support of the Gesellschaft für Technische Zusammenarbeit (GTZ) and the government of the Federal Republic of Germany for financing the project. Special thanks goes to all the wonderful people from the many different organizations (and diverse range of backgrounds) whom I worked with during this project. I would like to especially acknowledge Dr. Haruni Krisnawati and Dr. Dede Rohadi (Forestry Research and Development Agency, FORDA), who both contributed a lot to my learning in the subject. I wish to thank them for their significant scientific contribution to the papers in this thesis, for the good times in the field, and for their friendship.

I would also like to express my gratitude to the other members of the "BMZ-project": Chris Barr for always being so constructive and kind; Dr. Thomas Sikor for his scientific advice and the adventures in Vietnam; Ahmad Dermawan for guiding me with all the practical issues; and Philip Manalu, Dr. Louis Putzel, Dr. Moira Moeliono, Rubeta Adriani and Utomo Nughoro Adi. I also wish to thank Ramadhani Achdiawan, Ronnie Babigumira and George Schoneveld for their advice regarding data analyses (and also George for all his general life advice!), Rosita Go (for taking such good care of me), and the CIFOR library staff for their great help.

My gratitude also goes to the German and Vietnamese partners of the project for sharing their insights on tree planting within their areas of specialty. Furthermore, my deep gratitude goes to all the wonderful people helping me with the data collection in Indonesia, as well as guiding and supporting me while working in the villages. The staff of the Forestry Research Institute of Banjarbaru - particularly Didik Purwito, Marinus Kristiadi Harun, Idin Saefudin Ruhimat, Abdul Kodir, Supriyadi, Aditya Noor Robby, Dian Cahyo Buwono, Dian Lazuardi and Sofyan Agus; the staff of the Forestry Research Institute of Kuok, Riau – Sudar Malik, Yanto Rochmayanto, Agung Budi Supangat, Ahmad Rojidin and Roi; Wahyu Catur Adinugroho and Entin Hendartin from the Bogor Agricultural University (IPB) and Ibu Nani Djoko (CIFOR). "Terima kasih banyak dan minta maaf!"

I would also like to acknowledge the generous hospitality of the people in the study villages, who hosted us in their homes during the fieldwork. Furthermore, my great appreciation goes to

the respondents for their patience, kindness and willingness to answer my endless questions. Specific thanks goes to Pak Siman and Pak Heri Supriyanto for their generous hospitality and their extremely valuable insights into tree planting and management.

I am grateful to the anonymous reviewers of the peer-reviewed papers and the examiners of the thesis for their valuable comments that significantly improved the manuscripts. Thanks also goes to all my friends and colleagues at Viikki Tropical Resources Institution (VITRI) and in the Department of Forest Sciences at the University of Helsinki, who have supported me during my forestry studies and made it so much fun! Special thanks are reserved for Prof. (emeritus) Olavi Luukkanen for inspiring me in the field of tropical forestry and for guiding me during my studies. My gratitude also goes to Prof. Pasi Puttonen and Prof. Heimo Karppinen for their advice, and to the University of Helsinki for providing me funds during the final stages of the thesis.

I wish to thank my colleagues at CIFOR and all my friends in Bogor for their support, care and lots and lots of good times. My special thanks goes to Dr. Maria Brockhaus, Dr. Houria Djoudi, Dr. Cecilia Luttrell and Dr. Laura German for their great friendship and so many other things. I am really grateful to Maria, for pushing me to finish this thesis and for enabling me to continue my research in the field of tropical forestry science.

I also wish to thank all my friends in Finland, Spain and around the world, for their wonderful company and care. Thanks also for Pekka Tainio for supporting me during my early days as a researcher in Indonesia.

I wish to express my great gratitude for the constant and loyal support of my loving family; my father Ilkka Kallio, my mother Leena Kallio, my sister Riitta Korkeila, and my brother in law Sampo Korkeila. I also wish to thank them for their comments on the manuscript, and Sampo for the lay-out of the thesis. Thank you also to my nephews Lauri, Eelis and Eero for bringing me their toys when needed, and Maruna for lending me her room.

Last but not least, I wish to express my highest gratitude to Nick Hogarth, for his love and support, and for his extremely valuable and thorough reviewing and editing of the thesis and the journal articles.

This thesis is dedicated to the beloved foresters of the Kallio family that came before me; my great grandfather Jooseppi Kallio, my grandfather Kalevi Kallio, my great uncle Prof. Tauno Kallio, and my father Ilkka Kallio.

Bogor, May 2013

Maarit Kallio

List of original papers

This thesis is based on the following original papers:

I. Kallio, M.H., Kanninen, M. & Rohadi, D. 2011. Farmers' tree planting activity in Indonesia: Case studies in the provinces of Central Java, Riau, and South Kalimantan. *Forest, Trees and Livelihoods* 20: 191-210.

II Kallio, M.H., Krisnawati, H., Rohadi, D. & Kanninen, M. 2011. Mahogany and kadam planting farmers in South Kalimantan: The link between silvicultural activity and stand quality. *Small-scale Forestry* 10: 115-132.

III. Kallio, M.H., Kanninen, M. & Krisnawati, H. 2012. Smallholder teak plantations in two villages in Central Java: Silvicultural activity and stand performance. *Forests, Trees and Livelihoods* 21(3): 158-175.

Maarit Kallio and Markku Kanninen co-conceived the research idea. Maarit Kallio collected the data together with Haruni Krisnawati and Dede Rohadi. Maarit Kallio analyzed the data and prepared the manuscripts, which were then revised by the other authors (Dede Rohadi (Study I & II), Haruni Krisnawati (study II & III) and Markku Kanninen (Study I, II & III)). In study I and II Dede Rohadi supervised and participated in the collection of the socio-economic data, and in study II Haruni Krisnawati supervised and participated in the collection of the forest inventory data. Maarit Kallio supervised the silvicultural questionnaire in all the studies and all the data collection in study III. Haruni Krisnawati also contributed to the site selection in study III and to the data analysis of the plantation growth data (Study II & III).

List of main acronyms

ACIAR	Australian Centre for International Agricultural Research
DR	Danai Reboisasi (Reforestation Fund)
CIFOR	Center for International Forestry Research
DBH	Diameter at Breast Height (cm)
FAO	Food and Agriculture Organization of the United Nations
FLEGT	Forest Law Enforcement, Governance and Trade
GERHAN	Gerakan Rehabilitasi Nasional (Indonesian Forest Rehabilitation Program)
GDP	Gross Domestic Product
ha	Hectare
HKm	Hutan Kemasyarakatan (Community forest)
HPH	Hak Pengusahaan Hutan (Concession Right Holder)
HTI	Hutan Tanaman Industri (Industrial Plantation Forest)
HR	Hutan Rakyat (Farm Forest)
HTR	Hutan Tanaman Rakyat (People Plantation Forest)
M	Million
MAI	Mean Annual Increment
MARD	Ministry of Agriculture and Rural Development (Vietnam)
MoF	Ministry of Forestry (Indonesia)
NGO	Non-governmental Organization
NTFP	Non-timber Forest Product
PES	Payment for Ecosystem Services
REDD+	Reducing Emissions from Deforestation and Forest Degradation and enhancing forest carbon stocks
RRA	Rapid Rural Appraisal
TSP	Triple superphosphate

Table of Contents

1. Introduction

1.1. Expansion of tropical tree plantations in Indonesia

Since the 1990s the increase in the global forest plantation area has been significant, especially in Asia where the plantation area has increased by approximately 24% between 1990 and 2005, and is expected to continue to grow (FAO 2009a). The increase in the plantation area in the Asia-Pacific region has been driven largely by the increasing demand for sustainably produced industrial wood and by rapid GDP growth, especially in China (White et al. 2006, FAO 2009a). Several countries in the region - including Indonesia, China, Vietnam, Thailand, Laos and others – have responded to the projected increase in industrial wood demand by encouraging even further investments in plantation development (MARD 2000, Enters and Durst 2004, Rudel 2009, Barr et al. 2010). Asia is currently the leading region in the world in forest plantation development, with 131.89 M ha representing 49% of the global plantation area (including productive and protection functions) (FAO 2009a). China has the world's largest plantation forest area, but Indonesia is among the countries with the most plantation area in the region.

Indonesia has a growing demand for wood that is caused by a combination of population growth and economic development (general demand for wood based products), but also caused by a loss in the area and quality of the natural forest that has traditionally been the main and cheapest source of wood (Guizol and Aruan 2004, Barr et al. 2006). In 2011 the FAO reported that Indonesia's total forest area in 2010 was 94.4 M ha, however due to the high rates of deforestation and forest degradation, this area was decreasing between the years 2000-2010, with a deforestation rate of 0.498 M ha per year (FAO 2011). The deforestation is caused largely by logging (both legal and illegal), expansion of plantation crops (i.e. oil palm and other cash crops), uncontrolled fires, land-clearing for smallholder agriculture, and - paradoxically - by plantation produced pulpwood (Verchot et al. 2010, Barr et al. 2010).

Forest degradation in Indonesia is severe, and is mainly caused by unsustainable logging practices. In 2009, 41% (77.8 M ha) of Indonesia's forest estate had some degree of degradation (forest estate includes both forested and non-forested areas managed by the Ministry of Forestry (MoF) (MoF 2009). In addition, a significant amount of forest degradation (65% in 2006) has been taking place outside of forest areas managed by the MoF (MoF 2009). In 2005 the Bureau of Forest Planning from the MoF found that the highest incidence of deforestation and forest degradation was taking place on the islands of Sumatra and Kalimantan[1], but as these forests became diminished, pressure moved to the forests in Papua (Cited in FAO 2009b). Illegal logging has been estimated to account for more than 40% of Indonesia's total wood supply (Luttrell et al. 2011); with some estimates up to as much as 76% (Stark and Cheung 2006). The unsustainable logging (legal or illegal) is largely driven by the vast gap between the high processing capacity of woodworking industries and the limited supply of sustainably produced timber, accompanied by policy failures such as premature decentralization (Barr et al. 2010). Further drivers of unsustainable logging include governance problems (including corruption), legal uncertainties, poor law enforcement, market failures and broader socio-economic and political causes (Obidzinski 2005, Tacconi 2007, Nawir

1 In this thesis the island of Borneo is referred to as Kalimantan following the Indonesian language protocol.

2007). Indonesia's macro-level policy concerns related to deforestation and forest degradation are significant given that the forestry sector is the most important sector after oil and gas industry, and its decline in value is affecting the export earnings and economic development of the whole country (e.g. Guizol and Aruan 2004, Van Noorwijk et al. 2007).

In recent years, the government of Indonesia has taken many actions to deal with the imbalance between wood supply and demand, and in reducing illegal logging and further deforestation and forest degradation. For example, forest law enforcement operations have been hastened, forest-related governance and trade processes have been developed (FLEGT) and market instruments such as certification have been advanced (FAO 2009b, Obidzinzki and Darmawan 2010, Luttrell et al. 2011). Furthermore, sustainable forest management practices have been enhanced, illegal logging has been listed as a crime under anti–money laundering legislation, and bilateral coordination agreements and a presidential moratorium in 2011 on conserving the remaining primary natural forest were signed (Guizol and Aruan 2004, FAO 2009b, Obidzinzki and Darmawan 2010, Luttrell et al. 2011). Simultaneously, the government has also been pursuing ways to supplement the diminishing wood supply from the natural forest by developing a plantation timber industry targeting their vast areas of degraded land (FAO 2009b, Obidzinzki and Darmawan 2010).

Currently, Indonesia has approximately 4.0 M ha of industrial timber plantations, mostly on the islands of Java, Sumatra and Kalimantan (FAO 2009b, Barr et al. 2010). By 2008 these plantations had produced about 22.3 M m^3 of timber (MoF 2009, Verchot et al. 2010).[2] Large-scale plantation development in the region has been supported by the government and wood-based industries, however, efforts have also been made to engage smallholders in tree planting initiatives. Several government-led tree planting programs, international donor projects, and company-community partnerships have been developed in order to engage smallholders to plant trees (e.g. Nawir 2007, Barr et al. 2010).

Timber plantation development for industrial purposes and for rehabilitation of degraded land actually has a long history in Indonesia. Indonesia's rehabilitation initiatives (including reforestation and afforestation programs) can be divided into several different periods: pre-colonial to colonial, colonial to 1960s, 1960s to 70s, 1970s to 80s, 1980s to 90s, and 1990s onwards (Nawir 2007). During these periods the plantation objectives, approaches, techniques, funding and participating actors have evolved gradually in response to the prevailing economic conditions and government policies. Tree planting started as a spontaneous activity encouraged by cultural beliefs (e.g. teak planting was considered to protect future generations of the family), but then evolved into more planned and systematic tree planting programs implemented in priority areas for soil and water protection, for improving forest and land productivity, and for community welfare (Nawir 2007).

2 It is important to note that major inconsistencies related to land use data and definitions (including forests, plantations, and degraded lands) exist in Indonesia, giving the estimations on existing forest or plantation areas and their associated production levels questionable accuracy. For example, clear basic definitions, criteria and indicators associated with degraded land and their location is lacking, thus it is unclear where the planned future forest plantations should be allocated (Nawir 2007, Luttrell et al. 2011). Another illustration of this point is that World Bank analysts in Jakarta suggest that the effective area of productive industrial plantations (HTI) may be more than one-third less than the officially quoted numbers (World Bank 2006).

Between the 1950s-70s the main driving factor was rehabilitation in small to medium-scale management systems (including agroforestry systems in sloping areas) for preventing floods and other natural disasters, especially in Java (Nawir 2007). Large-scale timber plantation development began slowly in the mid-1980s in recognition of the increasing industrial demand for wood fiber and the inadequate supply of timber from natural forests as previously mentioned (Guizol and Aruan 2004, Nawir 2007). Over the following two decades plantation development was hastened and an extensive timber plantation program - dominated by large-scale plantations referred as "Industrial Plantation Forest" (Hutan Tanaman Industri - HTI) – was developed. The main objectives of these plantations were to restore the productivity of the degraded, over-logged areas, and reduce pressure on natural forests (yet not all the plantations were established on degraded lands leading to even further deforestation) (Nawir 2007, Barr 2010).

After several unsuccessful large-scale tree plantation efforts, it was generally accepted that the involvement of local communities is essential to improve the chances of plantations being successful (Guizol and Aruan 2004, Nawir 2007). Thus tree planting and other forms of forest management by smallholders has been increasingly encouraged through a number of forest management arrangements with multiple objectives referred as the "farm forest" (Hutan Rakyat),"community forest" (Hutan Kemasyarakatan, HKm), "village forest" (Hutan Desa) and "community-company partnerships" (e.g. Nawir and Santoso 2005, Van Noordwijk et al. 2007). Much of the tree planting programs in Indonesia have been funded by the government's Forest Rehabilitation Fund (Danai Reboisasi, DR), however these programs have for the most part had poor outcomes in terms of plantation areas established and plantation performance in terms of growth and quality (Nawir 2007, Barr et al. 2010).

One of the more recent and important land rehabilitation programs in Indonesia is GERHAN (Gerakan Rehabilitasi Nasional); a nation-wide initiative related to land rehabilitation. The program was initiated in 2003 using the central governments DR funds, with the aim to restore 3.0 M ha of degraded land within five years whilst at the same time reducing rural poverty (Nawir 2007). The program involves the local people planting and maintaining the plantations, which are mostly located in watersheds with low forest cover and high levels of degraded forest; land that is vulnerable to natural disasters. Technical assistance was meant to be provided for the local people under this program but was not always given (Santoso 2005 cited in Nawir 2007).

In 2006 the MoF announced a plan to accelerate the development of timber plantations in their long-term strategic plan for 2006-2025, with the aim to establish 9.0 M ha of new industrial tree plantations by 2016 (Kustiawan 2007). These plantations are intended to support the expansion of Indonesia's pulp industry from a capacity of 8.5 M tonnes per year in 2007 to some 18.5 M tonnes in 2020; and an expansion of paper and paperboard capacity from 6.5 M tonnes in 2007 to 16.0 M tonnes in 2020 (MoF 2007). A significant part of the plantation expansion is planned to be done under smallholder management, with 5.4 M ha of state owned land defined as production forest intended to be planted by smallholders under the so called "People Plantation Forest" program (Hutan Tanaman Rakyat -HTR). In this program the government is providing a range of incentives for the smallholders and communities, including low interest loans, assistance with the acquisition of land, streamlining application procedures and simplified reporting operations (Obidzinski and Dermawan 2010). The initiative is expected to directly involve about 360,000

rural households in the development of tree plantations (Emila and Suwito 2007) and is expected to generate employment for over 1.5 M people in rural areas (Sugiarto 2007). It is further expected that in addition to increased wood supply, involving smallholders in tree planting would generate new sources of income for rural people, and restore the productivity of degraded lands. The HTR development was originally planned for 102 districts in eight provinces in Kalimantan and Sumatra (MoF 2007), but was then extended to all of Indonesia soon after (Sugiharto 2007).

In addition to the government, other actors such as private companies and NGOs also support smallholder tree planting in Indonesia (e.g. Nawir and Santoso 2005). Company-community partnerships are a common arrangement that is usually established with the aim of benefitting both partners. The benefits that the company may receive include diversified wood supply and access to productive land, as well as reduced investment required in labor and other management costs. In addition, increased co-operation with the local communities can enhance the company's operating terms and public image (Arnold 1997, FAO 2001). The growers can potentially benefit by getting access to an additional, more diversified income, assured market for the products, reduced market risks, access to technical services, economic incentives, and in some cases secure land and tree tenure (Arnold 1997, FAO 2001). Some partnership arrangements also contribute to the broader development of the community, by offering employment and agricultural improvements, or by providing schools and other facilities (FAO 2001, Tyynelä et al. 2002). Unfortunately, both partners do not always benefit equally, or in some of the worse cases, the farmers do not benefit at all. Inequitable company-community partnerships are regularly mentioned as a major problem for forestry development throughout the developing world (FAO 2001).

As natural forest resources have declined in many places in Indonesia, millions of people have lost access to a range of forest products that they rely on for both cash and subsistence. This shortage has led to an independent response by smallholders who started planting trees on their own land (Guizol and Aruan 2004). But due to a lack of data, the real extent of Indonesia's smallholder tree plantation area and engagement levels remains unknown (FAO 2006, Barr et al. 2010). Van Noordwijk et al. (2007) and Brown and Simangunsong (2006) suggest, however, that tree plantations planted by farmers represents an underappreciated sector in the Indonesian economy. The study by Brown and Simangungson (2006), for example, found that based on 2002 data, the combination of smallholder tree-based and forest-based production activities – including agroforestry crops, non-timber forest products, and private forest production (Hutan Rakyat) – contributed USD 6.2 billion in economic value each year (Cited in Van Noordwijk et al. 2007). This accounts for over 3% of Indonesia's overall economic output and provides jobs for nearly 4 M people.

Despite all the tree planting efforts and achievements, the industrial demand for wood in Indonesia continues to exceed the available supply, whilst the area of degraded land continues to increase and the assets invested for forest industries are underused (e.g. the existing pulp mills and sawn factories) (Manurung et al. 2007, Nawir 2007).

1.2. Tree planting and rural livelihoods

In addition to timber production, tree plantations provide a wide range of important non-timber forest products (NTFPs) and other services for farmers (Evans 1992, Shackelton et al. 2007). For many farmers, tree planting is an economically driven activity, providing a source of income (e.g. Salam 2000, Arnold 2001). If there is demand and a market, farmers plant trees as cash crops in order to produce timber, poles, pulpwood, bark, fruits, medicine etc... (e.g. Scherr 1997). Wood, fodder and other NTFPs also make important contributions to domestic consumption (Harrison and Herbohn 2001a). For example, Scherr (2004) reported that the largest share of the wood produced in developing countries was used for domestic consumption.

Trees can sometimes serve as a 'savings account' and 'safety-net' for farmers, and in some ways act as rural insurance system. This is especially important for the poor who are highly vulnerable and subject to unexpected expenditures (Chambers and Leach 1989, Angelsen and Wunder 2003). The importance of trees as savings and security has been reviewed by Chambers and Leach (1989) with several examples from developing countries cited. For example in East Java, trees were sold to cope with drought, in Bangladesh they were sold to cope with famine, and in Kenya they were sold to pay school fees (See Chambers and Leach 1989). Furthermore, a relatively flexible harvesting time makes trees available for harvest (once a certain size is reached) if cash is urgently needed (Chambers and Leach 1989, Angelsen and Wunder 2003).

Besides products, trees planted on farms can provide a range of environmental services, including shade, wind breaks, soil enrichment and erosion prevention, water protection, rehabilitation of degraded lands, habitat development and carbon sequestration (Cossalter and Pye-Smith 2003, Kaimowitz 2003). Water and soil protection, and carbon sequestration can also provide opportunities via payments for environmental services (PES) (Wunder 2005), including Reducing Emissions from Deforestation and Forest Degradation and enhancing forest carbon stocks (REDD+) (Angelsen et al. 2009). Trees can also be favored by people because of their aesthetic characteristics and because they can provide recreational or spiritual value (Evans 1992). Tree planting can also provide employment and other indirect benefits, for example the company-community partnerships may provide incentives such as community infrastructure (Tyynelä et al. 2002). In some cases plantations can prevent the destruction of natural forests, but in other cases plantations have had adverse effects on natural forests causing even more marginalization for the forest dependent people (Cossalter and Pye-Smith 2003, Obidzisnki and Dermawan 2010).

Trees on smallholder farms usually provide several of the above mentioned roles simultaneously (Harrison and Herbohn 2001a). For example, in Indonesia Nibbering (1999) found that teak planting diversified income generation possibilities of the farmers by providing cash when sold, acted as safety-nets and a form of savings for the farmers when needed, and also provided construction material for subsistence use (Nibbering 1999). Within the context outlined above, smallholder tree-planting initiatives can contribute towards achieving at least two of the Millennium Development Goals; reducing poverty, and ensuring environmental sustainability.

1.3. Shortcomings of smallholder tree planting programs in Indonesia

Current and previous tree planting efforts in Indonesia vary in terms of the incentives provided, actors involved, species planted, planting systems, and resources allocated, but also in their success or failure. In general, however, the experience from previous and ongoing plantation initiatives in Indonesia is not positive (Luttrell et al. 2011). Studies on tree planting initiatives in Indonesia have shown that tree planting programs can bring with them significant risks to participating smallholders if they are poorly implemented, or if projected levels of productivity and profitability are not achieved (Guizol and Aruan 2004). In fact, tree planting programs in Indonesia - and other areas in the tropics - have often failed in reaching their planting area targets, or in reaching the productivity and quality potential (e.g. Thacher et al. 1997, Harrison and Herbohn 2001b, Varmola and Carle 2002, Enters and Durst 2004, Guizol and Aruan 2004, Nawir 2007, Van Noordwijk et al. 2007, FAO 2009b, Barr et al. 2010, Perdana et al. 2012).

In Indonesia for example, the ongoing HTR program has failed to reach its planting area targets, with only 350,000 ha established between 2007 and 2009 out of the intended 1.2 M ha target (MoF 2009). This is mainly attributed to failures by the government and other implementing actors by selecting unsuitable land, by providing inadequate tenure incentives, by having difficult and complicated application and funding procedures, and by the general unattractiveness of the program as a livelihood option for the farmers (Obidzinski and Dermawan 2010). Overall, fast-growing timber is not as profitable a livelihood option as planting other crops such as oil palm and rubber can be (Obidzinski and Dermawan 2010). The HTR program also carries the risk of contributing to even more deforestation and forest degradation because of the unclear definitions and user rights related to the "degraded lands" that are the target of the plantations (Obidzinski and Dermawan 2010). The productivity and quality of the established HTR plantations is still unknown due to lack of data and the young age of these plantations.

The GERHAN land rehabilitation program has also failed to reach its planting area targets, and the areas that have been planted under the program are mostly reported to be of poor quality and low productivity (Guizol and Aruan 2004, BPK 2008 as cited in Barr et al. 2010), although some successful GERHAN plantations have been recorded in Java (Santoso 2005 as cited in Nawir 2007). The failures in the previous and ongoing plantation initiatives in Indonesia, including GERHAN, are largely attributed to the limited capacity of the different government actors to deliver transparent and efficient allocation of funds through the Reforestation Fund (i.e. Dana Reboisasi, DR), with reported mismanagement of funds and fraudulent use of them by the recipients (Nawir 2007, Barr et al. 2010). The GERHAN program has especially suffered from the inflexible and short-term funding system, which often leads to seedlings not being planted at the right time (which is in the beginning or at the end of the rainy season). Furthermore, inadequate funding allocation for the maintenance of recently planted seedlings, as well as for long-term management and planning, has in general been a major problem in the field (Nawir 2007). There are no reliable records related to the actual area of land under rehabilitation in the GERHAN program (Nawir 2007).

The general low productivity and quality of the plantations reported for smallholder tree planting programs throughout Indonesia may also be related to unsuitable site-species matching, poor

seedling stock or poor silvicultural management and plantation protection. Many doubts have been expressed about the sustainability of tropical plantations, both in terms of biological productivity, and their potential impact on the environment (Nambiar 2008). Many traditional tree planting systems - such as different kinds of agroforestry systems - have been in practice by Indonesian farmers for a long time, thus some knowledge of tree planting already exists (Guizol and Aruan 2004). But despite being important, such traditional knowledge related to tree-planting is proving inadequate, with farmers throughout Indonesia and in many other tropical regions lacking the up-to-date silvicultural knowledge, planning capacity, and skills required to maximize productivity (if the objective is to produce wood for sell) (Carnea 1992, Gunasena and Roshetko 2000, Byron 2001, Nemoto 2002, Nawir 2007, Rohadi et al. 2012). Tree planting and management requires specific skills and knowledge of many silvicultural practices, including which species or provenances to select for a specific site, and when, and how to conduct planting, weeding, fertilizing, pruning, thinning, harvesting and plantation protection (Evans 1992). It is important to note that silvicultural techniques recommended for large-scale tree planting cannot necessarily be adapted to smallholder plantation systems (Byron 2001). In addition, the need for silvicultural management depends on individual farmers' objectives for planting trees.

Proper silvicultural management is especially important in tropical plantations in order to achieve the high quantity and quality production potential of various wood-producing species. According to Evans and Turnbull (2004) for example, the MAI of volume in tropical forest plantations is an average of between 15-40 m^3 ha^{-1} $year^{-1}$, whereas in natural tropical forests it is between 1-7 m^3 ha^{-1} $year^{-1}$. Similarly, Davis (1989) estimated that the wood production from one hectare of productive forest plantation was equivalent to that from 20 ha of natural forest in Indonesia. Furthermore, the commonly uniform structure of the plantations makes it relatively easy to conduct silvicultural practices and produce wood of a consistent quality. The quality requirements for different end uses varies, but for timber production – and particularly for manufacturing high quality products (e.g. high class furniture or cabinet work) – the stem generally needs to be large in diameter, straight, and without major irregularities or defects (Evans 1992).

As highlighted by the case of the HTR and GERHAN programs above, the success of tree planting and management is seldom due to technical factors only (Byron 2001, Harrison and Herbohn 2001a, Song et al. 2004, Walters et al. 2005, Nawir 2007, Obidzinski and Dermawan 2010). In fact there are several constraints that farmers may face related to tree planting; including unclear economic incentives or other market related constraints (Guizol and Aruan 2004, Scherr 2004, Nawir 2007), institutional or policy barriers (Barr et al. 2006, Sunderlin 2006, Nawir 2007, Barr et al. 2010, Rohadi et al. 2012), unclear benefit sharing arrangements and land tenure and user rights (Byron 2001, Nawir and Santoso 2005, Nawir 2007), cultural aspects (Hyman 1983, Song et al. 2004), and environmental constraints (Van Noordwijk et al. 2007, Jagger et al. 2005).

Another fundamental constraint often related to community and small-scale forestry development programs is that they fail to take account of the diversity of people within communities when planning and implementing their programs; a shortcoming that has led to varying degrees of success of such initiatives (e.g. Raintree 1987, 1991, Byron 2001, Harrison and Herbohn 2001b, Emtage and Suh 2004, Nawir 2007). It is widely perceived that taking account of the local economic and socio-cultural aspects in a project significantly enhances a community's long-term

commitment to tree planting (Nawir 2007). Farmers are indeed not a uniform group; they vary in their socio-economic and perceptional characteristics which influences the suitability of tree planting (a long-term investment) as a livelihood option for them, and the type of small-scale tree planting system the farmer is able to choose and maintain (Lamb 2011). In fact, several studies in the tropics and sub-tropics have found that socio-economic, perceptional and motivational factors have a significant effect on farmers' tree planting and silvicultural management activity (e.g. Amacher et al. 1993, Thacher et al. 1997, Ravindran and Thomas 2000, Salam et al. 2000, Mahapatra and Mitchell 2001, Simmons et al. 2002, Emtage and Suh 2004, Summers et al. 2004, Walters et al. 2005).

Eventually the Indonesian wood industry will have to rely on resources other than natural forests to meet their raw material requirements, thus the importance of productive plantations is continuously increasing (Guizol and Aruan 2004). Moreover, the Indonesian government aims to reinstate Indonesia as the world's leading tropical timber producer and exporter, thus the production capacity of the existing timber plantations need to be improved significantly, as they currently fall far short of the volumes of timber needed to achieve this aim (Obidzinski and Chaudhury 2009). But given the poor success rates of previous and planned smallholder tree plantation programs, much more information is needed.

Thus, in order to implement tree planting programs more efficiently, and to provide useful information for policy makers, it is important to study which socio-economic and perceptional factors influence farmers' tree planting and management activity, and how to improve the productivity and quality of their plantations. The range of constraints that farmers may face related to tree planting and management also need to be understood; for example why do or why don't farmers plant and manage trees? Due to the lack of data, policies and programs related to tree planting are largely based on assumptions rather than empirical data, a situation that may lead to poor land-use practice (e.g. Emtage and Suh 2004).

1.4. Aim of the study

This study was conducted in order to provide information for the actors implementing tree planting programs in Indonesia and elsewhere that can be used to improve the success of the current and planned smallholder tree-planting initiatives. The specific aim is to determine the factors that influence farmers' tree planting and management activities in four case studies from Indonesia's three major islands of Java, Kalimantan and Sumatra. The increased productivity and quality of the plantations can lead to improved livelihoods of the tree planting smallholders, increase the much needed supply of wood, and potentially reduce the pressure for harvesting the remaining primary forest.

The specific research questions are as follows:

(1) What are the differences in the socio-economic and perceptional characteristics of tree planters and non-tree planters? (Study I)

(2) What are farmers' motivations for planting or not planting trees? (Study I)

(3) How do farmers use the income derived from selling wood? (Study I)

(4) What are the main disadvantages related to tree planting? (Study I)

(5) How do smallholder tree-planters vary in their willingness to continue tree-planting under different conditions (external support, market conditions, and land use conditions)? (Study I)

(6) Do farmers' socio-economic and perceptional characteristics influence their silvicultural management activity? (Study II and III)

(7) What silvicultural practices do farmers currently apply, and how do these practices affect their plantation performance in terms of growth and quality? (Study II and III)

The hypotheses are:

(1) Farmers' tree planting and silvicultural management activities are influenced by: socio-economic characteristics of the farmer and the household; characteristics of the farm; farmers' and other peoples' attitudes towards tree planting; planting motivation; skills and knowledge; incentives received; access to markets; and farmers' participation in farmers groups.

(2) There is a positive relationship between farmers' silvicultural management activity and their plantation performance (growth and quality).

Together these papers contribute to a broader understanding of the factors influencing tree planting and silvicultural management of smallholder farmers in Indonesia and elsewhere with similar conditions. Theory and methods from the fields of forestry, and socio-economics were used to develop this research, which provided a multidisciplinary approach for understanding these concerns. The comparative approach between four case studies in three major islands in Indonesia provides a unique opportunity to study these factors under varying conditions, thus providing information for wide range of situations elsewhere in the tropics.

2. Theoretical framework and literature review

2.1. Theoretical framework of the study

Diverse perspectives from the social and economic sciences have been brought together to study the factors influencing farmers' adoption of rural innovations like tree planting (both in agroforestry and farm forestry systems), and the factors that lead to some forest users practicing better silvicultural management than others. Likewise, a diverse range of theoretical and methodological approaches have been used to study these factors (e.g. Amacher et al. 1993, Scherr 1995, Thacher et al. 1997, Salam et al. 2000, Byron 2001, Pattanayak et al. 2003, Mercer 2004, Walters et al. 2005). The theoretical framework used in this study is drawn from existing studies related to the socio-economic, perceptional and other possible factors affecting farmers' tree planting and management activity in tropical and sub-tropical countries.

Smallholders vary greatly in their socio-economic, perceptional (i.e. attitudes, beliefs) and motivational characteristics, as well as in the land-use related experiences they have. Such variation influences their willingness and ability to engage in certain land-use options and management strategies, including tree planting (e.g. Scherr 1995). Several studies in the tropics and sub-tropics have found that socio-economic, perceptional and motivational factors affect farmers' tree planting (e.g. Thacher et al. 1997, Ravindran and Thomas 2000, Salam et al. 2000, Mahapatra and Mitchell 2001, Simmons et al. 2002, Emtage and Suh 2004), and silvicultural management activity (e.g. Amacher et al. 1993, Summers et al. 2004, Walters et al. 2005). These factors are discussed in some detail in the following literature review section (2.2).

In addition to studies focusing on farmers' socio-economic or motivational characteristics, several other perspectives on farmers' adoption of management strategies are available in the literature. These perspectives – as listed by Walters et al. (2005) – include information sharing (Lionberger 1960), local knowledge (Redford and Padoch 1992), economic scarcities (Arnold and Dewees 1997, Mercer 2004), geographic location of the plantation (Dewees and Saxena 1997), socio-political structures and institutions, and government policies and incentives (Blundell and Gullison 2003, Enters and Durst 2004). In addition, participation in social organizations – including farmers' groups – is recognized as helping farmers to adopt new farming practices (Bebbington 1996). Other factors found to influence tree planting and management activity includes access to markets (Ravindran and Thomas 2000, Arnold 2001, Scherr 2004) and environmental factors such as site quality (Kumar 2003, Jagger et al. 2005). Similarly, in their broad literature review on agriculture and forestry technology adoption, Pattanayak et al. (2003) concluded that the following five general categories influence farmers' adoption: farmer preferences, resource endowments, market incentives, bio-physical factors, and risk and uncertainty. While Byron (2001) listed the 'keys' for successful tree planting to be: secure property rights to land and tree crops, a viable production technology, capacity for crop protection, and access to markets.

As shown by these previous studies, it is clear that there are a diverse range of factors influencing farmers' tree planting and management activity. This is because real world settings are complex and vary according to specific locations. Walters et al. (2005) argued that because of this complexity, holistic methods should be applied in order to fully understand why farmers have

adopted particular practices, and that clear questions should be answered about why particular users have, or have not, adopted desired practices in particular situations. Even the personal experiences of individuals and villages, and specific events, may influence farmers' adoption of practices (Walters et al. 1999).

In this study a diverse, interdisciplinary approach is used in order to detect why or why farmers are not conducting certain practices (in this case tree planting and management). Hence the socio-economic and perceptional variables of the household and the farm, as well as other possible factors influencing tree planting and management activity used in this study were drawn from a range of previous related studies (referred to above and in the section 2.2). This study attempts to minimize a priori theoretical preconceptions about which factors are more or less likely to be important.

Firstly, the socio-economic characteristics of the farmers and the households, and the characteristics of the farm are determined and linked to the planting and silvicultural management activities of the farmers (Figure 1, boxes A, B and C). Secondly, clear questions were asked from the farmers about their own, and other people's attitudes towards tree planting (Figure 1, box A); their reasons for planting or not planting trees (Figure 1, box A); how their income from selling wood was used (Figure 1, box F); what their disadvantages related to tree planting are (Figure 1, box A); who influenced their species selection (Figure 1, box A); the extent of their silvicultural knowledge and practices conducted (Figure 1, box A); their market access and perceptions on the prices received for their wood (Figure 1, box A); the government incentives they receive (Figure 1, box A); their participation in farmers or other social groups (Figure 1, box A); and their willingness to continue tree planting and motivations for it (Figure 1, box D). Finally, forest inventories were used to determine the productivity and quality of the plantations in order to link the information gained from the farmer surveys to the actual performance of their plantations (Figure 1, box E).

The selected socio-economic variables and farm characteristics were: land area owned and planted with trees, land tenure and the location of the land, farmers' age, education level, the number of household members contributing into income generation, household assets, household's yearly expenses per capita, and the importance of off-farm and on-farm income for the household. Studying the differences in various characteristics between tree planters and non-tree planters made it possible to analyze the factors that possibly influenced, restricted or enabled tree planting (indicated in Figure 1 by the arrow from box A to boxes B and D). Furthermore, studying the differences in the above mentioned characteristics between farmers conducting certain silvicultural practices or not, made it possible to analyze the factors that possibly influenced farmers' silvicultural management activity (indicated in the Figure 1 by the arrow from box A to box C).

Because of limitations on resources and time, all the possible factors influencing farmers' tree planting and management activity could not be studied. The factors that are shown in Figure 1 under the title "not included in the study", including governance, policies and institutions, farmers' access to credit or loans, site conditions and climatic factors, are the factors that are recognized as having an influence on tree planting and management activity, but were not included. In addition, gender has been found to influence tree planting activity (Scherr 1997), but was not analyzed because all the sample household heads were male.

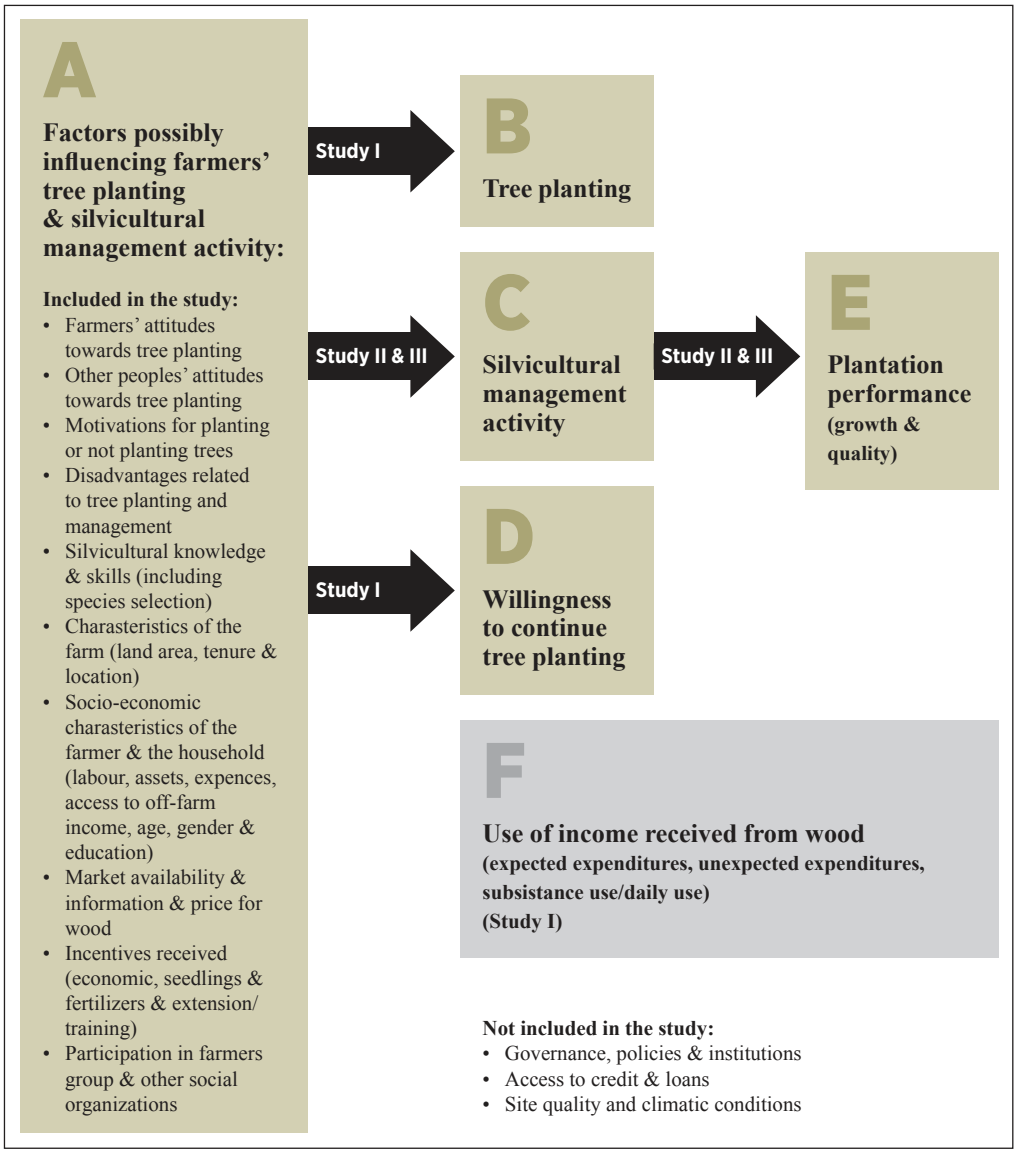


Figure 1. Theoretical framework for farmers' tree planting and management activity in four study sites in Indonesia. The black arrows show the possible influence of the studied factors (box A) to farmers' tree planting activity; silvicultural management activity; and the willingness to continue tree planting (boxes B, C, D). The possible influence of silvicultural management activity to plantation performance (box E) is also shown with a black arrow. The use of income from wood is shown in a separate box (F) because the factors influencing the use of the money received from wood was not analyzed, but this question was descriptive in nature.

2.2. Factors influencing farmers' tree planting and management activity

2.2.1. Attitudes, motivations and disadvantages

Previous studies show that farmers' favorable or unfavorable attitudes towards tree planting (Amacher et al. 1993, Nibbering 1999, Salam et al. 2000) as well as other peoples' attitudes around them (Mercer 2004) have influenced farmers' willingness to plant trees. Attitudes towards tree planting can also change over time, leading to increases or decreases in tree planting activity (Nibbering 1999). As pointed out in section 1.2, tree planting can contribute to farmers' livelihoods in various ways, and farmers plant trees based on different motivations. The motivation for planting trees - which can be economic, environmental, social or cultural - influences both the species selection and the associated requirements for silvicultural management (Evans 1992).

Farmers may face several disadvantages related to tree planting and management (as pointed out in section 1.3), such as environmental constraints or lack of labor, silvicultural skills, resources or markets. Such disadvantages obviously influence farmers' attitudes towards, and willingness to plant trees; as well as limiting the possibilities for proper silvicultural management.

2.2.2. Silvicultural knowledge and skills

There are conflicting opinions between different authors about how knowledge affects tree planting. Despite a large body of traditional knowledge on tree planting, there is a general lack of knowledge and skills related to tree planting and management amongst farmers, which is considered to be a major constraint to successful small-scale tree planting (Carnea 1992, Thacher et al. 1997, Byron 2001, Pattanayak et al. 2003, Cossalter and Pye Smith 2003). Smallholders in Indonesia and other developing countries in the tropics often manage their timber plantations using poor silvicultural practices with low levels of labor inputs, which lead to low quantities and quality of timber (Harrison and Herbohn 2001b, Maturana et al. 2005). Spacing is often irregular, species composition is sometimes result of chance rather than a conscious decision, and farmers often lack the technical skills necessary to achieve best practice (Gunasena and Roshetko 2000). The most common management activity is often limited to harvesting of wood, while trees are just let to grow without any silvicultural management between planting and harvesting (Roshetko et al. 2007). Hence, improved extension activities are commonly recommended in order to improve the success of smallholder tree planting and management (Thacher et al. 1997, Roshetko et al. 2007).

It is, however, also recognized that farmers often do have knowledge about tree planting and management, but this knowledge is often not applied because of other reasons such as socio-economic constraints (Byron 2001, Harrison and Herbohn 2001b, Walters et al. 2005, Maturana et al. 2005). Furthermore, it is questionable whether silvicultural techniques that are designed for large-scale plantation management can be adapted for smallholder plantation management (Byron 2001, Nawir 2007).

Selection of appropriate tree species is one of the most important silvicultural decisions to be made, and has a strong influence on the success of smallholder tree planting efforts. The species selected

should be suitable for the local environmental conditions, but should also suit farmers' objectives and livelihood strategies and available markets (e.g. Evans 1992, Scherr 2004). A major problem faced by Indonesian farmers, community organizations and even government projects/offices is that they often lack access to good quality tree seeds for the desired tree species (Roshetko et al. 2004).

2.2.3. Characteristics of the farm

Land area, tenure and location

Tree planting requires land, but the poorest farmers in the tropics generally have very little ownership or access to private land, or only very small areas of land, such that they have little choice but to plant staple food crops that provide annual returns, instead of the relatively slow growing trees (Salam et al. 2000, Simmons et al. 2002, Kumar 2003, Summers et al. 2004). Hence, it is often found that farmers with larger areas of land tend to plant and manage trees more than the farmers with limited land (Amacher et al. 1993, Thacher et al. 1997, Summers et al. 2004). Sometimes, however, poor farmers with small land areas have high densities of trees on part of their farms, because they are dependent on essential forests products (such as fuelwood) that may be otherwise scarce (Scherr 1997). Furthermore, as farmers are often highly dependent on the limited resources produced on their land for their livelihoods, they have an incentive for managing their crops, including trees, in the most sustainable and efficient way (Sen and Das 1988). Small land areas can also be more easily protected from damage (such as forest fires or diseases) and there is an incentive to focus on quality production. On the other hand, small sized land provides small volumes of wood, which can make harvesting and transportation to market uneconomical (Scherr 2004).

The often unclear land tenure in Indonesia and other areas in the tropics can discourage farmers from planting or managing trees if they cannot ensure the right to use or sell trees (Thacher et al. 1997, Byron 2001, Simmons et al. 2002, Pattanayak et al. 2003). Changes to forest governance structures that are strengthening local rights over the land and trees have been occurring throughout the tropics (White and Martin 2001, Kaimowitz 2003, Luttrell et al. 2011). Such changes can empower the farmers, improve their decision making power over their land and resources, and encourage them to plant and manage trees; but on the other hand it can sometimes make it even more difficult for the most vulnerable, landless poor (or other marginalized groups) to access the forest resources (Angelsen and Wunder 2003, Arnold 2001, Kaimowitz 2003, Luttrell et al. 2011). Land allocated for tree planting is often already used by rural people for other purposes, and such changes in land use allocation can negatively impact people's livelihoods and cause conflicts and marginalization (Nawir and Santoso 2005, Nawir 2007, Barr et al. 2010). This is especially the case in Indonesia where the definitions and data related to land and forest cover - including degraded land that is often targeted by the plantation programs - is not clear, and is often already inhabited, or under some form of agro-management by local people or settlers (Nawir 2007, Luttrell et al. 2011). The often imposed requirement for clear land ownership can even prevent farmers that have unclear land tenure rights from participating in tree planting programs (Hyman 1983). On the other hand, some case studies have shown that tree planting schemes that require titles over the land have actually helped farmers to be recognized as the legal land owner (Arnold 1997), so the influence of land tenure is clearly case specific.

The location of a farmers' land in relation to a range of factors - including their house, natural forest or other sources of forest products, wood industries and markets - can affect the farmers' decision whether to plant and manage trees or not (Arnold 1996, Dewees and Saxena 1997, Scherr 2004). For example, in many developing countries, working far from home (be it temporarily or permanently) is the only option for some groups of people seeking better livelihoods (Rudel 2009). If a farmer is living and working far from their land, planting it with trees is a productive option, and in some cases it has been known to secure the control over the land whilst they are away (Dewees and Saxena 1997, Van Noordwijk et al. 2007). This is often the case in Central Java, where at least one household member generally works as a migrant laborer in the bigger cities on Java. On the other hand, farmers often live in or near their farms, enabling them to protect and manage their trees in a more efficient manner (Arnold 1996, Race and Desmond 2000). Furthermore, the presence of trees on the farm reduces the household time spent and labor burden collecting forest products from distant areas, especially if natural forest is scarce (Arnold and Dewees 1997). The location of the farm in relation to markets influences tree planting activity, especially when wood is produced for cash sales. Remote areas, with a low population density and low levels of physical infrastructure, complicate the access to market. Peri-urban areas close to wood consuming industries are more viable, whereby transport costs to the markets are not a constraining factor (Scherr 2004).

Site conditions

Site conditions, including the soil characteristics and climatic conditions, affect the success of tree planting. Not all sites are suitable for tree planting or for all species; hence it is crucial to match the species with the site conditions. On the other hand, tree planting can often be a feasible option to make a use of marginal lands where agricultural crops are not suitable, and in fact tree plantations are generally relegated to such marginal lands (Hyman 1983, Evans 1992, Cossalter and Pye-Smith 2003). Tree planting can also have a negative effect on the site, and degrade the site quality, for example if it decreases the soil fertility or reduces the water availability in the watershed (Evans 1992, Cossalter and Pye-Smith 2003, Holden et al. 2003).

2.2.4. Socio-economic characteristics of the farmer and the household

Labor

If labor is a limiting factor, then tree planting can be favored as a relatively low labor-demanding land use option, whilst the limited labor can be allocated to other on-farm (e.g. agriculture) or off-farm activities to provide regular income (Arnold and Dewees 1997, Thacher et al. 1997, Dewees and Saxena 1997, Ravindran and Thomas 2000). It has been found that households whose main income is from off-farm sources are more likely to use their land for tree planting than those households reliant on on-farm income (Thacher et al. 1997, Salam et al. 2000). Sometimes, however, households with a large number of working age members are positively correlated with tree planting activity (Summers et al. 2004), which could be because in some remote rural areas in the tropics, few off-farm income options are available for the unskilled poor (Scherr et al. 2002). Yet farmers do not always have enough capital to use the land for the most profitable crop, due to high establishment or management costs (Dewees and Saxena 1997). If land is a limiting factor,

and households have enough capital and labor, livelihood activities with lower land requirements and high labor demand (and returns) are more likely to be selected over tree planting (Dewees and Saxena 1997, Byron 2001). If tree planting is selected as a livelihood option, adequate labor is required for the proper establishment and management of the plantations (Evans 1992).

Capital

Along the production chain, different capital demanding objectives are required to produce quality wood, such as seedlings, machinery, fertilizers, herbicides, and harvesting equipment etc. The capital intensity is even higher if more value is added to the production process, for example in the form of transportation, processing and product marketing. For poor farmers, a lack of capital is a major constraint for tree planting (Byron 2001), and it has been found that wealthier farmers, who are more capable of taking risky investments, are more likely to plant trees (Amacher et al. 1993, Scherr 1995, Mahapatra and Mitchell 2001, Franzel and Scherr 2002). Furthermore, trees take a long time to grow (depending on species and plantation objectives), making it a long-term investment with little-to-no intermediate returns. The relatively long time periods involved in tree farming exposes farmers to risks in terms of price fluctuations, tenure insecurity and natural hazards (Angelsen and Wunder 2003). This long waiting period combined with high risks does not favor poor farmers, who are highly dependent on their limited farm resources; often for day to day survival (Dewees and Saxena 1997). Only the farmers with on-farm food supply, off-farm income sources, or access to affordable loans are able to cope with the extended payback period between tree planting and harvesting (Arnold 1997). Furthermore, due to the limited access to capital and credit for investing in tree planting, and the financial inability to wait for trees to reach the minimum diameters required by industry, smallholders may also find it difficult to compete with the larger state and private owned plantation companies due to economies of scale (Maturana et al. 2005).

Compared to the cultivation of many other more intensive crops (such as oil palm), establishing and maintaining a tree plantation requires relatively low levels of capital investment (Ravindran and Thomas 2000). This means that tree planting is sometimes chosen over other alternatives simply because of a lack of start-up capital for another cash crop, or because of a lack of capacity to optimize the productivity (Dewees and Saxena 1997). In addition, tree planting often does not require hired labor, as most of the work is done by the farmers themselves (Evans 1992). Farmers are often even willing to work below the minimum wage if they are building assets on their own farms (Van Noordwijk et al. 2007).

Farmers' gender, age and education

Socio-demographic characteristics such as age, gender, education, and social status can be used as proxies for farmers' preferences for things such as risk tolerance and conservation attitude, factors that are otherwise difficult to measure (Pattanayak et al. 2003). Gender has been found to influence tree planting activity, with male headed households or households with more male members being found to be more active in tree planting (Scherr 1995, Pattanayak et al. 2003). In addition, age and education variables are indicators of human capital, which have been found to increase the likelihood of tree planting due to environmental awareness and knowledge of tree

planting techniques in some cases (Simmons et al. 2002). In fact, education is often seen as a key issue for all levels of sustainable forestry (Gordon et al. 1999), and it has been found that there is a positive relationship between formal education and tree planting enthusiasm (e.g. Thacher et al. 1997, Mercer et al. 2004).

The influence of farmers' age on tree planting activity is unclear. In some cases, however, it has been found that household age demographics can influence the household decision to plant certain crops (Walker et al. 1996). Older farmers generally have higher risk-bearing capabilities, lower household needs in terms of income, more time available (e.g. no need to take care of the children), and are interested in less labor-demanding activities such as planting trees (Thacher et al. 1997). Younger households are generally less established in terms of land areas owned, labor availability and resource requirements (i.e. high consumption demands relative to labor supply). Thus, younger households have less capacity to cope with risks, and they need to allocate their limited labor to varying forms of income earning (being more dependent on off-farm work). Having lower land areas, younger households generally need to choose a diversity of crops that can provide regular income and food instead of planting trees (Wilk 1984, Walker et al. 1996). Yet other studies have found that young, well- educated leaders in the village have been the innovative ones, engaging in tree planting (Song et al. 2004). In addition, personal characteristics can influence tree planting activity, as often tree planters come across in the literature as more innovative and courageous (in terms of risk) than non-tree planters (Mahapatra and Mitchell 2001). Farmers' ethnic group has also been found to influence their perceptions on tree planting (Hares 2008).

2.2.5. Markets

Whether the farmers are willing to plant and manage trees with an objective to sell wood is influenced by the availability of functional markets (Arnold 2001, Byron 2001, Scherr 2004). There are two main factors that often complicate the markets for small-scale wood production, namely low quantity and quality. These complicating factors especially apply to farmers with small land areas and poor silvicultural management skills (Sen and Das 1988, Arnold 2001, Byron 2001). The small harvest volumes of small tree plantations may increase harvest and logistic costs, especially if located far away from the production plants and markets, making them less attractive for the industries. Often, farmers that are located near the production plants and local markets, and with relatively good infrastructure, have good market conditions for planting and managing trees (Scherr 2004). Furthermore, the lack of continuous supply from small-scale plantations is a hindrance to industrial operations.

The price of wood in the tropics can be held low by the availability of cheaper non-wood substitutes or the availability of relatively cheaper wood from natural forests, or by subsidies that are designed to promote agricultural crops or other cash crops (Guizol and Aruan 2004, Scherr 2004). Low and unstable market prices for wood are major disadvantage for tree planters (Scherr 2004). The lack of an open market can also give companies influence over individual farmers' production decisions, for example on what species to plant or when to harvest. The farmers also often lack negotiation power on the prices they receive for the wood, and they often have little choice but to accept the company dictated price (even if it is well below market rates) because of their limited access to markets, limited market information, and inability to overcome

transaction costs (Perdana et al. 2012, Rohadi et al. 2012). The absence or lack of knowledge on price incentives for farmers to produce higher quality products is considered a barrier to improved silvicultural management practices (Van Noordwijk et al. 2007, Perdana et al. 2002). Moreover, the involvement of middlemen often decreases the profits reaching the farmer (Hyman 1983, Sen and Das 1988, Kumar 2003, Perdana et al. 2012). The presence of middlemen is not always negative, but they often play a significant role in marketing tree products from numerous smallholder plantations (Roshetko et al. 2007).

Although smallholders may face many market constraints, there are also many competitive advantages and market opportunities for smallholders in the tropics that have emerged due to the global forest transitions (as discussed by Scherr et al. 2002 and Scherr 2004). These are namely: growing local demand, especially for domestic production of small-diameter and lower-quality wood; increasing concern over the environment and social equality, which creates markets for certified forest products and ecosystem services; extensive need for tree growing and commercialization on small farms due to forest scarcity; increased prices of timber (in some cases); use of marginal lands, tree domestication and out-grower arrangements; globalized markets providing niche markets and contacts to buyers with special requirements; and finally, a general trend towards more democratic governance that gives greater voice to local people and support for indigenous land rights. These new opportunities, however, are not equally accessible for all groups of smallholders in the tropics (Scherr et al. 2002).

2.2.6. Incentives

Incentives can be defined as policy instruments increasing the comparative advantage of forest plantations and thus stimulating investments in plantation establishment and management (Enters and Durst 2004). In order to encourage farmers' tree planting activity and management, and to maximize their profitability, farmers are provided with different incentives such as land, seeds, seedlings, fertilizers or other planting material, extension services, cash handouts, assistance in harvesting, and guaranteed markets.

The use of economic incentives can be essential in order to stimulate small-scale tree planting (Carnea 1992), but according to some authors they should only be provided if they are well targeted and actually needed (Haltia and Keipi 1997). For the very poor who do not have access to credit or loans for tree planting and management, incentives can be crucial. Some authors, however, have criticized loans as they can cause dependency and be risky if expected out-comes are not reached (Arnold 1997).

Incentives can either have a positive effect for tree planting, or in a worst case scenario, can lead to unsustainable tree plantations. For example if the farmers' only reason for tree planting is to gain the economic incentives (cash) or fertilizers, this is unlikely to lead to good plantation management and quality yields (Haltia and Keipi 1997, Thacher et al. 1997). Complicated bureaucracy or unclear land titles can mean that farmers do not always have access to tree planting incentives, even if they are available in the area (FAO 2001).

2.2.7. Farmers' organizations

Farmers' group or organization may be defined as an informal, voluntary and self-governing group of farmers, formed at local level, for the purpose of economic cooperation aimed at improving the economic and social conditions of its affiliated individual members (modified form the definition of farmers' groups associations by FAO E-mail conference held in 1998). Farmers' organization into social groups is argued to have a positive influence on tree planting activity (Cernea 1992, Thacher et al. 1997, Mahapatra and Mitchell 2001, Emtage and Suh 2004, Summers et al. 2004). For example, farmers' bargaining power, and the price received for their products, can potentially be improved through collective action (Sen and Das 1988). Members of a farmer's organization can share information related to tree planting more efficiently (Mahapatra and Mitchell 2001). One example of an incentive for farmers to join together in an organization is that the government prefers that farmers are part of a group when they apply to be part of the HTR program, rather than applying individually. Such cooperative organizations usually experience a quicker approval process compared to individual smallholders (Obidzinski and Dermawan 2010).

2.2.8. Governance, policies and institutions

Government has a significant role to play in making smallholder tree planting more profitable, and in creating for the right conditions to encourage adequate investment and market development. This may be done by clear, consistent and stable policies and regulations, as well as providing a conductive investment climate, incentives, secure land rights, and adequate infrastructure and technology. In addition, governments can play a significant role in supporting the action of farmers' organizations, forest management associations or other institutions that support small-scale wood production and marketing (Current et al. 1995, Enters and Durst 2004).

However, in Indonesia as well as in other tropical developing countries, there are a range of potentially major governance-related obstacles to smallholder tree planting including policy failures, institutional weaknesses, unclear land-use related data and definitions, tenure issues, and the lack of trust towards the government (Barr et al. 2006, Luttrell et al. 2011). The essential pillars of good governance are often lacking, including proper information sharing, transparency, the rule of law, law enforcement, conflict resolution, proper decentralization, and dialogue-decision processes. In addition, Indonesia has only a limited number of experienced forestry officials, and their motivation to provide the most efficient service may be hampered by low salaries (FAO 2009b). In some cases the top-down distribution of the tree planting incentives have provided opportunities for local government officials to engage in corrupt practices (Barr et al. 2006).

There are also a number of government regulations that were designed to conserve and protect natural forests, but controversially, they restrict small-scale tree planting. Such regulations include the need for permissions for the farmers to harvest, transport, or sell their wood. The permission seeking processes are often complicated, costly or time-consuming for farmers (Ravindran and Thomas 2000, FAO 2001, Perdana et al. 2012). The link between low levels of smallholder participation in the HTR program and the difficult application process is a clear example of this (Luttrell et al. 2011). In addition, it is not uncommon that farmers or middlemen have to pay unofficial fees to several officials in the course of transporting their wood to the market. Other

policy failures that have influenced forest degradation, deforestation, and the poor success rates of tree plantation establishment in Indonesia include premature decentralization, uncontrolled logging licenses given to concessionaires, unsuccessful development – including miss-use of funds – of the HTI plantations and land rehabilitation programs (particularly the rehabilitation of the logged-over areas that were assigned for the state-owned companies in 1995/96), and the multiple policies keeping wood prices low (Nawir 2007).

2.3. Species description and silvicultural management

The species descriptions and silvicultural management described in this section are based on literature from Indonesia where possible, but due to a lack of relevant literature and data also literature from other parts in the tropics was used. The expansion of the literature to include a wider range of literature from the tropics provides a better understanding of the species, their management, and associated growth rates.

2.3.1. Acacia (*Acacia mangium*)

Acacia mangium Willd. (Family: *Leguminoseae*, Subfamily: *Mimosoideae*, Local name at the site: akasia; referred to in this study as acacia) is a fast growing tree species native to the humid tropical forests of north-eastern Australia, Papua New Guinea and the Molucca Islands of eastern Indonesia (National Research Council 1983). It is widely planted throughout Asia and the Pacific because of its rapid growth, good wood quality and tolerance of a wide range of soil and environmental conditions (National Research Council 1983). In Indonesia, acacia has been planted extensively, starting around the 1970s in the Molucca islands (Pinyopusarerk et al. 1993). The MoF (2003) reported that around 1.3 M ha of acacia has been established in Indonesia for pulp wood production, and Rimbawato (2002) and Barry et al. (2004) reported that around 80% of tree plantations managed by the state and private companies in Indonesia are composed of acacia (Figure 2). Smallholders also plant acacia in Indonesia, but the actual area of these plantations is unknown.

Acacia trees are generally large, and can reach heights of 30 m, and DBH of up to 90 cm maximum (DBH greater than 60 cm are, however, rare) (National Research Council 1983). On relatively poor sites acacia may develop as a large shrub, with average heights of between 7 and 10 m (Turnbull 1986). The stem has longitudinal furrows, and the bark in young trees is smooth and greenish, changing to become rough, hard and brown as they grow older (Hall et al. 1980). As juveniles, the true leaves have many leaflets that are similar to those of other species of the subfamily *Mimosoideae* (e.g. *Leucaena*). However, after a few weeks the leaves develop into simple and parallel veined phyllodes (up to 25 cm long and 10 cm wide). The flower is white, with numerous little flowers in spikes (Turnbull 1986, Krisnawati et al. 2011a), and develops into a green pod that darkens to blackish-brown at maturity (National Research council 1983).

Acacia is well adapted to a several soil types and environmental conditions, and it grows reasonably well on marginal lands with poor soil properties (National Research Council 1983, Otsamo 2002). However, as a pioneer species it is intolerant of shade, and is also intolerant of

salinity (National Research Council 1983). It is typically found in tropical lowland forests up to 480 m above sea level (Hall et al. 1980). In its natural habitat the mean maximum temperature range tolerated is approximately 31-34^{o}C, whilst the mean minimum temperature range tolerated is approximately 12-16^{o}C, and the mean annual rainfall ranges from 1,446-2,970 mm (National Research Council 1983).

Acacia wood is diffuse and porous. The sap wood is light colored and narrow, and heartwood is medium-brown, hard, strong and durable if well-ventilated (National Research council 1983). The wood density is in the range of 450-690 kg $^{-1}$ m^{3} at 15% moisture content. Acacia is a multipurpose tree species. The wood is suitable for pulp, paper, particle board, crates and woodchips, sawn timber, moulding, furniture, veneers, firewood and charcoal. The leaves can be used as fodder, and the flowers provide for honey production (Lemmens et al. 1995). Acacia is also used for ornamental purposes, fire or wind breaks, shading, and erosion control and being a nitrogen fixing species it is also used for soil improvement (National Research Council 1983). It is planted for industrial purposes, rehabilitation and in varying agroforestry systems.

Seedlings are planted in the rainy season on freshly prepared sites when they are approximately 25-40 cm in height (Srivastava 1993). Spacing depends on the intended uses and soil fertility, but normally varies from 2 × 2 to 4 × 4 m. In Indonesia, a spacing of 3 × 3 m is commonly used in both large-scale and small-scale plantations (Krisnawati et al. 2011a). Acacia generally shows little response to fertilizers, thus the plantations are typically not fertilized (National Research Council 1983), but in poor soils fertilizers can increase the growth (Srivastava 1993). Infilling is generally done as needed, usually 1-2 months after initial planting (but still during the rainy season). Singling, pruning and thinning are required only if the objective is to produce saw or veneer logs. Singling commonly starts at 4-6 months after planting and pruning after the first year of establishment. Depending on the site quality and spacing, the first thinning is recommended to start between the ages of 2 and 4 years (with tree height of approximately 9 m). The optimal rate of thinning during a rotation increases as initial spacing increases (Krisnawati 2007). The common rotation length for acacia plantations for pulp wood production is 6-8 years and for sawn timber production 15-20 years (Lemmens et al. 1995).

There are several studies on the growth of acacia in different sites in Indonesia summarized by Krisnawati et al. (2011a). In general, mean diameter increases relatively rapidly up to 15 cm in stands less than three years old, but then growth rates decrease significantly after the fifth year, and diameter begins to level off at around 25 cm by the age of 8 years. Tree height increases moderately in the first 2-3 years up to 10-15 m, and then increases rapidly up to 25 m at about 5 years, after which the height levels off (Krisnawati et al. 2011a). The MAI of DBH varies in different areas of Indonesia between 1.4-7.3 cm year^{-1}, and the MAI of height 1.8-5.8 m year^{-1} (Krisnawati et al. 2011a). The MoF (1992) reported average MAI of volume between 46-50 m^{3} ha^{-1} year^{-1} for acacia in Indonesia (cited in FAO 2009b). The FAO (2006) reported MAI of 20-32 m^{3} ha^{-1} year^{-1} for acacia in the Southeast Asian region with a rotation length varying from 6-12 years. In Indonesia acacia do not normally suffer from any serious diseases or pests, however, root rot and phyllode rust are the most common threats (Old et al. 2000).

Figure 2. *Acacia mangium* (acacia) plantation for pulp production in the study site in Riau, Sumatra.

2.3.2. Kadam (*Anthocephalus cadamba*)

Anthocephalus cadamba Miq. (Family: *Rubiaceae*, Subfamily: *Cinchonoideae*, Local name at the site: jabon), also known as kadam, is native to Indonesia and other areas of South Asia and Southeast Asia. It is a fast growing species, with favorable silvicultural characteristics, multiple uses, the ability to grow in a variety of soils, and tolerant to serious pests and diseases (Soerianegara and Lemmens 1993, Nair and Sumardi 2000, Krisnawati et al. 2011b). According Slik (2006), kadam has been planted on a large scale around Indonesia (for industrial plantations and for rehabilitation) since the 1930s due to its favorable characteristics. The species is expected to become increasingly important source for wood industries, particularly as supplies for plywood from natural forests decrease. More recently there has been expansion of kadam planting by smallholders, particularly in South Kalimantan and Java (Krisnawati et al. 2011b). The exact extension of the smallholder kadam plantations is not known due to the lack of data.

Kadam is a medium to large sized tree. Stem height can reach 45 m with DBH of 100-160 cm. Kadam may sometimes have a small buttress up to 2 m high. The bark is grey, smooth and very thin (in younger trees, but rough and longitudinally fissured in old trees). Kadam has a straight cylindrical bole and a broad umbrella-shaped crown (Figure 3). The branches are characteristically pendulous and arranged in tiers spread horizontally. Leaves are 13-32 cm × 7-15 cm in size,

glossy green, opposing, simple sessile to petiolate, ovate to elliptical. The flower heads are 3-5 cm wide. The fruits are numerous with yellow-orange infructescence, containing approximately 8,000 seeds.

Kadam is a typical light-demanding pioneer tree, and naturally occurs in mainly secondary vegetation, in fertile areas that are subject to periodical flooding, and up to an altitude of 1,000 m. In its natural habitat the maximum temperature range varies from 32-43^{o}C in the shade, and the minimum temperature range varies from 3-15^{o}C. The average annual rainfall ranges from 1,500-5,000 mm or more (Soerianegara and Lemmens 1993).

Kadam wood is a lightweight hardwood. The wood density ranges from 290-560 kg $^{-1}$ m^{3} with 15% moisture content. The wood is easy to work with and preserve, but not very durable. The wood needs to be treated soon after cutting in order to prevent blue stain (Soerianegara and Lemmens 1993).

Kadam wood has multiple end uses, including plywood, light construction, flooring, carving, boxes, chopsticks etc. It is also suitable for inexpensive furniture (if well-seasoned), or as pulpwood if mixed with other long-fibred material. Most kadam wood produced in Indonesia is used locally. The tree is also used for land rehabilitation, in agroforestry systems, and for ornamental purposes. It provides shade and shelter, as well as large amounts of leaf litter that can improve soil characteristics. Leaves and bark are also used as traditional medicine for fever, and the leaves may also be used as fodder or as plates and serviettes, whilst the flowers and fruits are also reportedly edible. Bark and roots are also used for producing yellow dye (Soerianegara and Lemmens 1993, Orwa et al. 2009, Krisnawati et al. 2011b).

Naturally regenerated kadam seedlings have more favorable growth rates than seedlings from nurseries (Soerianegara and Lemmens 1993), however smallholder plantations are often established by planting (Krisnawati et al. 2011b). The soil should be prepared before planting. Seedlings are planted in the field when they are approximately 30-40 cm tall, with a planting distance of 3-4 × 3-4 m generally used (Soerianegara and Lemmens 1993). Wider spacing is, however, commonly used by smallholders in South Kalimantan, especially if used in agroforestry systems (Krisnawati et al. 2011b). The seedlings are highly susceptible to weed competition; therefore the area around the young seedlings must be weeded (manually or chemically) at intervals of 3-6 months until canopy closure is achieved (Soerianegara and Lemmens 1993). In infertile sites, plantations need to be fertilized, which is often done at the time of planting using urea or TSP (Triple superphosphate). Infilling is normally done twice; one month after planting (in the rainy season) and at the end of the second year. Pruning is not required for kadam because it is a self-pruning tree species. Thinning is easy to apply due to the straight stem and the regular crown of kadam trees. Thinning should be done early and frequently (depending on the site quality and spacing), starting 2-4 years after planting and repeated 1-3 times during a rotation (Krisnawati et al. 2010a, Krisnawati et al. 2011b). The rotation length (harvest time) depends on the production purpose. For wood production the harvesting starts approximately at the age of 7-10 years or later (Soerianegara and Lemmens, Krisnawati et al. 2011b).

Kadam is a fast growing species (e.g. Soerianegara and Lemmens 1993, Orwa et al. 2009), however, few reliable experimental data are available to support this argument (Krisnawati et al. 2011b). An average DBH of up to 23.9 cm and a mean height of up to 17 m were recorded for kadam trees up to four years old growing in an experimental plot in Indonesia (http://www papadaanfoundation.com /tabel-pertumbuhan). For trees older than 10 years, the mean DBH across several sites in Java ranged from 18.6-42.3 cm, with a mean value of 29.3 cm. In West Java, kadam trees were reported to have an average height of 22 m and an average DBH of 40.5 cm in a 10.5 year-old stand (Soerianegara and Lemmens 1993). Soerianegara and Lemmens (1993) also reported that in a 30-year rotation in Indonesia, kadam produced 23 m^3 ha^{-1} $year^{-1}$ (including thinning). In Java, Sudarmo (1957) found that kadam reached a maximum volume MAI of 20 m^3 ha^{-1} by the age of 9 years in good quality sites. No serious diseases have been reported for kadam in Indonesia (Soerianegara and Lemmens 1993).

Figure 3. *Anthocephalus cadamba* (kadam) plantation in Jorong Village, South Kalimantan.

2.3.3. Mahogany (*Swietenia macrophylla*)

Swietenia macrophylla King. (Family: *Meliaceae*, Subfamily: *Swietenoideae*, local name at the site: mahoni), also known as mahogany, is a tropical tree species native to Central and South America. Its natural distribution extends from Mexico to Bolivia and central Brazil (Lamb 1996). The species is becoming scarce in its natural habitat as large areas of former mahogany forests have been converted to other uses (Shono and Snook 2006). This scarcity of mahogany has led

to concern for the future of the species and its commercial trade. Mahogany is widely planted in Southeast Asia and the Pacific (especially in India, Indonesia, Malaysia, the Philippines and Sri Lanka) for land rehabilitation, industrial, and ornamental purposes. According to Mayhew and Newton (1998), mahogany was first introduced in Indonesia in 1870 with seeds from India. In the mid-1990s the total area of industrial mahogany plantations in Indonesia was approximately 54,000 ha (Perum Perhutani 1995). Mahogany is mainly planted in Central Java and West Java (Ministry of Forestry and the National Statistics Agency 2004). Because mahogany produces high-quality wood that is used in the furniture industry, the species is also increasingly planted by Indonesian smallholders in both woodlots and agroforestry systems. The exact extend of smallholder mahogany plantations in Indonesia is unknown.

Mahogany is a medium to large sized tree with a height of up to 40-60 m and DBH of up to 1.5-2 m. The stem is branchless for up to 18-25 m, and is straight and cylindrical, slightly grooved with well-developed spurs. The crown of young trees is narrow, but the old trees have an umbrella-shaped, broad, dense and highly branched crown. The bark of older trees is brownish-grey to reddish-brown, scaly, shaggy, and deeply longitudinally furrowed. The leaves are paripinnate, sometimes imparipinnate, 12-45 cm long, made of up to 3-6 pairs of lanceolate or ovate leaflets. The leaflets are 5-12 cm long and 2-5 cm wide, asymmetrical, with a whole margin and an acute or acuminate apex. The unisexual flowers are 0.5-1.0 cm in length. The fruits are erect, capsular, woody, light grey to brown, oblong or ovoid, with 4-5 petals, and containing 22-71 seeds (Soerianegara and Lemmens 1993, Krisnawati et al. 2011c).

Mahogany is a pioneer species that naturally occurs in both deciduous and evergreen rain forest. It is adapted to a wide range of soils, and it reportedly grows reasonably well in unfertile soils in Indonesia, but does not tolerate water logging. It grows from sea-level up to an altitude of 1,500 m, in areas with a mean annual temperature range of 20-28^{o}C, with the coldest and warmest months being 11-22^{o}C and 22-20^{o}C, respectively. The optimum annual rainfall for mahogany is 1,400-3,500 mm, but can tolerate dry periods of up to four months (Soerianegara and Lemmens 1993).

Mahogany is one of the most important tropical timbers in the world market, and is regarded as one of the world's finest timbers for high-class furniture and cabinet work. The wood is used for construction material, plywood, veneer, paneling, framing, flooring, interior trim of boats, bodies of musical instruments, moulding and a range of other ornaments. It is attractive in appearance, reddish or pinkish, easy to work, and has excellent finishing qualities and dimensional stability. The wood is a rather soft, medium weight timber with a wood density of 485-850 kg $^{-1}$ m^{3} at 15% moisture content (Soerianegara and Lemmens 1993, Krisnawati et al. 2011c). Mahogany trees are also used for land rehabilitation and for improving soil quality and providing shade in agroforestry systems. Various medical uses from different parts of the tree have also been reported (Soerianegara and Lemmens 1993, Krisnawati et al. 2011c), such as for treating hypertension, diabetes, malaria and wounds (Koh et al. 2009).

Mahogany seedlings are usually planted in the field when they are approximately 50-100 cm tall, with spacing usually between 2-3 m, however wider spacing is also common in smallholder plantations in South Kalimantan and Java (4-5 × 4-5 m) for agroforestry systems (Krisnawati et al. 2011c) (Figure 4). Before planting, all weeds should be cleared and soil prepared. During the

first two years after planting, weeding should be repeated every six months (note mahogany may be harmed by herbicides, thus chemical weeding should be avoided). In Indonesia, fertilizers are usually applied after planting at a dose of 75-100 g NPK (Directorate of Industrial Plantation Forests 1990). Smallholders often apply organic fertilizers from animal waste instead of chemical fertilizers (Krisnawati et al. 2011c). Infilling is usually applied twice, first after planting to replace any dead seedlings, and then at the end of the second year (Directorate of Industrial Plantation Forests 1990).

Pruning is usually done for the first three years, just before the start of the rain season. Singling is conducted if the stem has multiple stems. Pruning for mahogany is especially important because it reduces the risk of attack by the shoot borer pest (Directorate of Industrial Plantation Forests 1990, Soerianegara and Lemmens 1993, Krisnawati et al. 2011c). In the thinning scenarios proposed by Krisnawati et al. (2010b) for industrial mahogany plantations in Indonesia, the first thinning should be conducted between 5-10 years after planting, and then repeated depending on site quality and initial stand density. The first thinning should be the heaviest to reduce the standing trees by 45-55% of stem number, and then the intensity of the subsequent thinnings should be less, approximately 25-30%. For stands with wider initial spacing (4 × 4 m) the suitable thinning intensity was found to be approximately 30-43% (Krisnawati et al. 2010b). Soerianegara and Lemmens (1993) reported that thinning of mahogany should start six years after planting, with a progressive reduction in stand density from 220-400 trees ha^{-1} in 20 year old plantations to 120-150 trees ha^{-1} in 35 year-old plantations. The rotation length was reported to be usually 40-60 years in South-East Asia (Soerianegara and Lemmens 1993). Krisnawati et al. (2010b) instead found that the feasible rotation length for mahogany plantations in Indonesia is between 15-30 years, depending on site quality and initial stand density.

Relatively little data is available on the growth of mahogany in Indonesia, especially for the whole rotation length (particularly for older trees) (Krisnawati et al. 2011c). In a study on mahogany plantations located Sumbawa (West Nusa Tenggara, Indonesia) Susila and Njurumana (2005) reported mean DBH of 16.6 cm and mean heights of 12 m in mahogany trees growing in 5-9 year-old stands, and mean DBH of 13.2 cm and a mean height of 9.6 m in 6-10 years old mahogany stands. In a study of mahogany plantion sites in Java, Suharlan et al. (1975) reported that trees older than 10 years (up to 57.6 years) had a mean DBH range of 9.4-57.1 cm with a mean value of 29.3 cm. Mahogany plantations in Indonesia are predicted to reach maximum volume MAI of 38.1 m^3 ha^{-1} $year^{-1}$ in the best sites (over rotation of 15 years) (Wulfing 1949), and MAI of 14.6 m^3 ha^{-1} $year^{-1}$ in moderate sites (over rotation of 30 years) (Suharlan et al. 1975). Krisnawati et al. (2010b) found lower MAI volume in both smallholder and large-scale plantations in Indonesia varying between 7.7-19.3 m^3 ha^{-1} $year^{-1}$ (over rotation of 15-30 years). The FAO (2006) reported MAI of 5-10 m^3 ha^{-1} $year^{-1}$ for mahogany in Southeast Asia, with a rotation length varying form 29-50 years.

The most destructive pest in mahogany plantations is a shoot borer (*Hypsipyla robusta*) that attacks shoots of the young trees and causes dieback and malformed trees with multiple leaders. The shoot borer can be controlled by effective pruning and by planting mahogany with other tree species such as *A. mangium* or neem (*Azadirachta indica*) (Soerianegara and Lemmens 1993, Suharti et al. 1995).

Figure 4. *Swietenia macrophylla* (mahogany) plantation and the farmer in Ranggang Village, South Kalimantan. Trees are often planted with wide spacing so that other crops or grass can be planted inbetween.

2.3.4. Teak (*Tectona grandis*)

Tectona grandis L.f. (Family: *Verbenaceae*, Subfamily: *Prostantheroideae*, local name at the site: jati), also known as teak, is a tropical tree species native to India, Burma, Thailand and Laos. It is planted extensively in Southeast Asia and several other tropical countries due to its favorable characteristics as a timber tree (Soerianegara and Lemmens 1993). In fact, teak is the most dominant species for planted tropical hardwood timber in the world and the demand for teak wood is always higher than supply (Rohadi et al. 2012) Teak was introduced to Indonesia several hundred years ago and is now considered to be naturalized (Soerianegara and Lemmens 1993, Rohadi et al. 2012). Teak was originally planted mainly by the state-owned company called "Perum Perhutani", but has increasingly been planted by smallholders across the country. In fact, teak has a long traditional use as a timber species favored by Indonesian farmers (Wiersum 1982, Slender and Lasco 2008). It is particularly popular in Java, where it was introduced to agroforestry systems by smallholders as early as 1856 (Wiersum 1982), and is now considered as part of Javanese culture and more desirable than other wood species (Muhtaman et al. 2006) (Figure 5). The increasing production from smallholder plantations has become an important source of teak for furniture producers in Java, where this furniture industry and its chains are providing livelihoods for millions of people (Ewasechko 2005). Despite that millions of households across

Indonesia are planting teak; the actual area of smallholder teak plantations in Indonesia is poorly documented. The census conducted in 2003 revealed that the total number of households that own teak trees on their private land had reached more than 3 Million, of which most plantations (about 63%) were located in Java. In Java, smallholder teak plantations were concentrated in three provinces; Central Java (26.47 %), East Java (21.28%) and Yogyakarta (8.89 %) (Pusat Inventarisasi dan Statistik Kehutanan 2004).

Teak is a medium to large sized tree and can reach a height of up to 50 m and DBH of up to 1.5-2.5 m. It has a straight, tall stem, sometimes with low buttresses at the base. The outer bark is grayish-brown with longitudinal cracks and the inner bark red with sticky sap. The leaves are broadly ovate, 11-55 cm × 6-37 cm of size (but much larger on suckers), stellate-floccose. The inflorescence is 40 × 35 cm with flowers of 3-6 mm long, calyx campanulate, corolla white with pink on the lobes. The fruit encloses by an inflated calyx (Soerianegara and Lemmens 1993).

Teak is a pioneer species with a long life span. It occurs naturally in varying types of deciduous forests, where it often is one of the dominant species, even in the climax phase of succession. The three main types of teak forest can be grouped into: moist natural teak formations (annual rain fall of 1,300-2,500 mm); dry natural teak formations (annual rainfall 760-1,500 mm); and Indonesian teak formations (annual rainfall 1,200-2,000 mm). It is most productive in the humid tropics with an annual rainfall of 1,200-2,500 mm, but it also needs a marked dry season. Several morphotypes of teak have been identified, mainly distinguished by leaf characteristics. Teak occurs in deep, fertile, well-drained soils, often in alleviating typography up to 1,000 m above sea level. It does not tolerate flooding or infertile soils, but is relatively tolerant to fire (Soerianegara and Lemmens 1993).

Teak seedlings are ready to be planted when they have strong roots with a porous medium, a single, strong and woody stem and healthy new leaves (Pramono et al. 2012). Teak is commonly planted in the field with spacings of 2 m × 2 m, 3 m × 1 m, 3 m × 3 m, 4 m × 4 m, 4 m × 2 m or 4 m × 4 m, depending on site conditions. In addition, it is often planted in varying types of agroforestry systems on, or around farm land. Teak can also be regenerated by using wilding or coppicing. The soil should be prepared before planting. Frequent weeding is required in the first years after planting, as teak seedlings are easily suppressed by weeds (Soerianegara and Lemmens 1993, Pramono et al. 2012). The recommended fertilizers dose per tree is 50 g of NPK in the first year, 100 g in the second year and 150 g in the third year. In addition, 10 kg of manure and 150-250 g dolomite (if soil with low pH) is recommended to be applied in the planting hole before planting. Infilling should be done for any dead seedlings during the rainy season. It is recommended that pruning should commence in the third year in the early rainy season, with less than 50% of the tree to be pruned (Pramono et al. 2012).

Thinning should commence when trees are three to four years old, and thinned frequently every 3-5 years until the trees reach the age of 15, and then every 5-10 years thereafter (Pramono et al. 2012). According to the thinning table from Perum Perhutani, when the average tree height reaches 13.5–15.5 m, the number of trees after thinning should be 1,000 – 1,100 trees ha^{-1}. This can be achieved on fertile soils in seven years and on low quality soils in up to 17 years (See Pramono et al. 2012). The thinning frequency depends on the site quality, being more frequent

in better quality sites (Soerianegara and Lemmens 1993). Teak trees are harvested when they are mature enough to produce good quality wood (minimum 15-20 years) and preferably when the price is high (Pramono et al. 2012). Teak should be grown for a longer period of time if possible, to produce larger diameter trees. Soerianegara and Lemmens (1993) for example, reported the teak harvesting age in Indonesia to be 80 years. Sometimes teak is girdled two years before logging in order to kill and dry the trees making them easier to transport.

Soerianegara and Lemmens (1993) reported the average yield of teak plantations in Java to be 60-100 m^3 ha^{-1} including thinnings. With a long rotation length (80 years) the final harvest may even reach 390 m^3 ha^{-1}. MAI of volume ranges from 1-15 m^3 ha $year^{-1}$. According to a study of industrial teak plantations in Java by Suharlan et al. (1975), the DBH of trees between the ages of 10-110 years in the lowest quality sites ranged from 5.8-28.4 cm, with a height range of 5.8-15.2 m. In the highest quality sites these values increased to a DBH range of 19.0-85.1 cm, and a height range of 21.0-49.4 m. The FAO (2006) reported MAI of 5-11 m^3 ha^{-1} $year^{-1}$ for teak in Southeast Asia, with a rotation length varying form 34-58 years.

Teak does not suffer of major pressures in terms of susceptibility to pests and diseases in Indonesia. Teak can be infected by bacteria such as *Pseudomonas solanacearum* and fungi such as *corticium salmonicolor*. It can also commonly be attacked by wood borers (such as *Monohammus rusticator* or *Xyleborus destruens*), leaf eating caterpillars (*Pyrausta machaeralis* or *Hybleae puera*), tree termite *Neotermes tectonae,* or infested by semi-parasitic mistletoes *(Loranthus spp.)* (Soerianegara and Lemmens 1993). The various pests and diseases may be controlled by, for example, removing the sick trees, proper thinning, or by chemical control (Pramono et al. 2012).

Figure 5. Teak plantation in Sendangijo Village, Central Java.

3. Site selection and description

3.1. Site selection

Case studies in three provinces from three of Indonesia's five major islands (that have the majority if Indonesia's industrial tree plantations) are included in this study; the province of Central Java in Java, the province of South Kalimantan in Kalimantan, and the province of Riau in Sumatra (Figure 6). Based on Rapid Rural Appraisals (RRA), seven villages were selected as study sites, from which four case studies were developed (Table 1). The RRAs were conducted with a multidisciplinary research group and consisted of site visits and interviews with key-informants from relevant subnational-offices, companies, organizations and local people. The villages were selected because they all were active in tree planting for timber or fiber production, and in addition, they varied in the species planted, the external support arrangements, the market conditions, the land-use competition, and the length of tree-planting experience.

In order to select the study sites in Kalimantan, rapid appraisals were conducted in four districts of South Kalimantan Province (i.e. Banjar, Tabalong, Hulu Sungai Selatan, and Tanah Laut) where smallholder timber tree planting took place and where there were plans to implement the HTR program. In South Kalimantan the district of Tanah Laut was selected as the research site because: a) there were clear government plans to expand smallholder tree planting under the HTR program; b) the district had a range of different timber plantation initiatives under way; c) markets and timber processing industries were available; and d) there was a significant level of land-use competition (mainly in form of oil palm and rubber plantations). Tanah Laut's sub-districts of Takisung and Jorong were selected as study areas based on the information collected from the District Forestry Office and key informant interviews during the site visits and RRA (Table 3). These two sub-districts were considered to be the most active sub-districts when it came to tree planting activities in the district. Finally, two villages that were actively involved in tree planting were selected based on key informant interviews and RRA as study sites, namely Ranggang village in Takesung Sub-district, and Asem Jaya village (formerly called Trans 400) in Jorong Sub-district.

In order to select the study sites in Sumatra, RRAs were conducted in four districts of Riau Province (i.e. Pelalawan, Kuansing, Rokan Hulu, and Kampar), where smallholder timber tree planting took place and where there were plans to implement the HTR program. In Riau we selected the district of Kuansing as a project site because: a) the government had plans for expanding the smallholder tree planting under the HTR program in the district; b) there were community-company partnerships for acacia plantations in the area; and c) there was a significant level of land-use competition (mainly in form of oil palm and rubber plantations). The sub-district of Logas Tanah Darat was selected as our specific study area based on the information collected from the District Forestry Office and key informant interviews during the site visits and RRA (Table 3). The sub-district was considered to be the most active sub-district involved in an acacia planting partnership scheme with a multinational paper company. Finally, we selected three villages involved in the acacia partnership as project sites, namely Situgal, Lubuk Kebun and Rambahan based on RRA. The selection of these three villages provided a representative number of households involved in the partnership project, but also provided

different age classes of plantations which were important for the other components of the larger research project under which this PhD study was conducted (Strengthening Rural Institutions to Support Livelihood Security for Smallholders Involved in Industrial Tree-planting Programs in Vietnam and Indonesia).

The Province of Central Java was selected as the study province in Java because that is where most smallholder timber tree planting in Java takes place (MoF and National Statistics Agency 2004). In Central Java, Wonogiri and Karanganyar Districts were selected as study sites following RRA, where it was determined that smallholder timber tree planting was very active. Because most of the planned HTR plantations are located outside Java, this was not used as criteria for the site selection in Java. However, it was important to include Java as a study site because the Javanese farmers have the longest experience in planting timber trees, and thus the site provided lessons learnt from previous experiences. In Wonogiri district we visited five sub-districts (Batuwarno, Giriwoyo, Manyaran, Pracimantoro, and Selogiri) and seven villages (Selopuro, Sumberejo, Piji Harjo, Sejati, Gumantar, Sendangijo, and Watang Rejo) to conduct RRAs. Finally, Sendangijo village in Selogiri sub-district (Table 3) was selected as being the most suitable study site. In Karanganyar we visited the sub-district of Gondangrejo (Table 3) and the villages of Dayu and Rejosari, of which Rejosari was selected as our study site. The villages were selected because both of them had a minimum of 40 farmers planting timber producing tree species in woodlots. Two sub-villages were selected as study units in each village because the village populations were too high to be study units, and because of the differences in socio-economic conditions between the sub-villages. The two sub-villages were selected randomly from those sub-villages that had high numbers of tree planters. In Sendangijo, the sub-villages of Kedung Banteng and Jethis were selected, and in Rejosari the sub-villages of Sosogan and Genjikan were selected (see Table 1).

Figure 6. The study sites in Java, Sumatra and Kalimantan islands.

Table 1. Key characteristics of the selected case study villages (modified based on Table 1 in Study I).

	Case study 1	Case study 2	Case study 3	Case study 4	
Island	Sumatra	Kalimantan	Kalimantan	Java	Java
Province	Riau	South Kalimantan	South Kalimantan	Central Java	Central Java
District	Kuansing	Tanah Laut	Tanah Laut	Karanganyar	Wonogiri
District coordinates	S 0º00'– S 1º00' E 101º02' – E 101º55'	S 3º30'– S 4º11' E 114º30' – E 115º23'	S 3º30'– S 4º11' E 114º30' – E 115º23'	S 07º28'– S 07º46' E 110º40'– E 10º70'	S 7º 32' – S 8º 15' E 110º 41'– E 111º18'
Sub-district	Logas Tanah Darat	Jorong	Takesung	Gondang Rejo	Selogiri
Village	Lubuk Kebun, Rambahan, Situgal	Asem Jaya	Ranggang	Rejosari	Sendangiijo
No of sub-villages	3	8	10	5	8
Sub-village names	NA	NA	NA	Genjikan, Sosogan	Kedung Banteng, Jethis
Species	*Acacia mangium* Willd.	*Anthocephalus cadamba* Miq.	*Swietenia macrophylla* King.	*Tectona grandis*	*Tectona grandis*
Native/exotic	Exotic (in Riau)	Native	Exotic	Exotic/ naturalized	Exotic/ naturalized
Growth pattern	Fast	Fast	Medium	Medium	Medium
Length of experience	Second rotation started 1995	First rotation started 2003	First rotation started 2003	Started in 1976	Started in 1973
No. of respondents selected	117	67	101	60	67
Availability of external support	Company-community partnership	Company initiated	Self-initiated and government supported (GERHAN 2007)	Self-initiated and government supported (GERHAN 2003, 2007)	Self-initiated and government supported (GERHAN 2003, 2004, 2007)
Management	Company	Farmer	Farmer	Farmer	Farmer
Market availability	Available but with low price	Difficult, not enough information	Available, industry	Available, middleman	Available, middleman
Land competition	High with rubber & oil palm	Medium with oil palm & agriculture, high with rubber	Medium with oil palm & agriculture, high with rubber	Medium with agriculture	Medium with agriculture

Table 2. Key characteristics of the selected case study districts.

District	Kuansing (Riau, Sumatra) [1]	Tanah Laut (South Kalimantan, Kalimantan)[2]	Wonogiri (Central Java, Java)[3]	Karanganyar (Central Java, Java)[4]
Coordinates	S 0º00'– S 1º00' E 101º02' – E 101º55'	S 3º30' – S 4º11' E 114º30' – E 115º23'	S 7º 32' – S 8º 15' E 110º 41'– E 111º18'	S 07º28' – S 07º46' E 110º40' – E 10º70'
Number of sub-districts	12	9	25	17
Number of villages	210	134	294	177
Population	221,676 (2000)	265,629 (2007)	1,212,677 (2008)	865,580 (2008)
Population density (persons/km^2)	29	73	665	1,119
Number of households	64,650[5]	70,382	407,629	221,949
Climate	Humid tropical	Humid tropical	Humid tropical	Humid tropical
Mean annual temperature ^oC	21 Cº –35 Cº	27 Cº – 28 Cº	24 Cº –32 Cº	22 Cº–31 Cº
Mean annual rainfall (mm/year)	229 – 1,133	2,766	NA	2,453
Total land area (ha)	765,603	363,135	182,236	77,379
Wet land (ha)	NA	77,105	32,235	22,474
Dry land (ha)	NA	286,030	62,434	54,902
Total government forestry land (ha)	225,003[6] Production Forest: 127,145 Protected Forest: 49,041 Conservation Forest: 48,817	131,718 Production Forest: 104,404 Protected Forest: 9,575 Conservation Forest: 17,739	20,117 Production Forest: 16,969 Protected Forest: 3,054; Forest with specific purpose: 93	7,633[8] Production Forest: 126 Protected Forest: 7,443 Conservation Forest: 64
Main agricultural crops planted	Rice, corn, soybean	Rice, corn, cassava, sweet potatoes, peanuts, soybean, mung bean	Rice, corn, cassava, peanut	Rice, corn, cassava, peanut
Main estate crops planted (ha)	Rubber (248,501), oil palm (147,936)	Oil palm (62,011), rubber (11,198)	Clove, sugar cane	Clove (1,509), tea, rubber
Main income sources of the people (%)	Agriculture[7] (68.4), trader (13.1), industrial or construction labor (8.9)	Agriculture 100%	Agriculture (own & labor) (40.2), industrial or construction labor (7.9), trader (7.5)	Agriculture (own & labor) (30.8), industrial or construction labor (21.6), trader (6.2)

Sources 1–8 (see Annex 2)

Table 3. Key characteristics of the study sub-districts.

Sub-district	Logas Tanah Darat[9] Kuansing Riau	Jorong[10] Tanah laut Kalsel	Takisung[10] Tanah Laut Kalsel	Selogiri[11] Wonogiri Central Java	Gondangrejo[12] Karanganyar Central Java
Number of villages	13	10	12	11	13
Population	14,039 (2000)	25,887 (2007)	26,997 (2007)	54,520 (2008)	68,571
Population density (people/km^2)	37	41	79	1,087	1,207
Number of households	3,614	7,819	6,289	11,402	18,114
Total land area (ha)	38,034	62,800	34,300	5,018	5,680
Elevation (m.a.s.l.)	NA	NA	NA	114	150

Sources 9–12 (see Annex 2)

3.2. Description of the study areas

3.2.1. Study islands and forestry

The circa 200 M people living in Indonesia are unevenly distributed across more than 17,000 islands, with approximately half the population on the island of Java, which constitutes only 6.9% of the country's total land area (Guizol and Aruan 2004).

Indonesia's forest resources are also unevenly distributed, with the most populated islands, such as Java and Bali, having lost most of their natural forests in a process that began in the colonial era and continued into the modern era. These heavily populated islands are now characterized by having diverse agroforestry and farm forestry systems that thrive in the fertile, volcanic soils (Figure 7). Java also has vast areas of teak plantations which are mainly managed by a state-owned company ("Perum Perhutani"), but there are an increasing number of smallholders farming teak (Wiersum 1982, Slender and Lasco 2008). In addition to teak, sengon (*Paraseriantes falcataria*) and mahogany are also commonly planted in Java (Guizol and Aruan 2004). During the 1970s most of Indonesia's degraded areas were found in Java due to the overexploitation of natural forests during the Dutch and Japanese colonial periods and onwards. Hence most of the early tree planting programs occurred in Java, driven by environmental objectives (flood prevention and soil erosion). Major flooding events in the late 1960s and early 1970s around Solo, Central Java, led to further land rehabilitation efforts (Nawir 2007). Due to the high population density on Java, farmers generally have limited land area, and so there is a lot of pressure to convert the remaining natural forest to agricultural land. However, despite that farmers' in Java have small land areas, tree planting is increasingly common, as the demand for wood products grows and local markets become available (Nawir 2007).

Figure 7. Diverse land use systems are found in the fertile soils of Central Java, with teak playing an important role; being planted inside and around agricultural systems.

The islands of Sumatra, Kalimantan and Papua were, until relatively recently, covered by extensive forests that accounted for approximately 80% of Indonesia's total natural forest area. In 1950 for example, Indonesia's forest cover was estimated to be 162 M ha, or 84% of the total land area (Hannibal 1950, cited in FWI/GFM 2002), whereas todays' figures are close to half of that (FAO 2011). These forests were, and still are, amongst the world's most biologically diverse forests. Although there are still vast areas of natural forest remaining in Indonesia's outer islands compared to Java, since the 1980s this area has been deforested or degraded at an alarming rate, and will continue to do so as they provide a cheap source of wood and land (Davis 1989, Guizol and Aruan 2004). Currently, the most degraded forest areas in Indonesia are located in Sumatra and Kalimantan, where a concentration of logging operations conducted by private companies with government authorized concessions (e.g. HPH – Hak Pengusahaan Hutan) have been taking place (Nawir 2007). The highest deforestation and degradation rates (and industrial plantation development) in Sumatra are concentrated in the province of Riau, whilst the highest concentration of degraded areas in Kalimantan are in Central Kalimantan (Nawir 2007).

Forest plantations in Kalimantan and Sumatra are commonly Industrial Forest Plantations (HTIs) that are managed by private or government companies. A concerted effort is now made to include smallholders and communities in these activities (via employment, company-community partnerships, or other incentives) after the realization that such programs were unsustainable

without the involvement of the local communities and due to the social and environmental pressure internationally. In the 1970s the Indonesian government implemented an intensive transmigration program with the aim to provide cheap labor for plantation companies, and to control population growth in the densely populated islands of Java and Bali. These transmigration programs played a major role in the development of plantations in Indonesia's outer islands, and also significantly affected forest cover by allowing conversion to agriculture (Guizol and Aruan 2004). In some cases the agricultural conversions were unsuccessful and so new forest areas were opened up; an process which sometimes led to conflicts with the local people (Nawir 2007). The plantations in Kalimantan and Riau are predominantly fast growing species producing wood for the pulp and paper industry (such as *Acacia mangium, Eucalyptus sp. and Pinus sp.*) (Guizol and Aruan 2004). The current HTR plantation development plan is focused mainly in Indonesia's outer islands, including Kalimantan and Sumatra (Obidzinski and Dermawan 2010).

Forest plantation development in Sumatra and Kalimantan also has to compete with oil palm and rubber plantations, with the oil palm sector in particular receiving a variety of government incentives that make it a very attractive land-use option (Potter and Lee 1998). The rubber plantations are either monoculture plantations or diverse "jungle rubber" systems (Figure 8), where a variety of native and multipurpose species - including fruit trees - are planted or enhanced to regenerate naturally (Nawir 2007). Other rehabilitation and afforestation programs, such as GERHAN, have also been taking place in both Java and the outer islands; but unfortunately most of the trees in the plantations associated with this program have had poor survival rates (Guizol and Aruan 2004).

Figure 8. The study area in Riau, Sumatra is still relatively forested compared to the other study sites. The forest areas around the villages are diverse and have been enriched by the local people with several fruit species and jungle rubber (*Hevea brasiliensis*).

3.2.2. Study districts and sub-districts

The characteristics of the four selected districts (Kuansing, Tanah Laut, Wonogiri and Karanganyar) and the five selected sub-districts (Logas Tanah Darat, Jorong, Takisung, Ratuwarno and Gondangrejo) are presented in Table 1, 2 and Table 3, respectively. In general the selected sites in Riau and South Kalimantan were significantly more forested, with a much smaller population with lower density compared to the sites in Central Java, which were densely populated with few natural forests remaining. In all of the selected areas, the main household income came from on-farm sources (e.g. agricultural crops and rubber), but in Java more income came from off-farm sources (e.g. agriculture and factory labor, construction etc...) compared to the Riau and South Kalimantan sites. The main land competition for tree planting in Riau and South Kalimantan was rubber and oil palm, whereas in Java it was paddy rice, clove, tea, sugar cane and other agricultural crops (Table 1 and Table 2).

3.2.3. Case Study villages

Case study I: Lubuk Kebun, Rambahan and Situgal Villages

The three villages in Riau Province (Sumatra) - Lubuk Kebun, Rambahan, and Situgal - were located close together and shared similar general conditions; thus these villages were considered as one case study for the analyses. There were 81 people living in Lubuk Kebun Village, 250 in Rambahan Village, and 85 in Situgal Village. Each of these three villages had only one sub-village. The main ethnic group was Riau Malays, but there were also immigrants from Java and different parts of Sumatra in the villages. The main livelihood of the people in this case study site was rubber tapping. In addition to rubber, farmers mainly planted oil palm, fruit trees, acacia and agricultural crops (such as cassava, corn and soya bean). In this case study site the research focus was on an acacia partnership plantation program between the farmers and a multinational pulp and paper company (Figure 9). In this partnership each participating farmer received a minimum of two hectares of village land from the village authorities, which they leased to the company to plant, manage and harvest acacia for pulp production (starting in 1999). At the end of each rotation, farmers received the pre-agreed amount of money from the company. Acacia is fast-growing species with each rotation for fiber production set at six years. At the time of this study, the plantations were on their second rotation (Table 1).

Figure 9. Some of the incentives provided by the pulp and paper company benefited all the villagers, such as the development of the village road, Riau, Sumatra.

Case study II: Ranggang Village

Ranggang Village in South Kalimantan Province had a population of 738 people, of which most were from the Banjarnese ethnic group (approximately 80%), and the rest were Javanese. There were 10 sub-villages in the village. The main livelihood activity was rubber tapping, although farmers also planted fruit, mahogany and a range of agricultural crops such as cassava, corn and soya beans. In this case study the research focus was on mahogany planting. In order to encourage the farmers to plant trees on their private land, since 2003 the local government provided free mahogany seedlings under the GERHAN program (Figure 10). Most of the mahogany planting occurred in the two sub-villages that were dominated by Javanese people, and all silvicultural management was conducted by the farmers. There was a market for mahogany in Ranggang Village that supplied a furniture company in the neighboring sub-district. Mahogany is a moderately fast growing species, and the farmers planned to harvest the timber between 10 and 25 years. At the time of this study, the plantations were on their first rotation (Table 1).

Figure 10. Cows were able to pasture between the widely planted mahogany trees, Ranggang Village, South Kalimantan.

Case study III: Asem Jaya (Trans 400) Village

Asem Jaya Village, South Kalimantan Province, had a population of 383 people living in eight sub-villages. The village was formerly called 'Trans 400', and was founded as part of the government's transmigration program in 1970s. Thus most of the people in the village were Javanese migrants. As was the case in Ranggang Village, the main livelihood activity in this village was also rubber tapping; but in addition they also planted kadam trees, fruit trees, and agricultural crops such as cassava, corn and soya beans. In this case study the research focus was on kadam planting on farmers' private land. The kadam seedlings were supplied by a plywood company which, at the time of the plantation establishment (starting in 2003), promised markets and income. However, at the time of the field-work the market for kadam timber was unsecure because the company that provided the seedlings went out of business. The silvicultural management in the village was conducted by the farmers. Kadam is a fast growing species, but the farmers had not planned a rotation length because of the lack of markets. At the time of the study the plantations were on their first rotation (Table 1).

Case study IV: Sendangijo and Rejosari Villages

The two sample villages in Central Java - Rejosari and Sendangijo - were also grouped as one case study because of their similar conditions related to the species planted, external support arrangements, market conditions, land-use competition, and length of timber tree planting experience. The populations of the two studied sub-villages of Rejosari Village were, 191 in Sosogan and 188 in Genjikan; and the populations of the two studied sub-villages in Sendang Ijo were 146 in Kedung Banteng and 76 in Jethis. The main livelihood activity in these two villages was agriculture (mainly rice, but also cassava, corn and soya beans) (Figure 11). In addition, most households had some family members working as migrant laborers in bigger cities in Java (e.g. in the industrial or construction sectors). Most households that had land also planted teak which was the research focus in this case study. In both villages, farmers planted teak either under their own initiative or they had received seedlings from the government's rehabilitation program (GERHAN). The silvicultural management was conducted by the farmers themselves. Marketing teak was easy for farmers in these study sites because they could even sell individual trees to the local middlemen who then harvested and transported the wood. Teak is a moderately slow growing species, and the farmers planned to harvest timber at the approximate age of 20 years and older, depending on their needs for income. At the time of this study, the plantations were on their first rotation (Table 1).

Figure 11. In Central Java the main land use activity was paddy rice; but teak plantations can be seen bordering the rice fields.

4. Methods

4.1. Respondent selection

4.1.1. Grouping of respondents

Key-informant interviews and participatory mapping were conducted in 2008 in Kalimantan and Sumatra and in 2010 in Java in order to collect base-line information about potential study villages, and to identify – for the purpose of sampling – who the tree planters and non-planters were. The model of how the farmers planted trees was also determined; whether in woodlots, home gardens or on agricultural borders of their land. Tree planters and non-tree planters were defined for each study site according to the different species they were planting. In the three villages in Riau the farmers were divided into acacia planters and non-acacia planters; in Asem Jaya Village into kadam planters and non-kadam planters; in Ranggang Village into mahogany planters and non-mahogany planters; and in the two villages in Central Java teak planters and non-teak planters. Most of the farmers in all the villages planted several other tree species on their land (mainly fruit trees, and in South-Kalimantan and Riau also rubber; *Hevea brasiliensis* Muell. Arg), however only tree species that were planted primarily for timber or fiber production were included in the analyses. This means that when we refer to 'tree-planters', we are referring to farmers planting acacia, kadam, mahogany or teak only; whereas 'non-tree planters' are those farmers not planting these species.

Initial wealth ranking was conducted in order to have representative number of farmers from different wealth categories in the sample. The three different wealth categories were; poor (1), moderate (2), and wealthy (3), and the rankings were based on village statistics and the criteria determined by the key informants (Annex 1). The key informants included participants from the village, sub-village, and farmers' group levels.

4.1.2. Sampling

The aim was to select the household respondents using stratified random sampling. First the province, district, sub-district, village, and sub-villages (in the case for the Central Java case study) were purposefully selected according to the criteria explained in section 3.1. Tree planting and non-tree planting respondents were randomly selected in each village, in proportions according to their wealth ranking (poor, medium, and rich). A minimum of 30 tree planters and non-tree planters per site were selected if available (the three villages in Riau were considered as one site while selecting the respondents and during the analyses). Modification of the sampling plan was required however, because random sampling would not have guaranteed a representative number of tree planters. This is why the farmers planting mahogany in Ranggang village, kadam in Asem Jaya village and teak in the sub-villages in Sendangijo were purposefully selected (all the households planting trees in even-aged woodlots were selected). In addition, in Ranggang village 24 households planting mahogany on the borders of their land were selected (however these households were not used for the study on the silvicultural practices and the quality of the stands). A total of 412 farmers were interviewed; including 78 acacia planters and 39 non-acacia planters, 31 kadam planters and 36 non-kadam planters, 44 mahogany planters and 57 non-mahogany

planters, 67 teak planters and 60 non-teak planters. The number of the selected respondents varied between the villages because of the varying number of households, the varying number of tree planters and non-tree planters in the villages, and because of variation in the time, resources, and number of researchers available during each site visit.

4.2. Inventory methods

All of the selected tree planter's stands that were planted in multiple rows with regular spacing were inventoried in the four villages in South Kalimantan and Central Java (excluding trees planted only in the borders of the land). Links were made between the household surveys and the forest inventories for all selected farmers except for the three villages in Riau, where the link could not be made because farmers did not know exactly where their two hectares of land was located (that was planted with acacia in the village land as part of the company-community partnership), and were not involved in the silvicultural management. This made it impossible to study the factors influencing farmers' silvicultural management in Riau, thus only the factors affecting farmers' decisions to join the partnership in this site were studied.

The unit of analysis for the inventory was a tree stand with an area of 0.1 ha or greater and containing a minimum of 50 trees that were planted by a farmer or their forbearers. The aim was to measure 20 trees per sample plot, and to establish one or more fixed area of sample plot (circular plots) in each stand (depending on stand size and planting density). Each stand was classified using visual observations in one of the following three stand quality groups: (1) well-maintained trees in generally good condition; (2) overall condition acceptable, some problems are likely to appear; and (3) poorly managed, and success or survival of the stand is doubtful. DBH was measured for each tree. Total tree height and the height of the crown base were measured for 25-30% of the trees in each plot in the villages in South Kalimantan and for all the trees in the plot in the villages in Central Java. Each tree was classified into one of the following stem quality classes related to sawn wood value: (1) high, no major irregularities or defects; (2) medium, in part usable as sawn wood, some defects; and (3) poor, unsuited for sawn wood, too many defects. In addition, trees were classified into three groups according to their overall condition with respect to viability and growth potential: (1) dominant, in the upper crown layer and superior to immediate neighbors; (2) sub-dominant, in the lower crown layer and receiving less light, smaller than immediate neighbors; and (3) others, all trees that neither had major nor medium irregularities and defects, that are not in groups 1 and 2.

4.3. Interview methods

Two structured questionnaires, a socio-economic and a silvicultural management-oriented questionnaire, were applied in the household interviews. The questionnaires were field-tested and then modified before implementation. Interviews were conducted at farmers' houses by enumerators from the local Forestry Research Institutes and the Forestry Research and Development Agency (FORDA). The enumerators were trained, supervised and accompanied by the researcher. The socio-economic questionnaires collected data on household characteristic including the number

of the household members, age, gender, education, occupation, expenses, assets, income sources, market access, and participation in farmers' groups or other social organizations and on farm characteristics including land area, land use and land ownership. The silvicultural management questionnaire included questions on: (1) farmers' selection of species, silvicultural knowledge and practices; (2) farmers' motivations and attitudes towards tree planting; (3) incentives received for tree planting; (4) disadvantages related to tree planting; (5) previous or planned use of income received from timber; and (6) farmers' ideas for improving tree planting activity.

The socio-economic questionnaire was administered to all farmers, whilst the silvicultural management questionnaire was administered only to the tree planters. The questions related to farmers' silvicultural practices were applied for each stand separately in South Kalimantan and Java.

4.4. Statistical analyses

Descriptive statistics, chi square, Mann-Whitney U test and *t*-tests were used for the analyses conducted in Study I in order to study the relationships between farmers' socio-economic characteristics and their tree planting activity. To study the relationship between socio-economic factors and farmers' silvicultural activity, data were analyzed using Spearman correlations, descriptive statistics, Mann–Whitney U tests and cross tabulations (Study II and III). The relationship between plantation quality and the silvicultural practices applied by the farmers was analyzed using descriptive statistics and by hypothesizing and statistically fitting a general linear model (Study II).

5. Results

5.1. Factors influencing farmers' tree planting activity (Study I)

The socio-economic characteristics of tree planters and non-tree planters differed significantly within each of the four case studies (Table 4). However, between the case studies the socio-economic characteristics that differed significantly between the tree planters and non-tree planters were different, and thus were specific for the conditions at each site (such as markets, access to off-farm income sources, length of tree planting experience etc.). Tree-planters had the following socio-economic characteristics:

- Ownership of larger areas of land (in all four cases)
- Higher value of total assets (acacia, mahogany, and teak planters)
- More likelihood to be members of a farmers group (acacia, mahogany, and teak planters)
- More likelihood to be members of other social organizations (acacia and mahogany planters only)
- Higher total yearly expenses per capita (acacia and mahogany planters only)
- They were generally older (household heads) (acacia and teak planters only)
- Their most important income source came from on-farm (mahogany planters only)
- Other peoples' attitudes towards tree planting was more important to them while deciding whether or not to plant trees (mahogany planters only)
- They had more household members (acacia planters only), compared to the non-tree planters.

Socio-economic characteristics that did not differ between tree planters and non-tree planters were:

- The number of income earning household members,
- Years joining the farmers group,
- Years of education,

Furthermore, the attitudes towards tree planting were not significantly different between tree planters and non-tree planters in any of the case studies.

Farmers' willingness to continue tree planting also varied between the case studies. In the mahogany and teak planting villages, where markets were available, almost all farmers wanted to continue tree planting (mahogany 88% and teak 98%), regardless of their socio-economic characteristics. Over a third (39%) of kadam planters did not want to continue tree planting under the current arrangement, with several farmers (with enough resources) even replacing their kadam stands with rubber trees. This was due to a lack of confidence related to markets, since the company that initially supported kadam planting (and promised to buy the wood) went bankrupt. No statistical comparisons were conducted between the socio-economic and perceptional characteristics of the farmers who wanted to continue kadam planting or not due to the small sample size. Acacia planters were the group least satisfied with their current land use

system. Almost half of the farmers (44%) were unwilling to continue under the acacia partnership. The farmers that were not willing to continue under the current partnership had less household members contributing towards household income, joined fewer years in the farmers group, had higher levels of education, and although not significant, they also had a higher value of assets compared to the farmers that wanted to continue acacia planting.

Table 4. Comparison of the socio-economic and perceptional characteristics between: (a) the acacia planters (*n*=78) and the non-acacia planters (*n*=39); (b) the kadam planters (*n*=31) and the non-kadam planters (*n*=36); (c) the mahogany planters (*n*=44) and the non-mahogany planters (*n*=57); (d) and the teak planters (*n*=67) and the non-teak planters (*n*=60) (modified based on Table 2 in Study I).

Variable	Acacia planters Mean ± std	Non-Acacia planters Mean ± std	*p*	Kadam planters Mean ± std	Non-kadam planters Mean ± std	*p*	Mahogany planters Mean ± std	Non-mahog-any planters Mean ± std	*p*	Teak planters Mean ± std	Non-teak planters Mean ± std	*p*
Age of farmer (years)	43.14±13.59	27.85±5.80	***	47.58±14.45	45.39±15.37	NS	46.41±12.70	42.19±10.80	NS	49.78±13.44	40.17±13.83	***
No. of household members	4.29±1.52	3.38±0.96	***	4.10±1.40	4.44±1.54	NS	3.70±1.00	4.00±1.44	NS	4.37±1.62	4.227±1.52	NS
No. of income earning household members	1.35±0.58	1.26±0.45	NS	1.77±0.88	1.94±1.17	NS	1.68±0.83	1.53±0.71	NS	2.66±1.10	2.33±1.10	*NS*
Total land area (ha)	4.95±2.79	1.22±2.19	***	3.05±3.20	1.96±1.82	*	3.37±2.15	1.01±1.14	***	1.10±1.41	0.11±0.27	***
Total value of assets (millions of IRp)	15.51±21.50	5.72±10.56	***	14.14±14.59	15.56±17.41	NS	25.58±22.59	15.57±20.53	***	19.38±27.93	10.65±18.34	***
Total expenses per capita (millions of IRp/year)	5.36±3.63	4.43±4.27	***	3.55±2.94	2.99±2.07	NS	4.88±3.56	3.58±2.75	*	3.22±1.77	3.03±1.64	*NS*
No. of years membership in the farmers' group	10.21±2.55	5.40±5.18	NS	8.07±7.37	8.61±7.17	NS	9.76±7.31	6.52±5.38	NS	5.40±6.18	3.64±2.68	*NS*
Education (years)	5.54±3.65	6.38±3.52	NS	6.86±3.70	6.72±3.07	NS	7.76±3.37	6.96±2.29	NS	7.96±3.06	8.53±3.11	*NS*
Membership in farmers' group (%)	93.6	12.8	***	71.0	61.1	NS	81.8	29.8	***	70.1	30.0	***
The most important income source from off-farm (%)	1.3	7.7	NS	64.5	58.3	NS	13.6	52.6	***	71.6	83.3	*NS*
Membership of social organization (%)	97.4	33.3	***	90.03	83.3	NS	93.2	63.2	***	97.0	93.3	*NS*
Favorable or very favorable attitudes towards tree planting (%)	84.4	81.1	NS	76.7	52.4	NS	95.2	ND		97.0	98.3	*NS*
Other peoples' attitudes towards tree planting being very important for decision to plant trees (%)	6.6	5.4	NS	3.3	8.0	NS	47.1	6.3	***	95.4	100	NS

Note: for the total assets in Java furniture was not included; NS (not significant) = ≥0.05, * = ≤0.05, ** = ≤0.01, ***= ≤0.001; ND = no data

Note: t-test and Mann-Whitney-U test were used to compare the characteristics of the tree planters and non-tree planters

5.2. Farmers' reasons for planting or not planting trees (Study I)

Farmers typically indicated several reasons for planting trees, but in each case study the main reason for planting was economic (Table 5). For acacia planters, social reasons for tree planting were also important, as one third of respondents mentioned the 'existence of the acacia partnership', 'following the other farmers', or 'social pressure' to be the reasons for planting. Environmental reasons for tree planting were mentioned by one third of the teak and mahogany planters, by approximately one fifth of the kadam planters, and only by approximately one tenth of the acacia planters. In Java, teak was also planted for making use of bare land (i.e. land with limited use; mainly because of a lack of labor, resources, or suitability for agriculture). Farmers planting teak and mahogany also often reported that trees were planted in order to provide wood for their own construction needs.

The main reason reported for households not participating in the acacia partnership was that these households were not established at the time of the program implementation, thus they were not allocated village land for the acacia planting. The households that were not planting kadam mainly reported that they preferred rubber planting because it provided regular income. In the mahogany and teak planting villages, farmers who did not plant trees were mainly those who did not have land (Table 5). In fact, according to observations and the key informant interviews in the two Java villages, almost all the farmers who owned land actually planted - or allowed natural regeneration of - at least some teak.

Trees mainly acted as saving accounts, as most of the tree planters (83% of the acacia planters, 85% of the kadam planters, 84% of the mahogany planters, and 80% of the teak planters) used or planned to use the income received from wood for anticipated expenditures, such as for school fees. Almost all acacia planters (95%) and most of the kadam planters (74%) also used or planned to use the income from wood for daily consumption. More than half of the acacia planters also had used or planned to use the income as a safety-net for unexpected expenditures.

Table 5. Farmer's reasons for planting timber trees (a) and not planting timber trees (b). Figures show the percentage of farmers citing the given reason to plant or not plant timber trees (modified based on Table 3 in Study I).

(a) Reasons for planting timber trees	Acacia planters (%)	Kadam planters (%)	Mahogany Planters (%)	Teak Planters (%)
Savings/investment	46	83	86	58
Building material	13	0	21	37
Fuel wood	3	0	2	0
Wood price/existing markets	0	0	16	6
Incentives	5	10	2	2
Involved in a company partnership/participate in a program/ follow the other farmers/social pressure	33	20	5	0
Environmental reasons (erosion, rehabilitation, water conservation)	13	23	33	33
Hobby/satisfaction	1	0	2	0
Characteristics of wood as an asset (can be sold little by little)	1	0	5	0
Land border/for land security	12	0	0	0
Land suitable for teak	0	0	0	22
Low labor requirements	0	0	0	2
Use the bare land	0	0	0	27
Difficult access to the land	1	0	0	0

(b) Reasons for not planting timber trees	Acacia planters (%)	Kadam planters (%)	Mahogany Planters (%)	Teak Planters (%)
Prefer rubber trees	4	43	2	0
Prefer agriculture	0	5	0	7
No land	20	5	74	85
No seedlings	0	5	6	0
Not profitable/no resources	0	10	10	0
No help/incentives	0	5	2	0
No markets	4	0	0	0
New household	60	5	0	0
Do not like tree planting	0	5	0	0
Farmer illness	0	5	0	0
Long rotation	0	5	0	2
No time/labor	0	5	0	2
Land not suitable	0	5	0	5
Land too far/too near the road	0	0	4	0
Already family members planting	0	0	2	0
New comer in the village	12	0	0	0

Note: (a): Farmers could mention several reasons for planting. Data from acacia planters (n=78), kadam planters (n=30), mahogany (n=43), and teak planters (n=67)

Note: (b): Farmers could mention several reasons for not planting. Data from acacia planters (n=25), kadam planters (n=21), mahogany (n=50), and teak planters (n=60)

5.3. Disadvantages related to tree planting (Study I)

The most often cited disadvantages related to tree planting by the acacia planters were the slow growth or long rotation length. Low prices received for the wood or unfair benefit sharing arrangements were also often cited by the farmers. Long rotation length was mentioned because rubber planting, the most popular land use option in this area of Sumatra, provided regular income to farmers once established. Half of the acacia farmers could not name any disadvantages, as they had never seen their plantation or they did not even know where it was physically situated. This was because the two hectares of land that the farmers had received existed on paper, but it was not known specifically where the farmers' land was within the acacia plantation, as previously mentioned. This lack of knowledge related to the plantation could be considered as a disadvantage in itself (Table 6).

The most cited disadvantage related to tree planting mentioned by kadam planters was the lack of capital, fertilizers, and markets. The lack of markets was cited as being the main problem related to kadam planting, even during the participatory interviews. In the mahogany planting villages markets were not cited as a problem (although tree planting had not yet reached optimal production levels), with the most cited disadvantages being related to access to production inputs such as fertilizers, and silvicultural management. In the two villages in Java (that had experience in timber tree planting since the 1970s) most farmers said that they did not face any disadvantages related to tree planting. In the rare cases where farmers did cite disadvantages, they were mainly disturbances caused by fire, pests (mainly larva), disease (mainly fungus), or browsers (livestock) (Table 6).

Table 6. Percentages of farmers mentioning a specific disadvantage related to timber tree planting (modified based on Table 4 in Study I).

(%) Disadvantages	Acacia planters Riau	Kadam planters South Kalimantan	Mahogany planters South Kalimantan	Teak planters Central Java
Lack of fertilizers (difficult to get)	0	30	33	0
Lack of knowledge/capacity	6	7	2	0
Low management	17	17	24	0
Fire	0	13	21	10
Slow growth/long rotation/unsuitable soil	28	3	10	2
Pest/disease/browsers	3	17	21	19
Environmental (water shortage, flooding)	4	3	0	2
Lack of capital	5	33	2	0
Marketing	6	27	0	0
Low price/unfair benefit sharing	22	0	0	0
No knowledge on price	4	0	0	0
Unclear contract	0	3	0	0
Community not involved	3	0	0	0
Competition with other land-use practices	6	3	9	0
Don't know/never seen the plantation	35	0	0	0
No disadvantages	9	0	0	67

Note: Farmers could mention more than one disadvantage. Data from acacia planters (n=78), kadam planters (n=30), mahogany (n=42), and teak planters (n=67).

5.4. Current silvicultural practices of the farmers (Studies II and III)

All the teak and mahogany farmers, and nearly all the kadam planters personally conducted the silvicultural practices, having learnt about the practices mostly through their own experience or from other tree planters. In the teak case study it was common for the farmers to have inherited the plantation from their parents, from whom they also had learnt the management practices. The acacia case study is not considered in this section because the company conducted all the silvicultural management in the company-community partnership plantations.

All the teak planters and most of the mahogany planters had decided themselves which species to plant, while most of the kadam planters' decisions on species selection were influenced by the company that provided the seedlings. Almost all the farmers prepared the land, fertilized and weeded, regardless of the species planted (Table 7). Fertilizing was recognized as an important practice – in order to improve wood production – by 49% of the kadam and mahogany planters. In the mahogany and kadam case studies, fertilizers were usually added into the holes before seedlings were planted, whereas teak planters fertilized during the first and the second year of growth. Farmers used chemical or organic fertilizers. Weeding was done around the trees as required, not routinely.

Mortality rates of more than 20% were only reported in 9% of mahogany stands, and in 4% of kadam stands, whilst mortality rates in teak stands were always lower than 20%. Infilling was done by most of the teak planters (74%), and by approximately half the mahogany (56%) and kadam (50%) planters. This relatively active rate of infilling may reflect farmers' interest in stand productivity, but is also a factor of their access to low-cost seedlings. In the teak case study farmers could easily collect naturally regenerated seedlings from the surrounding area.

Protection measures were conducted by approximately one in four tree planters, and included using herbicides (in the teak case study) to control competition from grasses, and mainly fire protection in the kadam and mahogany case studies.

Pruning was done by most of the mahogany and teak planters, whereas it was not required for kadam as it is a self-pruning species. In mahogany stands the mean age for the first pruning was 1.04 years, but ranged from under one year up to three years. Pruning was especially important in mahogany to reduce the threat of shoot-borers. In teak plantations the average age for the first pruning was 2.7 years, but ranged from one to five years. The pruned teak branches were mainly used for fuel-wood.

None of the kadam or mahogany planters thinned their plantations. Thinning was not even required in the studied kadam and mahogany stands because they were still young and the planting density was low because several of the farmers planted agricultural crops between the tree lines. Very few teak planters thinned their plantations, even though the density was high and thinning was required if the aim was to produce wood with high diameter. Thinning was done by removing the low quality trees, which were often then used as fuel-wood. In 75% of the thinned plantations, the practice was not done properly, and densities after thinning remained high (1,950 trees ha^{-1}).

Of the entire sample population, only two of the teak planters had harvested their plantations, whilst none of the kadam or mahogany planters had. Some mahogany planters (39%) had a planned rotation length for their stands, ranging from 10 to 25 years. The main factor that determined rotation length was when the trees reached merchantable size. Teak planters did not have a specific rotation length for their stand, but they mainly did selective cutting, choosing individual trees with large enough diameters to be sold when cash was required (minimum DBH of 30 cm). Most of the kadam planters (85%) did not have a planned rotation length, due to the market uncertainty regarding potential buyers. Very few farmers knew how to estimate their stand yield.

Approximately half of the mahogany planters and one-third of those planting kadam conducted management activities together with other tree planters. When such activities took place it was mainly in the form of fire protection (for mahogany planters) and tree planting (for kadam planters). Joint management was conducted mainly in order to reduce the time required for forestry activities, but also for social reasons. More than half of the kadam and mahogany planters had suggestions on what future activities could be done with other tree planters, including fire control and road building (to improve accessibility). None of the teak planters conducted management activities together with the other tree planters, nor gave ideas on future collaborations. In the key informant interviews it was revealed that the teak planters preferred to operate individually because: a) they already had good markets and accessibility to their plantations, b) their plantations were regenerated mainly by natural regeneration and enrichment planting, and c) they wanted to decide exactly when to selectively harvest trees depending on their household needs for income or construction material.

Table 7. Percentages of the stands where specific silvicultural practices have been conducted (partly modified based on Table 3 in Study III).

Management activity	Kadam (%)	Mahogany (%)	Teak (Rejosari) (%)	Teak (Sendangijo) (%)
Land preparation	94	96	100	97
Fertilizing	91	100	100	92
Infilling	50	56	70	78
Weeding	97	93	100	100
Pruning	6	78	83	72
Protection	35	19	33	22
Thinning	0	0	10	14
Harvesting	0	0	0	6
Joint management	26	44	0	0

Number of stands: kadam *n*=34, mahogany *n*=27, teak (rejosari) *n*=30, teak (Sendangijo) *n*=36

5.5. Factors influencing farmers' silvicultural activity (Studies II and III)

In two of the three case studies the socio-economic and perceptional characteristics of the farmers influenced their silvicultural activity. The market conditions at the site had a strong influence on farmers' silvicultural activity in all sites.

In the teak case study in Java, farmers' silvicultural activity was not influenced by any of the socio-economic or perceptional characteristics that were tested, mainly because tree planting acted more as a safety-net rather than a main income source. Consequently, the households allocated their labor mainly to other on-farm and off-farm activities. In addition, all the teak planters - regardless of their socio-economic characteristics - had similar silvicultural knowledge and had favorable or very favorable attitudes towards teak planting due to the long term teak farming experience and established markets in the area. Teak wood was easy for farmers to sell to middlemen (even individual trees with small diameter) and the farmers thought they received a good price from the wood as it was currently managed. Approximately half of the farmers already thought that their plantations were of good quality (as their products matched the market requirements) and therefore did not see the need for improving silvicultural management.

Farmers who planted mahogany in multiple woodlots conducted more silvicultural practices, which is an indication of their strong interest in tree planting (Table 8). This was not, however, the case with kadam planters. In the mahogany and kadam case studies the opposite correlation signs (between the species) of the grade of silvicultural activity and the socio-economic variables in seven of the 12 cases were mainly caused by differences in market conditions between the villages (Table 8). For example, although not significant, mahogany planters' silvicultural activity was positively correlated with the household assets (which are a proxy for household wealth) because of markets available in the village, while kadam planters - with more household assets - conducted less silvicultural practices because the lack of a market in the village discouraged them from doing so. The availability of markets also influenced farmers' attitudes toward tree planting. For example all the mahogany planters (who had a clear market for their wood) had favorable or very favorable attitudes towards tree planting, while some of the kadam planters (28%) did not have favorable attitudes towards tree planting. Kadam farmers with favorable or highly favorable attitudes towards tree planting conducted more silvicultural practices on their land than the ones with non-favorable attitudes (Table 9).

In the kadam case study the number of income earning household members was positively correlated with their silvicultural activity, showing that they probably had more labor available for silvicultural management. The age of the farmer, years of education, number of household members, distance to stand, and household assets and expenses, were not significantly correlated with the grade of silvicultural activity in the kadam and mahogany case studies (Table 8).

Farmers within the kadam and mahogany groups had similar characteristics in regard to land ownership (almost all held legal title over the land), planting motivation, species selection, the seedlings and economic incentives they received, and whether they joined the farmers' group or other social organizations (Table 10). Thus the variation in silvicultural activity was almost

certainly not caused by these characteristics. In the teak case study none of the above mentioned factors affected farmers' silvicultural activity, even though there was some variation in: a) the level of seedling or economic incentives received (Rejosari Village), b) if they mentioned economic reasons for tree planting or not (both villages), and c) if they were members of farmers' groups or not (Sendagijo Village) (Table 10). Only approximately half of the teak planters mentioned the economic motivation (cash), because they often used teak for their own subsistence use (building material) (Table 10).

In terms of training for tree planting, none of the teak planters received any, whereas c.40% of the mahogany planters and c.20% of the kadam planters did. The training received by mahogany planters was focused on seedling preparation and planting techniques. Of the mahogany planters, those who received training always applied four or five of the recommended silvicultural practices whilst those without any training applied fewer practices. The difference between silvicultural activity within the groups of farmers receiving or not receiving training was, however, not statistically significant.

Most of the farmers belonged to a farmers group, thus participation in the farmers group did not explain the variation found in farmers' silvicultural management activity. Among kadam planters, however, those who had belonged to a farmers group for a longer period of time were more active in applying silvicultural practices (Table 8). In addition, being a member of a farmers' group helped farmers learn silvicultural practices from other tree planting members. As members of such a collective, farmers also obtained seedlings easier from the government or plantation companies. Nearly all the interviewed tree planters also belonged to some other social group (e.g. religious group).

The possible factors influencing farmers' silvicultural management activity was not studied in the acacia case study because the company conducted all the silvicultural management on their behalf as part of the arrangement.

Table 8. Farmers' socio-economic characteristics and Spearman correlations for grade of silvicultural management and socio-economic variables (modified based on Table 5 in Study II).

Variable	Mahogany planters				Kadam planters			
	n	Mean	SD	r	*n*	Mean	SD	r
Age of farmer (years)	27	45.41	11.70	–0.25	31	50.11	11.59	–0.13
Number of household members	27	3.89	1.01	0.01	34	4.18	1.34	–0.19
Number of income-earning household members	27	1.78	0.89	–0.07	34	1.74	0.86	0.36*
Total farm area (ha)	27	3.08	1.55	0.12	34	3.29	3.29	–0.21
Total area planted to mahogany/ kadam (ha)	27	1.50	1.13	0.28	34	1.01	1.48	–0.31
Percentage of planted area of total land area (%)	27	50.03	28.95	0.26	34	37.86	27.48	–0.08
Number of woodlots planted to mahogany or kadam	27	1.59	0.93	0.49*	34	1.50	0.78	–0.23
Distance from plantation to farmer's house (km)	12	1.05	0.73	–0.13	23	0.56	0.42	–0.18
Total value of household assets (Millions IRp (2008)/year)	27	34.74	31.30	0.10	34	14.26	14.10	–0.08
Household total expenses (Millions IRp (2008)/year)	26	19.02	13.04	0.13	33	12.61	9.61	0.31
Education (years of study)	25	7.44	2.62	0.29	32	6.66	3.71	0.06
Years of membership in farmers group	21	9.36	4.71	0.33	23	7.53	7.39	0.43*

Number of stands: mahogany n=27, kadam n=34, * = $p < 0.05$

Table 9. Number of silvicultural practices conducted by kadam planting farmers cross tabulated with farmers' attitudes towards tree planting (modified based on Table 6 in Study II).

Grade of management	Favorable or highly favorable		Indifferent or unfavorable		Total	
	Frequency	Relative frequency (%)	Frequency	Relative frequency (%)	Frequency	Relative frequency (%)
One practice	1	4	0	0	1	3
Two practices	0	0	1	11	1	3
Three practices	10	40	7	78	17	50
Four practices	14	56	1	11	15	44
Total	25	100	9	100	34	100

Number of kadam stands n= 34.

Table 10. Qualitative characteristics describing tree planters and their stand (modified based on Table 3 in Study II and the Table 6 in Study III).

Qualitative characteristics	Kadam (Asem Jaya)		Mahogany (Ranggang)		Teak (Rejosari)		Teak (Sendangijo)	
	n	Yes %	*n*	Yes %	*n*	Yes %	*n*	Yes%
Has clear land title over tree plantation land	34	94	26	92	30	100	35	80
Decide themselves which species to plant	33	21	27	78	30	100	36	100
Conducts silvicultural management themselves	34	97	27	100	30	100	36	100
Can measure stand yield	23	9	20	25	30	10	36	0
Received seedlings as incentives	34	85	27	100	30	50	36	100
Received economic incentives	34	3	27	93	30	47	36	100
Received training	34	21	27	37	30	0	36	0
Mentioned economic motivation for tree planting	32	97	26	100	30	57	36	47
Has favourable or highly favorable attitude towards tree planting	34	73	27	100	30	93	36	100
Member of farmers group	34	77	27	89	30	80	26	64
Member of other social organization	34	91	27	96	30	100	36	94
Think they receive a good price for their wood	23	30	20	65	30	93	36	100

Number of stands: mahogany *n*=27, kadam *n*=34, teak *n*=66

5.6. Plantation growth and quality, and the link with silvicultural activity (Studies II and III)

The growth characteristics of the study plots are summarized according to villages in Table 11, with the mean, minimum and maximum values of all the measured plots presented. All the stands were young, varying in age between one to 12 years. Mortality was low, being above 20% in only 9% of mahogany stands and 4% in kadam stands, and always below 20% in teak stands.

In approximately 10% of the teak plots the trees were substantially shorter in height compared to trees of a similar age reported in Suharlan et al. (1975) for intensively managed, state-owned teak plantations in Java. This implies that the 10% of smallholder plantations were most likely established in very poor sites not suitable for teak.

Stand density was low in kadam and mahogany plantations in South Kalimantan, where farmers planted other crops between the tree lines. In teak plantations in Java the density was high and negatively correlated with the mean DBH in the plots. The DBH in the studied teak plantations was similar to the average DBH in the intensively managed state-owned teak plantations that Suharlan et al. (1975) reported up to the age of about six to seven years. In plantations older than seven years the DBH of the studied smallholder teak plantations were below the average of that reported by Suharlan et al. (1975). The high density (and probably thus the low DBH growth of the older teak plantations) was caused by lack of, or poor techniques of, thinning.

The proportion of potentially merchantable wood ($m^3\ ha^{-1}$) from the total tree volume ($m^3\ ha^{-1}$) varied between 13 – 73% for mahogany, 68 – 86% for kadam, 31 – 54% for teak in Rejosari, and 31 – 63% for teak in Sendangijo. The mean annual increment of the volume (MAI_v) ranged between 0.39 – 13.68 $m^3\ ha^{-1}\ year^{-1}$ in kadam plots between the ages three to five years, 0.08 – 8.40 in mahogany plots between the ages of one to five years, 0.58 – 22.88 $m^3\ ha^{-1}\ year^{-1}$ in Rejosari between the ages three to 12 years, and 0.17 – 23.68 $m^3\ ha^{-1}\ year^{-1}$ in Sendangijo between the ages three to nine years (Figure 12 and Table 11).

As determined by the field team observations, most of the mahogany stands were classified as high quality, most of the kadam and teak stands in Rejosari were classified as medium quality, while teak stands in Sendangijo varied between all three quality classifications. Farmers' observations on the stand quality were, however, quite different from the field team's observations. Comparing observations between the field team and the farmers' perceptions on kadam and mahogany stand quality, it was found that 48% of the observations were the same, 41% of the observations varied by one quality class, and 11% varied by two quality classes, without any constant direction of variation. In teak stands, 35% of the observations were the same, but notably, 44% of the farmers reported their stands to be one quality class higher, and 12% reported their stands to be two quality classes higher than the field team observations. Only 9% indicated the quality class to be one lower than the field team's assessment (Table 12).

The mean percentage of high quality stems was approximately 60% in the kadam plots, approximately 50% in the mahogany plots, and approximately 30% for teak in both villages.

Variation in the performance (quality or growth) of the Java teak plantations cannot be explained by whether farmers conducted a certain silvicultural practice per se because there was no variation found in the teak planter's silvicultural practices. The variation in plantation performance is therefore most likely explained by variations in the seedling or site quality, plantation age, and the specific application, frequency and timing of the silvicultural practices conducted. However, the effect of these factors on plantation performance would require further research. Similarly in kadam and mahogany plantations in South Kalimantan, most of the farmers carried out land preparation, fertilizing and weeding, and thus the variation in the performance (quality or growth) cannot be explained by whether the farmers conducted these practices or not. Like in the case of teak, the specific techniques, frequency and timing of the kadam and mahogany farmers' practices could well have affected the plantation performance, but this would also require more research. Protection and infilling was not studied further, because the need for these practices differ among the stands. Pruning was selected for a closer look as to whether or not it had any effect on mahogany plot quality, and it was found that whether the plots were pruned or not did not affect the merchantable volume (V_m). The statistically significant factors affecting the merchantable volume were site quality, plot age and tree density. In addition, the age of the trees at the first pruning, the amount of time for recovery from pruning (until the time of measurements), and the percentage of dominant trees in the plot caused variation in the volume of potentially merchantable wood in the medium quality sites that were planted with mahogany.

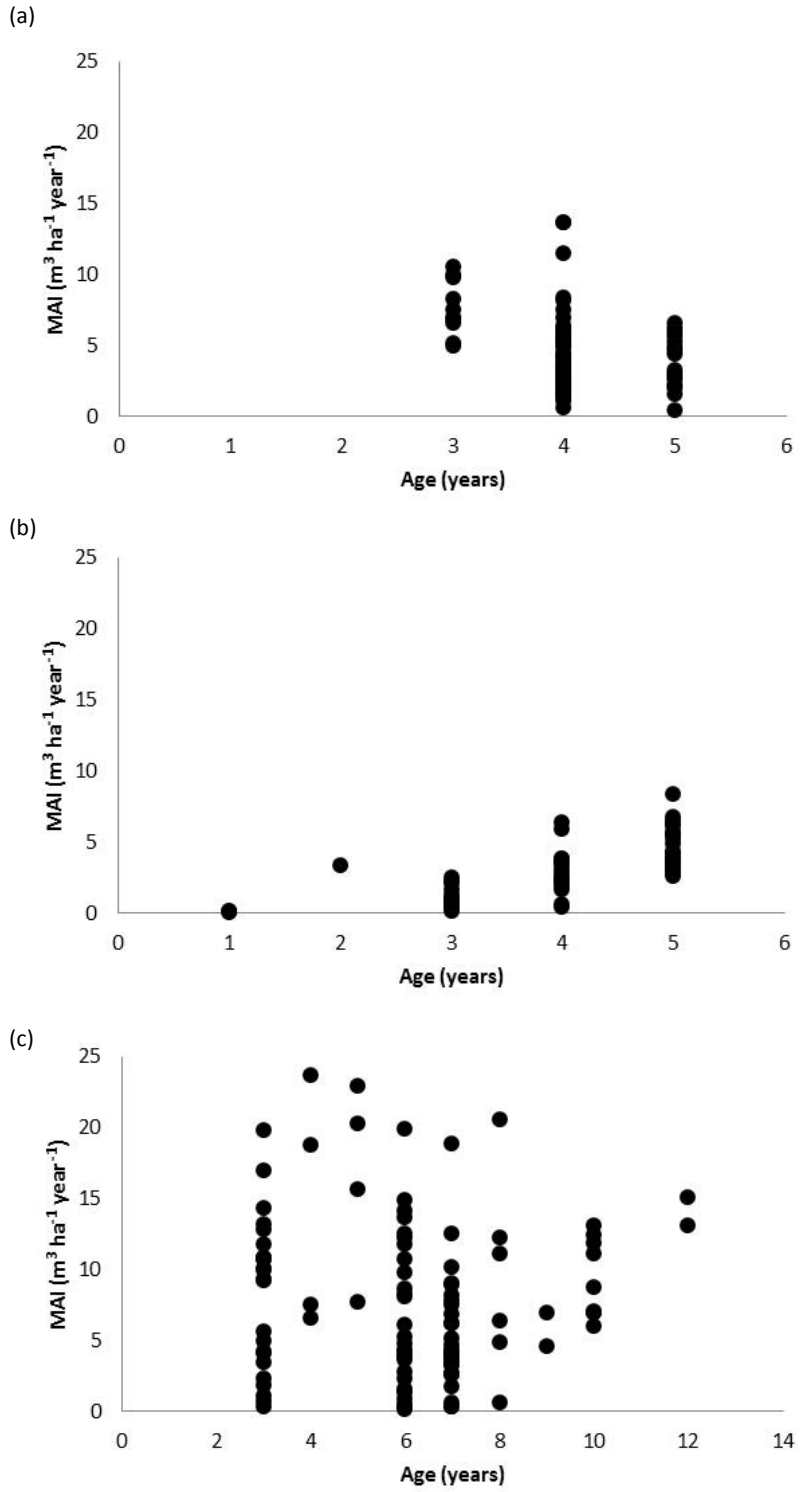


Figure 12. Mean annual increment (MAI, m^3 ha^{-1} $year^{-1}$) of the kadam (*n*=83), mahogany (*n*=66) and teak (*n*=121) plots.

Table 11. Summary of the inventory data (modified based on Table 8 in Study II and Table 4 in Study III).

Variable	Kadam			Mahogany			Teak (Rejosari)			Teak (Sendangijo)		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Age of the stand (years)	4.03	3.00	5.00	3.78	1.00	5.00	6.04	3.00	12.00	6.14	3.00	9.00
DBH (cm)	11.84	1.70	25.30	8.44	0.50	58.20	8.53	0.90	14.0	7.41	0.20	20.70
Height (m)	8.29	2.20	17.10	6.27	0.68	11.80	7.91	0.30	20.50	6.53	0.60	15.50
Basal area (m^2 ha^{-1})	8.61	1.88	17.16	3.60	0.11	11.37	14.26	1.59	40.94	8.02	0.59	22.19
Stand volume (m^3 ha^{-1})	36.04	4.02	110.77	13.47	0.80	42.00	71.69	3.35	211.98	33.92	0.86	131.9
Merchantable volume of stand (m^3 ha^{-1})	30.79	2.75	94.95	7.34	0.10	20.84	31.58	1.68	89.20	14.97	0.45	64.23
Stand density (trees ha^{-1})	727	360	1 375	533	280	875	2 225	898	4 578	1 775	495	6 531
MAI_V (m^3 ha^{-1} $year^{-1}$)	4.52	0.39	13.68	2.97	0.08	8.40	10.39	0.58	22.88	5.80	0.17	23.68
Mortality (%)	2.72	0	25.00	7.48	0	41.67	0.53	0	12.50	0.27	0	5.26

Number of plots: kadam *n*=83, mahogany *n*=66, teak Rejosari *n*=53 and teak Sendangijo *n*=68

Table 12. Percentages of observed stand qualities and farmers' perceptions on the quality of their stands in the kadam, mahogany and teak case studies (modified based on Table 9 in Study II and Table 5 in Study III).

	Kadam		Mahogany		Teak (Rejosari)		Teak (Sendangijo)	
Quality class	OSQ (%)	FPQ (%)	OSQ (%)	FPQ (%)	OSQ (%)	FPQ (%)	OSQ (%)	FPQ (%)
Low	15	16	19	15	17	3	33	6
Medium	47	36	33	30	76	50	45	36
High	38	48	48	56	7	47	22	58

OSQ=Observed stand quality by the field team (%), FPQ=Farmers' perception of quality (%)

5.7. Summary of the main findings

The main findings of the study are summarized below in Table 13.

Table 13. Summary of the main study findings.

Research questions	Hypotheses	Main findings
(1) What are the differences in the socio-economic and perceptional characteristics of tree planters and non-tree planters? (Study I)	(1) Farmers' tree planting and silvicultural management activities are influenced by: socio-economic characteristics of the farmer and the household; characteristics of the farm; farmers' and other peoples' attitudes towards tree planting; planting motivation; skills and knowledge; incentives received; access to markets; and farmers' participation in farmers groups.	• Tree planters & non-tree planters vary significantly in their socio-economic characteristics, but this variation is specific to the site conditions, such as market access, access to off-farm income sources & length of tree planting experience. However, tree planters were generally older, with more land, higher value of total assets & more active participation in farmers' groups or other social organizations. • The attitudes towards tree planting were not significantly different between tree planters and non-tree planters.
(2) What are farmers' motivations for planting or not planting trees? (Study I)		• Altough tree planting was not the main livelihood activity or income source for the farmers; the main reason for planting trees across the sites was economic. • Trees acted mainly as farmers' saving accounts, especially with long-rotation species & established markets (teak & mahogany). • Most of the farmers mentioned several other reasons for planting trees (environmental & social). • In some cases farmers also planted trees because of social pressure or fear of being missed out from potential revenue (acacia partnership). • Farmers cited environmental purposes as the reason for tree planting more often if: a) the species planted were relatively long-rotation species (teak & mahogany); b) the species had a long history of being planted at the site (teak): and c) farmers had experienced major environmental crises at the site (such as floods in Java).
(3) How do farmers use the income derived from selling wood? (Study I)		• Income received from wood was mainly used for planned expenditures, such as school fees or house construction, but also for unexpected expenditures such as medical care and to compensate for poor returns from agricultural crops (safety nets).

Research questions	Hypotheses	Main findings
(4) What are the main disadvantages related to tree planting? (Study I)		• Long rotation length, lack of capital, low wood prices, poor access to production inputs or markets were the main disadvantages related to tree planting. • In some areas farmers did not find any disadvantages related to tree planting (teak in Java). • The type of disadvantages mentioned varied among farmers within the sites.
(5) How do smallholder tree-planters vary in their willingness to continue tree-planting under different conditions (external support, market conditions, and land use conditions)? (Study I)		• Farmers willingness to continue tree planting in the future was mainly related to market access and the price received for the wood; farmers with ready market access were more interested in continuing the planting (teak and mahogany). • Farmers with more off-farm income earning options were more willing to continue tree planting than the farmers that lacked markets for wood and had few off-farm income options.
(6) Do farmers' socio-economic and perceptional characteristics influence their silvicultural management activity? (Study II and III)		• Socio-economic factors did not influence the silvicultural management activity when other important income earning options and markets were available. In these situations all the households allocated most of their labor to these other activities and silvicultural management was consistently low (Java). • When farmers already thought they produced good quality wood, or were happy with the market access and price received, minimum silvicultural practices were conducted regardless of the farmer's socio-economic characteristics. • Where few off-farm income earning options existed (Kalimantan), farmers with the following attributes conducted more silvicultural practices: a) more favorable attitudes, b) labor, c) longer participation in farmers group (kadam), and d) more land area planted in timber trees (mahogany).
(7) What silvicultural practices do farmers currently apply, and how do these practices affect their plantation performance in terms of growth and quality? (Study II and III)	(2) There is a positive relationship between farmers' silvicultural management activity and their plantation performance (growth and quality).	• Most of the farmers conducted the same silvicultural management practices within a study site, but just conducting them did not in itself cause the variation in plantation performance. The varying quality of the stands in all the sites was most likely attributed to the varying seedling or site quality, or the specific methods and timing used for the silvicultural practices. Only approximately half of the mahogany and kadam plantations were of high quality. • In Java all the teak planters conducted the same minimum silvicultural practices (without thinnings), which lead to low or medium stand quality and thereby low productivity of the older teak plantations.

6. Discussion

6.1. Factors influencing farmers' tree planting activity

This study clearly shows that tree planters and non-tree planters varied in their socio-economic characteristics; a result commonly reported in other studies (Salam et al. 2000, Byron 2001, Mahapatra and Mitchell 2001, Simmons et al. 2002, Emtage and Suh 2004). However, the socio-economic characteristics that were significantly different between tree planters and non-tree planters varied between the different case studies, and thus were specific for the conditions at each site (such as market related conditions, access to off-farm income sources, length of tree planting experience etc.).

In all four case studies tree planting farmers owned larger land areas compared to non-tree planters, a pattern found in other studies in the tropics (Salam et al. 2000, Summers et al. 2004). It was also found that acacia, mahogany, and teak planters had higher total value of assets compared to non-tree planters, and it was suggested that farmers with limited land and resources prefer agriculture or off-farm employment over tree planting for food security reasons; a situation described in other developing countries (Roder et al. 1995, Thacher et al. 1997, Kumar 2003). In addition, farmers with more resources could better afford the long waiting period before receiving the income from wood; thus a lack of capital can – in general – be a major barrier to engaging in tree planting for poor farmers (Byron 2001). In Java it could be that teak planters had more assets because they had already been growing teak for a few generations (sometimes up to 40 years), and thus had gained more income from teak planting than the non-tree planters. But this contribution of income related to teak planting in farmers' total income requires further, focused research.

Participation in social organizations – including farmers' groups – was found to be beneficial by farmers for learning new or improved practices (Bebbington 1996). In this study, acacia, mahogany, and teak planters were more likely to be members of a farmers' group than the non-tree planters. Communicating with other tree planters could have encouraged the farmers to plant trees. For example mahogany planters were more influenced by other peoples' attitudes while deciding whether or not to plant trees than non-mahogany planters. Furthermore, the mahogany planters in Kalimantan were mainly of Javanese origin, which perhaps made it natural for them to become closely organized and influenced by each other. There were also motivated and skilled key people in the farmers group with well-tended mahogany stands, who advised the other farmers on mahogany planting.

Farmers closer to retirement age are often more open to participating in tree planting because they have lower household needs, and tree planting requires relatively low labor inputs (Thacher et al. 1997). In addition, in many areas – such as found by Preston (1989) in Central Java, and Dewees and Saxena (1997) in Kenya – farmers plant trees because they have land available and labor shortages for conducting more intensive agricultural activities due to most of their labor being used for off-farm employment. In this study, the teak and acacia planters were significantly older than the non-tree planters. In the teak planting villages of Central Java, young people were often working as migrant laborers in other parts of Java, leaving less labor available for agriculture on the family farm; a pattern that contributed towards more tree planting. Some migrant workers

returned to the village after saving money and bought or inherited land, on which they were then able to plant trees. In the three villages in Riau, the non-acacia planters were mostly those that did not have the opportunity to join the partnership program at the time of the implementation because they were new households, young and recently married.

In the tropics, tree planters have been found to be more educated than non-tree planters (e.g. Nkamleu and Manyong 2005), but in this study there were no statistically significant differences found. Likewise, farmers' attitudes towards tree planting in the tropics and elsewhere have been found to affect their decision to plant trees (Mahapatra and Mitchell 2001), but in this study there were no statistically significant differences found between the attitudes of tree planters and non-tree planters. Although the non-tree planters mainly stated that their attitude towards timber tree planting was favorable, this is somewhat questionable as they yet did not actually plant timber trees, but preferred to grow other crops or trees producing non-timber forest products (such as rubber). It is, however, possible that the favorable attitudes that the non-timber tree planters were referring to was in relation to tree planting in general (including NTFPs), and not timber tree planting (even though it was specifically highlighted in the questionnaire that timber tree planting was the focus).

Farmers typically cited multiple reasons for tree planting, but as found in previous studies in the tropics (Amacher et al. 1993, Salam et al. 2000), our study also showed that the main reason for planting trees in each case-study was economic. Planting trees for environmental services was a less common reason, but the species with the longer rotation lengths – teak and mahogany – were seen to contribute more towards environmental services (such as water conservation and erosion control) by the farmers. This could be because teak and mahogany farmers were more aware of the environmental advantages of tree planting because of their long-term experiences (especially in the case of teak planters), and because of information derived from the active farmer's group (in the case of mahogany planters). Because of the longer rotation length, there is more potential for these species to provide environmental services than short-rotation species (Lamb 2011). A few farmers in the Central Java sites said that teak was initially planted because it helped to prevent floods (related to the major flooding events in the 1970s around Solo, in Central Java). Furthermore, in the Java case-study, several farmers mentioned that they planted teak to make use of bare land or land unsuitable for agriculture, strengthening other studies in the tropics that found farmers tend to plant trees on less productive or marginal lands (Hyman 1983, Nibbering 1999, Jagger et al. 2005). In terms of the main reasons for planting, one third of the acacia planters cited social reasons, such as 'the acacia partnership', 'following the other farmers' and 'social pressure'. This emphasizes that the decision to participate in the partnership was not necessarily agreed upon by all the villagers (since the partnership was conducted on communal village land), yet farmers considered it better to join the activity than to be excluded from using the village land.

The income gained from tree planting can contribute to farmers' daily income and consumption, but in many developing countries trees can also act as farmers saving accounts and safety nets (Chambers and Leach 1989, Van Noordwijk et al. 2008, Perdana et al. 2012). In West Java, Manurung et al. (2008) found that in traditional agroforestry systems the amount of timber species planted increased when the farmers anticipated additional income requirements in the medium to longer term. In this study, the household economic situation and rotation length of

the species was found to influence the planned end-use of the income received from wood. For example, mahogany and teak planters – with longer rotation lengths and higher value of household assets – planned to save income derived from wood for future anticipated expenditures; whilst acacia and kadam planters – with shorter rotation lengths and less household assets – planned to use their income from wood for daily consumption and urgent needs (in addition to future anticipated expenditures). Teak in particular was used as a farmers' savings account, because even individual trees were sold when income was needed, a pattern also found by Perdana et al. (2012) in Kunung Kidul, Java. This was only possible because of long established markets, strong demand for teak wood, and the presence of middlemen.

As pointed out by Byron (2001), smallholder tree planting can only be successful if all the "keys" of successful tree planting are in place (i.e. secure property rights to land and tree crops; a viable production technology; capacity for crop protection; and access to markets). This was also emphasized by this study, especially in the sites where timber or fiber-based tree planting activity was still developing (in the acacia, kadam and mahogany cases). Long rotation lengths, lack of capital, low wood prices, and poor access to production inputs or markets were cited as being the main disadvantages for tree-planting, and these factors influenced farmers' willingness to continue tree planting. Notably in the mahogany case, markets were not cited as a problem, however plantation production had not yet reached optimal production levels and the most cited disadvantages were related to access to production inputs and 'poor silvicultural management'.

In Java, where teak planting was already an established activity (established markets, production inputs readily available, and some silvicultural knowledge amongst farmers), most of the farmers said there were no disadvantages related to tree planting. In rare cases where farmers did cite disadvantages, these were mainly related to natural disturbances such as pests and diseases. This pattern has been found in other studies in Pakistan and China, whereby it takes a relatively long period of time for tree planting activity to fully adapt to the local conditions and to be integrated into local livelihoods and the local economy (e.g. Amacher et al. 1993, Song et al. 2004). The fact that the teak farmers did not cite any disadvantages could also be because they were not aware of the market opportunities they were missing out on by having lower than optimal wood quality and stand productivity, and by improved market access and knowledge of prices for different qualities of wood. In fact, the farmer perception that there were no disadvantages was a disadvantage in itself. This point is well supported by the relatively low quality of the trees observed in our study sites. Further support of this finding comes from a similar study conducted by Perdana et al. (2012) in Gunung Kidul District, Java (close to this study's sites), that found smallholder teak plantations were of low quality and the silvicultural management was poor because farmers lacked economic incentives to conduct proper silvicultural management.

Farmers' willingness to continue tree planting was mainly related to the availability of markets for wood and if adequate prices were paid for wood; thus strengthening other study's findings that farmers are willing to plant timber trees only if it makes economic sense (e.g. Byron 2001, Scherr 2004, Rudel 2009). For example, in the case of acacia, the key informant interviews and household surveys revealed that land use options other than acacia planting – such as rubber or oil palm planting – were more profitable in the area. However, the farmers with inadequate resources and decision-making power did not have the ability to change their land use, even though

only half of them were willing to continue under the partnership arrangement. All the teak and mahogany planters – with clear market access – instead wanted to continue tree planting, while less kadam planters – without clear market access – were willing to do so.

6.2. Factors influencing farmers' silvicultural management activity and plantation performance

There are a range of factors that can influence farmers' silvicultural management activities and thus the quality of the plantations, but these factors are very much dependent on site specific conditions including socio-economic and perceptional factors, market conditions, and the importance of wood production as a livelihood option.

6.2.1. Attitudes, perceptions and lack of silvicultural knowledge

Kadam planters with favorable or highly favorable attitudes towards tree planting were more active in silvicultural management, supporting earlier studies in the tropics that have found that farmers' attitudes towards tree planting can affect their tree planting behavior (e.g. Mahaptra and Mitchell 2001). In this study almost all the mahogany and teak planters had favorable attitudes towards tree planting, thus the attitude – per se – did not influence the silvicultural management activity in these sites. However, farmers' perceptions related to their plantation quality, the price they received for wood, and the behavior of other tree planters around them, influenced their silvicultural management; a finding supported by other studies in the tropics (e.g. Song et al. 1997, Perdana et al. 2012).

For example, the fact that approximately half of the teak planters thought that their plantations were of a high quality (whilst the field team found few high quality plantations), influenced farmers' silvicultural management activity. In other words, because farmers' already thought that their plantations served their objectives as 'saving accounts' under the current management system, they did not see the need for improved silvicultural management. The field team's definition for stand quality classes was based on the idea that DBH and stem quality of trees should be optimized by conducting thinning and pruning; but this definition differed from farmers' perception of stand quality. Most of the farmers even thought that they received good prices for their wood, but hadn't realized that the prices they received could be greatly increased. It can therefore be concluded that farmers did not fully recognize the importance of proper silvicultural management to improve their plantation productivity and quality, and potentially, the price they received for their wood.

Thinning is a crucial silvicultural practice that is used in order to maximize the growth of individual trees in the plantation. The inadequate thinning of teak reported in this study was reflected in the high mean density of 1,950 trees ha^{-1} in plots between the ages of four and 12 years. As a comparison, in the intensively managed plantations reported by Suharlan et al. (1975) the density in five to 15 year old plantations was 1,660 trees ha^{-1}. The lack of thinning probably also contributed to the slow growth rates recorded in plantations older than five to seven years, however it could also be that the older plantations were grown in low quality sites. Thinning

is especially important during the early phase of growth when teak grows fast (Kanninen et al. 2004, Soerianegara and Lemmens 1993). For example, in teak plantations in Costa Rica, Kanninen et al. (2004) observed that in terms of the remaining stand volume, tree size and rate of recovery, heavy thinning is better than light thinning, and early thinning is better than late thinning. In a study of smallholder teak demonstration plots in Kunung Kidul, Java, Rohadi et al. (2012) found that thinning 60% of stem number and conducting pruning increased DBH by 60% and tree height by 124% over a two year period compared to the control (no pruning, no thinning). As a generalization, the farmers shared an idea that 'the more trees, the better', which did not encourage proper thinning practice. Instead, thinning most commonly took the form of harvesting the largest trees when cash was needed, rather than for improving the growth and quality of the remaining trees.

Pruning was also mainly conducted for reasons other than best practice management; in this case to provide firewood rather than to improve the quality of the stem, which was reflected by the low number of high quality stems in the Central Java sites. Similar results on the lack of proper silvicultural management and low quality of the smallholder teak plantations were found in other studies in Java (Roshetko and Manurung 2009, Perdana et al. 2012). In fact, Roshetko and Manurung (2009) describe the smallholder teak systems in Java as being over-stocked, slow growing, and thus of suboptimal quality and production.

The lack of thinning and relatively short rotation lengths, especially in the teak case, also influences the wood quality. Longer rotations are essential if the aim is to produce good quality logs for high-end uses, as longer rotations produce higher diameter stems with more heart wood (Bhat 1997, Krishnapillay 2000, Kollert and Cherubini 2012). In the smallholder teak plantations in this study, the rotation lengths were mostly shorter than 20 years, from which less high quality wood can be produced. The study in India by Bhat (1997) also showed that faster diameter growth rates were associated with higher heartwood content and thus higher timber value. Thus, using thinning for improving the diameter growth of selected trees is important if the aim is to maximize the diameter growth of individual trees and improve the wood quality. Perez and Kanninen (2005) also found that thinning techniques influence the quality of teak wood, whereby moderate and heavy thinning yielded the highest percentages of heartwood volume.

Furthermore, most of the mahogany planting farmers indicated that they compared the quality of their stands with the stands of other farmers that were known to have high quality stands. The farmers with high quality stands were two farmers that were particularly active in farmers groups who practiced proper silvicultural management and had several mahogany stands of a high quality. These farmers were highly motivated and skilled in mahogany planting and they readily advised the other farmers. Their well-managed woodlots provided an important demonstration for other farmers to understand the importance of adequate silvicultural management. The enthusiasm of these role-model mahogany planters encouraged other farmers to improve their own silvicultural management practices. This is a pattern found also in other studies, whereby the demonstration effect of successful tree planters (especially if they have 'social status') has encouraged others planting activities (Current et al. 1995, Mahapatra and Mitchell 2001, Walters et al. 2005, Perdana et al. 2012).

It has been demonstrated that the personal character and enthusiasm of the people guiding tree planting and management is highly important for success (Amacher et al. 1993, Song et al. 1997). Sometimes however, the demonstration effect may not be positive. For example, in teak plantations in Kunung Kidul, Java, Perdana et al. (2012) found that farmers observations of their neighbors conducting the same sub-standard practices as themselves tended to reinforce these habits. In such a case, farmers did not realize the potential improvements that could be made to the quality and growth (and potentially the price) of their wood through improved silvicultural management practices. Similar tendencies were occurring in the teak study sites in Central Java in this study.

A lack of technical knowledge or training is often mentioned as a factor limiting farmers' silvicultural activity (e.g. Byron 2001), and thus forest extension services have been found to have a positive effect on tree planting activity and management (Salam et al. 2000). In this study, none of the teak planters, only 40% of the mahogany planters, and about 20% of the kadam planters received training (forest extension). Mahogany planters who received training always applied four or five of the recommended silvicultural practices, while farmers who did not receive training applied fewer practices.

Most of the mahogany and kadam planters conducted the recommended silvicultural practices, but just conducting them did not in itself cause the variation in farmers' plantation performance. Only approximately half of the mahogany and kadam plantations were of high quality. The varying quality of the stands in all the sites was most likely attributable to the varying seedling or site quality, or the specific methods and timing used for the silvicultural practices. Approximately half of the field team's observations on stand quality were similar to farmers' observations. When the farmers' perceptions and field teams' observations differed, it was without any constant direction.

All the teak planters and most of the mahogany planters decided themselves which species to plant, while most of the kadam planters' species selection decision was influenced by the company that provided the seedlings. The fact that so many farmers had decided to plant mahogany and teak themselves is a strong indication of the perceived value of tree farming, if only as a part of their livelihood strategy. The farmers that decided which species to plant themselves were more likely to have favorable or highly favorable attitudes towards tree planting, and were more likely to be willing to continue tree planting. The kadam planters, however – who had less favorable attitudes towards tree planting – consequently conducted fewer silvicultural practices. These results, as found by several other researchers (e.g. Hyman 1983, Evans 1992, Arnold 2001), emphasize the importance of species selection that is matched to the local conditions and markets. There is a risk that farmers who plant trees that are only suitable for timber production (as advised by foresters or industries) could be doing so despite that more convenient and or more beneficial species would better suit their livelihood needs (e.g. multipurpose trees with different products and services). But as pointed out by Jagger et al. (2005), and as emphasized by the success and popularity of teak planting in Central Java, planting multipurpose species is not always a more suitable option than planting species with a single product. There are also risks that farmers are encouraged by rehabilitation programs to plant local species (for environmental purposes) for which markets do not yet exist (e.g. Schackelton et al. 2007).

6.2.2. The importance of tree planting for farmers' livelihoods

Earlier studies from the tropics have found that farmers with more land and resources are able to invest more in tree planting and management (Amacher et al. 1993, Summers et al. 2004), however they will only do so if they have the right motivation for it (Mahapatra and Mitchell 2001). In this study it was found that the level of the silvicultural management applied (and the labor and resources allocated for the activity), are strongly influenced by the importance of the tree planting income in farmers livelihoods and the availability of off-farm income earning options (with its influence on labor availability). This is supported by studies in the developing countries of the tropics that found that only farmers with a certain level of food security (i.e. self-sufficient food supply), off-farm income sources, or access to loans, were willing and able to allocate part of their resources for tree planting and management activities (Arnold 1997, Byron 2001). For example, teak planting was without exception rated by the farmers as the least important income source for them (it did not contribute significantly to farmers' daily income, but acted mainly as a saving account), thus farmers allocated minimum inputs to manage their plantations. In this way they were able to use the available labor mainly for other on-farm or off-farm activities that provide regular income (such as agriculture and migrant labor). These results complement the study by Manurung et al. (2008) and Perdana et al. (2012), who found that tree planting was generally not farmers' primary income source in Java. Perdana et al. (2012) also similarly found that farmers used their teak as financial reserve of last resort, and maintained it until all other disposable assets had been sold. Furthermore, Perdana et al. (2012) also reported that teak plantations received little attention from farmers, and were mainly managed when opportunity costs were low for off-farm work. But in the kadam case study, the number of household members contributing income to the household was positively correlated with their silvicultural activity, which was because few off-farm income earning options were available in the area (thus surplus labor could be allocated for silvicultural management).

6.2.3. Socio-economic factors

Some studies in the tropics and sub-tropics have found that a range of socio-economic factors affect farmers' silvicultural management activity (e.g. Amacher et al. 1993, Summers et al. 2004, Walters et al. 2005). It has been found that wealthier farmers – who are more capable of taking risky investments – are more likely to plant trees (Amacher et al. 1993, Scherr 1995, Mahapatra and Mitchell 2001, Franzel and Scherr 2002). Among mahogany planters, those with the largest area with trees conducted more silvicultural practices in their stands. In addition, although not significant, the household assets (which were a proxy for household wealth in this study) were positively correlated with the silvicultural management activity in the mahogany site.

The farmers' age, the number of years of education of the farmer, the number of household members, the distance to the tree stand from the house, and household assets and expenses were not significantly correlated with the grade of silvicultural activity in any of the case studies. Within the groups of kadam and mahogany planting farmers, the farmers had similar characteristics in regard to land ownership, planting motivation, species selection, seedlings or economic incentives they received, and whether they joined the farmers' group or other social organizations. Thus the variation in silvicultural activity was not caused by these characteristics. In the teak case

study none of the above mentioned factors affected farmers' silvicultural activity either, although there was variation between farmers in whether they received seedlings or economic incentives (Rejosari Village), if they mentioned economic reasons for tree planting or not (both Villages), and whether they joined farmers' groups or not (Sendagijo Village).

In the Central Java case study none of the socio-economic factors influenced farmers' silvicultural management activity. Farmers had similar silvicultural and market knowledge, perceptions on plantation quality and price received for wood, and they all considered tree planting as the least important source of household income, thus minimal management and labor inputs were given (as explained in previous paragraphs). It is important to note that in Central Java, although there were some significant variations between people's socio-economic characteristics; it was observed that the households were more equally established compared to the sample households in South Kalimantan and Sumatra. For example, the study villages in Central Java had better infrastructure (roads, water, hospitals), and households had 'nicer' houses (concrete or traditional buildings made from teak) with more furniture than in the villages studied in the outer islands.

6.2.4. Markets

Farmers have an incentive to manage their timber plantations only if they are relatively sure that their efforts will benefit them in the future. Thus if trees are grown for selling wood, functional markets are required (e.g. Evans 1992, Byron 2001, Scherr 2004). If the markets are insecure or lacking, such as in the kadam case study, farmers do not have any incentive for improved silvicultural management. In the mahogany case study, where the markets were available but the silvicultural management had not reached the optimum production level, it made sense to allocate land and labor to silvicultural management. The well established markets in the teak case study meant that farmers could easily sell wood – even individual trees with small DBH – when they needed the cash, which influenced their silvicultural management practices such that there was little incentive to maximize productivity when there was a market that would buy almost anything, anytime, with little restrictions imposed on quantity, quality and price.

These findings are complemented by other studies in a range of developing countries by Scherr et al. (2002 and 2004) that identified the production of small-diameter, lower-quality wood for local demand and domestic consumption to be a competitive advantage and market opportunity for smallholder tree planters (especially when using marginal lands and when natural forests are scarce). Scherr (2004) specifically emphasized that producing low quality wood is not an option for all farmers, but that farmers living near rapidly growing population centers, industries and markets, could benefit the most (as was the case for the teak planters in the Central Java study site). But despite these things, it still makes economic sense for farmers to maximize the diameter and quality of trees by applying appropriate thinning and pruning practices, and thus receive better prices for their wood. But this is only possible if the farmers fully recognize the importance of proper silvicultural management in improving the wood quality, and if they are able to wait until the trees reach large DBH.

An often mentioned problem related to smallholder tree planting in the tropics is that farmers have a limited influence over the prices they receive from the wood they grow (e.g. Sen and

Das 1988, Scherr 2004, Perdana et al. 2012). As reported by Perdana et al. (2012) in Gunung Kidul, Java, smallholders often sell trees without a clear understanding of the value of different qualities of wood. The silvicultural management, and thus the quality and productivity of the teak plantations, could be improved if the farmers would have better knowledge on the price of the wood for different wood qualities, and if they were able to measure the real value of their own plantations (Perdana et al. 2012). Furthermore, farmers' negotiation powers should be improved, regulations for timber trade simplified, and direct links between teak producers and industries developed (Perdana et al. 2012); conclusions that equally apply to this study site. Very few farmers in this study could measure their standing yields, which could influence their understanding of the real value of their stands and the importance of proper silvicultural management to improve quality and yields.

6.2.5. Incentives (seedlings)

Most farmers in this study had received seedlings as incentives from the government, or in the kadam case study, from the company that initially encouraged tree planting. It is highly likely that the seedlings received varied in quality, and therefore affected stand performance, but verifying this would require more research. Nawir (2007) also found that tree planting programs in Indonesia often suffered from inadequate seedling maintenance and untimely planting, despite that these are very important factors to maintain viability of the seedlings (Evans 1992). Kadam and mahogany planters reported that seedlings were generally easy to obtain and that seedling quality was mainly good or moderate. However, the key informant interviews and observations during the field work revealed that in the mahogany study sites, some mahogany seedlings were stored in the village for long periods before planting, which could diminish the viability of these seedlings.

In teak planting villages, farmers could easily collect naturally regenerated seedlings from the local area to enrich their teak plantations. The quality of these seedlings was not tested in this study, but in general, naturally regenerated seedlings (especially those moved from one place to another) are not of the highest quality compared to improved genetic sources, even though they may be adapted to the local environmental conditions and contribute to genetic diversity (Evans 1992, Krishnapillay 2000). Furthermore, despite on-going research on the genetic improvement of tropical tree species, Nawir (2007) found that local communities in Indonesia were not yet to benefit from any improved seedling material. Infilling was done by most of the teak planters, and in approximately half the mahogany and kadam stands, although the mortality was more than 20% in only a few plantations. The relatively active infilling reported in this study may reflect farmers' interest in stand productivity, but most probably it is more indicative of their access to low-cost or free seedlings.

6.2.6. Site selection

In approximately 10% of the teak plots inventoried, trees were substantially shorter in height than trees of a similar age reported in the study by Suharlan et al. (1975). This implies that these 10% of study plantations were most likely established in very poor sites not suitable for teak (the densities of these poorly growing plots were not significantly different from the other studied

plots). This finding complements the general silvicultural knowledge about the importance of proper species selection matched to site conditions. In highly marginal lands with low fertility or water availability, species that are adapted to such conditions should be selected. However, farmers in the tropics often simply select the species according to its availability and familiarity, rather than matching the species to the site quality (Evans 1992). This most probably is the case with teak in the studied villages in Central Java, where teak is a familiar species for the farmers, and the seedlings are easily available from the government or are freely collected from the local area (naturally regenerated seedlings).

6.2.7. Farmers' groups

Interaction with other farmers – such as in a farmers' groups – is found to encourage better farming practices (Bebbington 1996). Most of the tree planters in this study belonged to a farmers group, thus participation in the farmers group per se, did not explain the variation in farmers' silvicultural management activity. Among kadam planters, however, those who had belonged to a farmers group for a longer period of time were more active in applying silvicultural practices. Furthermore, several farmers stated that they had learnt silvicultural practices from other tree planters. Farmers could also more easily obtain seedlings from the government or companies collectively, rather than individually. In some cases it was easier for famers to sell their wood to the company collectively (e.g. in the case of mahogany). Nearly all the interviewed tree planters also belonged to some other social group (e.g. religious group), thus the variation in silvicultural activity was not caused by whether the farmers joined such social groups or not.

6.3. Limitations of the study

There are some limitations associated with this study. First of all, this study was conducted under a large multidisciplinary research project with several research components, all with their own specific aims. Research sites were therefore selected so that the aims and objectives of the large multidisciplinary project could be achieved. Therefore, compromises had to be made and not all the selected sites were optimal for the purpose of this study. For example, the acacia site in Riau was not suitable to address the research question number 6 – "which factors influence farmers' silvicultural management" – because the company conducted all the silvicultural management. Secondly, although the sites were selected for being active in tree planting, the actual number of tree planters (that planted trees in even-aged woodlots) turned out to be much less than the rapid appraisals and key informant interviews indicated, causing limitations to the sample size. The selection of the study sites where tree planting for timber or fiber production was a common activity could influence the generalization of the results in areas where tree planting is not common. Thirdly, the initial field-work was conducted with a relatively large research team in the Kalimantan and Sumatra sites, but the field-work conducted later in Java had a much smaller research team. This variation in the size of the research teams, as well as the varying populations and tree planters in the villages, led to unavoidable variation in the sample populations between the research sites. In addition, the larger research team in Kalimantan and Riau conducting interviews and inventories may have caused errors because of differences in the personal characteristics of the group members.

The usual level of human error is to be expected in this study, as is the case with any research involving the kind of interviews conducted. Also, the fact that the PhD researcher was a foreign woman, and attended most of the interviews, may have caused some bias to the answers that farmers gave due to cultural differences and expectations from both sides. For example the farmers tended to give positive answers when asked about their attitudes towards tree planting because perhaps that was what they thought the researcher wanted to hear. In some cases, farmers tended to initially under-report their land area or assets owned, but with some probing it was revealed that they owned more land or assets. Similar issues related to positive and negative bias in data collection have been found by other researchers, and triangulation and probing can help to overcome these issues to a certain degree (Angelsen et al. 2011).

Finally, the aim of this study was to determine the factors influencing farmers' tree planting and management activity, and to achieve this, a wide range of factors were studied. It is recognized however, that more detailed – and perhaps repeated – research on each of these factors would provide for deeper understanding. More detailed research on some of these factors was conducted as part of the larger research project of which this study was a part (e.g. markets) (Obidzinski and Dermawan 2010, Krisnawati et al. 2010ab, Krisnawati et al. 2011abc, Sikor 2011).

7. Conclusions and recommendations

The aim of this study was to determine the factors that influence farmers' tree planting and management activities in Indonesia's three major islands of Java, Kalimantan and Sumatra. The study was conducted in order to provide information for the actors designing and implementing tree planting programs (e.g. government, international donors, NGOs, private companies) in Indonesia and elsewhere, that can be used to improve the success of the current and planned smallholder tree-planting initiatives (enhanced participation of the farmers for tree planting and improved productivity and quality of the plantations). Better success of the initiatives could benefit smallholder's livelihoods, increase the much needed supply of wood, contribute towards environmental services, and potentially reduce pressure on the remaining primary forest.

This study has shown that the success of smallholder tree planting is not only affected by technical factors, but also by socio-economic, perceptional and market related factors. In particular, the availability of wood markets and the specific role of tree planting activity in farmers' livelihoods (i.e. in relation to other on-farm or off-farm sources of income) influenced farmers' willingness to plant and manage trees. The socio-economic characteristics that were significantly different between tree planters and non-tree planters, and between the farmers with more active management and less active management, varied between the different case studies, and thus were specific for the conditions at each site.

The farmers were not aware of the importance of thinning to improve the diameter growth and the quality of the selected trees (and thus the wood price). The lack of thinning then led to poor productivity and mostly low or medium stand quality. Even in the cases when the farmers conducted the recommended silvicultural practices, just conducting them did not in itself cause the variation in farmers' plantation performance. The varying quality of the stands in all the sites was most likely attributable to the varying seedling or site quality, or the specific methods and timing used for the silvicultural practices.

Although tree planting was not the main livelihood activity (income source) for the farmers, trees were mainly planted for economic purposes, while environmental or social reasons were complementary. Trees with longer rotation lengths and reasonable market availabilities acted as farmers' saving accounts that were harvested when cash was needed. The income received from wood was mainly used for expected expenditures such as school fees or house construction, and also for unexpected expenditures such as illness and poor returns from agricultural crops (safety nets). In the site where trees were planted under a company-community partnership, farmers' motivation for joining the activity was often social. Long rotation lengths, lack of capital, low wood prices, and poor access to production inputs or markets were found to be the main constraints to smallholder tree planting, and these factors influenced farmers' willingness to plant trees in the future.

Several lessons can be drawn from this study related to the expansion, improved productivity and quality of smallholder tree planting initiatives with application for Indonesia and beyond. Some of these lessons outlined below are not only drawn from the results of this thesis, but are also based on the authors' experience gained during the course of this research.

The diversity of smallholder socio-economic and perceptional characteristics should always be taken into account while promoting tree planting programs. The alternative land-use practices and livelihood strategies need to be considered in order to know whether tree planting is a feasible option for farmers' livelihoods in each particular situation. The policy implication is that before implementing new tree planting programs, specific characteristics of the sites should be carefully surveyed. Moreover, if the aim is to involve farmers with fewer resources to plant trees for timber or fiber, then adequate mechanisms are needed to support them during the long waiting period endured before receiving income from the trees, or existing mechanisms (such as loaning systems, or application of agroforestry systems) should be improved.

In order to contribute the goal of poverty alleviation, the species selected for tree planting should be the ones that people need (e.g. multifunctional species), or that can be sold at a good price. Furthermore, tree species that are environmentally sustainable in the long term should be planted, perhaps in more diverse and resilient systems. It is important to recognize the diverse products and services that tree planting can provide, as well as the different ways that tree planting can contribute to peoples' livelihoods, including: income generation, domestic/subsistence use, safety-nets and livelihood security. Furthermore, trees should be planted preferably on marginal and degraded lands that are unsuitable for agriculture, or in places that do not otherwise threaten local peoples' livelihoods, food security or the environment.

Policies and other interventions that are conducive to the establishment of markets for fiber and timber, with fair and reasonable pricing structures for smallholders, are needed. Because farmers plant trees mainly for economic reasons, it is unrealistic to expect them to plant – and especially to manage – plantations without expectations of fair and reasonable income. Assistance should be given by capacity-building and via cooperatives for farmers to have better access to market information, especially related to the grading system and quality standards required by industry. Farmers planting under company-community partnerships should be provided with better knowledge and skills to negotiate fairer contracts.

Mechanisms to assist farmers to better organize themselves and to develop activities jointly (cooperatives and farmer's groups) should be developed by the government and other organizations such as NGOs. Better organization could potentially decrease farmers' transaction costs (e.g. bulk purchase of fertilizers, cooperative harvesting and transporting etc.), and improve information sharing and farmers' ability to interact directly with the wood industries. Direct contacts between the wood industries and smallholders could potentially improve the match between the required wood qualities and production, and thus potentially enhance the price that smallholders receive for wood. Simplified regulations related to wood harvesting, transporting and marketing could also enhance smallholder tree planting activity.

In order to improve the quality of the plantations, motivated and skilled government extension officers are needed to advise farmers on improving silvicultural practices; especially in regards to the importance of proper site-species matching, fertilizing, thinning and pruning. Smallholder plantation demonstration plots should be developed that showcase best practice silvicultural management with an emphasis on wood-quality matching to the market requirements. The quality of stands could be improved with further research and training on the timing, frequency

and methods used for silvicultural management. By conducting proper silvicultural management, farmers could more efficiently use the available household labor, especially when other income generating options are limited. It should be noted, however, that silvicultural management training should be appropriate and realistic for the small-scale planters to adapt, and local knowledge on silvicultural management should be acknowledged and integrated with any new or improved practices. In addition, to produce high quality wood, the farmers need to learn mensuration skills. This would help them to determine the potential value of their plantation and thus better avoid selling their wood below its real market value (Hyman 1983, Kumar 2003).

Government intervention would be well served to provide smallholders with better access to production inputs such as improved seedlings and fertilizers. Attention should, however, be directed towards ensuring that the seedlings provided to farmers are of a consistently high quality. But as found by Byron (2001), tree planting cannot be successful if all the "keys" of tree planting are not in place, Thus in addition to the provision of these kinds of basic support measures, some of the more complex constraints to smallholder plantation development – such as market related issues – should also be tackled. Once these key requirements are in place, including secure property rights to land and tree crops, a viable production technology, capacity for crop protection, and access to markets, then "fine tuning" can make tree planting even more profitable for the farmers. Some of these "fine tuning" opportunities include the use of improved planting material, improved silvicultural techniques, production of good quality timber matched to particular markets, benefiting from payments for ecosystem services, improved communication systems and direct market access.

Given the increasing demand for wood, non-wood forest products and environmental services, opportunities related to small-scale tree planting in the tropics are expected to increase. For example, the increasing political interest in climate change and the ability of forests to sequester carbon is expected to encourage more state led efforts to expand plantations, while also providing supplemental income for the rural poor via payments for carbon sequestration.

References

Amacher, G.S., Hyde, W.F. & Rafiq, M. 1993. Local adoption of new forestry technologies: An example from Pakistan's northwest frontier province. *World Development* 21(3): 445–453.

Angelsen, A., Brockhaus, M., Kanninen, M., Sills, E., Sunderlin, W.D. & Wertz-Kanounnikoff, S. (eds.) 2009. Realising REDD+: National strategy and policy options. CIFOR, Bogor.

Angelsen, A, Olsen, C.S. Larsen, H.O., Lund, J.F. and Wunder, S. (eds.). 2011. Measuring Livelihoods and Environmental Dependence: Methods for Research and Fieldwork. London, UK: Earthscan Publishers.

Angelsen, A. & Wunder, S. 2003. Exploring the forest-poverty link: Key concepts, issues and research implications. CIFOR Occasional Paper No. 40. CIFOR, Bogor.

Arnold, J.E.M. 1996. Economic factors in farmer adoption of forest product activities. FAO, Rome.

Arnold, J.E.M. 2001. Forestry, poverty and aid. CIFOR Occasional Paper No. 33. CIFOR, Bogor.

Arnold, J.E.M. & Dewees, P.A. (eds.). 1997. Farms, trees and farmers: Responses to agricultural intensification. London, Earthscan Publications.

Arnold, M. 1997. Trees as out-grower crops for forest industries: Experience from the Philippines and South Africa. Rural Development Forestry Network, Network Paper 22a (winter 1997/1998). ODI, London, United Kingdom. Agricultural Intensification. Earthscan Publications, London.

Barr, C., Dermawan, A., Purnomo, H. & Komarudin, H. 2010. Financial governance and Indonesia's Reforestation Fund during the Soeharto and post-Soeharto periods, 1989–2009: A political economic analysis of lessons for REDD+. CIFOR Occasional Paper 52. CIFOR, Bogor.

Barr, C., Resosudarmo, I.A.P., Dermawan, A. & McCarthy, J. 2006. Decentralization and forest administration in Indonesia: Implications for forest sustainability, community livelihoods, and economic development. CIFOR, Bogor.

Barry, K.M., Irianto, R.S.B., Santoso, E., Turjaman, M., Widyati, E., Sitepu, I. & Mohammed, C.L. 2004. Incidence of heartrot in harvest-age *Acacia mangium* in Indonesia, using a rapid survey method. *Forest Ecology and Management* 190: 273-280.

Bebbington, A. 1996. Social capital and rural intensification: Local organizations and islands of sustainability in the rural Andes. *The Geographical Journal* 163(2): 189-197.

Bhat, K.M. 1997. Characterization of juvenile wood in tropical hardwood teak. Paper presented at the Conference on Forest Products for Sustainable Forestry, Pullman, Washington, USA.

Byron, N. 2001. Keys to smallholder forestry. *Forests, Trees and Livelihoods* 11(4): 279-294.

Carnea, M.M. 1992. A Sociological framework: Policy, environment and the social actors of tree planting. In: Sharma, N.P. (ed.) 1992. Managing the world's forests. Looking for a balance between conservation and development. Kendal/Hunt Publishing Company. Iowa. 301-335 pp.

Chambers, R. & Leach, M. 1989. Trees as Savings and Security for the Rural Poor. *World Development* 17(3): 329-342.

Cossalter, C. & Pye-Smith, C. 2003. Fast-wood forestry: Myths and realities. Forest Perspectives No. 1. CIFOR, Bogor.

Current, D. & Scherr, S.J. 1995. Farmer costs and benefits from agroforestry and farm forestry projects in Central America and the Caribbean: Implications for policy. *Agroforestry Systems* (30): 87-103.

Davis, C.W. 1989. Outlook and Prospects for Indonesia's Forest Plantations. UTF/INS/065/INS: Forestry Studies Field Document No. I-3. Ministry of Forestry-FAO.

Dewees, P.A. & Saxena, N.C. 1997. Tree planting and household land and labour allocation: Case studies from Kenya and India. In: Arnold, J.E.M., Dewees, P.A. (eds) Farms, trees and farmers: responses to agricultural intensification. Earthscan, London. 242–267 pp.

Emila & Suwito. 2007. People's Plantation Forests (HTR). A new agenda for poverty alleviation? *Warta Tenure* 4: 14-19.

Emtage, N.F. & Suh, J. 2004. Socio-economic factors affecting smallholder tree planting and management intentions in Leyte province, Philippines. *Small-scale Forest Economics, Management and Policy* 3(2): 257–271.

Enters, T & Durst, P.B. 2004. What does it take? The role of forest incentives in forest plantation development in Asia and the Pacific. FAO, Bangkok.

Evans, J.E. 1992. Plantation Forestry in the Tropics. 2nd edition. Oxford University Press, USA.

Evans, J. & Turnbull, J.W. 2004. Plantation Forestry in the Tropics: Role of silviculture and use of planted forests for industrial, social, environmental and agroforestry purposes. 3rd edition. Oxford University Press, Oxford.

Ewasechko, A.C. 2005. Upgrading the Central Java wood furniture industry: A Value-Chain Approach. Manila, ILO.

FAO. 2001. Forestry out-grower schemes: A Global view. Based on the work of Digby Race and Helen Desmond. Mead, D.J. (ed.). FAO, Rome.

FAO. 2006. Global planted forests thematic study: results and analysis, by Del Lungo, A., Ball, J. and Carle, J. Planted Forests and Trees Working Paper 38. FAO.

FAO. 2009a. Planted forests. Uses, impacts & sustainability. Evans, J. (ed.) FAO, Rome.

FAO. 2009b. Indonesia forestry outlook study. By Center for Forestry Planning and Statistics Ministry of Forestry. Working paper No. APFSOS II/WP/2009/13.

FAO. 2011. State of world's forests 2011. FAO, Rome.

Gordon, J.C., Berry, J.K. & Schmidt, R. 1999. The problem and potential solutions. A summary. In: Schmidt, R., Berry, J.K. & Gordon, J.C. (eds.) 1999. Forests to fight poverty: Creating national strategies. Vail-Ballou Press, USA. 168-181 pp.

Guizol, P. & Aruan, A. 2004. Impact of incentives on the development of forest plantation resources in Indonesia, with emphasis on industrial timber plantations in the outer islands. In: Enters, T & Durst, P.B. (eds.). 2004. What does it take? The role of forest incentives in forest plantation development in Asia and the Pacific. FAO, Bangkok. 103-124 pp.

Gunasena, H.P.M. & Roshetko, J.M. 2000. Tree Domestication in Southeast Asia: Results of a Regional study on institutional capacity, ICRAF, Bogor.

Hall, N., Turnbull, J.W., Doran, J.C. & Martinez, P.N. 1980. *Acacia mangium*. In: Australian Acacia Series. CSIRO Forest Research Leaflet 9. CSIRO, Canberra.

Haltia, O. & Keipi, K. 1999. Financing forest investment: The issue of incentives. In: Keipi, K. (ed.) Forest resource policy in Latin America. Inter-American Development Bank. Washington, D.C., 63-78 pp.

Hares, M. 2008. Perceptions of ethnic minorities on tree growing for environmental services in Thailand. In: Snelder, D.J. & Lasco, R.D. (eds.). 2008. Smallholder tree growing for rural development and environmental services: Lessons from Asia. Springer Science+ business Media B. V. 411-425 pp.

Harrison, S.R. & Herbohn, J.L. 2001a. Evolution of small-scale forestry in the tropics. In: Harrison, S.R. & Herbohn, J.L (eds.). 2001. Sustainable farm forestry in the tropics. Social and economic analysis and policy. Edward Elgar, Cheltenham, UK & Northampton, MA, USA. 3-8 pp.

Harrison, S.R. & Herbohn, J.L. 2001b. Towards a vibrant tropical small-scale forestry industry: Imperatives, opportunities and challenges. In: Harrison, S.R. & Herbohn, J.L (eds.). 2001. Sustainable farm forestry in the tropics. Social and economic analysis and policy. Edward Elgar, Cheltenham, UK & Northampton, MA, USA. 271-282 pp.

Hyman, E.L. 1983. Loan financing of smallholder tree farming in the provinces of Ilocos Norte and Ilocos Sur, the Philippines. *Agroforestry Systems* 1(3): 225-243.

Jagger, P., Pender, J. & Gebremedhin, B. 2005. Trading off environmental sustainability for empowerment and income: Woodlot devolution in northern Ethiopia. *World Development* 33(99): 1491-1510.

Kaimowitz, D. 2003. Not by bread alone... Forests and rural livelihoods in Sub-Saharan Africa. In: Oksanen, T., Pajari, B. and Tuomasjukka, T. (eds.). Forests in poverty reduction strategies: Capturing the potential. EFI, Joensuu, Finland. 5-64 pp.

Kanninen, M., Pérez, L.D., Montero, M. & Viquez, E. 2004. Intensity and timing of the first thinning of *Tectona grandis* plantations in Costa Rica: Results of a thinning trial. *Forest Ecology and Management* 203: 89-99.

Koh, H.L., Chua, T.K. & Tan, C.H. 2009. A guide to Medical Plants. Illustrative, Scientific and Medical Approach. World Scientific Publishing.

Kollert, W. & Cherubini, L. 2012. Teak resources and market assessment 2010. FAO Planted Forests and Trees Working Paper FP/47/E, Rome.

Krishnapillay, B. 2000. Silviculture and management of teak plantations. *Unasylva* 51 (201):14-21.

Krisnawati, H. 2007. Modelling stand growth and yield for optimizing management of *Acacia mangium* plantations in Indonesia. PhD thesis, the University of Melbourne, Australia.

Krisnawati, H., Kanninen, M. & Kallio, M.H. 2010a. Stand growth and management scenarios for *Anthocephalus cadamba* Miq. plantations in Indonesia. Unpublised manuscript.

Krisnawati, H., Kanninen, M. & Kallio, M.H. 2010b. Stand growth and management scenarios for mahogany (*Swietenia macrophylla*) plantations in Indonesia. Unpublished manuscript.

Krisnawati, H., Kallio, M.H. & Kanninen, M. 2011a. *Acacia mangium* Wild. Ecology, silviculture and productivity. CIFOR, Bogor.

Krisnawati, H., Kallio, M.H. & Kanninen, M. 2011b. *Anthochepalus cadamba* Miq. Ecology, silviculture and productivity. CIFOR, Bogor.

Krisnawati, H., Kallio, M.H. & Kanninen, M. 2011c. *Swietenia macrophylla* King. Ecology, silviculture and productivity. CIFOR, Bogor.

Kumar, A., Sinha, A.K. & Singh, D. 2003. Studies of Eucalyptus plantations under the farm forestry and agroforestry systems of U.P. in Northern India. *Forests, Trees, and Livelihoods* 13: 313-330.

Lamb, D. 2011. Greening the Bare Hills. World Forest 8. Springer Science+Business Media B.V.

Lamb, F.B. 1966. *Swietenia macrophylla* of tropical America: Its ecology and management. University of Michigan Press, Ann Arbor, Michigan, USA.

Lemmens, R.H.M.J., Soerianegara, I. & Wong, W.C. (eds.). 1995. Plant resources of South-east Asia No. 5(2). Timber trees: Minor commercial timbers. Backhuys Publishers, Leiden.

Luttrell, C., Obidzinski, K., Brockhaus, M., Muharrom, E., Petkova, E., Wardell, A. & Halperin, J. 2011. Lessons for REDD+ from measures to control illegal logging in Indonesia. Working paper No. 74. United Nations Office on Drugs and Crime and CIFOR, Jakarta and Bogor.

Mahapatra, A.K. & Mitchell, C.P. 2001. Classifying tree planters and non planters in a subsistence farming system using a discriminant analytical approach. *Agroforestry Systems* 52 (1): 41-52.

Manurung, G.E.S., Roshetoko, J.M., Budidarsono, S. & Kurniawan, I. 2008. Dudukuhan tree farming systems in West Java: How to mobilize Self-Strenghtening of Community-Based Forest Management? In: Snelder, D.J. & Lasco, R.D. (Eds.) Smallholder Tree Growing for Rural Development and Environmental Services. Lessons from Asia. Springer 2008. 75-98 pp.

Manurung, E.G.T, Simangunsong, B.C.H, Sukardi, D., Widyantoro, B, Justianto, A., Ramadhan, S., Sumardjani, L., Rochadi, D., Permadi, P, Priyono, B.M. & Supriyanto, B. 2007. Road map revitalisasi industry kehutanan Indonesia (Road map revitalizing Indonesia's forestry industry). Ministry of Forestry, Jakarta.

Maturana, J., Hosgood, N. & Suhartono, A. 2005. Moving towards company-community partnerships: Elements to take into account for fast-wood plantation companies in Indonesia. CIFOR, Bogor.

Mayhew, J. E. & Newton, A.C. 1998. The silviculture of Mahogany. CABI Publishing, New York.

Mercer, D.E. 2004. Adoption of agroforestry innovations in the tropics: A review. *Agroforestry Systems* 61(2): 311–328.

Ministry of Agriculture and Rural Development (MARD). 2000. Task Force I Report: Clarification of the Five Million Hectare Reforestation Program. Hanoi.

Ministry of Forestry (MoF) and National Statistics Agency. 2004. Potential of the Private Forestry in Indonesia.

Ministry of forestry (MoF). 2007. Department of Forestry allocates forest land of 5.4 million hectares for People's Plantation Forests to support Rehabilitation. Press release No. S.51/II/PIK-1/2007, 22 February 2007.

Ministry of Forestry (MoF). 2009. Forestry statistics of Indonesia. Department of Forestry, Ministry of Forestry, Jakarta.

Muhtaman, D., Guizol, P., Roda, J.M & Purnomo, H. 2006. Geographic indications for Javanese teak: A constitutional change. Paper presented at the 11th Biennial Global Conference of The International Association for the Study of Common Property (IASCP) on 19-23 June 2006 in Bali, Indonesia.

Nair, K.S.S & Sumardi. 2000. Insect pests and diseases of major plantation species. In: Nair, K.S.S. (ed.) Insect pests and diseases in Indonesian forests: An assessment of the major treats, research efforts and literature. CIFOR, Bogor.

Nambiar, E.K.S (ed.). 2008. Site Management and Productivity in Tropical Plantation Forests. Proceedings of Workshop in Piracicaba (Brazil) 22-26 November 2004 and Bogor (Indonesia) 6-9 November 2006. CIFOR, Bogor.

National Research Council, 1983 Mangium and other fast-growing Acacias for the humid tropics. National Academy Press, Washington, D.C.

Nawir, A.A. 2007. Forest rehabilitation in Indonesia: Where to after three decades? Nawir, A.A., Murniati, Rumboko, L. (eds.) CIFOR, Bogor.

Nawir, A. & Santoso, L. 2005. Mutually beneficial company-community partnerships in plantation development: Emerging lessons from Indonesia. *International Forestry Review* 7(3): 177–192.

Nibbering, J.W. 1999. Tree planting on deforested farmlands, Sewu Hills, Java, Indonesia: Impact of economic and institutional changes. *Agroforestry Systems* 46(1): 65–82.

Nkamleu, G.B. & Manyong, V.M. 2005. Factors affecting the adoption of agroforestry practices by farmers in Cameroon. *Small-scale Forest Economics, Management and Policy* 4(2): 135-148.

Obidzinski, K. 2005. Illegal logging in Indonesia: Myth and reality. In Resosudarno, B. (ed.). The politics and economics of Indonesia's natural resources. Institute of Southeast Asian Studies, Singapore. 193-205 pp.

Obidzinski, K. & Chaudhury, M. 2009 Transition to timber plantation based forestry in Indonesia: Towards a feasible new policy. *International Forestry Review* 11: 79–87.

Obidzinski, K. & Dermawan, A. 2010. Smallholder timber plantation development in Indonesia: What is preventing progress? *International Forestry Review* 12(4): 339-348.

Old, K.M., Lee, S.S., Sharma, J.K. & Yuan, Z.Q. 2000 A manual of diseases of tropical acacias in Australia, South-east Asia and India. CIFOR, Bogor.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R. & Anthony, S. 2009 Agroforestry tree database: A tree reference and selection guide version 4.0. http://www.worldagroforestry.org /treedb2/ AFTPDFS/*Anthocephalus _cadamba*.pdf [7 December 2010].

Otsamo, R. 2002. Early effects of four fast-growing tree species and their planting density on ground vegetation in Imperata grasslands. *New Forests* 23: 1–17.

Pattanayak, S. K., Mercer, D. E., Sills, E., & Yang, J. C. 2003. Taking stock of agroforestry adoption studies. *Agroforestry Systems* 57(3): 137-150.

Perdana, A., Roshetko, J. & Kurniawan, I. 2012. Forces of competition: Smallholder teak producers in Indonesia. *International Forestry Review* 14(2): 238-248.

Perez, D. & Kanninen, M. 2005. Effect of Thinning on Stem Form and Wood characteristics of Teak (*Tectona grandis*) in a humid tropical site in Costa Rica. *Silva Fennica* 39(2): 217–225.

Perum Perhutani. 1995. A glance at Perum Perhutani (Forest State Corporation) Indonesia. Perum Perhutani, Jakarta.

Pinyopusarerk, K., Liang, S.B. & Gunn, B.V. 1993. Taxonomy, distribution, biology and use as an exotic. In: Awang, K. & Taylor, D. (eds) *Acacia mangium*: Growing and utilization. Winrock International and FAO, Bangkok. 1–19 pp.

Pramono, A.A., Fauzi, M.A., Widyani, M., Heriansyah, I. & Roshetko, J.M. 2011. Managing smallholder teak plantations: Field guide for farmers. CIFOR, Bogor.

Pusat Inventarisasi dan Statistik Kehutanan. 2004. Potential of Indonesian Private Forestry. Department of Forestry, Jakarta.

Raintree, J. B. 1987. The state of the art agroforestry diagnosis and design. *Aroforestry Systems* 5: 219-250.

Raintree, J.B. 1991. Socioeconomic attributes of trees and tree planting practice. FAO, Rome.

Ravindran, D.S. & Thomas, T.H. 2000. Trees on farms, stores of wealth and rural livelihoods — Insights and evidence from Karnataka, India. *International Forestry Review* 2(3): 182–190.

Rimbawanto, A. 2002. Plantation and tree improvement trends in Indonesia. In: Barry, K. (ed.) Heartrots in plantation hardwoods in Indonesia and Australia, 3–7. ACIAR Technical Report 51e. ACIAR, Canberra.

Rohadi, D., Roshetko, J.M., Perdana, A., Blyth, M., Nuryartono, N., Kusumowardani, N., Pramono, A.A., Wdiyani, N., Fauzi, A., Sanono, J., Sumardamto, P. & Manalu, P. 2012. Improving economic outcomes for smallholders growing teak in agroforestry systems in Indonesia. ACIAR, Canberra.

Roshetko, J. M., Mulawarman & Dianarto, A. 2004. Tree seed procurement-diffusion pathways in wonogiri and Ponorogo, Java. Indonesia's main source of tree seed. ICRAF Southeast Asia working paper 2004-1.

Roshetko, J.M., Nugraha, E., Tukan, J.C.M., Manurung, G., Fay, C. and Van Noordwijk, M. 2007. Agroforestry for livelihood enhancement and enterprise development. Proceedings of the international workshop for Integrated Rural Development in East Nusa Tengara held 5-7 April 2006 in Kupang, West Timor, Indonesia.

Rudel, T.K. 2009. Tree farms: Driving forces and regional patterns in the global expansion of forest plantations. *Land Use Policy* 26: 545-550.

Salam, M.A., Noguchi, T. and Koike, M. 2000. Understanding why farmers plant trees in the homestead agroforestry in Bangladesh. *Agroforestry Systems* 50(1): 77–93.

Scherr, S.J. 1995. Economic factors in farmer adoption: patterns observed in Western Kenya. *World Development* 23: 787–804.

Scherr, S.J. 1997. Meeting household needs: Farmer tree-growing strategies in western Kenya. In: Arnold, J.E.M., Dewees, P.A. (eds). 1997. Farms, trees and farmers: responses to agricultural intensification. Earthscan, London. 141–169 pp.

Scherr, S.J. 2004. Building opportunities for small-farm agroforestry to supply domestic wood markets in developing countries. *Agroforestry Systems* 61-62(1): 357–370.

Sen, D. & Das, P.K. 1988. Poverty alleviation through group farm forestry - a Case-Study. *Journal of Rural Development* 7(6): 663-673.

Shackleton, C.M. & Shackleton, S.E., Buiten, E. & Bird, N. 2007. The importance of woodlands and forests in rural livelihoods and poverty alleviation in South Africa. *Forest Policy and Economics* 9(5): 558–557.

Shono, K. & Snook, L.K. 2006. Growth of big-leaf mahogany (*Swietenia macrophylla* King) in natural forests in Belize. *Journal of Tropical Forest Science* 18: 66-73.

Sikor, T. 2011 Financing household tree plantations in Vietnam: Current programmes and future options. Working Paper 69. CIFOR, Bogor.

Simmons, C.S., Walker, R.T. & Wood, C.H. 2002. Tree planting by small producers in the tropics: A study of Brazil and Panama. *Agroforestry Systems* 56(2): 89–105.

Slender, D.J. & Lasco, R.D. 2008. Smallholder Tree Growing in South and Southeast Asia. In Slender, D.J. & Lasco, R.D. (eds). Smallholder Tree Growing for Rural Development and Environmental Services. Lessons from Asia. Springer 2008. 3-36 pp.

Slik, J.W.F. 2006. Trees of Sungai Wain. Nationaal Herbarium Nederland, Leiden University Branch, Leiden.

Soerianegara, I. & Lemmens, R.H.M.J. 1993. Plant resources of South-east Asia: Timber trees: Major commercial timbers. Pudoc Scientific Publishers, Wageningen.

Song, Y., Burch, W.R., Geballe, G. & Geng, L. 1997. New organizational strategy for managing the forests of Southeast China. *Forest Ecology and Management* 91: 183–194.

Song, Y., Wang, G., Burch, W.R. & Rechlin, M.A. 2004. From innovation to adaptation: Lessons from 20 years of the SHIFT forest management system in Sanming, China. *Forest Ecology and Management* 191: 225–238.

Srivastava, P.B.L. 1993. Silvicultural practices. In: Awang, K. & Taylor, D. (eds.). *Acacia mangium*: Growing and utilization. Winrock International and FAO, Bangkok. 113-148 pp.

Stark, T. & Cheung, S.P. 2006. Sharing the blame: Global consumption and China's role in ancient forest destruction. Greenpeace International and Greenpeace China. Amsterdam.

Sudarmo, M.K. 1957. Preliminary yield table for *Anthocephalus cadamba* Miq. (jabon). Pengumuman No. 59. Forest Research Institution, Bogor.

Sugiharto. 2007. Local people's readiness and the right pattern. *AgroIndonesia* 3(131): 5.

Suharlan, A., Sumarna, K. & Sudiono, J. 1975. Growth table for ten industrial species. Technical Information No 29. Headquarters of Forest Research and Development, Bogor.

Suharti, M., Asmaliyah & Hawiati, W.P. 1995. The mimba (*Azadirachta indica*) plant as a source of plant-based insecticide for controlling forest pests. *Buletin Penelitian Hutan* 589: 1-26.

Summers, P.M., Browder, J.O. & Pedlowski, A.M. 2004. Tropical forest management and silvicultural practices by small farmers in Brazilian Amazon: Recent farm-level evidence from Rodonia. *Forest Ecology and Management* 192(2-3): 161-177.

Sunderlin, W.D., Angelsen, A., Resosudarmo, D.P., Dermawan, A. & Rianto, E. 2001. Economic crisis, small farmer well-being, and forest cover change in Indonesia. *World Development* 29: 767-782.

Sunderlin, W.D. 2006. Poverty Alleviation Through Community Forestry in Cambodia, Laos and Vietnam: An assessment of the potential. *Forest Policy and Economics* 8(3): 386-396.

Susila, I.WW. & Njurumana, G.N.D. 2005. Productivity of mahogany pantations in Kanar, Sumbawa and Takari, Kupang. *Info Hutan* 2(4): 273-279.

Thacher, T., Lee, D.R., & Schelhas, J.W. 1997. Farmer participation in reforestation incentive programs in Costa Rica. Working paper 97-11. Department of Agricultural, Resource and Managerial Economics; Cornell University, Ithaca, New York.

Turnbull, J.W. 1986. Australian acacias in developing countries. Proceedings of the International workshop held at the Forestry Training Centre, Gympie, Queensland, Australia, 4–7 August 1986. ACIAR Proceedings No. 16. ACIAR, Canberra.

Tyynelä, T., Otsamo, A., Otsamo, R. 2002. Changes and alternatives in farmers' livelihood planning in an industrial forest plantation area in West Kalimantan, Indonesia. *Forests, Trees and Livelihood*s 12(4): 257–281.

Van Noordwijk, M., Budidarsono, S., Sakuntaladewi, N., Roshetko, J.M., Tata, H.L., Galudra, G. & Fay, C. 2007. Is Hutan Tanaman Rakyat a new paradigm in community based tree planting in Indonesia? ICRAF working paper No. 45. ICRAF Southeast Asia, Bogor.

Varmola, M.I. & Carle, J.B. 2002. The importance of hardwood plantations in the tropics and sub-tropics. *International Forestry Review* 4(2): 110-121.

Verchot, L.V., Petkova, E., Obidzinski, K., Atmadja, S., Yuliani, E.L., Dermawan, A., Murdiyarso, D. & Amira, S. 2010. Reducing forestry emissions in Indonesia. CIFOR, Bogor.

Walker, R.T. & Homma, AK.O.1996. Land use and land cover dynamics in the Brazilian Amazon: an overview. *Ecological Economics* 18: 67-80.

Walters, B.B., Cadelina, A., Cardano, A. & Visitacion, E. 1999. Community history and rural development: Why some farmers participate more readily than others. *Agricultural Systems* 59(2): 193–214.

Walters, B.B., Sabogal, C., Snook, L.K. & de Almeda, E. 2005. Constraints and opportunities for better silvicultural practice in tropical forestry: An interdisciplinary approach. *Forest Ecology and Management* 209(1-2): 3–18.

White, A. & Martin, A. 2002. Who own the world's forests?: Forest tenure and public forests in transition. Forest Trends, Center for International Environmental Law, Washington, DC.

White, A., Xiufang, S. Jintau, X., Barr, C., Katsigris, E., Bull, G., Cossalter, C. & Nilsson, S. 2006. China and the global market for forest products: Transforming trade to benefit forests and livelihoods, Washington, D.C.: Forest Trends, CIFOR, Rights and Resources Initiative, and Center for Chinese Agricultural Policy.

Wiersum, K.F. 1982. Tree gardening and taungya on Java: Examples of agroforestry techniques in the humid tropics. *Agroforestry Systems* 1:53-70.

World Bank. 2006. Sustaining economic growth, rural livelihoods, and economic benefits: Strategic options for forest assistance in Indonesia. Worl Bank, Jakarta.

Wulfing, H.H.W.V. 1949. Preliminary yield table of *Swietenia mahogany/ macrophylla*. Pengumuman No. 7. Lembaga Penelitian Kehutanan, Bogor.

Wunder, S. 2005. Payments for environmental services: Some nuts and bolts. CIFOR Occasional Paper No. 42. CIFOR, Bogor.

Annex 1. The criteria used by the village representatives for household wealth ranking in: a) Ranggang Village, b) Asem Jaya Village, and c) the four sub villages in Central Java.

a) Ranggang Village

Criteria	Poor	Medium	Wealthy
Housing	Non or semi-permanent housing	Any that are not categorized as poor or wealthy	Permanent housing
Ownership of vehicles	No vehicle		Car or motorcycle
Ownership of furniture	No		Yes
Ownership of livestock	Small amount of poultry		Large amount of livestock
Ownership mahogany/ rubber plantation	Less than 1 ha		More than 2 ha
Security of income	Insecure income		Stable
Education of the children	Junior high school or lower		Senior high school, employees

b) Asem Jaya Village

Criteria	Poor	Medium	Wealthy
Housing	House has not been renovated (standard house as given from government)	Any that are not categorized as poor or wealthy	House has been renovated permanently.
Ownership of vehicles	No vehicle		Car or motorcycle
Ownership of furniture	No		Yes
Ownership of livestock	No livestock or may have few poultry		At least 1 cow
Ownership of rubber plantation	No rubber plantation		Rubber plantation with production age (more than 6 years old)
Security of income	Insecure income/depend only from farm products (annual crops)		Stable (have continues source of income either from latex production or off farm job)
Education of the children	Junior high school or lower		Senior high school, employees

Note: The criteria used in Riau were similar to South Kalimantan, but not available.

c) Four sub-villages in Central Java

Criteria	Poor	Medium	Wealthy
Sendangijo (Kedung Banteng and Ngawen sub-villages)			
Income	Working in someone else's land	At least one person goes out of the village to work	Have land for agriculture and one person goes out the village to work
Land	Have land but not productive	Land with medium productivity	Large area of productive land > 3 ha
Capability to think of new ideas for income development	No new ideas for development	Ideas for development	Ideas for development and implemented successfully
Education of the children	Junior high school or lower	Senior high school	Higher than senior high school
Rejosari (Sosogan sub-village)			
Income source	labor, no land	Farmer on own land or labor	Work on own land, and have another income source
Heritage	little land, house inherited	house, land inherited	house, land inherited
House	Made from bamboo	from wood, floor not ceramic	Concrete house, floor ceramic
Education of the children	Junior high school or lower	Senior high school	University
Rejosari (Genjikan sub-village)			
Land	no land for agriculture	< 2 ha	>2 ha
House	Floor not ceramic	cement	Floor from ceramic

Annex 2. Sources for the statistical data on the study districts and sub-districts (Table 2 and Table 3).

[1] Situs Resmi Kabupaten Kuantan Singingi (Kuansing). Available at http://www.kuansing.go.id (Accessed 28 June 2010).

[2] Kabupaten Tanah Laut Dalam Angka 2007/2008. Badan Pusat Statistik Kabupaten Tanah Laut, Kalimantan Selatan; Situs Resmi Pemerintah Kabupaten Tanah Laut. Available at http:// tanahlautkab.go.id/ kondisi-wilayah/ (Accessed 15 Sep 2009).

[3] Kabupaten Wonogiri dalam Angka 2008. Badan Pusat Statistik Kabupaten Wonogiri, Jawa Tengah ; Database Kehutanan 2009. Dinas Kehutanan dan Perkebunan Kabupaten Wonogiri.

[4] Kabupaten Karanganyar dalam Angka 2009. Badan Pusat Statistik Kabupaten Karanganyar, Jawa Tengah.

[5] http://www.riaupos.com/berita.php/act=full&id=3716&kat=7.

[6] Statistik Dinas Kehutanan Provinsi Riau 2006. Dinas Kehutanan Provinsi Riau.

[7] Riau dalam Angka 2006. Badan Pusat Statistik Propinsi Riau.

[8] Statistik Kehutanan Provinsi Jawa Tengah 2007. Dinas Kehutanan Provinsi Jawa Tengah.

[9] Situs Resmi Kabupaten Kuantan Singingi (Kuansing). Available at http://www.kuansing.go.id (Accessed 28 June 2010).

[10] Kabupaten Tanah Laut Dalam Angka 2007/2008. Badan Pusat Statistik Kabupaten Tanah Laut. Kalimantan Selatan.

[11] Kecamatan Selogiri dalam Angka Tahun 2008. Badan Pusat Statistik dan Bappeda Kabupaten Wonogiri, Jawa Tengah.

[12] Kacamatan Gondangrejo dalam angka 2009. Koordinator statistic kacamatan. Kacamatan Gondangrejo kabubaten Karanganyar, Jawa Tengah.

Annex 3. The silvicultural questionnaire (a) and the socio-economic questionnaire (b) used in this study.

(a) Silvicultural questionnaire

[Questions asked from the farmer only once:]

A. General information on the tree plantations/woodlots

No block/ stand	Area (ha)	Species	Density (trees/ha)	Accessibility to the plantation	Age of the plantation (years)

Select the accessibility: 3: difficult, have to walk; 2: regular, accessible by motorcycle; 1, easy: accessible with car

B. Species planted outside the woodlots (home garden, fallow, other)

Do you have any other tree species in your land? If yes, which species and why?	Planted/natural regeneration	Number of trees	Reason
Species 1			
Species 2			
Species 3			
Species 4			
If not, why not?			
Did you plant/grow other species which you don't plant/grow anymore? If yes, which species and why did you stop growing them?			

C. Attitudes/perception of tree planting (acacia, kadam, mahogany and teak)

1. What is your attitude towards tree planting?	Very favorable	Favorable	Indifferent	Unfavorable	Very unfavorable
2. What do you think the attitudes of other people towards establishment of tree plantation are?	Very favorable	Favorable	Indifferent	Unfavorable	Very unfavorable
3. How important are the attitudes of other people to you regarding your decision making on plantation establishment?	Very important	Important	Indifferent	Not important	

D. Why do you plant trees? (Write reasons mentioned in an order of priority)

Give the farmer's reasons for planting trees	Rank in order of priority
1.	
2….	

[Questions asked for each block separately]

E. Information related to silvicultural activities

1. Who influenced your decision to plant this species?	Myself	Government	Company	Association	Other, what?
2. What is the seedling source? (Name, define company/government/ other, what?)					
3. Seedling availability:	Easy	Moderate	Difficult		
4. Seedling quality	Low	Moderate	Good		
5. Do you practice yourself silvicultural management in your woodlots?	Yes	No			
6. Who does it, if not yourself?					

F. Management history of the plots

Number of the block _____ Species _____						
Operation	When? (Year and month)	Who?	Labor time (days)	Material needed	How conducted? (Amount, techniques etc.)	Why conducted?
Land preparation/ Land clearing						
Seedling preparation/storing						
Planting						
Replanting						
Fertilizing						
Weeding						
Pruning						
Thinning						
Protection						
Harvesting						
Measuring						
Transporting						

G. Plantation performance

1. How do you describe the current growth and quality of your plantation/ block?	Low	Regular	Good	Excellent	I don't know
2. Why?					

H. Disadvantages

1. What kind of disadvantages/problems do you think the plantations can have?	How important do you think this disadvantage is in your plantation? Rank the importance. Code: 1 = not important; 2 = important, 3 = very important
1.	
2…	

I. Harvesting

1. Who influences your decision on when to harvest your trees?	Myself	Company	Government	Other (who?)
2. Why do you plan to harvest at the specific rotation length?	Identify the rotation length: (years)	Reason for the harvest:		
3. Do you think you can estimate the yield?		Yes	No	I don't know
4. Do you think you get a good price?		Yes	No	I don't know
5. If you have already harvested and sold the trees, how did you use the revenues? Rate: 1: not important, 2: important, 3: very important.		For regular consumption	1-3 ☐	
		For savings/investment (expected expenditures)	1-3 ☐	What:
		To unexpected expenditures	1-3 ☐	What:
			1-3 ☐	
			1-3 ☐	What:
			1-3 ☐	What:

J. Incentives

1. Which kind of incentives did you receive? Identify the type and how much.	Access to land ownership ☐	Seedling and material ☐	Help in extension/training ☐	Economic incentive ☐	Help in marketing ☐
Amount:					
2. What kind of technical assistance did you receive?	Seedling preparation ☐	Site preparation and weeding ☐	Pruning ☐	Thinning ☐	Protection ☐
Assistance to:	Measuring ☐	Harvesting ☐			
3. If you received economic incentives, how did you use them? (open ended)					

4. Rate the importance of different types of incentives regarding to your decision to plant trees.	Not important (1)	Important (2)	Very important (3)
Economic incentives (money)			
Seedlings and material (fertilizers)			
Help in education, training, extension			
Help in marketing			
Access to land			
5. Would you join the incentive program again?	Yes ☐ No ☐	Why?	
6. Did you plant trees before receiving incentives?	Yes ☐ No ☐	Which species? Why?	

[Questions asked from the farmer only once:]

K. Joint management with other tree planters

1. Do you do any management activities together with other tree planters in the area?		Yes ☐ No ☐
If yes:	1.1. Which activities?	
	1.2. Why do you do the joint activities?	
2. Which management activities do you think would be good to do together with other tree planters in the area, if not already done?		

L. Learning silvicultural management

1. Where did you learn the management of tree plantations?	Other tree planters ☐	Public institution ☐	Company ☐	Farmers' association ☐	Other ☐ (what?)

M. Improving tree planting activity and future planting

1. How do you think the silvicultural management could be improved?
2. How do you think you could get better price from your plantation?
3. Do you think you will continue planting trees, and if yes under what conditions?
4. If you won't plant more trees, why not?

(b) Socio-economic questionnaire

1. Respondent identification

Name of Respondent	
Name of the household head	
Status in the family	
Age of respondent (years)	
Address of respondent	
RT/RW	
Village	
District	
Code of respondent	
Name of Enumerator	
Date of interview (dd/mm/yy)	
Name of supervisor	
Date of questionnaire checking by supervisor (dd/mm//yy)	
Signature of supervisor	

2. Household members

No	Name
Name	
Sex	Male/female
Age	Years
Status in the family	
Marital status	Not married/married/widow
Education level	Educational level: 1. Never joined the formal school; 2. Elementary school; 3. Secondary school; 4. Senior high school; 5. Diploma; 6. Bachelor; 7. Master degree; 8. Doctor degree; 9. Informal school or pesantren (state the level or number of years in pesantren)
Current main occupation	Current occupation: 1. Farmer working on own land; 2. Govt. employee; 3. Private company employee; 4. Daily labor; 5. Farm fixed labor; 6. House wife; 7. Student; 8. Jobless; 9. Retired; 10. Disabled to work; 11. Others (please specify).

Notes: The record covers all persons, including the respondent and other HH members who share the same house, including those who left in less than two months.

3. Tenure and land use system

No of block	
Land use system	Land use system: 1. Home garden = land area surrounding the farmers' house; 2. Sawah, irrigated land mainly used for growing rice and other agricultural crop production; 3. Fallow = rain-fed dry land area, mainly used for perennial crops and could be mixed with some tree plantation. When trees exist, record the predicted percentage of land area used for tree plantation (or record the density of trees); 4. Woodlot = Land area mainly used for tree production, could be monoculture or mixed species; 5. Oil palm plantation; 6. Rubber plantation; 7. Other types (please specify).
Area	ha
Land ownership	Land ownership: 1. Privately owned with certificate / "Surat Keterangan Tanah (SKT)"; 2. Privately owned without certificate; 3. Rented land; 4. Land generated from shifting cultivation activities; 5. Land owned by someone else and managed under benefit sharing system; 6. Others (please specify)
Land ownership inheritance	Land ownership inheritance: 1. Gift/inherited from parents; 2. Purchased land; 3. Rented land; 4. Generated from shifting cultivation activities; 5. Permit from local government; 6. Permit from company; 7. Permit from other parties (specify the party who issued the permit).
Land management system	Land management system: 1. Self-managed; 2. Paid labor; 3. Partnership model; 4. Rented by someone else; 5. Managed by someone else with benefit sharing system; 6. Others (please specify) Species/commodities: Write down the major species or commodities planted and put the approximate percentage in parentheses where mix planting occur
Frequency of visit to land	Number of visits per unit time
Distance from house/ settlement	km or specify the unit system
Species/ commodities	
Age of plantation	years
Main reasons for planting these species/commodities	*Main reason for planting the species/commodities:* 1. Subsistence purposes; 2. Economical purposes or source of cash income; 3. Environmental purposes; 4. Social purposes; 5. Other purposes, please specify.

Note: For all the blocks separately

4. Additional questions for the non-tree planters

1.	Why do you not plant trees on your land?
2.	Have you ever plant trees on your land? Yes or No. If Yes, what kind of species have you planted and what was the main purpose?
3.	Do you want to plant trees in the future? Yes or No. If Yes, which species and what is the main purpose?
4.	What are the advantages or disadvantages of tree planting in your opinion?
5.	How do you describe the attitudes of the people important to you on establishing a tree plantation? _____ very favorable _____ favorable _____indifferent _____unfavorable _____very unfavorable
6.	Are these attitudes of other people important to you regarding your decision to establish tree plantations? _____ very important ____somewhat important _____ indifferent _____ not important _____ I don't know

5. Household income

Household members	Source of household income
Note: Rank based on the greatest share to household income.	Source of household income: Off farm: 1. Labor; 2. Fix employee; 3. Trader; 4. Home industries; 5. Service provider On farm: 1. Labor; 2. Animal husbandry; 3. Agricultural crops; 4. Timber; 5. Oil palm; 6. Rubber latex; 7. Others (please specify)

Note: Record all HH members who generate income and share for HH income.

6. Household expenses

Source of expenses	Average expenses per unit time (Rp per day/week/month/year)
1. Food	
2. Education	
3. Health	
4. Clothes	
5. Housing:	
5a. Electricity	
5b. Drinking water and sanitation	
5c. House maintenances	
6. Social costs	
7. Recreations	
8. Others (specify!)	

Note: This sheet is used to predict the approximate average yearly household expense

7. Housing and housing assets

Housing ownership

1. Certified privately owned	2. Privately owned but not certified	3. Rented	4. Permit to use from legal institutions	5. Permit to use from relatives

Housing quality:

1. Permanent	2. Semi-permanent	3. Not permanent

Electricity:

1. Private electricity facility	2. Own electric generator	3. Access from neighbor	4. Does not have electricity facility

Cooking energy:

1. LPG	2. Kerosene stove	3. Charcoal	4. Purchased fuel wood	5. Collected fuel wood

Drinking water:

1. Private PAM facility	2. Private well	3. Access PAM from neighbor	4. Access well from neighbor	5. Public well	6. Lake/river

Sanitation facility:

1. Private toilet	2. Access toilet from neighbor	3. Public toilet

8. Household assets

Note: This sheet is used to describe the current assets owned by household

Types of assets	Number of units owned	Current value (Rp)	Brand	Date of purchase (year)
Car				
Motorcycle				
Bicycle				
Horse wagon				
Television				
Radio				
Furniture				
Hand phone				
Agricultural tools and equipment				
Jewelry				
Others				

9. Animal husbandry

Domesticated animals	Age (month or year)	Number of animals owned	Ownership	Current value (Rp)
Bull				
Cow				
Horse				
Goat/sheep				
Duck				
Chicken				
Others (specify!)				

Ownership: 1. Privately owned; 2. Benefit sharing (explain the benefit sharing scheme); 3. Others (explain)

10. Social capital

Name of association/ group	Period of membership (year)	Type of group	Meeting frequency / year	Household participa-tion/ year	HH role in the group	Benefits received by HH
1.						
2.						

Note: Explain the range of associations or groups (the five most important according to household perception) that household currently is engaged.

Type of group: 1. Farmer group; 2. Cooperative; 3. Cultural/art group; 4. Sport group; 6. Womens group; 7. Professional group; 8. Political party; 9. Other (specify)

Role in the group: 1. Member; 2. Head of the group; 3. Executive officer

UNIVERSITY OF HELSINKI
Viikki Tropical Resources Institute
VITRI

TROPICAL FORESTRY REPORTS

No. 1	Johansson, S. (ed.) 1989. Tutkimus ja kehitysmaiden metsät. Raportti Espoossa 6.–7.10. 1988 pidetystä seminaarista. Forestry research needs in developing countries. Proceedings of seminar held in Espoo 6–7 October 1988 (in Finnish, with an English appendix).
No. 2	Salo, T. 1989. Study on export possibilities of mechanical forest industry products from selected Eastern and Southern African countries.
No. 3	Pietarinen, I. 1989. Agroforestry systems and intergrated land-use in the humid tropics.
No. 4	Johansson, S., Luukkanen, O., Kaarakka, V. & Mulatya, J. 1990. Forestry in irrigation schemes I. Research activities at Bura, Kenya 1984–87.
No. 5	Kaarakka, V., Johansson, S., Luukkanen, O. & Maingi, J. 1990. Forestry in irrigation schemes II. Research activities at Bura, Kenya 1988–89.
No. 6	Sirikul, W. 1990. Shoot growth and flower development in tropical pines: Studies on genetic and environmental variation. Doctoral thesis (limited distribution).
No. 7	Luukkanen, O. & Hakulinen, M. (eds.) 1991. From Bangkok to the Blue Nile. Review of the first decade of the Tropical Silviculture Research Group 1980–1990 and abstracts of Research reports.
No. 8	Otsamo, A., Laxén, J., Johansson S., Kaarakka, V., Kuusipalo, J., Luukkanen, O. & Odhiambo Maua, J. 1993. Forestry research in Bura, Kenya 1984–1993. Final report of the research component in Bura Fuelwood Project.
No. 9	Laxén, J., Koskela, J., Kuusipalo, J. & Otsamo, A. (eds.) 1993. Proceedings of the Bura Fuelwood Project research seminar in Nairobi 9–10 March, 1993.
No. 10	Johansson, S. 1995. Forestry in irrigated agricultural schemes with special reference to the Bura Irrigation and Settlement Project, Kenya. Doctoral thesis (limited distribution).
No. 11	Ibrahim, A. M. 1996. Genetic variation in Faidherbia albida: Implications for conservation of genetic resources and tree improvement. Doctoral thesis.
No. 12	Pipatwattanakul, D. 1996. An analysis of the functional and structural basis of the yield in Eucalyptus camaldulensis progenies grown in Thailand. Doctoral thesis.
No. 13	Tuomela, K. 1997. Physiological and morphological responses of Eucalyptus microtheca provenances to water availability in tropical drylands. Doctoral thesis (limited distribution).
No. 14	Sharawi, H. A. 1997. Socioeconomic evaluation of land-use alternatives in the Blue Nile flood basin of the Sudan. Doctoral thesis.

No. 15 Mustafa, A. F. 1997. Regeneration of Acacia seyal forests on the dryland of the Sudan clay plain. Doctoral thesis.

No. 16 El Fadl, M. A. 1997. Management of Prosopis juliflora for use in agroforestry systems in the Sudan. Doctoral thesis.

No. 17 Kaarakka, V. & Holmberg, G. 1999. Environmental conflicts and development cooperation with special reference to conservation and sustainable management of tropical forests.

No. 18 Li, C. 1999. Drought adaptation and genetic diversity in Eucalyptus microtheca. Doctoral thesis (limited distribution).

No. 19 Suoheimo, J. 1999. Natural regeneration of sal (Shorea robusta) in the Terai region, Nepal. Doctoral thesis.

No. 20 Koskela, J. 2000. Growth of grass-stage Pinus merkusii seedlings as affected by interaction between structure and function. Doctoral thesis (limited distribution).

No. 21 Otsamo, R. 2000. Integration of indigenous tree species into fast-growing forest plantations on Imperata grasslands in Indonesia - Silvicultural solutions and their ecological and practical implications. Doctoral thesis (limited distribution).

No. 22 Koskela, J., Nygren, P., Berninger, F. & Luukkanen, O. 2000. Implications of the Kyoto Protocol for tropical forest management and land use: prospects and pitfalls.

No. 23 Otsamo, A. 2001. Forest plantations on Imperata grassland in Indonesia – Establishment, silviculture and utilization potential. Doctoral thesis (limited distribution).

No. 24 Eshetu Yirdaw 2002. Restoration of the native woody-species diversity, using plantation species as foster trees, in the degraded highlands of Ethiopia. Doctoral thesis.

No. 25 Appiah, M. 2003. Domestication of an indigenous tropical forest tree: Silvicultural and socio-economic studies on Iroko (Milicia excelsa) in Ghana. Doctoral thesis.

No. 26 Gaafar Mohamed, A. 2005. Improvement of traditional Acacia senegal agroforestry: Ecophysiological characteristics as indicators for tree-crop interaction in western Sudan. Doctoral thesis.

No. 27 Glover, Edinam K. 2005. Tropical dryland rehabilitation: Case study on participatory forest management in Gedaref, Sudan. Doctoral thesis.

No. 28 Hares, M. 2006. Community forestry and environmental literacy in northern Thailand: Towards collaborative natural resource management and conservation. Doctoral thesis.

No. 29 Eskonheimo A. 2006. Women, environmental changes and forestry-related development: Gender-affected roles of rural people in land degradation and environmental rehabilitation in a dry region of Sudan. Doctoral thesis.

No. 30 Raddad, E.Y.A. 2006. Tropical dryland agroforestry on clay soils: Analysis of systems based on Acacia senegal in the Blue Nile region, Sudan. Doctoral thesis (limited distribution).

No. 31 Luukkanen, O., Katila, P., Elsiddig, E., Glover, E. K., Sharawi, H. and Elfadl, M. 2006. Partnership between public and private actors in forest-sector development: Options for dryland Africa based on experiences from Sudan, with case studies on Laos, Nepal, Vietnam, Kenya, Mozambique and Tanzania.

UNIVERSITY OF HELSINKI
Viikki Tropical Resources Institute
VITRI

TROPICAL FORESTRY REPORTS

No. 32 Laxén, J. 2007. Is prosopis a curse or a blessing? – An ecological-economic analysis of an invasive alien tree species in Sudan. Doctoral thesis.

No. 33 Katila, P. 2008. Devolution of forest-related rights: Comparative analyses of six developing countries. Doctoral thesis.

No. 34 Reyes, T. 2008. Agroforestry systems for sustainable livelihoods and improved land management in the East Usambara Mountains, Tanzania. Doctoral thesis (limited distribution).

No. 35 Zhou, P. 2008. Landscape-scale soil erosion modelling and ecological restoration for a mountainous watershed in Sichuan, China. Doctoral thesis (limited distribution).

No. 36 Hares, M. & Luukkanen, O. 2008. Research Collaboration on Responsible Natural Resource Management, The 1st UniPID Workshop.

No. 37 Husgafvel, R. 2010. Global and EU governance for sustainable forest management with special reference to capacity building in Ethiopia and Southern Sudan. Doctoral thesis.

No. 38 Walter, K. 2011. Prosopis, an alien among the sacred trees of South India. Doctoral thesis.

No. 39 Kalame, F.B. 2011. Forest governance and climate change adaptation: Case studies of four African countries. Doctoral thesis (limited distribution).

No. 40 Paavola, M. 2012. The impact of village development funds on community welfare in the Lao People's Democratic Republic. Doctoral thesis.

No. 41 Omoro, Loice M.A. 2012. Impacts of indigenous and exotic tree species on ecosystem services: Case study on the mountain cloud forests of Taita Hills, Kenya. Doctoral thesis (limited distribution).

No. 42 Alam, S.A. 2013. Carbon stocks, greenhouse gas emissions and water balance of Sudanese savannah woodlands in relation to climate change. Doctoral thesis.

No. 43 Rantala, S. 2013. The winding road from exclusion to ownership: Governance and social outcomes in contemporary forest conservation in northeastern Tanzania. Doctoral thesis (limited distribution).

No. 44 Negash, M. 2013. The indigenous agroforestry systems of the south-eastern Rift Valley escarpment, Ethiopia: Their biodiversity, carbon stocks, and litterfall. Doctoral thesis (limited distribution).

No. 45 Kallio, M.H. 2013. Factors influencing farmers' tree planting and management activity in four case studies in Indonesia. Doctoral thesis. (limited distribution).

ISBN 978-952-10-9551-1 (paperback)
ISBN 978-952-10-9552-8 (PDF)
ISSN 0786-8170
Helsinki 2013
Unigrafia Oy