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2. Acronyms

ACIAR	Australian Centre for International Agricultural Research
AGB	Above ground biomass
AIC	Akaike Information Criterion
AMF	Arbuscular Mycorrhizal Fungi
ANOVA	Analysis of Variance
ASec	Assistant Secretary
ASEM	Agricultural Systems Management
BA	Basal Area
BMP	Best Management Practice
BN	Briefing Note
BONGO	Business-oriented NGO
BUB	Bottom-Up Budgeting
CBFM	Community-based Forest Management
CBFMA	Community-based Forest Management Agreement
CBFMP	Commuunity-based Forest Management Program
CDM	Clean Development Mechanism
CEEDA	Cabibihan Ecological and Economic Development Association
CFPBA	Community Forestry Program Beneficiaries Association
CIFOR	Centre for International Forestry Research
CSC	Certificate of Stewardship Contract
DAO	DENR Administrative Order
DASS	Department of Agronomy and Soil Science
DBH	Diameter at Breast Height
DENR	Department of Environment and Natural Resources
DILG	Department of Interior and Local Government
DMC	DENR Memorandum Circular
DTI	Department of Trade and Industry
EO	Executive Order
ERDB	Ecosystems Research and Development Bureau
ERDS	Ecosystems Research and Development Service
FGD	Focus Group Discussion
FLUP	Forest Land Use Planning
FMB	Forest Management Bureau
FMS	Forest Management Service
GIS	Geographic Information Systems
GLMMS	Generalized Linear Mixed-Effects Models
GPS	Global Positioning System
IFMA	Integrated Forest Management Agreement
ITP	Industrial Tree Plantation
IUCN	International Union for Conservation of Nature
KASA	Knowledge, Attitudes, Skills and Aspirations
KCPA	Kawayan Community-based Forest Management Program Association
KFAI	Kawayanon Farmers Association
KII	Key Informant Interview
KLEEDA	Kawayanon Livelihood Economic Ecological Development Association
LAI	Leaf Area Index
LEDAV	Livelihood and Ecological Development Association of Villavicenta
LEV	Land Expectation Value

LGU	Local Government Unit
LMEM	Linear Mixed Effect Model
MAI	Mean Annual Increment
MC	Memorandum Circular
MIS	Mixed Introduced Species
ML	Maximum Likelihood
MONGO	Money-oriented NGO
NGO	Non-government Organization
NGP	National Greening Program
nMDS	Non-metric Multi-dimensional Scaling
NPK	Nitrogen, Phosphorus, Potassium (complete fertiliser)
NPV	Net Present Value
NTFP	Non-timber Forest Product
OC	Organic Carbon
OIC	Officer In-charge
PAGUADCo	Paglaum Upland Agricultural Development Farmers Cooperative
PAIBA	Periodic Annual Increment of Tree Basal Area
PENRO	Provincial Environment and Natural Resources Office/r
PhilGEPS	Philippine Government Electronic Procurement System
PhP	Philippine Peso
PO	People's Organization
QPM	Quality Planting Materials
R10	Region 10
R8	Region 8
RA	Republic Act
RCBD	Randomised Complete Block Design
REDD	Reducing Emissions from Deforestation and Forest Degradation
REML	Residual Maximum Likelihood
RF	Rainforestation Farming
RTD	Regional Technical Director
RVI	Relative Variable Importance
SALT	Sloping Agricultural Land Technology
SCUs	State Colleges and Universities
SES	Socio-economic Status
SIFMA	Socialised Industrial Forest Management Agreement
SOC	Soil Organic Carbon
SPSS	Statistical Package for Social Sciences
TV	Total Volume
UDP	Upland Development Program
USD	United States Dollar
USec	Undersecretary
VIF	Variation Inflation Factor
VSU	Visayas State University
VTPA	Villa Consuelo Tree Planters Association

3. Executive Summary

The aim of the ASEM/2010/050 project was to improve the rehabilitation of critical watersheds in the Philippines by identifying the key technical, socio-economic and policy drivers for successful rehabilitation and then applying this knowledge to design and pilot test initiatives to improve the outcomes of watershed rehabilitation. These outcomes include improved watershed health, sustainable land use, and increased livelihood opportunities for rural upland poor leading to decreased poverty. The timing of the project has coincided with the implementation of the National Greening Program (NGP), which aimed to reforest 1.5 million hectares from 2011 to 2016. The project's application of a systems approach in analysing community forestry programs, and its use of genuine participatory processes among stakeholders for designing, implementing and monitoring intervention measures has proven to be effective in improving watershed rehabilitation outcomes. The project is one of only a handful of studies to investigate the impacts of reforestation on water movement in a degraded tropical catchment. In the case of our paired catchments, the gains in water flows through increased infiltration associated with reforestation exceed the losses from transpiration, thus resulting in increased stream baseflow. This is a significant contribution to the on-going debate about whether planting trees can reduce stream flows through additional water losses from transpiration. Our study also found that shifting cultivation may not be as detrimental to soil quality in upland watersheds as suggested in the literature.The field trials established and the research conducted on existing tree plantations have provided crucial silvicultural information including that regarding appropriate mixtures of tree species, adequate spacings, and the importance of germplasm sources and fertilising regimes. Unfortunately, many of our field trials were badly damaged by Typhoon Haiyan in 2013 and most had to be abandoned. However, this typhoon provided an opportunity to undertake a study on typhoon damage which revealed that in general, native species are more resilient to typhoon damage compared to exotic species, and that mixtures of between six and eight species are less prone to wind damage than monocultures. These results have important implications for the design of reforestation systems in typhoon-prone areas and are now being incorporated into the design of NGP plantings. The project identified the factors that contribute to the success or failure of reforestation programs in the Philippines and analysed the interactions among these factors. The analyses led to the identification of drivers and indicators of reforestation success. We developed a Bayesian Belief Network and used this model to identify intervention points for improving watershed rehabilitation outcomes. That analysis identified the critical importance of livelihoods as a driver of reforestation success. While livelihood projects have previously been incorporated into community-based reforestation programs in the Philippines, most of these projects have failed to provide benefits to communities. A major activity of the project was to draw on our research to design and implement a 'best practice' pilot reforestation project in Biliran in partnership with the community and local Department of Environment and Natural Resources (DENR) staff. The pilot community-based reforestation in Biliran has demonstrated that a critical key to the success of people-based forest landscape restoration programs is addressing the socio-economic and food security issues of smallholder farmers. The social landscape is equally as important as the biophysical landscape of a reforestation project site. The lessons learnt from the Biliran pilot project have wide application in the Philippines and the site is now being used by DENR as an exemplar of how to implement successful projects as part of the NGP. With the strong linkage and support of DENR at the local and national level, there is a substantial opportunity to incorporate the key findings of the ACIAR ASEM/2010/050 project into national policies to improve the outcomes of forest and landscape restoration programs throughout the Philippines.

4. Background

Substantial deforestation has occurred in many critical watersheds in the Philippines. This has led to severe environmental, social and economic problems within, and outside, these watersheds. Chokkalingam et al. (2006) observed that the Philippines, like many other Asian countries, lost its forest cover rapidly over the last century through heavy logging, upland migration and agricultural expansion. Forestland (>18% slope) comprises about 45% of the total land area in the Philippines and is home to about 30% of the country's population, with most of these people having incomes below the poverty line. Many upland areas in critical watersheds have been severely degraded through a combination of uncontrolled legal and illegal logging and unsustainable agricultural practices. Logging roads typically provided access to squatters who migrated from lowland areas and subsequently cleared the remaining forest as part of slash and burn (*kaingin*) agriculture. There is a desperate need to both rehabilitate critically degraded watersheds and develop financially and environmentally sustainable livelihood opportunities for the rural poor residing in these areas. Rehabilitation of critical watersheds through reforestation and associated forest-based livelihood opportunities has the potential to provide substantial social, economic and environmental benefits.

The scale of the watershed rehabilitation required in the Philippines is enormous, with DENR having identified 3,882,808 ha in critical watersheds needing urgent rehabilitation (DENR Memorandum Circular (MC) 2009-03, Annex A). In response, the Philippine government launched the Upland Development Program (UDP). As part of the UDP, the resources of the DENR in forest development and management for 2009 were "*substantially reconfigured in order to accelerate the restoration of the environmental service functions of vital watersheds and protected areas. This, in addition to simultaneously catalysing the improvement of productivity of the uplands, creating incomes for upland poor, mitigating hunger among highly-vulnerable populations, engaging organized upland communities, civil society and local governments in sustainable upland and forest management, and providing the climate for gainful economic production for poor upland dwellers."* (DENR MC 2008-04).

The initial phase of the UDP had a target of rehabilitating 51,518 ha (DENR MC 2009-03, Annex B), which is only 1.3% of the total area needing rehabilitation in critical upland areas. This highlights the enormity of the watershed rehabilitation problem facing the Philippines. In March 2011, President Aquino announced the National Greening Program (NGP) through Executive Order 26, which represents a very significant commitment to reforestation in the Philippines. The NGP aimed to establish 1.5 Million ha of forest over 6 years (2011-2016) – with a focus on the benefits of tree planting accruing to local communities. DENR has the primary responsibility for implementing the NGP, with the UDP to be subsumed into the NGP.

In order for large-scale rehabilitation to occur as proposed in the NGP, two things are critical. First, the limited resources that are available need to be expended in an effective and efficient manner. Second, alternative mechanisms need to be identified to facilitate the expansion of the current reforestation being undertaken as part of the UDP. Central to both of these outcomes is identifying forest-based income-generating opportunities for local communities involved in watershed rehabilitation to ensure reforested areas are not subsequently deforested as a livelihood option.

Past watershed rehabilitation efforts in the Philippines have had limited success and it is far from certain that the NGP will achieve the specified targets. Often failure has occurred, even when the technical aspects have been appropriate, due to a failure to adequately address key social, economic and political aspects within the rehabilitation programs (see Chokkalingam 2006 and Le et al. 2012 for further discussion). As well, even when these aspects have been recognised, they have been addressed in isolation. Recent community-based reforestation approaches in the Philippines have recognised the importance of social dimensions (e.g. by incorporating livelihood projects) including the need for community empowerment (e.g. by including communities in implementing reforestation projects). However, even these projects have largely failed due to a combination of factors including the project not being implemented in the way set out in the development plan. While projects are community-based, implementation is also largely agency-driven and this invariably leads to failure. In addition, poor institutional arrangements, corruption and inappropriate or poorly designed livelihood projects appear to contribute to poor outcomes. As such, an integrated (systems) approach which captures the key biophysical, social, economic and policy aspects is required in order to understand the issues that lead to the success or failure of watershed rehabilitation efforts.

The ASEM/2010/050 project was implemented in a transdisciplinary manner adopting the systems approach. This project was built directly upon our past research projects - ASEM/2006/091 *Enhancing tree seedling supply via economic and policy changes in the Philippines nursery sector* and ASEM/2003/052 *Improving financial returns to smallholder tree farmers in the Philippines*. The ASEM/2006/091 project applied the systems methodology to improve the supply of high-quality seedlings in tree farming and reforestation programs in the country. A key output of this project was the institutionalisation of a national policy to regulate the quality of seedlings in government-funded reforestation programs. The ASEM/2003/052 project provided substantial information directly relevant to the promotion of smallholder tree farming.

The current project has undertaken a number of research activities aimed at improving the outcomes of watershed rehabilitation programs in the Philippines. These include field trials to provide information regarding improved silvicultural technologies; social and economic investigations to understand the links and interactions between these factors and the success or failure of community-based reforestation programs; and policy and governance research to investigate existing policies and governance gaps that hinder the success of watershed rehabilitation programs in the country. Biophysical studies on the effects of reforestation on the volume and quality of stream baseflow, and the response(s) of various timber species to typhoons were also conducted.

Central to the implementation of the project was the pilot testing of best practice in community-based reforestation. This case study was evidence-based, drawing on the research project’s key findings including results of the analysis of reforestation systems using the policy assessment model we developed from our assessments of past reforestation projects in the country. It followed the systems principle and adopted the participatory approach involving the active participation of stakeholders especially the DENR in designing the case study, implementing the acivities, and monitoring the impacts of interventions. Meetings with stakeholders and top officials of DENR were held to convey results of the case study that are crucial for improving the outcomes of watershed rehabilitation in the country.

The implementation of the ASEM/2010/050 project has been very timely. In December 2015, the objective of the NGP was expanded to rehabilitate a further 7.1 M ha by 2028. With the strong relationship with and participation of DENR in the implementation of the project, there are excellent prospects for the uptake of key results of our research activities and recommendations for policy formulations or amendments to existing policies to further the success of community-based watershed rehabilitation in the Philippines.

5. Objectives

The aim of this project is to improve the rehabilitation of critical watersheds in the Philippines by identifying the key technical, socio-economic and policy drivers for successful rehabilitation and then applying this knowledge to design and pilot test initiatives to improve the outcomes from watershed rehabilitation including improved watershed health, increased livelihood opportunities for rural upland poor and decreased poverty in upland areas.

The objectives and activities are:

Objective 1: Identify the key factors that have led to the success or failure of watershed rehabilitation/reforestation programs in the Philippines
Activities:

1.1 Assess the success of past reforestation projects
1.2 Understand decision-making by households in relation to reforestation
1.3 Conduct a national workshop to collate existing information and experiences on watershed rehabilitation

Objective 2: Identify key intervention points and design initiatives to improve watershed rehabilitation outcomes by working with communities, Local Government Units (LGUs) and DENR.
Activities:

2.1 Develop a policy assessment model
2.2 Identify and develop interventions and policy initiatives to pilot test

Objective 3: Pilot test initiatives to improve watershed rehabilitation outcomes and implement local-level policy changes in conjunction with communities, DENR and LGUs
Activities:

3.1 Assemble existing spatial data in pilot study watersheds
3.2 Develop and pilot test reforestation-based livelihood initiatives
3.3 Pilot test changes to policy at the local level to address social, institutional and political problems
3.4 Assist DENR and other groups to implement NGP reforestation initiatives using identified best practice
3.5 Improve current reforestation techniques

Objective 4: Design and implement on-going monitoring of the effectiveness of interventions and initiatives to improve watershed rehabilitation outcomes and develop policy recommendations based on outcomes
Activities:

4.1 Design and implement a monitoring program to assess the social and economic impact of reforestation
4.2 Design and implement a monitoring program to assess the impact of reforestation on watershed health
4.3 Design an on-going monitoring program suitable for implementation after the completion of the project
4.4 Develop policy recommendations and communicate results to key stakeholders

Appendix 12.1 illustrates how the project's various activities are interconnected along with the key partnerships with stakeholders. The information generated from Activities 1.1 and 1.2 served as inputs in developing the policy assessment model under Activity 2.1. Working with stakeholders, in Activity 2.2 the model was used to identify intervention measures and policy initiatives that were pilot tested under Activities 3.2, 3.3, 3.4 and 3.5. Monitoring the short- and long-term effectiveness and impacts of pilot tested interventions on the biophysical and socio-economic components of the community-based forestry system were performed under Activities 4.1, 4.2 and 4.3. The outputs were used in Activity 4.4 to design policy options and recommend policy developments for improved outcomes of watershed rehabilitation in the Philippines.

6. Methodology

6.1. Overview of general approach

The mixed results of community-based watershed rehabilitation programs in the Philippines is attributed to several underlying issues, which are influenced by many factors. These factors are intricately connected; hence promoting a successful watershed rehabilitation program requires a holistic view of community-based watershed rehabilitation systems. Along this premise, the project involved a multi- and inter-disciplinary approach implemented within a systems framework with strong participation of researchers from Australia and the Philippines, and DENR personnel at the local, regional and national levels. The systems framework adopted in conceptualizing and implementing the project allowed effective integration of information generated from different disciplines and scales. A number of research methods were employed in various research activities including measurements of trees and ecological parameters, along with surveys of smallholders and community attitudes, to determine drivers and indicators of reforestation success; nursery surveys to assess the quality of seedlings and the effectiveness of DENR policy on seedling quality regulation; field inventory of seedling survival in NGP plantations; surveys to determine the socio-economic impacts of the NGP; field trials to design improved silvicultural systems; ecohydrological studies to determine the effect of trees on stream baseflow; and tree measurements to assess the vulnerability of mixed-species and monoculture plantations to typhoons.

A Bayesian Belief Network using Netica™ as the modelling platform was used to analyse the reforestation systems and identify best-bet interventions including policy options for improving watershed rehabilitation outcomes. The project team worked closely with DENR at the provincial level to pilot test the implementation of an evidence-based community reforestation program. This case study adopted an action research methodology and it was implemented to showcase best practices in community-based reforestation with the ultimate intention to influence policy formulation at the regional and national levels of DENR so as to improve overall outcomes of community-based watershed rehabilitation in the Philippines.

The Visayas State University (VSU) was the implementing agency for the project in the Philippines. VSU is situated in Baybay, Leyte. The research sites included Region 8 (Eastern Visayas) and Region 10 (Northern Mindanao). The pilot evidence-based community reforestation program is implemented in Biliran, which is one of the six provinces in Region 8.

The project was implemented in four phases (see Appendix 12.1). The first phase was to understand the various drivers and indicators of reforestation success and how these drivers interact to influence the performance of watershed rehabilitation programs (Objective 1). The second phase involved developing a policy assessment model and using this model to identify key intervention points for improving the reforestation system and then identify and develop specific pilot programs together with stakeholders (Objective 2). The third phase involved the pilot testing of interventions including improved reforestation approaches, best practice silviculture, sustainable livelihood projects, and the enabling policy environment (Objective 3). The last phase focused on developing and implementing methods for monitoring the effectiveness of pilot tested interventions on improving watershed rehabilitation outcomes (Objective 4). Part of this phase was also to develop policy recommendations based on the outcomes of pilot tested interventions. The following sections provide a general outline of the methods used in the research. They are organised along the lines of key activities, which in turn are linked to the four project objectives. The methods described below are organised by task rather than objective, and many of the tasks or activities spanned across all four objectives.

6.2. Identifying drivers of reforestation success

The project has carried out a number of research activities geared towards understanding the many factors that influence reforestation success and failure. This section presents the rationale of each research activity and the corresponding methods for data collection and analysis.

6.2.1. Drivers and indicators of success and failures of reforestation programs in the Philippines

Reforestation is not a straightforward process that invariably leads to tree cover increase. Rather, the outcome of forest rehabilitation itself is influenced by many factors (Chokkalingam et al. 2005; Le et al. 2012). Through a comprehensive review of the literature we have identified a list of potential success drivers and grouped these into technical/biophysical drivers; socio-economic drivers; institutional, policy and management drivers; and reforestation project characteristics (Le et al. 2012). We also identified a large set of indicators that have been used to measure the success of reforestation projects. Nonetheless, a critical shortcoming in our understanding concerns the relationships between the drivers of reforestation success and the indicators. Research was undertaken to gain a deeper understanding of these relationships by investigating the drivers that have determined reforestation success in the Philippines. We did this by surveying 43 reforestation projects on Leyte Island, covering 98 potential drivers and 12 success indicators.

The survey was broken into two components: an 'interview' and a 'field survey'. The 'interview' component comprised of a questionnaire designed to collect data on general project characteristics, project reforestation process, technical aspects of site management, project socio-economic aspects, and project institutional aspects. The 'field survey' component was designed to collect data on project site biophysical characteristics, tree establishment success, forest growth performance and forest environmental success.

IBM SPSS Statistics 20 (2011) was used for data analysis. Bivariate analysis was used to identify associations between success drivers (independent variables) and success indicators (dependent variables). Indicators were also compared against indicators in this analysis. For binary indicators (0 or 1), the Student's t test was used to explore associations with continuous drivers and the Pearson's χ^2 test was used to explore associations with categorical drivers. For continuous indicators, linear regression was used to explore associations with continuous drivers and the Student's t test was used to explore associations with categorical drivers. Drivers found to be significantly associated with indicators in the bivariate analyses ($p < 0.05$) were considered as candidates in stepwise multiple regressions with indicators.

Before conducting stepwise multiple regressions, preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearity and homoscedasticity among the variables. For continuous indicators, standard stepwise multiple linear regression was used. For binary indicators, forward stepwise binary logistic regression was used. Drivers were entered into the stepwise regressions if the significance of their relationship with an indicator was $p < 0.05$ and removed from the stepwise regressions if the significance of their relationship with an indicator became p 0.10. Drivers were entered into the stepwise regressions in order of their correlation with an indicator, from most strongly (lowest p value) to least strongly correlated (highest p value) (Brace et al. 2006).

A set of significant drivers for each indicator was the result of the stepwise regressions. Relationships among these significant drivers were then tested for using Pearson's correlation. The end result was a set of significant driver-indicator, indicator-indicator and driver-driver relationships that was used to identify a system of relationships that affect reforestation success.

Further details of the methods employed in this research can be found in Le et al. (2014) (see Section 11.2 of this report for reference). Results are presented in Section 8.1.1.

6.2.2. Assessing the tree establishment success of the National Greening Program

The assessment of the establishment success of the National Greening Program was undertaken in Eastern Visayas and Northern Mindanao in response to the request of DENR to assess the biophysical 'success' of the 2011 and 2012 NGP plantings and establish how socio-economic conditions in these rural areas had impacted on the effectiveness of the program. Data collection to assess health and survival of seedlings in NGP plantings consisted of field measurements of seedling survival and health. In consultation with DENR regions 8 and 10, the usual inventory method favoured by DENR, i.e. strip inventories, was modified to facilitate data collection. In situations where grazing had resulted in widespread seedling mortality, strips could not be followed across the planting area. In this situation, 0.1 ha circular plots were used to tally seedling survival and health. The plots were spaced across the planting area on a 100 m grid. In practice, field crews found that many plantations included kaingin, coconut plantations and residual native forest. In this situation, plots were established in logical locations so as to obtain the best estimate of seedling survival and health.

Data were sampled across the range of situations in which trees may be planted. In the provinces of Misamis Oriental, Bukidnon, Biliran, Leyte, Southern Leyte and Samar, seedlings were measured at 31 sites. The sites were spread across 2011 and 2012 plantings for production and protection forest, agroforestry and fruit trees.

The technical report of Baynes et al. (2013) listed in Section 11.2 and cited in Section 7 of this report presents the details of the methods adopted in this research. The results of this research are presented in Section 8.1.2.

6.2.3. Assessing the quality of seedlings in the NGP and determining the effectiveness of forest nursery accreditation policy

In the Philippines, a national policy has been in place since 2010 to regulate the quality of seedlings for reforestation programs. However, the use of low quality seedlings has been cited as a major contributor to the low survival rate of seedlings in NGP plantations (Israel and Lintag 2013; Ranada 2014; Ranada 2015; Egento 2016). Surveys were conducted to determine the effectiveness and challenges in regulating the quality of seedlings. These included personal interviews with operators and managers of nurseries supplying seedlings for the NGP, and a key informant survey with relevant DENR officials. Assessment of the quality of seedlings in nurseries was also undertaken. The survey sample included 23 nurseries, nine from Region 10 (eight from Bukidnon and one from Misamis Oriental) and 14 from Region 8 (five from Biliran, three from Leyte, three from Southern Leyte, and three from Samar).

Nurseries included in the survey were selected based on DENR recommendations. Using an open-ended questionnaire, information on seedling production systems including nursery silvicultural practices and quality control measures, and the market for seedlings, were gathered during interviews. The respondents were also asked about constraints experienced in nursery operations and marketing of forest reproductive materials. Discussions were also held with senior personnel of the Forest Management Service (FMS) and the Ecosystems Research and Development Service (ERDS) in both regions to obtain information regarding the organisation of seedling production for the NGP. The seedling quality control protocol of the DENR and challenges encountered in its implementation were also discussed.

The quality of seedlings was assessed through destructive sampling of 50 seedlings of plantable size (i.e. at least 20 cm tall) at each nursery and recording five morphological criteria, namely: seedling health, stem form, root form, sturdiness and root-to-shoot ratio. The sturdiness value and root-to-shoot ratio were computed. A total of 1,150 seedlings of 54 species from 23 nurseries in the two regions were examined. Data were organised and analysed using the SPSS.

The published article Gregorio et al. (2016) listed under Section 11.2 of this report details the methods employed in this research. Section 8.1.3 presents the results of this study.

6.2.4. Effectiveness of Local Government Units in the implementation of the National Greening Program

Executive Order 26, otherwise known as the National Greening Program (NGP), states the significant roles and responsibilities of LGUs in the implementation of the NGP including production of high quality seedlings, greening plan development for urban and sub-urban areas, communal tree farm establishment and management, building-up of access roads and construction of trails to planting sites, and providing technical assistance and extension services. It is the intent of this study to examine the roles and participation of the Biliran LGUs at the provincial, municipal and barangay levels in the implementation of the NGP. It is expected to bring about outputs that will serve as a basis for identifying interventions and recommendations to strengthen LGU participation and commitment to NGP implementation in the province of Biliran.

The study was conducted in the three municipalities of Biliran Province. Secondary data and records of policies were collected from LGU files. Key Informant Interviews (KII) using a semi-structured interview schedule were performed to gather the primary data. Data were analysed using the SPSS. Descriptive statistics were used in the analysis of the information generated from the KIIs.

The results of this research are presented in Section 7.1.4.

6.2.5. Smallholders' perspectives of 'participation' in community-based reforestation projects

Social cohesion is a major challenge in implementing a community-based reforestation program. Almost always, community organisations disband shortly after project funds are exhausted. A study was undertaken to understand how members of Kawayanon Farmers Association (KFAI) perceive their participation in community-based reforestation projects. KFAI is a chapter of a confederation of people's organisations called the Community Forestry Program Beneficiaries Association (CFPBA). The CFPBA possessed a Community-based Forest Management area in Kawayanon, which the organisation has been planting under the NGP. The organisation is also managing a plantation of *Acacia mangium* in the community, a remnant of the contract reforestation in early 1990's.

The study was anchored on the constructivist research perspective applying a qualitative methodology, and using the case study research design. Focus group discussions (FGDs) and in-depth interviews were used in gathering the needed information. A total of 35 farmers participated in the study. Proceedings of the in-depth interviews and FGDs were recorded.

To determine the level of program outcomes, the Bennett's Hierarchy of Program Outcomes (Table 1) was used as guide. The outcomes were categorized into four levels.

Table 1. Levels of program outcomes based on Bennett's Hierarchy of Program Outcomes (de los Santos, 1992)

LEVEL	DESCRIPTION
Outcomes	
7	Consequences for society and target group
6	Behavioral changes in the target group
5	Changes in knowledge, attitude, skills, and group norms
4	Opinions in extension activities
Inputs	
3	Farmers' participation in extension activities
2	Implementation of the program by implementers
1	Programming of extension activities

Further details of the methods employed in this research are presented in Gravoso et al. (in prep.) listed in Section 11.2 of this report. Section 8.1.5 details the results of this research.

6.2.6. The socio-economic effects of the NGP on smallholders in Biliran Province

While the full economic benefits of the NGP may not yet be felt because trees take time to mature, members of the Peoples Organizations (POs) involved in the implementation of the NGP have financially benefitted through the payments they have received for the services they have provided. The POs were tasked with and paid for site preparation, seedling production, and planting and maintaining the seedlings. The overall objective of this study was to determine the effect of the monetary incentives the participating households received from NGP on their socio-economic status (SES). Specifically, the study determined if there was improvement in the SES of participants implementing the NGP, and determined respondents' recommendations to improve similar programs in the future.

The study was conducted in three communities in the town of Caibiran in Biliran Province to compare the SES of two groups: PO (CFPBA)-member and non-member households. The baseline survey was conducted in January 2014 while the endline survey was completed in June 2016. The study employed a mixed-method strategy that combines quantitative and qualitative methods. The CFPBA chapter presidents selected the member respondents and each CFPBA-member respondent was asked to identify who among the non-member neighbors had a similar SES. Table 2 below shows the distribution of respondents.

Table 2. Distribution of survey respondents

Barangay	No. of active members	Percentage of chapter members to total members from three chapters	Chapter members quota sampled	Respondents included in the analysis	Non-member respondents
Kawayanon	22	51	11 (one died later)	10	10
Cabibihan	11	26	3 (one migrated later)	2	2
Villavicenta	10	23	2	2	2
Total	43	100	16	14	14

The unit of analysis in this study was the household, not the respondent because it was the household's SES that was assessed through the household's housing condition, goods and livestock owned, and food eaten. Interview schedules were used for data collection. To compare the SES between CFPBA and non-CFPBA households, the Mann-Whitney U test was used while Wilcoxon Signed-Rank Test was used to compare the SES of the same set of respondents in 2014 and 2016.

The article Goltiano et al. (in prep.) listed in Section 11.2 of this report provides further information regarding the methods employed in this investigation. The results of this study are presented in Section 8.1.6.

6.2.7. Financial Outcomes of the Rainforestation Farming Pilot Systems in Leyte

One of the reforestation strategies used in the Philippines is the Rainforestation Farming (RF) system, a high-density agroforestry system that combines food production, income generation and environmental benefits (Milan and Margraf, 1994; Milan et al. 1998). The RF system was introduced as a replacement for environmentally-damaging *kaingin* (traditional slash-and-burn) practices for smallholders in the province of Leyte. A study was conducted with an overall aim of evaluating the financial outcomes of the pilot RF plantations. Interviews with RF implementers were carried out. Biophysical data collected from permanent plots in 2006, 2008 and 2012 were used (see Nguyen et al. 2014a).

A cash-flow analysis was performed for each of the 25 RF sites. Cash outflows included the establishment and maintenance costs and the opportunity cost of the land. Seedling costs were not included in the analyses as the seedlings were donated. Planting activities were only included when performed by implementers and not program staff. Cash inflows included the financial return from crops, fruits and timber. A financial value was given to products harvested from the RF plantations and consumed by the household. Prices and costs were adjusted for inflation using the consumer price index (World Bank, 2016). A discount rate of 12% was used in this study.

Assumptions were made for the financial analyses: a) no costs for harvesting trees were included because in the usual arrangements, harvesting operation and permit costs are met by buyers; b) one day of work was considered to cost 150 Philippine pesos (PhP) in 2015; c) the opportunity cost of the land was considered PhP 100 $ha^{-1}year^{-1}$ if the main source of income was based on farming activities; and d) in the first two years of fruit production the yield was 40% of the annual average for a fully mature fruit tree.

Project balances and the Net Present Value (NPV) were calculated in PhP. The net future value was calculated (Equation 1a) and then the Land Expectation Value (LEV) per hectare was calculated with the use of the Equation 1b. Because the start date differed between projects, LEV was calculated in 2013's value. The resulting LEVs were transformed to American dollars using the currency exchange rate of USD 1: PhP 44.62.

a) $NFV = (1+r)^R NPV$ b) $LEV = \frac{NFV}{(1+r)^R - 1} A$

Equation 1. a) Net Future Value (*NFV*); b) Land Expectation Value (*LEV*)

where *NPV* is the net present value of one rotation in PhP; *A* is the area in hectares; *R* is the rotation length in years; and *r* is discount rate.

Three categorical variables with no statistically significant (p>0.05) correlations between each other were included in a two-step cluster analysis with the use of the Schwarz's Bayesian Criterion. The variables included were tenure wealth and education. The LEV of the clusters were then compared. Chi-square tests of independence were performed to evaluate whether there were statistically significant differences between the clusters in relation to the categorical variables included in the cluster analysis.

Ota et al. (see Section 11.2 of this report) provides a detailed explanation of the methods adopted in undertaking this research. Salient results of this study are presented in Section 8.1.7.

6.2.8. Assessment of the implementation of the National Greening Program in Biliran Province

The implementation of the NGP in various regions of the Philippines has been a huge success regarding achieving the target area of land for planting and the number of seedlings planted. However, reports from other government and research agencies revealed low seedling survival and less impressive growth of planted seedlings. A study was undertaken to determine the realities of NGP implementation in the case of Biliran Province, including the issues and challenges as revealed by stakeholder groups including the PO implementing the program, the DENR which is the main support agency of the program, and residents of the community where the NGP is implemented.

The Kawayanon community was chosen as the case study site through the recommendation of key officials of the DENR Provincial Office in Biliran. The existence of the NGP, adverse biophysical condition of the reforestation site, government ownership of the land but with local land claims, the disbanded situation of the PO, and the socio-economic status of the community altogether make Kawayanon a good representation of NGP sites not only in the province but in the entire country.

A series of meetings with stakeholders including key DENR officials at the provincial and community levels, LGU officials, community residents and the PO members were undertaken to gather information about the process of implementing the NGP and previous reforestation initiatives in the community. Personal interviews with DENR personnel incharge of the NGP at the regional and provincial levels were conducted to understand the mechanisms of the NGP implementation including the approach, support schemes for POs, methods of auditing the success, and challenges in implementing the program. Using a semi-structured interview schedule that was tested prior to field use, face-to-face interviews with forty randomly selected PO members were carried out to determine their knowledge, understanding and perception of the NGP. The respondents were also asked about their experience in implementing the NGP including the challenges in maintaining the cohesiveness of the PO, the constraints preventing the successful implementation of the program and the potential interventions. The technical capability of the PO members in nursery seedling production was assessed by examining the quality of seedlings. Inventories of seedling survival in the field were carried out in a parallel study.

A focus group discussion (FGD) was held with stakeholders to validate the results of the meetings and interviews, and assessments of seedling quality and survival.

The paper Gregorio et al. (2015a) (see Section 11.2) published by IUCN provides the details of the method used in this study. The results are presented in Section 8.1.8.

6.2.9. Drivers of tree growth, mortality and harvest preference in species-rich plantations for smallholders and communities in the tropics

In the tropics there is increasing interest in establishing mixed-species plantations for a wide range of economic, silvicultural and sustainability objectives. Although mixed-species plantations can have many benefits for smallholders and communities, none of these benefits are assured because there remain substantial knowledge gaps concerning the combination and performance of species in these complex plantings. The RF system in the

Philippines provides a unique opportunity to understand the underlying processes affecting tree performance within diverse plantings.

A study was undertaken to investigate the factors influencing growth, probability of harvest, and death of trees to assist understanding of the underlying processes affecting tree performance within diverse plantings. The study was conducted in Leyte Province. Data were collected from 85 permanent plots. Measurements of trees and site properties were collected from the circular plots with a radius of 5 m (78 m^2 area) randomly located within the rainforestation plantations.

Site/plot characteristics such as soil type, slope, elevation, and location of plots (i.e. at edge or center of planting) were recorded. Tree basal area was derived from the diameter at breast height (DBH) of each measured tree in the plots. Periodic annual increment of tree basal area (PAIBA) was calculated as the average annual tree growth between two consecutive measurements. Mean DBH and mean PAIBA of species were calculated across all the individual trees of each species. Tree species diversity was measured by species richness (i.e., number of species observed) and effective species diversity (i.e. exponential Shannon's index that takes into account both species diversity and evenness within stand) in each plot. The proportions of surviving trees, harvested trees and dead trees were calculated for each species.

Generalized Linear Mixed-Effects Models (GLMMs) were used to test the hypotheses and the package 'lmerTest' was used to evaluate model fit and significance of random and fixed effects. All analyses were conducted in R 3.1.0. Three global GLMMs were built in order to examine each outcome, i.e. responses of tree growth or tree status (i.e. survival, dead or harvested), in the relationship with characteristics of tree/species (i.e. DBH, species shade tolerance and species origin), stand structure (i.e. species richness indices, tree density and basal area of stand) and/or site description (i.e. plot location, slope and soil type) as explanatory variables, and a random effect of plot nested in site. The indices measured in the previous period (2006–2008) were used as explanatory variables to predict tree growth and tree status in the subsequent period (2008–2012). Models were developed to identify factors influencing variation in the performance of individual trees in the community (called community models hereafter). These models used the combined data from the 32 common species that comprised 96.3% of the data and species models were applied for some individual species.

The draft article for publication by Nguyen et al. (see Sections 7 and 11.2 of this report) provides further information on the methods used in this research. The published article by Nguyen et al. (2014a) listed in Section 11.1 also provides additional information regarding the methods used in this research. The results are presented and discussed in Section 8.1.9.

6.2.10. Investigation of pests and diseases and their management in tree nurseries in Biliran Province

The implementation guidelines of the NGP mandate the use of high quality planting materials to ensure high seedling survival and establishment. Surveys on pests and diseases and their management in nurseries and in NGP plantations were conducted in two municipalities in Biliran Province that are supplying seedlings for the NGP. Incidence and severity of pests and diseases in the nurseries were determined based on ocular observation of twenty seedlings of each tree species. When necessary, microscopic examination of affected samples was performed to confirm the presence of pathogens. Photos were taken of affected tree seedlings.

KIIs were also carried out with nursery managers to determine their level of awareness and knowledge of pests and diseases; examine the existing management approaches employed; identify the learnings and extent of exposure of nursery operators to pests and disease management practices; and determine the training and information needs to improve their knowledge of and skills for pest and disease management.

A workshop with nursery operators was held to present the results of the survey and solicit pest management options. The underlying factors contributing to the occurrence of the pest problems were also identified. A coffee table book presenting the pest and diseases observed in the study and their control measures was developed as part of the training and extension materials of the ACIAR ASEM 2010/050 project.

Details of the methods employed in this research are presented in the article by Mangaoang et al. (in prep) listed in Section 11.2. The results are presented in Section 7.1.10.

6.2.11. Identification of mother trees of native species from the natural forests in Leyte and Biliran Islands

The implementation guidelines of the NGP stipulate that high quality seedlings (physical and genetic) will be used in the program. Also, the DENR has a directive to increase the use of native trees in reforestation programs. One major challenge to satisfy these requirements is the limited sources of high quality germplasm, especially of native trees. With this, the DENR engaged the ACIAR Watershed Project to provide the necessary technical support in assessing phenotypically superior mother trees from the natural forests in Leyte and Biliran provinces.

The identification of individual plus trees in both provinces hinged on the output of the reconnaissance survey undertaken by the technical personnel from the Provincial Environment and Natural Resources Office (PENRO) Leyte and Biliran, and ERDS of the DENR Regional Office. In Leyte, the inventory was carried out inside the Mahagnao Natural Park. The natural forest in Barangay Villaconsuelo was the site of the inventory in Biliran.

A team of staff members of DENR PENRO Biliran and Leyte pre-identified 1000 potential mother trees from the natural forests. The pre-selection was based on the subjective judgment by DENR personnel. On another occasion, staff members of the ACIAR Watershed Project, in partnership with DENR personnel, tracked the identified trees, assessed the physical quality using a set of criteria developed during the ACIAR ASEM 2010/050 project, and marked those that passed the assessment criteria. Using a global positioning system (GPS) device, the coordinates of plus trees were determined and recorded.

The criteria used to assess the phenotypic quality of mother trees was an improved version of the method stipulated in the DENR Administrative Order (DAO) 2010-11 - 'Revised Regulation Governing Forest Tree Seed and Seedling Production, Collection and Disposition'. Tree characteristics that were considered during the assessment process included the total height, DBH, stem straightness, stem forking, stem circularity, tree health, branch angle, branch thickness and branch persistence/pruning ability. The total height was measured using a laser hypsometer while the DBH was measured with the use of the diameter tape.

A score on the scale of 1 to 6 was accorded for each tree parameter. A score of 1 = very unacceptable; 2 = unacceptable; 3 = slightly acceptable; 4 = acceptable; 5 = highly acceptable and 6 = ideal. The overall rating of each tree was determined by computing the mean score of all parameters. Trees with the mean score of 1 to 2 were considered unacceptable as plus trees, 3 to 4 as acceptable and 5 to 6 as highly acceptable.

As part of the individual plus trees monitoring and evaluation system of DENR, a database of information was developed to serve as data bank useful for search, query, and retrieval of information specific to the individual plus trees. The database also contains information on the location, tree species, traits or physical attributes of plus trees, and photographs. The database also includes GIS capability to automatically chart locations of individual trees and generate thematic maps.

6.3. Developing the policy assessment model

The project has developed a policy assessment model to uderstand the complex interactions of the many factors that influence the success and failure of community-based reforestation programs in the Philippines. The model informed crucial decisions for designing interventions that were pilot tested as part of the project implementation.

6.3.1. Development of a Bayesian network model for assessing reforestation success

One of the project's early research activities was the survey of 43 reforestation projects in Leyte Island that were at least five years old to assess the success of past reforestation initiatives. Data were collected from 43 out of a possible 62 reforestation projects on Leyte. Both biophysical and socio-economic data were gathered from the selected reforestation projects. Data collection, which covered both reforestation success indicators and drivers, involved both interviews and field survey work. Data collected from the interviews and field surveys were subjected to stepwise multiple regressions in order to identify drivers significantly related to reforestation project success indicators. A set of significant drivers for each indicator was the result of the stepwise regressions. Relationships among these significant drivers and indicators were then tested for significance using Pearson's correlation. The end result was a set of significant driver-indicator, indicator-indicator and driver-driver relationships that were used to identify a system of relationships that affect reforestation success and to guide construction of a Bayesian Network model of reforestation success in the study area.

Netica software version 3.25 was used to construct the BN model. The causal dependencies among reforestation success indicators and drivers were determined from statistical analysis conducted on data collected from reforestation projects in the study area.

The states (categories) of variables included in the BN model were determined in two ways. First, for discrete variables, states were based on those categories used in the data collection interviews or field surveys (e.g. was grazing management applied at the reforestation site? Yes or No). Second, for continuous variables, states were based on previously established cut-offs (e.g. the requirement in the Philippines is that after 1 year of planting, reforestation projects must obtain a minimum threshold of 80% tree survival in order to be eligible for CBFMA tree planting payments), or statistical cut-offs (e.g. the median elevation of surveyed reforestation sites was 204 m), or cut-offs estimated by local forestry experts (e.g. MAI of tree volume for trees with DBH ≥5 cm is considered low if less than 20 m3 $ha^{-1}yr^{-1}$, and high if greater than or equal to 20 $m3ha^{-1}yr^{-1}$).

To parameterise the BN model (i.e. populate the conditional probability tables), we used Netica's default counting algorithm. The data used for parameter learning was the raw interview and field survey data collected from the 43 reforestation projects in the study area. To validate the BN model we used model behavioural, calibration and model accuracy tests. Sensitivity to findings analysis was used as a model behavioural test to compare the relative influence of reforestation success drivers on reforestation success indicators with that found in the statistical analysis (Le et al. 2014). Model calibration tests were conducted to test how well probabilities predicted by the model for reforestation success indicators reflected observed probabilities in the data. Overall predictive accuracy, true positive and true negative prediction rates, the true skill statistic and times surprised were used to test model predictive accuracy.

Further details of the methods used to develop the model are presented in Le et al. (2015) (see Section 11.2 of this report). Section 8.2.1 presents the results of this research.

6.4. Pilot testing initiatives to improve watershed rehabilitation outcomes

Investigations of the drivers of success and failures of resforestation projects, and the series of socio-economic investigations and policy analyses undertaken by the project have provided critical information for improving watershed rehabilitation outcomes. This section provides details on pilot testing interventions that were envisaged to improve the success of people-based reforestation programs.

6.4.1. Evidence-based best practice community-based forest restoration in Biliran: Integrating food security and livelihood improvements into watershed rehabilitation in the Philippines

The less successful results of people-based reforestation programs in many regions in the Philippines is repeated elsewhere in the world. While a number of studies have revealed the factors for the limited success of people-based forestry, very little attempt has been made to design and implement reforestation programs which take into account the multitude of lessons from reforestation failures. As part of the ASEM/2010/050 project, an evidence-based best practice watershed rehabilitation project has been developed in Kawayanon, Biliran to address the key deficiencies of the previous community-based reforestation programs.

The design of the pilot watershed rehabilitation project draws on the results and experience of the Philippine Government's reforestation programs, findings of past research activities undertaken as part of a series of ACIAR smallholder forestry projects in the Philippines, and empirical data. The project adopts the systems approach, which takes into account social, economic, biophysical, policy and governance aspects in forest landscape restoration. The design, implementation and monitoring of the pilot watershed rehabilitation project adopts a participatory approach.

A set of intervention measures suggested by stakeholders during the series of meetings and consultations have been implemented. These interventions are outlined below:

1. Appropriate site selection involving consultations with key officials of the local DENR office, community leaders, PO members, land claimants and other stakeholders.
2. Organizational preparation including information and education campaigns to inform the community and adjacent areas about the project.
3. Rejuvenation of the PO starting with assessment of the PO institution and then undertaking necessary rejuvenation to strengthen cohesiveness of the PO and boost the morale of the group.
4. Empowering the re-organized PO through training and capacity-building programs to improve the capacity of the PO to implement and monitor the project.
5. Identification and implementation of livelihood projects for income and food security. Includes designing the most appropriate livelihood projects in terms of PO preferences, capability to implement such livelihood activities, and the market viability of products.
6. Appropriate site preparation applying the best management practice including dividing the planting area into blocks according to intended use of the plantation, i.e. production, protection and agroforestry zones.

7. Improved nursery seedling production with application of best practice, and species selection based on site characteristics and preferences of the PO, land claimants and the community. Includes an inventory of plus trees (superior phenotypes) as germplasm sources from the natural forest in the community and on farms.
8. Application of best practice in plantation establishment and demonstration of appropriate methods for seedling transport to the planting site, site preparation and planting.
9. Adequate and appropriate plantation maintenance and protection including improving the skills of PO members for post-planting silviculture.
10. Proper project monitoring including establishment of permanent plots to monitor and record the survival and growth rates of seedlings, and surveys of the project's impact on the technical knowledge and capability of the PO members, their socio-economic status and improvement in the biophysical condition of the reforestation site.
11. Improved policy environment to promote community forestry. It includes reviewing existing PO and DENR policies and revising or developing new policies to support the sustainability of the community-based reforestation program.

Further details of methods used to design, implement and monitor the pilot community-based reforestation program are discussed in Gregorio et al. (2015), listed in Section 11.2 of this report. The results are presented and discussed in Section 8.3.1.

6.5. Influence of reforestation on watershed health

The project has investigated the impacts of reforestation on watershed health. A major hydrology experiment in Tacloban was established to compare stream baseflows in grassland and reforested sites. Assessments of the effects of reforestation in Biliran on soil biophysical properties and avifaunal components were also carried out.

6.5.1. Impacts of reforestation on baseflow

Two headwater catchments on solid mafic rock with fire-climax grassland and semi-mature community-managed aided regeneration forest in Tacloban were identified. These watersheds were instrumented in April-May 2013 and monitoring of rainfall inputs, streamflow outputs, soil water dynamics and water quality commenced in June 2013. Weirs were constructed and various field instruments including soil moisture sensors and weather stations, were installed. Research partners from VSU were trained to install the field instruments, gather experiment samples, and measure respective hydrological and soil physical variables. In both sites, locals were employed to look after the instrumentation.

In addition to the field research activities in the two catchments in Tacloban, soil sampling was undertaken in 40 tree plantations across Leyte and Biliran to determine basic hydrologically-relevant soil physical variables to demonstrate the impact of vegetation development on soil and hydrology. Most of the physical and chemical analyses of soil and water samples were performed in the newly established ACIAR Analytical Laboratory at the College of Forestry and Environmental Science in VSU. For analyses beyond the capability of the VSU Analytical Laboratory and other laboratories in the Philippines, samples were sent to Canada and Netherlands.

The passing of Typhoon Haiyan in November 2013 provided the opportunity to determine the buffering effects of trees against strong winds and limiting the stormflow.

The details of instrumentation, data collection, and analysis are presented in articles by Zhang et al. listed in Sections 7 and 11.2 of this report.

6.5.2. Avifaunal diversity in fragmented forest landscape in Biliran

The forest landscape at the ACIAR pilot community reforestation site in Kawayanon in Biliran Province has been modified and fragmented primarily by anthropogenic interventions. The landscape is divided into various land-uses including secondary forests, grasslands, agricultural cultivations, and tree plantations. A study was carried out to relate avifaunal species diversity and distribution to landscape connectivity in the pilot reforestation project. A gully corridor at the lower slope of the pilot project site was selected for the study. This gully corridor was centrally located and structurally connected to the various landscape elements such as the secondary forest in the community, grasslands, the ACIAR pilot reforestation projects, coconut plantations, naturally regenerating forests. Generally running along a stream channel, this corridor is a mixture of coconuts, fruit trees and natural regeneration with rich undergrowth.

The composition and distribution of avian species were assessed using the transect survey method. A transect line measuring 1 km was established. All species of birds encountered along the transect were recorded. For each species seen or heard, the following information was noted: species name, number of individuals and habitat types. The avifaunal surveys were conducted early in the morning (from 6:00 – 9:00am) and late in the afternoon (from 3:00 – 6:00pm) to give a total of six hours observation per day. Observation in each transect was repeated for three days making an observation period of 18 hours per transect.

The report by Patindol et al. listed in Section 11.2 of this report provides details of the methods used in undertaking the avifaunal inventory. An overview of the results are presented in Section 8.4.1.

6.5.3. Soil dynamics of degraded land after restoration using *Acacia mangium* and *Pterocarpus indicus*

Tree species usually prescribed in reforestation projects in the Philippines are those that are fast-growing, able to improve soil fertility, and have good economic value such as the exotic *Acacia mangium* Willd. However, there have been concerns about the use of exotic tree species in reforestation projects particularly regarding their negative effects on biodiversity. Indigenous tree species such as *Pterocarpus indicus* Willd have been promoted. A study was conducted to determine the extent of change to soil physico-chemical and microbiological properties one year after the establishment of *A. mangium* and *P. indicus* on marginal grassland. It was hypothesized that the difference in growth rate of these two tree species would result in varying degrees of changes to soil properties.

Using sequential coring, one soil sample from both 0-5 cm and 5-10 cm depths were randomly collected from three locations at each of the three experimental plots and combined for each soil depth to form a composite sample thereby having nine composite samples per site. A soil core from each depth of each experimental plot was taken for the determination of bulk density. Biomass samples were collected both from aboveground and belowground by laying out a 25 cm x 25 cm wooden frame on top of the spot where the soil sample was taken. Composite samples per experimental plot were collected. The aboveground plant biomass inside the wooden frame was collected. The belowground plant biomass was mainly composed of roots taken from the nine soil cores for bulk density determination per site. The weight of biomass was determined after oven-drying at 70ºC for 24 hours.

Soil bulk density, particle size, soil organic carbon and soil pH were determined. Soil samples were also analysed to determine exchangeable bases, exchangeable Al, extractable P and total N. Measurements of microbial biomass and metabolic quotient were also undertaken.

All statistical analyses were done using Minitab 17 Statistical Software. Mean values of soil attributes were tested for differences using one-way analysis of variance (ANOVA), with the Tukey's honest significant difference as a post hoc test at the 5% probability level. The relationship between soil property values was explored using the Pearson's correlation coefficient.

The results of this research are presented in Section 7.4.3.

6.6. Developing policy recommedations

The project has had a major influence on DENR policy-making and also that of the partner PO in Biliran. This largely relates to implementation of the pilot reforestation program. The project is also working with stakeholders to transform research results into national policies. Outlined below is one of the project's initiatives to improve an existing national policy on regulating seedling quality. With several policy research activities started in the ASEM 2010/050 project that will be subsumed in the new ASEM 2016/103 project, it is expected that several policy recommendations will be advocated at the national level during the implementation of the ASEM 2016/103 project.

6.6.1. Developing the implementing guidelines of the national policy on Forest Nursery Accreditation

The DENR, through the partnership with the ACIAR ASEM/2006/091 project, developed a national policy on Forest Nursery Accreditation to regulate the quality of seedlings in reforestation programs in the country. This policy is stipulated in DAO 2010-11. However, the policy, as it was institutionalised by DENR lacks any implementing guidelines. DENR offices across the country have devised strategies to implement the policy and developed seedling quality assessment criteria. However, the criteria were less appropriate and the seedling assessment was less rigorous. Accordingly, low quality seedlings are still largely used in reforestation programs.

The ACIAR ASEM 2010/050 project has developed implementing guidelines for Forest Nursery Accreditation, which includes a set of criteria for assessing seedling physical quality and the process of accrediting forest nurseries. The guidelines were drafted during the implementation of the ACIAR ASEM/2006/091 project through a series of consultation meetings and workshops with stakeholders. The guidelines were modified during the ACIAR ASEM/20010/050 project to attune with the promulgation of the NGP and tested in Philippines regions 8, 10, 11 and 12. Recognizing the need to include implementing guidelines of the national Forest Nursery Accreditation Policy, the ACIAR ASEM/2010/050 project has advocated the national adoption of the guidelines by DENR.

A series of meetings with DENR at the regional and national levels were undertaken to discuss the shortcomings of the existing policy and present recommedations to improve the policy including the incorporation of implementing guidelines. DENR staff members at the local level who were involved in pilot-testing of the suggested guidelines provided results including success stories of using the guidelines to the top officials of DENR.

Key findings of this intiative are presented in Section 7.5.1.

6.7. Field trials and plantation experiments

The project has managed eight field trials, established either under the ASEM/2010/050 or ASEM 2006/091 projects. However, the typhoon Haiyan in 2013 damaged most of the trials and rendered them inappropriate for continued data collection. Only two trials, in Biliran and Mindanao, are currently being monitored.

6.7.1. Establishing a mixed species trial in the pilot community-based reforestation project in Caibiran, Biliran

It is critical to identify suitable tree species and planting systems in promoting large-scale community-based forestry programs in the Philippines. However, there is a dearth of information regarding the growth of many tree species especially indigenous trees that have potential for reforestation programs and smallholder tree farming projects in the country. As part of implementing the ACIAR-funded research project in the Philippines (ASEM/2010/050), a mixed-species trial was established to identify native and exotic species which exhibit promising characteristics for community-based reforestation programs (i.e. high rates of survival and fast early growth, and those that can be planted togther in the same stand). Twenty species of timber trees were planted, and the early survival and growth has been monitored to identify the best possible species for reforestation (Appendix 12.2). Species were selected based on recommendations of DENR, findings of past ACIAR research assessing the performance of trees in RF farms, community preferences, successional status, and availability of germplasm. Exotic species known to perform well in the region were included in the trial as a baseline against which performance of native species can be measured. Appendix 12.2 presents the list of species included in the trial.

A randomised block design was used in which 20 individuals of each species were planted at the spacing of 3 m x 3 m in a block randomly located within the plot. Initial field measurements of seedling height and base diameter were carried out at outplanting and three months thereafter for two years. Measurements will be taken at six month intervals between years 3 to 5. A yearly measurement will be conducted after this period. Seedling mortality and general health were also recorded. The photosynthetic rate of seedlings was measured using the infrared gas analyser. DBH was recorded using a diameter tape as soon as the trees reached three meters in height. Seedling height was measured using a meter stick. Data organisation was performed using Microsoft Excel.

6.7.2. Response to inorganic fertiliser and arbuscular mycorrhizal fungi inoculation of *Paraserianthes falcataria* grown in rice hull potting mix

Inoculating tree seedlings with arbuscular mycorrhizal fungi (AMF) has been suggested as a possible solution for attaining good growth performance of seedlings in the NGP reforestation sites (Alave, 2011, Que, 2016). In 2013, the DENR produced 155 tons of AMF inoculant and distributed it to various regions in the Philippines to ensure the supply of AMF inoculum for planting materials for the NGP. While mycorrhizal inoculation could potentially benefit seedlings, the success rate of inoculation could vary considerably due to differences in the interaction of the tree genera and fungi, and the environment. A study was carried out to investigate the main effects of AMF inoculation on the nursery growth performance of *Paraserianthes falcataria* grown in potting medium of low fertility.

A factorial experiment was conducted with eight treatment combinations from two types of potting medium, two levels of inorganic fertilizer, and two levels of AMF inoculation. Seedling height and base diameter were measured bi-weekly from 2 to 14 weeks after potting. A separate factorial experiment was also conducted with eight treatment combinations from two types of potting medium and four types of AMF inoculation. All seedlings in every treatment combination received 8 mg N, 6 mg P and 6 mg K. In both experiments, seedlings were harvested four months after potting. Seedling height, base diameter, nodulation, biomass and nitrogen, phosphorus and potassium concentrations were determined.

Details of the methods used in this research are presented in the IUFRO Conference paper by Ferraren et al. (2015) listed in Section 11.2 of this report. The results of this study are presented in Section 8.6.2.

6.7.3. Importance of tree characteristics and wood quality for determining best end-use of smallholder tree farms

In the Philippines, most smallholder woodlots produce merchantable volumes of less than 44% of their site potential due to a lack of appropriate silviculture (Herbohn et al. 2014; Le et al. 2014). Whatever end-use is chosen by smallholders for their trees, it is critical that the community must perceive the resource to be meeting their needs, otherwise they are likely to destroy it (Le at al. 2012). An opportunity to inventory and undertake a trial harvest of a poorly managed stand of *Acacia mangium* in the Philippines permitted an assessment of the importance of tree characteristics and wood quality for determining the best end-use for the stands.

Assistance was provided to the PO (i.e. CFPBA) to collect inventory data and to undertake a harvesting trial. The assistance included technical advice on how to undertake a timber inventory, liaising with DENR, and investigating potential markets for rough-sawn and processed lumber. A 1.5 ha stand of *A. mangium* at Sitio Cansiso[1] in the Barangay[2] of Cabibihan was selected for a trial harvest and an inventory of trees was undertaken to meet DENR administrative requirements for a Resource Use Permit to fell the trees. To collect data on lumber quality, 50 trees were selected across the diameter range. Before these trees were cut into lumber, measurements were taken of tree DBH, bark thickness and basal diameter. After felling, the trees were cut into lumber with minimum dimensions of 8' length and 2x2" cross section[3]. The lumber recovery of each tree was recorded together with the number of slabs which were left as off-cuts. The bow and twist of each piece of lumber was recorded as well as the presence of fungal decay, termites and wane[4].

The effect of drying on lumber degrade, e.g. by increased bow, twist or cracking, was assessed by randomly selecting 50 pieces of lumber, 25 with end dimensions of 4x2" and 25 with end dimensions of 6x2" and stacking them in a well-ventilated open shed for two months. For each tree sampled, the sawn lumber was measured and tallied and because of its irregular dimensions, waste wood was weighed.

The article by Baynes et al. (2014) published in Small-scale Forestry (see Section 11.2 of this report) provides more information on the methods used in this research. The results are discussed in Section 8.6.3.

6.7.4. Effects of regeneration types on recruitment of species and functional diversity in human-oriented landscape

Management techniques used in small-scale community-based plantation projects differ to those used in an industrial timber estate. In particular, harvesting of timber products for sawmills occurs more sporadically and silvicultural practices such as thinning and weed control are often neglected (Herbohn et al. 2014); therefore, understories often develop within these plantations. This increases the potential of these plantations to contribute to conservation, including increasing species diversity at both the site and landscape levels. Understanding seedling recruitment within small-scale community-based reforestation is, therefore, an important research goal for both biodiversity and socio-economic outcomes.

A study was undertaken to investigate seedling diversity in the understorey of different forest types, i.e., monocultures, mixed-species plantations and regenerating selectively logged

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[1] A sitio is a small village or cluster of houses.
[2] A barangay is the smallest unit of political administration in the Philippines. It may comprise several villages and the surrounding land.
[3] In the Philippines, log and board dimensions are recorded in imperial units.
[4] In sawn boards, wane occurs when the curved outer surface of the log is included as one face of a piece of lumber, resulting in a board with imprecise dimensions.

forests, across a highly modified agricultural landscape on Leyte Island, Philippines. The study aimed to measure and compare seedling abundance and composition of species and traits beneath each forest type; identify species or functional traits that are favoured beneath each forest type; and identify species or functional traits limited in their reproductive ability and therefore, represent species or traits of conservation significance.

Two and four plots were established per site, depending on the size of the forest, to prevent edge effects. A total of 35 plots were established across across all the 15 sites. All individual trees and shrubs below 2 m in height were sampled. Tree and shrub species' height and either diameter at base or DBH (individuals >130cm) were measured and recorded. Also, herbs, vines and ferns were identified and either the number of individuals or vegetation cover was recorded. Leaf area index (LAI) of the canopy was measured. Soil nitrogen (N) and phosphorus (P) samples were collected and analysed with a colorimetric determination of N using the salicylate-hypochlorite method and P using a single solution method.

Most analyses were conducted using R statistical computing version 3.1.1. Microsoft Excel and SigmaPlot version 12.5 were also used. To test if understorey species diversity was adequately sampled, we constructed species accumulation curves using the Specaccum function in the vegan package. We investigated if soil phosphorus, soil nitrogen and LAI, varied depending on forest types using linear mixed effect models (LMEMs). All LMEMs were fitted using the nLME package (Pinheiro et al. 2016). Understorey diversity was quantified using species richness, Shannon's diversity index, Simpson's diversity index, mean number of seedling individuals and functional traits (i.e. dispersal, fruit type, fruit size and seed size) (Magurran, 2004). To assess the relationship between understorey diversity and forest type, and abiotic conditions (e.g. soil phosphorus, soil nitrogen and LAI (proxy for light availability)), we again used LMEMs estimated with Maximum Likelihood (ML) and a random effects structure of plots nested within sites. Because our study has a balanced design, we used F-statistics to assess the significance of fixed effects as explanations of variation in the response variables (Pinheiro & Bates, 2001); and the effects package (Fox, 2016) was used to graph the higher-order fixed effects in the LMEMs. We log transformed the response variable, the number of individuals, due to breaches of normality.

Non-metric multi-dimensional scaling (nMDS) was used to compare both understorey species richness and abundance (to compare evenness across forest types), based on the Bray-Curtis similarity matrix, as it performs most satisfactorily with datasets with high numbers of 0 values. We also developed nested permutational ANOVAs with 1000 permutations using the Biodiversity R package (Anderson and Walsh, 2013). Trait richness and abundance data was log (x+1) transformed due to breaches of normality.

The article listed in Section 11.2 by Wills et al. (2016) published in the Journal of Applied Ecology provides more information regarding the methods used in this study. The results of this study are presented in Section 8.6.4.

6.7.5. Biodiversity and carbon stock assessment in the post-kaingin secondary forests in the upland Philippines with implications for land-use policy development

In the Philippines, post-*kaingin* secondary forests have the potential to participate in carbon or biodiversity offset projects under REDD+ and the CDM, and to attract funds to protect and conserve the country's forests with greater community involvement (Lasco and Pulhin, 2003; Lasco et al. 2001). However, such projects require better understanding of the biodiversity and carbon dynamics associated with related land-uses (Budiharta et al. 2014; Niles et al. 2002).

In the case of shifting cultivation, there has been a great variability among findings from studies focusing on the ecology and successional development of forests post-*kaingin*. Studies have found different fallow lengths are required for forest to return to its earlier condition, and that there are different levels of impacts on forests and related environmental parameters (Mukul and Herbohn, 2016; Bruun et al. 2009). Against this backdrop, a study was carried out to shed light on secondary forest dynamics after shifting cultivation in the Philippines uplands.

Vegetation survey, biomass inventory and soil sampling was undertaken in post-*kaingin* secondary forests and in old-growth forests. Altogether, 100 transects (50 m x 5 m) established at 25 sites belonging to four fallow categories (e.g. fallow for less than 5 years, fallow between 6-10 years, fallow between 11-20 years, and 21-30 year old fallow) and control old-growth forest sites were used.

Additional information on the methods used in this reseach is presented in Mukul and Herbohn (2016) and Mukul et al. (2016) listed in Section 11.1 and Mukul (2016) in Section 11.2 of this report. Key findings of this research are presented in Section 8.6.5.

7. Achievements against activities and outputs/milestones

Objective 1: Identify the key factors that have led to the success or failure of watershed rehabilitation/reforestation programs in the Philippines

No.	Activity	Outputs/ milestones	Completion date	Comments
1.1	Assess the success of past watershed rehabilitation programs	Socio-economic survey developed and pilot-tested Biophysical data collection pro-forma developed. Data collection completed in Leyte.	Oct 2012 Oct 2012 Dec 2012	Survey of 38 past reforestation projects older than 5 years in Leyte Island completed. Socio-economic and biophysical data analysed. Published research articles from this activity include: ***Le et al. 2013.*** *What drives the success of reforestation projects in tropical developing countries? The case of the Philippines. Global Environmental Change. 24:334-348.* ***Le, H.D., Smith, C., Herbohn, J. and Harrison, S. 2012.*** *'More than just trees: Assessing reforestation success in tropical developing countries'. Journal of Rural Studies 28:5–19*
		Data collection completed in Mindanao. Laboratory analysis completed. Report outlining assessment of past and current reforestation initiatives in the Philippines	Data collection dropped in favour of undertaking NGP assessment in Regions 8 (Eastern Visayas) and 10 (Mindanao) May 2013 August 2013	Mindanao component of the survey has been dropped in favour of undertaking an assessment of National Greening Program sites in Leyte and Mindanao at the request of DENR. The field works for the NGP assessment completed in June 2013. Key findings of NGP assessment have been reported to stakeholders, primarily DENR, through meetings and research reports. The following article was published from the survey: ***Gregorio et al. 2016.*** *Regulating the quality of seedlings for forest restoration: Lessons from the National Greening Program in the Philippines*. Small-scale Forestry. Technical report describing the establishment success of NGP in Regions 8 and 10: ***Baynes et al***. *An Investigation into the Effectiveness of the National Greening Program in the Provinces of Misamis Oriental, Bukidnon*
				Meetings and workshops with stakeholders including DENR, POs and LGUs in Biliran were carried out to gather more information regarding

				the causes of reforestation failures in the province, and strategies to improve the success of upland rehabilitation programs. These activities were undertaken as a component of implementing the pilot community-based reforestation program in Biliran Province.
				Survey on the socio-economic effect of NGP for farmers in Biliran was undertaken. Investigation of the financial outcomes of rainforestation farming in Leyte was also carried out, and a survey on the engagement of LGUs in the NGP. Scientific articles prepared for publication: ***Goltiano et al.*** *The effect of the NGP on the socioeconomic status of the households of PO-member participants in Caibiran, Biliran Province, Philippines.* ***Mangaoang, E., Gloria, J. and Pasa, A****. Effectiveness of Biliran Local Government Units in the Implementation of the National Greening Program (NGP).* The effectiveness of rainforestation farming as one of the reforestation strategies of the government was assessed. An article has been submitted to Agroforestry Systems for publication: ***Ota et al.*** *Livelihood outcomes of the pilot rainforestation farming program in Leyte Province, the Philippines.*
1.2	Understand decision-making by households in relation to reforestation	Field work completed Report completed	Apr 2013 Jul 2013	Fieldwork and report completed. The following article was published from this activity: ***Baynes et al. 2016.*** *Power relationships: their effect on the governance of community forestry in the Philippines.* Land Use Policy 54:169-176.

1.3	Conduct a national workshop to collate existing information and experiences on watershed rehabilitation	Workshop conducted Proceedings published and distributed	Deferred	The workshop was envisaged to provide important inputs for the implementation of the follow-on ACIAR-funded project that is designed to scale-up the initiatives of the ACIAR Watershed Project in Biliran to other regions in the Philippines. In addition, a workshop on Forest and Landscape Restoration will be held in the second half of 2017 and at this workshop, many of the results of the current project will be presented. The primary purpose of the national workshop was to gather existing information concerning reforestation in the Philippines. It was decided that a better approach was to focus on data collection from Activity 1.1 and a comprehensive review of the literature (**see *Baynes et al. 2015***). In addition, the project's strong partnership with DENR at the local, regional and national levels, and the active involvement of stakeholders including POs, LGUs and DENR in designing, implementing and monitoring research initiatives of the project has provided substantial information on watershed rehabilitation that was originally intended to be gathered from the national workshop.

Objective 2: Identify key intervention points and design initiatives to improve watershed rehabilitation outcomes by working with communities, LGUs and DENR

No.	Activity	Outputs/ milestones	Completion date	Comments
2.1	Develop a policy assessment model (PAM).	Model framework developed with stakeholders PAM populated with data from 1.1, 1.2 and expert opinion	Sept 2012 June 2013	Model framework developed, populated and validated. The key drivers and interventions for improving watershed rehabilitation success have been identified and interactions among the drivers were analysed. The following article has been published from this work: ***Le et al. 2015.*** *Identifying interactions among reforestation success drivers: A case study from the Philippines.* Ecological Modelling 316:62-77.

2.2	Identify and develop interventions and policy initiatives to pilot test	Workshops held with stakeholders to identify interventions and policy options using PAM. Tentative list of intervention steps identified for each option	July 2013	Workshops with stakeholders were held. Description of specific initiatives to pilot test to improve outcomes has been completed. This information has been used in designing the improved community-based reforestation program being pilot tested in Biliran Province indicated on the briefing note ***BN 5-2014*** *Implementing a pilot community-based reforestation program.* The following journal articles outlining potential interventions and policy options arising from this work were published: ***Gregorio et al. 2015***. *Evidence-based best practice community-based forest restoration in Biliran: integrating food security and livelihood improvements into watershed rehabilitation in the Philippines.* Best practice guidelines for the identification of mother trees, protocols in accrediting forest nurseries, and criteria for assessing morphological quality of seedlings have been promoted to the national level of DENR to improve the stipulations of DAO 2010-11, which sets out the Forest Nursery Accreditation policy for reforestation programs in the Philippines. Drafts of Technical Bulletins have been submitted to ERDB during the meeting with top DENR officials: ***FMB Technical Bulletin***: *Guide on the selection of mother trees for timber species.* ***ERDB Technical Bulletin***: *Guide in the assessment of forest nursery and seedling quality for accreditation.*

Objective 3: Pilot test initiatives to improve watershed rehabilitation outcomes and implement local-level policy changes in conjunction with communities, DENR and LGUs

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1	Assemble existing spatial data in pilot study watersheds.	GIS developed for each watershed using available data layers.	March 2013	Spatial data has been compiled for the sub-catchment in Biliran which is the site of the pilot reforestatation program. In addition, data has been collected for the paired catchments

				at Manobo and Basper that were used for the hydrology research related to the impacts of reforestation. Initially it was planned to undertake all project activities in the same catchments and to link these to another ACIAR soils project. This proved to be infeasible due to the conflicting requirements of each study. Following an extensive survey of possible sites, we decided to use separate sites for the hydrology research (paired catchments at Basper and Manobo located outside of Tacloban) and the reforestation pilot program (Biliran). Separate spatial datasets have been compiled for these areas.

3.2	Develop and pilot test reforestation-based livelihood initiatives.	Report outlining financial analysis of forest-based livelihood options. Report outlining social acceptability and analysis of implementation issues for livelihood options.	Mar 2013 Apr 2013	Analysis completed. Green charcoal has been eliminated as an option after extensive investigation and consultation. Nursery seedling production and production of vegetables, crops, abaca fiber, fruit trees, fuelwood and furniture making were identified by the PO as preferred livelihood options. Value-adding opportunities for existing mature forest resources were identified as a promising option. An article outlining the identification of livelihood options has been published: ***Gregorio et al. 2015.*** *Evidence-based best practice community-based forest restoration in Biliran: integrating food security and livelihood improvements into watershed rehabilitation in the Philippines.* In: Kumar C, Saint-Laurent C, Begeladze S, Calmon M (eds) Enhancing food security through forest landscape restoration: lessons from Burkina Faso, Brazil, Guatemala, Viet Nam, Ghana, Ethiopia and Philippines. IUCN, Gland, pp 174–217. Harvesting trials were completed in Feb 2014, and the journal article below reporting the results has been published: ***Baynes et al. 2015.*** *How useful are small stands of low quality timber?* Small-scale Forestry 14:193-204 Pilot testing of improved community-based reforestation procedures is on-going. A communal agroforestry farm has been established and planted with crops including cassava, sweet potato and pineapple in 2015. Banana, coffee and abaca have also been planted. Fuelwood trees have also been planted along the boundary of the reforestation site during this period.

		Livelihood initiatives developed for nurseries, wilding collection and green charcoal	May 2013 – implementa-tion plan completed; June 2013 – Implementa-tion commenced as part of the pilot community reforestation program in Biliran.	A communal nursery was established as part of the livelihood initiatives. The nursery set-up and quality of seedlings passed the evaluation on seedling quality conducted by the DENR. This evaluation is a requisite for becoming a DENR-accredited seedling supplier for reforestation programs in the country.
				The PO has identified over 300 trees of premium native species from the natural forest managed by the community. A mother tree protection program has been established in partnership with the LGU. The details of the mother trees are presented in the manual developed by the project: ***Gregorio et al.*** *Phenotypically superior mother trees in Kawayanon and Villa Consuelo, Philippines.*
		Assessment of the potential sale of carbon offsets via the VCS REDD and CDM A/R pathways. Development of an "integrated catchment carbon" concept with financial modelling of carbon sales and associated report. Pilot test of an ICC scheme to develop carbon offset projects and sell carbon offsets, including analysis of the associated economic, social and ecological outcomes.	June 2013	A watershed in Biliran had been identified as a potential site. However, implementation of this activity was postponed due to the negative impacts of typhoon Haiyan that badly destroyed most places in Region 8 which includes Biliran. Because of these issues, we undertook a modified study with a more limited scope which was focused on secondary forests. That study has now been completed and results have been published: ***Mukul et al. 2016b.*** *Co-benefits of biodiversity and carbon sequestration from regenerating secondary forests in the Philippines: Implications for forest landscape restoration.* Biotropica 48(6)882-889. ***Mukul et al.*** *Environmental and financial viability of a novel carbon payment scheme for swidden fallow secondary forests in the Philippines.*
		Prioritisation and implementation of additional initiatives identified in 2.2	Oct 2013 - financial analysis completed; Dec 2013 – implementa-tion plans completed; May 2014 – implementa-tion commenced	Value-adding of timber harvested from mature timber tree plantations has been discounted as an option for small stands of timber trees with variable wood characteristics because of issues associated with poor quality timber. This is based on the findings of the harvesting trial conducted in November 2013 to February 2014 and reported in:

				Baynes et al. 2015. *How useful are small stands of low quality timber? Small-scale Forestry 14:193-204*. High-value premium native and exotic species were planted in blocks in the production zone of the pilot community-based reforestation site. A mixture of early and late succession ecologically important native tree species was planted in the designated protection zone.

3.3	Pilot test changes to policy at the local level to address social, institutional and political problems.	Implement pilot tests of local-level initiatives to address key institutional, policy and management impediments to improve watershed rehabilitation.	Aug 2014 - one initiative implemented in at least one watershed. Aug 2015 - two additional initiatives implemented.	A policy on the adoption of the implementing guidelines of the Forest Nursery Accreditation developed by the previous ACIAR Q-seedling Project (ASEM/2006/091) and promoted by the current Project has been implemented in Biliran Island through the issuance of a DENR-PENRO Memorandum Order: Mandatory province-wide accreditation of all seedling suppliers for the NGP. This will promote the production of high quality seedlings and the sustainable seedling nursery livelihood option for farmers. The DENR-ERDS in Regions 8 and 10 have used the same guidelines in regulating the quality of seedlings for the NGP. Meetings with top DENR officials in DENR Central Office in Manila were undertaken to discuss the continued national adoption of the forest nursery accreditation guidelines and mother tree selection criteria promoted by the ACIAR Watershed Project. Interventions to improve the implementation of watershed rehabilitation and management programs have been pilot tested in the on-going community-based reforestation program in Biliran Island. These interventions are envisaged to inform, improve and modify relevant existing forestry policies pertaining to community-based forestry. Report outlining findings of the pilot reforestation program conveyed to the DENR at the national level to improve the implementation of the NGP. These are indicated in the Briefing Notes: ***BN1-2016*** *Meeting-workshop with DENR* and ***BN2-2016*** *The pilot community-based reforestation in Biliran.*

3.4	Assist DENR and other groups to implement the NGP reforestation initiatives using identified best practice.	Develop best practice guidelines (BPG)	April 2013 - BPG 1st edition developed; Mar 2015 – BPG 2nd edition developed; Mar 2017 3rd edition completed.	Best practices manuals in community-based watershed rehabilitation and management have been developed. Training and extension materials for seedling production in smallholder nurseries and appropriate plantation silviculture were also produced. Guidelines for mother tree selection and nursery accreditation have been developed and adopted at the provincial and regional levels of DENR. Staff members of DENR at the local level have been trained by project researchers on the application of nursery and seedling quality assessment criteria. Researchers of the project were requested by DENR Region 8 to evaluate the phenotypic qualities of about 3,000 potential mother trees of native species that the department had identified from the natural forest in three municipalities in Region 8. The evaluation also served as hands-on training of DENR personnel on assessing mother trees of timber species. The output of this partnership is presented in the spreadsheets: *Inventory data of mother trees in Burauen, Leyte*; and *Inventory data of mother trees in Biliran.* A pilot community-based reforestation project is currently implemented in Biliran Island applying the smallholder-based best practices for effective watershed rehabilitation and management. This project is inside the NGP project site of the PO and also within the CBFM area of the organisation. The implementation is a collaboration between the DENR, upland communities and the ACIAR Watershed Project. The nursery and plantation of the PO has been used as a model for educating other POs in the province regarding best practice in seedling production and plantation establishment.

		Adapt existing extension material for the NGP and test effectiveness; Identify gaps in extension material then develop and test new material.	April 2014 – assessment of existing materials completed; Aug 2016 – new materials developed.	Training and extension materials developed by the government specifically for the implementation of the NGP are limited. Meetings were held with DENR at the local and national level to determine how to best improve the materials. Using the existing manuals as the starting point, improved versions were then developed. A number of training and extension materials for effective watershed rehabilitation and management were drafted. These include manuals on high-quality seedling production, selection of mother trees and plantation establishment, maintenance and protection. These materials were tested during training events held by the Project in communities within the project site in Biliran Island and other areas in Regions 8 and 10. These were also presented to the DENR officials for review. Comments and suggestions from stakeholders have been incorporated in finalising these materials.
		Assist in implementing best practice in pilot watersheds.	Mar 2014 – commenced.	A pilot large-scale community-based reforestation project is implemented in Biliran Island since March 2014. This pilot project adopts the best practice in watershed rehabilitation and management and is designed to address the shortcomings of the NGP and previous reforestation projects in the country. This initiative is implemented in partnership with DENR.
3.5	Improve current reforestation techniques.	Develop field trial designs to test improved reforestation techniques.	Field trials established Aug 2012, Aug 2013, Aug and Dec 2014.	Most of the field trials established were severely damaged by the Typhoon Haiyan and were subsequently abandoned. These included the mixed-species trial and variable spacing trial that were established in Dec 2012 in Ormoc. However, Typhoon Haiyan presented an opportunity to study the impacts of typhoons on key native and exotic species. A substantial post-typhoon assessment of wind damage to tree farms and field trials was undertaken and has revealed substantial new information to guide the design of reforestation in typhoon-affected areas (see ***Nguyen et al. in prep***). A field trial on fertiliser and shade influence on the growth of dipterocarps has been concluded, the following is the published article:

				Gregorio, N., Herbohn, J. and Vanclay, J. 2012. *Developing establishment guidelines for Shorea palosapis in smallholder plantings in the Philippines. International Forestry Review* A nursery trial dealing with fertilizer and arbusular mycorrhizal fungal (AMF) inoculation using *Pterocarpus indicus* has been concluded. A nursery trial on fertilizer application and AMF inoculation using *Paraserianthes. falcataria* was concluded and a field trial to assess the field growth performance of the nursery-treated seedlings has been established in Region 10. These trials are reported in: ***Ferraren, A., Gregorio, N., Agne, L., Avela, M., and Pasa, A. 2016***.*Response to Inorganic Fertilizer and Arbuscular Mycorrhizal Fungi Inoculation of Paraserianthes falcataria (L.) Grown in Rice Hull Potting Mix* ***Ferraren, A., Gregorio, N., Agne, L., Avela, M., and Pasa, A***. *The Effects of Rice Hull Potting Mix, Chemical Fertilizer, and Arbuscular Mycorrhizal Fungi Inoculation on the Growth, Nutrient Uptake and Mycorrhizal Infection of Paraserianthes falcataria Seedlings in the Nursery.* Various research on existing plantations to determine improved reforestation techniques was also conducted. Results have been published in top quality journals including: ***Nguyen, H., Herbohn, J., Firn, J., and Lamb, D. 2012.*** *Biodiversity-production relationships in small-scale mixed-species plantations using native species in Leyte Province, Philippines. Forest Ecology and Management,* ***Nguyen H, Lamb D, Herbohn J, Firn J. 2014a.*** *Designing Mixed-Species Tree Plantations for the Tropics: Balancing Ecological Attributes of Species with Landholder Preferences in the Philippines. PLoS ONE 9(4):* ***Nguyen H, Firn J. Lamb D, Herbohn J. 2014.*** *Wood density: a tool to find complimentary species for the design of mixed species plantations. Forest Ecology and Management*

				Nguyen, H., Vanclay, J., Herbohn, J. and Firn, J *Understanding drivers of tree growth, mortality and harvest preferences in species-rich plantations for smallholders and communities.* ***Mukul, S.A., Herbohn, J. 2016.*** *The impacts of shifting cultivation on secondary forests dynamics in tropics: a synthesis of the key findings and spatio temporal distribution of research. Environmental Science & Policy* ***Mukul, S.A., Herbohn, J., Firn, J. 2016.*** *Tropical secondary forests regenerating after shifting cultivation in the Philippines uplands are important carbon sinks. Scientific Reports, 6: 22483* ***Wills, J., Herbohn, J., Moreno, M. O. M., Avela, M. S. & Firn, J. 2016.*** *Next-generation tropical forests: reforestation type affects recruitment of species and functional diversity in a human-dominated landscape. J Appl Ecol.* A number of articles are also in preparation for journal submission. A mixed-species trial involving the planting of 20 tree species has been established inside the pilot reforestation site in Biliran.

Objective 4: Design and implement on-going monitoring of the effectiveness of interventions and initiatives to improve watershed rehabilitation outcomes and develop policy recommendations based on outcomes

No.	Activity	Outputs/ milestones	Completion date	Comments
4.1	Design and implement a monitoring program to assess the social and economic impact of reforestation.	Baseline social and economic data collected in three watersheds.	Mar 2013	Baseline socio-economic data were collected from research communities within the pilot watershed in Biliran in which the pilot reforestation project and associated existing livelihood projects are implemented. A report outlining the methods of assessing and monitoring the socio-economic impacts of the pilot community-based reforestation program in Biliran is presented in: ***Goltiano et al.*** *The effect of the NGP on the socioeconomic status of the households of PO-member participants in Caibiran, Biliran Province, Philippines.* Another research paper presenting the results of this activity is:

				Gravoso et al. *Meaning of participation and stories of change from reforestation projects by upland farmers: A case in Biliran Province, Philippines.*
		Annual snapshots of selected socio-economic indicators and more detailed socio-economic data collected on the completion of each pilot study.	March 2014, March 2015, Dec 2016	Surveys were undertaken when the pilot reforestation commenced in the first quarter of 2014 to characterise household members of the PO including their socio-economic status. Surveys to assess the socio-economic impacts of the pilot reforestation program were undertaken in 2015 and 2016. A report outlining the methods of assessing and monitoring the socio-economic impacts of the pilot community-based reforestation program in Biliran is presented in: ***Goltiano et al.*** *The effect of the NGP on the socioeconomic status of the households of PO-member participants in Caibiran, Biliran Province, Philippines.* Another research paper presenting the results of this activity is: ***Gravoso et al.*** *Meaning of participation and stories of change from reforestation projects by upland farmers: A case in Biliran Province, Philippines.*
		Report outlining social and economic impacts of each pilot study of the livelihood initiative.		A report outlining the methods of assessing and monitoring the socio-economic impacts of the pilot community-based reforestation program in Biliran is presented in ***Goltiano et al****. The effect of the NGP on the socioeconomic status of the households of PO-member participants in Caibiran, Biliran Province, Philippines.* Another research paper presenting the results of this activity is: ***Gravoso et al****. Meaning of participation and stories of change from reforestation projects by upland farmers: A case in Biliran Province, Philippines.*
4.2	Design and implement a monitoring program to assess the impact of reforestation on watershed health.	Design of monitoring program. Implementation of program and collection of data.	March 2013 Annual reports (2013 to 2016) tabulating key data.	Paired watersheds in Tacloban (one watershed having been reforested about 15 years ago and the other watershed in a degraded condition) were monitored until August 2014. Data collection has been completed and the results are being analysed and written up.

				A third watershed in Biliran is the site of the ACIAR pilot reforestation project. Research was undertaken to determine the soil amelioration attributed to the plantation. Also, a study was conducted to assess the avifaunal biodiversity improvement as influenced by the reforestation. Results outlining the environmental impacts of reforestation on the hydrology and water quality, soil properties and avifaunal biodiversity are presented in: ***Zhang et al.*** *Comparative soil physical characterization of fire-climax grassland and community-aided reforestation in Eastern Leyte, Philippines: Implications for runoff generation.* ***Zhang et al.*** *Water budget and runoff response of a degraded fire-climax grassland catchment, Leyte, the Philippines.* ***Zhang et al.*** *Typhoon Haiyan's effect on rainfall interception losses from a secondary tropical forest, Leyte Island, the Philippines.* ***Zhang et al.*** *Typhoon impact on water budget and runoff response of a community managed secondary tropical forest catchment, Leyte Island, the Philippines.* ***Van Meerveld et al.*** *Contrasting runoff response of degraded and reforested land on Leyte, the Philippines.* ***Abulencia, M.*** *Soil Dynamics of Degraded Land One Year After Restoration Using Acacia mangium Willd. and Pterocarpus indicus Willd.* ***Patindol, T. et al.*** *Avifaunal diversity in a fragmented forest landscape in Caibiran, Biliran.*

4.3	Design an on-going monitoring program suitable for implementation after the end of the project.	Monitoring plan for each watershed.	Jun 2014 (watershed 1); June 2015 (watersheds 2 and 3)	Community members were involved in the monitoring of the paired watersheds and this experience will be incorporated into the recommendations for on-going monitoring programs. In addition, community members from the Biliran watershed have been involved in the monitoring activities associated with the pilot community-based reforestation program. The PO has developed an effective monitoring scheme to prevent forest fires and members learnt how to monitor the growth of trees and appropriate control measures of pests and diseases. The DENR PENRO of Biliran is actively involved in the pilot reforestation program starting from program designing, through to monitoring. This office has also provided funds to assist the PO implement the preferred livelihood projects. This office will spearhead the monitoring of the program in partnership with the PO once the ACIAR Watershed Project will culminate in 2017. The pilot reforestation site is within the Community-based Forest Management Area of KFAI, which is technically under the jurisdiction of DENR PENRO Biliran. These ooutcomes are all reported in ***BN2-2016*** *The pilot community-based reforestation in Biliran* and in ***Gregorio et al. 2015.*** *Evidence-based best practice community-based forest restoration in Biliran: integrating food security and livelihood improvements into watershed rehabilitation in the Philippines.*
4.4	Develop policy recommendations and communicate results to key stakeholders.	Hold regular briefing sessions with senior DENR management in Manila. Hold sub-national workshops with policy practitioners.	Feb 2012, Jul 2013, 2014, 2015, Jun 2016. One per year – 2012, 2013, 2014, 2015.	A meeting with top DENR officials, namely USec Adobo, ASec Amaro and USec Ignacio was held on March 23, 2016 at the main office of DENR in Manila to present the findings of the pilot community-based watershed rehabilitation program. The meeting was also undertaken to discuss the proposed revision of criteria for mother tree selection and assessment of seedlings for nursery accreditation stipulated in DAO 2010-11.

				Another meeting with top officials of DENR ERDB to discuss the proposed revision of the Forest Nursery Accreditation Policy in DAO 2010-11 was held. A Technical Bulletin for the national adoption of the criteria for mother tree selection and assessment of seedling quality is being developed by the project in partnership with ERDB. Research findings and publications indicating policy recommendations include: ***Gregorio et al. 2016.*** *Regulating the quality of seedlings for forest restoration: Lessons from the National Greening Program in the Philippines. Small-scale Forestry. doi: 10.1007/s11842-016-9344-z* ***Baynes et al.*** *An Investigation into the Effectiveness of the National Greening Program in the Provinces of Misamis Oriental, Bukidnon, Biliran, Samar, Leyte and Southern Leyte.*
				Gregorio et al. 2015. *Evidence-based best practice community-based forest restoration in Biliran: integrating food security and livelihood improvements into watershed rehabilitation in the Philippines.* ***Mangaoang, E., Gloria, J. and Pasa, A.*** *Effectiveness of Biliran Local Government Units in the Implementation of the National Greening Program (NGP).* ***Goltiano et al.*** *The effect of the NGP on the socioeconomic status of the households of PO-member participants in Caibiran, Biliran Province, Philippines.* ***Gravoso et al.*** *Meaning of participation and stories of change from reforestation projects by upland farmers: A case in Biliran Province, Philippines.* Meetings and Workshops with DENR, as reported in: ***BN1-2015*** *– Meeting with top DENR Officials.* ***BN1-2016*** *Meeting-workshop with DENR.*

		Conduct mid-term and end-of-project workshops to be run in conjunction with mid-term and end-of-project reviews, respectively.		The mid-term workshop was undertaken in November 2013. It was only possible to hold a desktop review over two days in Manila due to the Typhoon Haiyan (Yolanda) that hit the Philippines two days before the workshop and damaged major parts of Leyte Island. Nonetheless, the VSU conducted the Research, Development and Extension In-house Review on July 14-16, 2014. During the event, various biophysical and socio-economic research activities of the project and key findings were presented to the faculty and staff of VSU and participants from various government agencies. A symposium to present the various research activities of the project was held in March 2015. Professor Herbohn and other research partners from Australia, and all of the researchers of the ACIAR Watershed Project attended the symposium. Some of the research presented during the symposium includes the following: 1. *Enhancing participation of Biliran Local Governments in the National Greening Program Implementation*. 2. *Analysis of the effect of the Pilot reforestation program on the socio-economic status of participating households*. *3. Identification and pilot implementation of livelihood systems in support of watershed rehabilitation.* *4. Design, implementation and evaluation of pilot reforestation project in Biliran.* *5. Elevating the Q-seedling and nursery accreditation system into a national policy under DAO 2010-11.* *6. Field trial in selected sites in Region 8 and 10.* *7. Investigation of pests and diseases and their management in tree nurseries and plantations in Region 8.* *8. Effects of Arbuscular Myccorhiza Fungi and inorganic fertilizer application on nursery seedlings* A project review was undertaken on March 15, 2017.

8. Key Results and Discussion

8.1. Identifying drivers of reforestation success

8.1.1. Determining drivers and indicators of success and failures of reforestation programs in the Philippines

Revegetation methods, funding source, education and awareness campaigns, the dependence of local people on forests, reforestation incentives, project objectives, forest protection mechanisms and the condition of road infrastructure were highly connected drivers that influenced multiple success indicators either directly or indirectly.

Reforestation success

Establishment success. As reported by key informants, the mean short-term tree survival rate of reforestation projects was quite high (77%) and most projects meet the 80% survival rate requirement. This is consistent with previous research carried out by the Centre for International Forestry Research (CIFOR) in the Philippines, which reported a short-term tree survival rate for Forest Sector Loan I projects (contract reforestation projects) of 64%–68% and for Forest Sector Loan II projects (community-based forest management agreement projects) of 71–93% (Chokkalingam 2006).

Forest growth performance. Compared to the actual area planted, most reforestation projects achieved an intact forested area of >70% of the actual planted area, the mean intact forested area being 88% of the actual area planted. Mixed introduced species (MIS) plantations had the best growth performance, with a significantly higher mean annual increment compared to mixed native species plantations. MIS plantations also had a higher, but not significantly different, MAI for total volume compared to monoculture plantations.

Environmental success. Overall, MIS plantations produced the most biomass. Mixed native species plantations were the most diverse, and significantly more likely to report a decrease in soil erosion compared to monoculture plantations. Mixed-species plantations were also significantly more likely to report a decrease in landslide frequency compared to monoculture plantations, which is consistent with those reported from Indonesia (Nawir et al. 2007).

Key drivers affecting reforestation project success

Survival rate of trees. Grazing management applied, weed control applied, and road conditions were statistically significant in distinguishing between projects that did or did not achieve a short-term tree survival rate of 80%. The odds of a project achieving a short-term tree survival rate of 80% were improved by about 20 times if grazing management was applied, by about 18 times if weed control was applied, and 12.5 times if road conditions did not cause transport problems.

Actual planted area compared to target area. The main funding source, integrated project economic objective, road conditions to the project site, soil depth, and the short-term tree survival rate were statistically significant in predicting the actual planted area compared to the target area. Interestingly, we found that good road conditions improved both the short-term survival rate of trees, as well as the ability of reforestation projects to meet their planting area targets.

Area remaining intact compared to actual planted area. Three variables (distance from project site to the nearest town, profit sharing arrangements, and actual planted area compared to target area) were statistically significant in predicting the forest area remaining intact compared to the actual planted area. The beta weights suggest that the distance from the project site to the nearest town explained most of the variance, followed by profit sharing arrangements and the actual planted area compared to the target area.

Mean annual increments for total volume and aboveground biomass. The revegetation method (MIS vs monoculture species, mixed native species), elevation, climate type, tree density with DBH 10 cm, stand age and slope were statistically significant in predicting MAIs for both total volume and aboveground biomass. The beta weights suggest that revegetation method explained most of the variance, followed by elevation, climate type, tree density with DBH 10 cm, stand age and slope.

Tree species diversity. Four variables were statistically significant in predicting tree species diversity measured by the Simpson's diversity index. The beta weights suggest that rock type explained most of the variance, followed by tree DBH size diversity, revegetation method, and seedlings sourced from a government nursery.

Soil erosion and landslide frequency. The revegetation method, fire breaks, education and awareness campaigns, and actual planted area compared to target area were statistically significant in distinguishing between projects that did or did not reduce soil erosion. Four variables (actual planted area compared to target area, protection mechanism implemented, education and awareness campaigns, and revegetation method) were statistically significant in distinguishing between projects that did or did not reduce landslide frequency. We found that mixed-species plantations (either MIS or mixed native species) had a significant effect on reducing reported soil erosion and landslide frequency in our study area. Reforestation education, information or awareness raising campaigns also had a significant effect on reported soil erosion and landslide frequency in our study area.

Jobs. Four variables were statistically significant in predicting the number of jobs provided by a reforestation project. The beta weights suggest that fencing explained most of the variance; followed by the number of participants when the project was issued, direct payments for planting and project location.

Market access. Two variables were statistically significant in distinguishing between projects that did or did not increase market access. The odds of a project improving market access increased by 8 times if timber was harvested from the project site, and by 2 times if the project municipality class improved by one class (for example from class 5 to class 4). Projects located within higher income municipalities were more likely to report an increase in market access as a result of reforestation projects.

Cash income. We found that the dependence of local people on forests for subsistence, education and awareness campaigns, province, number of jobs provided by the reforestation project, and increase in market access resulting from the reforestation project, all had significant relationships with reported increases in cash income for local communities.

Food security. The odds of a project improving food security increased by 61 times if a project increased cash income, by 14 times if a project included an agroforestry economic objective, and by 8 times if a project site had a southeast or southwest aspect.

Correlation tests among the reforestation success drivers revealed 21 drivers had significant relationships with other drivers, with 10 of these having relationships with more than one other driver. Province had significant relationships with four other drivers. Rock type and main funding source were significantly related to three other drivers, while elevation, revegetation method, weed control, grazing management, direct payments for planting and road conditions were significantly related to two other drivers. There were 9 drivers that were only related to indicators and no other drivers.

The overall pattern of significant relationships among reforestation project success drivers and indicators in our study area reveals a highly interconnected system. Revegetation method (mixed-species vs monocultures), funding source, education and awareness campaigns, the dependence of local people on forests, reforestation incentives (such as payments for planting and profit sharing arrangements), project objectives (such as integrated production systems, agroforestry and timber production), forest protection mechanisms (such as fire, weed and grazing control) and the condition of road infrastructure are among the most highly connected drivers, influencing many success indicators either directly or indirectly. The success indicators themselves are also connected, with significant relationships between establishment and environmental success indicators, between growth performance indicators and between socio-economic success indicators.

A wide range of biophysical, socio-economic, institutional and management factors influence reforestation success and these factors form a complex system of relationships. Therefore, focusing on performance indicators alone will not improve our understanding of why reforestation projects succeed or fail. We must look at reforestation as a system and understand how success drivers and indicators interact so that policies can be formulated that have broad systemic benefit and avoid unintended negative consequences. A number of indicators were affected by both biophysical and socio-economic drivers, indicating that social and economic components of reforestation must be considered simultaneously.

The article by Le et al. (2012) published in Global Environmental Change (see Section 11.1 and 11.2 of this report) provides more information about the findings of this research.

8.1.2. Findings of the assessment of tree establishment success of the NGP

The NGP has generated a high level of commitment by DENR officers in engaging local people to plant trees on land managed under CBFMAs. The NGP is closely aligned with PO members' farming systems in R10 and has resulted in the reforestation of unused land in R8. However, the program suffers from problems which are best classified as being either general, i.e. applying to most NGP plantings, or specific to a particular area and situation. PO respondents indicated that a general problem with the NGP is a lack of follow-up finance to maintain and protect newly planted seedlings. A further problem is the influence of adverse claimants and other land users burning newly planted seedlings, grazed livestock or cleared seedlings for *kaingin* agriculture. Resolution of competing land uses – in a manner which will enable NGP plantings to survive – has not been achieved.

It is apparent that PO members generally lack the skills and training to manage tree plantations, as evidenced by a high incidence of inappropriate silviculture, and DENR staff lack resources (e.g. vehicles) to provide assistance and training and to monitor PO work programs. The growth of several native species has been very poor. Without knowing the silvicultural requirements of the species, firm conclusions on the suitability of particular species cannot be drawn. An allied problem is that planting seedlings underneath a dense canopy of residual native forest has resulted in seedlings becoming suppressed. Problems specific to particular areas include gall rust in high-elevation plantings of falcata (*Paraserianthes falcataria*) in Misamis Oriental (Appendix 12.3a). Planting trees on very poor soils in Bukidnon has resulted in high seedling mortality, reduced growth in the survivors and little chance that trees will grow into a merchantable crop.

The assessment of the effectiveness of the seedling production system found that seedlings produced in the nurseries for the NGP are generally of low quality. It is evident that POs lack the technical skills to produce high quality seedlings. Further, scheduling of seedling production for the NGP is almost always within a very limited timeframe due to the delayed release of funds which has negatively affected seedling quality.

Overall, the ACIAR inventory indicated that the success of the NGP is likely to be diminished by poor seedling survival and growth. A combination of four factors – time, targets, resources and complex socio-economic issues − have made the task of DENR staff very difficult. The short timeframe for program implementation and high planting targets have required mobilisation of almost all available POs. Many of these POs appeared to have acted in good faith but high planting targets combined with low levels of finance per hectare have resulted in essential early-age seedling maintenance being neglected. The low (or nil) stocking of surviving trees in some plots indicates that seedlings were either not planted, or they were planted but follow-up maintenance has been neglected. Rather than carry out expensive brushing, fertilising, firebreak construction and patrolling, it is cheaper for a PO to abandon a plantation before final payments and consequent audits are made.

The sheer scale of the NGP has made it very difficult for DENR staff to adequately monitor tree establishment and management. Terrain is often difficult and an inventory may take several days. Managing the complexity of competing land uses and adverse claimants appears to be one of the most difficult aspects of the program. It is difficult to make recommendations for solving this problem, but extensive consultation with community members and reassurance that the government does not wish to resume land may prove helpful. Integrating small-scale nurseries into communities and developing this into a livelihood project may also assist.

Further information about the results of this research are presented in the technical report by Baynes et al. (2013) listed in Section 11.2 and cited in Section 7 of this report.

8.1.3. Results of seedling quality assessment and evaluation of the effectiveness of the forest nursery accreditation policy

The seedling production system for NGP implementation in the Philippines' Regions 8 and 10 illustrates that the production of planting materials is divided between the government and non-government sectors, with the latter having the greater share of production. Seedling production within the non-government sector is categorised into direct contracting with POs and open bidding from accredited nurseries (including private seedling producers, POs and NGOs). In areas with a prior tenurial agreement with communities, the PO beneficiaries were given direct contracts by DENR to produce seedlings. Seedling production by POs provides income to the organisations, and is an important livelihood activity associated with reforestation. Importantly, it also avoids damage to seedlings during transport when seedlings are purchased outside the community where the reforestation project is located. In areas without existing tenure arrangements[5], selection of nurseries to supply seedlings is conducted through a bidding process following the Philippine Government Electronic Procurement System (PhilGEPS). The government tends to take the lowest bidder and the lack of seedling quality checks makes the bidding scheme prone to favouring the proliferation of low quality seedlings that are usually sold at lower prices.

About 80% of accredited seedling suppliers for the NGP in Regions 8 and 10 are NGOs and private seedling producers. A relatively small quantity of seedlings from POs (approximately 20% of the overall seedling requirement) is planted at sites without existing tenure instruments because few POs have been able to obtain nursery accreditation. A DENR

[5] Reforestation projects are mainly implemented on public land and participating communities obtain a tenurial contract with DENR to possess the land, develop, and utilize the resources therein for 25 years and the contracts are usually renewable for another 25 years. Untenured areas are public land subjected to reforestation by POs or NGOs but without an existing tenurial agreement. In this case, the role of POs and NGOs is limited to rehabilitation of the area, which usually spans for three years.

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officer in Region 8 indicated that the technical requirements set out in DAO 2010-11 and the lack of familiarity with the online bidding system have discouraged POs from applying for nursery accreditation. In addition, many POs lack the financial resources to establish nurseries that meet the required standards.

Another mechanism of seedling production is the POs with contracts to produce seedlings for their respective NGP areas also purchase seedlings from other nurseries (particularly from other POs and private nurseries mostly unaccredited by DENR) instead of establishing their own nurseries. In such cases, seedlings are often sold at lower prices but with seedlings purchased from unaccredited sources, the objective of using high quality seedlings in the program can be undermined. Accredited seedling producers having seedling production contracts with the DENR also engage in the purchasing of seedlings from unaccredited nurseries. Approximately 80% of accredited private nurseries included in the study have purchased seedlings from unaccredited seedling suppliers. An extreme case is that some accredited nursery operators cease operating their nurseries and purchase seedlings from unaccredited seedling producers.

Another seedling production pathway is the DENR purchasing seedlings from accredited nurseries and delivering these to POs for planting in tenured and untenured sites. The POs that are recipients of the seedlings indicated that this approach is undesirable. In particular, there was seldom any attempt to take into account the characteristics of the site at which the seedlings were to be planted, resulting in a mismatch between species provided and their suitability to the site. In addition, the communities were seldom consulted as to what species they would prefer to grow. Also, seedlings were frequently damaged during transportation to planting sites. Purchasing seedlings from private seedling producers removes the opportunity for the PO to derive income from seedling production.

Of the 23 nurseries investigated, only three were found to have produced seedlings which met the quality criteria used in assessing the seedlings during the survey. Most of the sampled seedlings (88%) appeared healthy with relatively straight stems. However, many of them (36%) either had root systems that were deformed (J-rooting and coiling) or grew outside the base of the container. Further, the majority of the seedlings were not sturdy (82%) and had an unbalanced shoot-to-root ratio (79%).

The DENR has been producing high quality seedlings in their clonal nurseries and has collaborated with academic institutions in the Philippines with forestry expertise to establish clonal propagation nurseries for native tree species (DENR 2014). In 2015, almost 2 million seedlings were produced from DENR clonal nurseries, of which about 26% were clones, 49% were from seeds and 33% from wildlings. About 800,000 seedlings were produced from clonal nurseries in State Colleges and Universities (SCUs), although only 41% of these were clones (DENR 2015). It appears that the high quality seedling production quantity of the ERDB only comprises a small proportion of the overall seedling requirement for the NGP. For example, the nationwide demand for NGP plantings in 2015 was 300 million seedlings. In that year, the seedling production from DENR clonal nurseries and SCUs was only about three million seedlings. With such a limitation on high quality seedling production by DENR and SCUs, it is apparent that regulating the quality of seedlings from other seedling producers (POs, private nurseries and NGOs) is imperative to improve the overall quality of seedlings for reforestation programs in the country.

The article by Gregorio et al. (2016) published in Small-scale Forestry (see Section 11.2 of this report) provides further information on the findings of this research.

8.1.4. Effectiveness of participation of the Local Government Units in the NGP

Results of the study revealed that DENR-PENRO Biliran has been engaged in several partnership programs and projects with LGUs, other than the NGP. One major project is seedling production under the Barangay Forest Program (BFP). LGUs have also been engaged in mangrove reforestation and fuelwood plantation establishment under the Bottom-Up Budgeting (BUB) Program of the DILG and DENR. Other major programs include Forest Land Use Planning (FLUP) and the short-lived Upland Development Program (UDP). With these partnership programs and projects, it can be intuitively assumed that the DENR has already established deep working relationships with the Local Governments. However, some anecdotal evidence indicates that, at least in Biliran, LGUs particularly at the provincial and municipal levels did not have a clear and substantial level of participation in the implementation of the NGP.

Responses from the Provincial Governors' office indicate less awareness and understanding of the NGP and in particular, the office's participation in its implementation. Seventy-eight (78) percent of the municipal LGU officials interviewed are aware of the program but have less understanding of their respective roles and responsibilities in its implementation. Barangay LGUs have better awareness and understanding (89%) of the program than the provincial and municipal LGUs. The reason behind this is that most of the projects of the DENR-PENRO have been engaged directly with partner barangays or with POs in barangays.

DENR-PENRO expressed that changes to LGU leadership has been a major hindrance in the active involvement of LGUs, and has caused a lack of continuity of most of the partnership projects leading to the failure to build long-lasting and sustained working relationships with the LGUs. Aggravating the situation is the lack of LGU leadership's interest and commitment to the government's environment-related programs, and the usual one-way perception of LGU officials of just being support recipients rather than also counter-parting or providing support in a partnership program or project.

LGUs perceived that their lack of technical know-how has hindered them from actively participating in the government's reforestation programs. Their lack of interest to actively participate, particularly at the provincial and municipal levels, was brought about by their limited acquaintance with DENR-PENRO officials and associated ability to jointly discuss problems and needs and come-up with suitable plans, programs and strategies for their implementation.

In view of the problems and issues raised by the respondents regarding LGU participation, several suggestions were shared by the DENR-PENRO, LGUs and POs as follows:

1. One particular recommendation is for the DENR to coordinate with the DILG for the mandatory creation of Municipal Environment and Provincial Environment offices at the LGUs. This way, DENR will be able to establish active and sustained links with LGUs regarding environmental programs and projects.
2. Establish intensified capacity-building programs for LGUs, which will improve not only their capacity but their interest and participation in the NGP and related programs. DENR can tap into the support of academic institutions in this particular endeavor.
3. Creating and sustaining continuously flowing joint NGP activities with the LGUs will promote better and closer relationships which will eventually lead to improved working partnerships and trust.
4. A paradigm shift is needed in the way DENR rolls out its extension activities. It is suggested that extension works must begin with the DENR's office heads and that the

task should not simply be handed down to the usually neophyte and inexperienced extension workers. Involvement of the experienced and respected office heads can lead to the establishment of greater trust and confidence among the partner LGUs and local communities.

5. Establish and sustain big-brother, small-brother working relationship with LGUs. LGUs should be able to feel and recognize DENR's helping hand and as an inspiring partner to work with.
6. Building LGU champions and a composite LGU-DENR NGP team will boost LGUs morale and participation in the NGP. This seems to be an effective platform for creating real and sustainable working partnerships between the DENR and LGU partners.

The paper by Mangaoang et al. (in prep.) cited in Section 7 of this report gives further details of the salient findings of this study.

8.1.5. The meaning of smallholders' participation in community-based reforestation projects

Respondents reported that they have learned about the reforestation projects from the meetings organized by the staff of the DENR and the non-government organizations (NGOs). The activities they have participated in included nursery operations, plantation establishment, planting and maintenance. The women said that they preferred to work in the nursery than in the field. Respondents indicated that their participation in reforestation projects is part of their responsibilities as PO members. Another reason for participation was that by joining the PO and participating in the reforestation activities, they had the chance to obtain land to cultivate. But the most important reason for their participation was the payment for their labour rendered to the project - "*When we worked in the reforestation project, we were paid for our labour*", related a farmer leader. Respondents said that without the pay it would be difficult for them to devote their time to taking care of the tree plantation and they emphasized the importance of receiving wages in a timely manner.

Respondents revealed a number of problems they encountered in their reforestation projects. These include grazing of farm animals in the tree plantation, vandalism of newly planted seedlings, and the occurrence of forest fires. Stealing of agroforestry products was also mentioned.

Across FGD groups and interview respondents, participation in reforestation means "*suhol*" or payment for their labour in the project. They said that in initial activities, they can provide voluntary labour to implement reforestation projects but in subsequent activities, they expected the pay. As one respondent put it, "*We cannot work in the reforestation project while our family has nothing to eat*".

Participants were also asked for their suggestions on how participation in reforestation projects can be improved. The most dominant suggestion was to provide their pay every week so they could provide for the needs of their respective families. They said that when they work in the reforestation project, they are depriving themselves of their opportunity to earn income - "*Thus, we rely on the payment for our labour*".

Respondents reported a number of changes that they have observed from their reforestation projects. Among these is that the reforestation project they have participated in provided them with an additional source of income and food, improved their capacity through training activities, provided lumber for house repairs, access to public land, and environmental benefits including an improved microclimate, reduced landslides and improved wildlife habitat.

To assess the levels of outcomes of the reforestation projects, the changes reported by the respondents were classified according to Bennett's Hierarchy of Program Outcomes. Results show that the outcomes reached Levels 7 and 5, which indicate high levels of outcomes. Improved knowledge and skills in reforestation fell into Level 5. The Level 7 outcomes included providing a source of income, providing a source of lumber for house repair, obtaining an area for cultivation, obtaining security of the land being cultivated, improving the landscape of the forest, improving biodiversity, improvements in microclimate, lessening of the impacts of erosion and landslides, and improved soil fertility.

The report by Gravoso et al. (in prep.) (see Section 7 of this report) provides more information regarding the results of this investigation.

8.1.6. The socio-economic effects of the National Greening Program on smallholders in Biliran Province

Analysis of data shows that except for residential lot occupancy there was no significant difference between CFPBA-member households and non-member households' overall SES scores in 2014. The results also indicate that except for water source and durable goods owned, there was no significant difference between the two groups' overall SES scores in 2016. The Wilcoxon Signed Rank Test shows that aside from specific indicators of house floor type, durable goods owned and food, CFPBA member households' overall SES score improved significantly from 2014 to 2016. On the other hand, no significant difference occurred between non-CFPBA member households' 2014 and 2016 SES scores. The following quotes were statements of CFPBA members regarding their perceptions whether they fared better than their non-CFPBA member neighbours:

Respondent A: '*To me, there's no difference between the socio-economic condition of CFPBA members and non-members. We're just the same, while we were paid for our participation in the NGP, it's not also daily.'*

Respondent B: '*Presently, it's the same. The NGP was not properly implemented. As if nothing happened*.'

Respondent C: '*I think, the same. Those who don't work for NGP get to work in other farms where they were paid P400 per day. With NGP, people were paid only P150 per day. In other farms, the man works with the carabao and each gets P200 a day. With the NGP, the man works with his bolo, but only the man is paid, not the bolo. Maybe, even if NGP pays less, PO members can be encouraged to support it if it had a livelihood component. Work with the NGP was not every day, so we could have undertaken livelihoods that could be done by us or the members of our households during days when we don't have NGP-related work.'*

Respondent D: '*We ended up losers in our participation in the NGP. We were given targets to accomplish at certain schedule. After accomplishing each project activity, we were supposed to be paid by DENR. But at times payments were delayed and we were forced to borrow money at an interest of 10%. Who would be willing to work without pay? Workers have families to feed. Delays in payments discouraged many members. We don't even call meetings anymore because members don't come. When money come, we (*the chapter presidents*) just go to the members individually and allocate targets depending on the capacity of the household to handle. Inspection of accomplishments was usually delayed and plantations were overtaken by unfortunate events like fire. Burned plantation means additional burden to us because we have to replant it. While we get some assistance from DENR for replanting, it does not cover the total cost. Also, assistance is only for first burning but* *sometimes, plantations get burned twice or thrice. The extension officers, maybe because they covered many areas, seldom visit us.'*

Respondent E: '*It's the same. But maybe we can see a difference when the trees we planted will be harvestable because only members can benefit from it. Maybe that time our socio-economic status will be better than the non-members.'*

The above testimonies indicate that while there is significant SES improvement for the two years of participation in the NGP, PO members did not realize this change but instead focused on the constraints they experienced in the project's implementation. When asked about their perception of the outcomes of their established plantations, PO members expressed less expectations of success because of multiple factors including the use of low quality seedlings due to the limited production period; planting of native trees directly in open grassland causing high seedling mortality; wide spacing of trees as directed by DENR which allows the growth of *Imperata* thereby suppressing seedlings and increasing biomass that fuels forest fires; and the very low funds for plantation maintenance.

Results of this study are further discussed in Goltiano et al. (in prep.) cited in Section 7 of this report and listed in Section 11.2.

8.1.7. Financial Outcomes of the Rainforestation Farming Pilot Systems in Leyte

Fourteen (or 54%) of the 25 RF plantations yielded a positive LEV (Table 3). The LEVs varied from USD -175 to USD 2837, with a mean of USD 214. The length of time required to recover the costs of the investment varied between one and 18 years. The three plantation sites with a payback period of four years or less had early income from crops. The two sites that had high LEVs also had most of their farmland occupied by the RF system.

Table 3. Details on the 25 Rainforestation Farming cases under study

Case	Percentage of RF area in relation to total farmland	Adjacent land use	Harvested	LEV (USD)	Payback period
A	9%	grassland with coconuts	Crops	-175.65	-
B	95%	grassland with coconuts	Crops	-149.72	-
C	44%	flat grassland	Crops	-141.61	-
D	12%	forest	Nothing	-111.54	-
E	1%	grassland with coconuts	Nothing	-108.59	-
F	22%	abandoned land	Nothing	-42.03	-
G	9%	grassland with coconuts	Crops	-31.54	-
H	20%	grassland and agricultural crops	Fruits	-26.52	-
I	36%	sparse coconuts for copra	Timber	-19.20	16
J	11%	grassland	Nothing	-16.20	-
K	51%	steep grassland	Nothing	-4.99	-
L	56%	grassland	Timber	1.28	17
M	85%	abandoned land	Fruits and timber	8.86	11
N	33%	sparse coconuts for copra	Crops	24.93	1
O	75%	agricultural crops and forest	Crops and fruits	34.63	-
P	47%	grassland	Timber	49.84	17
Q	41%	grassland	Fruits and timber	63.58	8
R	34%	grassland with coconuts	Fruits and timber	132.24	18
S	10%	steep grassland	Timber	137.12	12
T	48%	grassland and rice	Timber	143.90	17
U	88%	sparse coconuts for copra	Fruits and timber	216.75	18

V	87%	grassland	Crops and fruits	312.88	2
W	6%	rice	Crops, fruits and timber	387.29	4
X	78%	grassland with coconuts, bananas and grazing animals	Fruits and timber	1831.65	10
Y	91%	grassland with coconuts, bananas and grazing animals	Crops and fruits	2837.60	8

Note. LEV in 2013's value.

The sensitivity analysis revealed that by increasing the discount rate from 12% to 16%, a 38.8% decline in the mean LEV is observed. Nonetheless, 48% of the LEVs remain positive. To achieve at least 50% positive LEVs, the discount rate must be no higher than 13.4%. The use of the opportunity cost of land based on the adjacent land use caused a higher impact to the financial outcomes than the discount rate tested, resulting in 44% of positive cases, and a mean LEV of USD 106. Lastly, the LEVs were recalculated to include a seedling purchase expense. The inclusion of seedling purchase had the highest impact on the financial outcomes, with only 16% of the RF cases achieving positive NPVs.

The cluster analysis indicated a statistically significant difference between the two clusters in terms of the distribution of values for Wealth, Tenure and Education. Cluster 1 had higher values for all variables. Both Wealth and Tenure had a strong and significant effect on cluster membership. Education had a strong but non-significant effect on cluster membership. However, the p-value found was 0.051, which is extremely close to the threshold used of 0.050.

The LEVs of cases X and Y are comparable to financial outcomes of other agroforestry systems in the Philippines. The LEV (r=15%) of high and low timber yield scenarios of agroforestry systems with *Gmelina arborea* ranged from USD 1,448 to 2,279 ha^{-1} (Bertomeu 2006). The range of LEVs (r=15%) calculated for several maize and tree intercropping systems under three scenarios was between USD 1,231 and 1,364 ha^{-1} (Bertomeu et al. 2011). As proven by these two cases, RF has the potential to achieve a financial performance comparable to other agroforestry systems, but in over two fifths of the cases the financial outcomes were negative.

The inclusion of tree species has been promoted for several decades but the inclusion of crops in reforestation systems is a more recent topic. Around 70% of the RF implementers with positive results harvested more than one of the three components investigated (fruits, agricultural crops and timber). All the negative financial results came from sites from which only one component or none was harvested. This indicates that the diversification of products favours the achievement of positive financial outcomes in smallholder reforestation projects.

Lessons from the financial analysis of the RF pilot sites can have a broader application, including for the ongoing NGP. When pursuing positive financial returns in smallholder reforestation, there is the need to promote the cultivation, management and harvesting of several reforestation products; diversify the returns from the reforestation plantations; diminish upfront costs and provide access to financing systems that match the long-term nature of smallholder forestry investments; and introduce extra assistance for resource-deficient smallholders to achieve similar levels of financial return as resources-rich smallholders.

The draft article for publication by Ota et al (see Section 11.2 of this report) provides more information of the salient findings of this study.

8.1.8. Findings on the assessment of NGP implementation in Biliran Province

Only three officials represented the KFAI in 2014, which is down from the 189 members when it was formed in 2002. These officials were managing the NGP project in the community together with their families and a few other members whom they hired as labourers. The exhaustion of project funds and failure of livelihood projects prompted the disbandment of the PO. Also, the concentration of power and short-term benefits to the few PO members precluded the voluntary shared effort of the community to manage the plantation.

It was found that PO members have understood the multiple ecological and socio-economic benefits of reforestation projects. A Chi-square test revealed that education is not related to PO members' understanding of the benefits of reforestation. However, the PO members' awareness of the multiple benefits of reforestation does not correspond to their knowledge about the NGP program.

Payment for labor was identified as the primary reason for PO member participation. While most PO members understand their ownership of the planted trees, there was less expectation of harvesting the trees (i.e. only 5% indicated source of timber for household use and 2.5% cited income from trees when harvested). Most members expressed that trees planted in the NGP will eventually be decimated by fire and grazing, similar to past reforestation initiatives at the site. Also, PO members expressed that they will not be able to harvest the trees because of the difficulty in obtaining a harvesting permit.

The summary of the issues and constraints experienced by stakeholders in implementing the NGP is presented in Appendix 12.4. It appears that most of the problems and issues are a recurrence of problems that led to unsuccessful outcomes in early reforestation programs in the Philippines (Israel and Lintag 2013; Israel and Arbo 2015). Although literature about the challenges of early forest rehabilitation and management programs in the Philippines and how to overcome these challenges are available, it is apparent that the design and implementation of the recent NGP at the study site has not learnt much from these lessons.

The quality of seedlings produced by the PO was low. Over half of the sampled seedlings were healthy and with acceptable stem form and root form. However, just over 20% of the sampled seedlings were sturdy and less than 20% had an acceptable shoot-to-root ratio. Inventory of the PO's three-year-old plantation revealed a seedling survival rate of only 24%. Fire, low quality seedlings and a lack of post-planting maintenance contributed to this result. Approximately, 37% of the surviving seedlings were unhealthy, showing signs of pest infestations and symptoms of nutrient deficiency.

The paper by Gregorio et al. (2015a) published by IUCN listed in Section 11.2 of this report provides more details of the results of this study.

8.1.9. Determining drivers of tree growth, mortality and harvest preferences in species-rich smallholder plantations

We found 32 common species amongst the RF plantations including 4 shade-tolerant exotic species, 9 shade-intolerant exotic species, 8 shade-tolerant native species and 11 shade-intolerant native species. A higher survival rate was found for the shade-tolerant species (e.g. *Parashorea plicata* and *Shorea palosapis*); whereas the shade-intolerant species were more likely to be harvested. The mortality rate was likely low in shade-tolerant species (less than 5% over the 6 year period). Species with a larger mean DBH tended to have a faster-growth rate, a low survival rate and a higher probability of being harvested than species with a smaller mean DBH.

Tree and species characteristics (i.e. DBH, origin and shade tolerance), and stand, plot and site characteristics (i.e. location, slope, soil type) had a high relative importance in predicting the variance in tree growth over the two time periods with the exception being tree density. This suggests that tree growth in the stands was not influenced by tree density from the time period before. The final growth model showed that growth of individual trees in the community was predicted by tree DBH in the first time period, species origin (whether native or exotic) or the interaction between origin and shade tolerance. For example, tree DBH was positively correlated to growth rate; whereas native species was negatively correlated. This result suggests larger trees were still growing well in the subsequent period; yet individuals of native species grew more slowly than exotic species. Shade-tolerant and intolerant species did not show significant differences in growth rates although shade-tolerant species tended to grow more slowly than shade-intolerant species. However, individuals of shade-tolerant native species tended to grow faster than the other individual trees. A significant negative relationship between tree growth and stand basal area suggests that trees in stands with a higher basal area grew slower than those in stands with a lower basal area in the later period. Our results also showed that tree growth depended on site-level factors such as slope and soil type; suggesting that trees in these stands might grow faster on low slopes and on volcanic soils. Other factors including species shade-tolerance, species diversity and plot location, although important in the model, were not found to be significant for tree growth in these stands.

Variables associated with stand structure or geographical characteristics were not important to the status of a tree (i.e. being dead or harvested), suggesting that species diversity, tree density, or stand productivity did not drive the status of trees in these plantings. The important variables including tree diameter and shade tolerance of species were significant predictors of the status of a tree. Larger trees in the stands were predicted to have a higher probability of being harvested in the subsequent period whereas smaller trees had a higher probability of mortality. A higher probability of harvesting or mortality was found for shade-intolerant trees in the later period. Conversely, shade-tolerant trees were predicted to have a low mortality and only a small likelihood of harvesting in the next period.

Our study found that small individuals of shade-intolerant species in the plantings were likely to have a higher risk of mortality because these trees were shaded by larger trees. This consequence driven by competitive thinning is often observed in young stands as the trees within these stands begin to show different rates of growth and resources (e.g. light become limiting with canopy closure) (Coomes and Allen, 2007; Lorimer et al. 2001). For plants that are competing for light, shorter trees produce many of their leaves in the shade of taller neighbours, resulting in slow growth and in some cases this can result in death depending on the silviculture of the respective species (Adler, 1996; Givnish, 1988). Such asymmetric competition for light provides the simplest explanation for greater mortality among small trees in stands (Adler, 1996).

Finally, the RF plantings appear to have developed some typical characteristics of natural forests in dynamics of growth and mortality; shade-intolerant species and small trees had a higher mortality rate in the RF plantings. For instance, in a natural forest in Borneo, higher low-light mortality and lower growth rates are common for juvenile trees with lower shade tolerance. These results support the view that shade tolerance involves a trade-off between high-light growth and low-light survivorship (Kobe et al. 1995; Walters and Reich, 1996). Baraloto et al. (2005) also found that a negative trend existed between growth rate and survival. Pioneer species are thought to either grow well or die (Lieberman and Lieberman, 1987). Higher low-light growth is related to shade tolerance in tree species as higher growth is often linked to higher survival (Walters and Reich, 1996; Denslow, 1990). However, this advantage does not hold except in very low-light levels where growth of less shade-tolerant species may be lower than growth of more shade-tolerant species. We found a similar result in our study as the lower mortality probability was found in shade-tolerant and low wood-density species that grew faster than other species groups in the community.

Overall we found that tree growth, mortality and farmers' timber harvesting preferences in species-rich plantations is influenced by both abiotic and biotic factors including anthropogenic influences. Dynamics of tree growth and mortality in these plantings are approaching what might be expected in a natural forest system being driven by the combination of interspecific and intraspecific competition in these now complex species-rich forest communities. For plantations greater than 10 years old, stand basal area affected individual tree growth negatively but did not appear to be resulting in mortality due to self-thinning from competition when the canopy was closed in these plantings. The higher mortality of shade-intolerant species appears to be the result of light competition, while more harvesting of shade-intolerant species was due to timber demands by farmers. In the early years, shade-intolerant species were preferred for harvesting most likely for local community needs, e.g. house building, fuel wood. Our study confirms that generalizable species traits like shade tolerance are an important factor in selecting species for planting, and that selective harvesting or thinning of small and shade-intolerant trees could be practiced for highly productive stands at age 10+ years. This practice may be beneficial in reducing both inter- and intra-specific competition, thus enhancing growth of residual individuals in mixed-species stands. These results could be applied in designing a diverse planting. The planting's growth and dynamics could then be predicted based on selected species traits and site characteristics.

The results of this study are further discussed in Nguyen et al. (see Section 7 of this report) and Nguyen et al. (2014a) published in PLOS ONE (see section 11.2).

8.1.10. Pests and diseases and management practices in smallholder nurseries

Observations from the pest and disease survey revealed low to high incidence (5-95%) of pests on narra (*Pterocarpus indicus*), mahogany (*Swietenia macrophylla*), yakal (*Shorea astylosa*), falcata (*Paraserianthes falcataria*), toog (*Petersianthus quadrialatus*), gmelina (*Gmelina arborea*), white lauan (*Shorea contorta*), bahai (*Ormosia calavensis),* dao (*Dracontomelon dao*), and ipil-ipil (*Leucaena leucocephala*). Pests observed were mostly leaf-eating arthropods including grasshoppers, mirid bugs, hoppers, thrips, scales, whiteflies, psyllid, caterpillars, mealy bugs, and gall-forming mites. Fungal and bacterial leaf spot pathogens were also present particularly on narra, acacia, da-o, and mahogany. Degree of severity or damage to the plant varied with the pest type. For example, hopper damage on narra and mite damage to yakal had 100% and 80% severity, respectively.

Observations of the nursery conditions showed factors which may have contributed to pest and disease incidence, namely: improper sanitation practices, overcrowding of seedlings on beds, weeds near the nursery harboring insects and other pests, and inappropriate shading of seedlings. Environmental factors such as dry conditions, poor ventilation, high humidity, excessive fertilization, prolonged sun exposure and shading were some underlying factors that might have contributed to the occurrence of pests and diseases.

Generally, nursery managers were familiar with the symptoms but had minimal knowledge of pest and diseases identification. Local knowledge on pest management was limited to the use of chemicals that sometimes were inappropriate due to incorrect identification of disease-causing agents. Nursery managers applied various management approaches including covering seedlings with nets and chambering seedlings on beds. There was very limited knowledge on the use of fungicides even though fungi was the main pathogen.

Overall, nursery managers exercised observation and control of pests and diseases. However, it was very clear that there is a need to improve their knowledge and skills in the identification of symptoms and casual agents of seedling diseases, and the application of appropriate control measures.

Using the information obtained from the survey, a manual on pests and diseases in tree nurseries was developed. This extension material contains information on tree nursery pests and diseases observed during the sruvey, their causal agents, damage and symptoms, factors enhancing the infestation, and control and management options. It is envisaged that this manual will improve the knowledge and skills of seedling producers in controlling pests and diseases of forestry seedlings in nurseries not only in Biliran but also in other provinces in the Philippines.

The coffee table book (Mangaoang 2016) listed in Section 11.2 of this report was developed using findings from this investigation.

8.1.11. Results of the inventory of mother trees of native species from the natural forests in Leyte and Biliran Islands

The inventory has identified a considerable number of potential mother trees of several native species that will become important germplasm sources for reforestation programs in the Philippines. Interestingly, there is still a considerable number of dipterocarp trees despite the continued illegal logging activities targeting this species. The result showed that Biliran had a higher diversity of dipterocarp species and a higher frequency of dipterocarp trees than Leyte.

The 1000 potential mother trees identified by DENR personnel in Mahagnao Natural Park were composed of 27 species (see Appendix 12.5). Of these, four species were dipterocarps. The largest DBH was 196.3 cm while the smallest was 11.2 cm. The tallest tree was 34.7 m while the shortest was 5.6 m. The top 20 tallest and largest trees were all dipterocarps (i.e. tanguile, white lauan, bagtikan and mayapis).

The overall rating of identified potential plus trees indicated that only 35 trees were categorized as ideal plus trees, 614 trees were regarded as highly acceptable, and 341 trees were regarded as acceptable. Height and DBH categories have the lowest frequency counts in terms of ideal mother trees. Also, tree health is below the ideal level for a considerable number of the trees. It should be recalled that the assessment was carried out after Typhoon Yolanda in 2013 wherein a number of assessed potential plus trees were badly affected. Nonetheless, circularity, branch persistence and other categories showed higher frequencies of trees having the most preferred characteristics.

Based on the 20 cm minimum diameter limit of trees to be included as potential mother trees, only 816 trees were considered in the assessment out of the 1000 trees identified by DENR personnel in the natural forest of Villa Consuelo, Biliran. A total of 58 species were identified (Appendix 12.6). Ten species composed of 539 trees were dipterocarps. The tallest tree was tanguile with a total height of 36.19 m while the shortest was almaciga reaching a total height of only 12.18 m. Tanguile also has the largest DBH at 90 cm while yakal has the smallest DBH of 21 cm. White lauan, tanguile, and red lauan were the tallest trees while the largest were tanguile, white lauan, mayapis, and kalumpit.

Results of the assessment of potential mother trees in Biliran revealed that only six trees possessed the ideal characteristics of a mother tree, 500 trees have highly acceptable grades, 308 trees were acceptable, and only two trees have a moderately acceptable grade. Similar to the findings in Mahagnao, a considerable number of trees in Biliran have unacceptable height and DBH although most of them have straight circular stems with a dominant stem leader.

The inventory proved to be an effective learning exercise for DENR personnel. The fieldwork has improved their skills in assessing the physical characteristics of potential mother trees. The lectures and hands-on activities have provided considerable knowledge and experience for DENR personnel which is crucial for satisfying the interest of DENR to broaden the species base of native trees in reforestation programs and to improve the genetic characteristics of germplasm.

Recognizing the continued pressure on remaining forests in the country, it is imperative to design a mother tree protection program to protect and conserve the identified mother trees. It is also necessary to monitor the phenology of the mother trees for timely collection of seeds. The involvement of local communities in these necessary tasks would be very useful.

8.2. Developing the policy assessment model

8.2.1. Development of a Bayesian Network for assessing reforestation success

The Bayesian Network model for reforestation project success is shown in Appendix 12.7. The probabilities shown in the model are the prior probabilities learnt from the reforestation project data. These represent the initial beliefs about states of reforestation project success drivers and indicators in the study area.

For establishment success indicators, there were small non-additive effects among all driver scenarios except one (an additive effect on short-term survival rate of trees when road conditions did not cause transport problems, grazing management was applied, and weed control was applied), and all of these non-additive effects were synergistic except one (an antagonistic effect on short-term survival rate of trees when road conditions did not cause transport problems and weed control was applied). The largest non-additive effect was the synergistic effect on planted area compared to target area when the main funding source was from the government, short-term survival rate of trees was high (≥80%), and soil was deep (80–100 cm).

For forest growth success indicators, interactions among drivers were mostly antagonistic. The exception was the synergistic effect on MAI Total Volume (TV) when MIS were used for reforestation and the density of trees with DBH ≥10 cm was high (1000–2000 stems ha^{-1}).The largest non-additive effect was the antagonistic effect on MAI TV when the density of trees with DBH ≥10 cm was high (1000–2000 stems ha−1) and the stand age was young to middle-aged (5–15 years).

For environmental success indicators, the interactions among drivers were mostly synergistic. The exceptions were an additive effect on Simpson's diversity index when MIS were used for reforestation and the seedlings were sourced from government nurseries, and two antagonistic effects: one on MAI AGB when MAI TV was high (20–45 m3 ha^{-1} yr^{-1}) and stand wood density was high (≥0.5) and the other on decrease in soil erosion when MIS were used for reforestation and firebreaks were implemented. The largest non-additive effect was the synergistic effect on decrease in landslide frequency when the planted area compared to the target area was high (>50%), education, information or awareness building campaigns were implemented, and MIS were used for reforestation.

For socio-economic success indicators, interactions among drivers were again mostly non-additive with a mix of synergistic and antagonistic interactions. For increase in cash income, all driver interactions were strongly antagonistic. Strong antagonistic interactions also occurred for the number of jobs provided by the reforestation project when the number of initial project participants was high (50–200), the government provided direct payment for planting, and fencing was part of the reforestation project. However, when fencing was part of the reforestation project, a strong synergistic effect on the number of jobs provided by the reforestation project was found when the number of initial project participants was high (50–200) and the government provided direct payment for planting. The largest non-additive effect was the antagonistic effect on increase in cash income when market access was increased by the reforestation project, the dependence of local people on the forest for subsistence was high, and the number of jobs provided by the reforestation project was high (50–200).

The results of the study suggest that non-additive interactions abound within reforestation systems that when not accounted for in reforestation planning, may lead to an over- or under-estimation of reforestation success. Nearly 90% of the interactions that were tested were non-additive, although we cannot be confident that all of these are truly non-additive due to uncertainties in model performance and due to some interactions being only slightly synergistic or antagonistic. An example of where we can be reasonably confident that the interactions modelled are indeed non-additive is the strong synergistic effect on the indicator 'number of jobs provided by project' when the number of initial project participants were high (50–200) and the government provided direct payment for planting trees. Not only was the non-additive effect strong, but the model was reasonably well calibrated for the indicator and while the model predictive performance was mediocre (TSS = 0.44) the times surprised was lower than expected.

A particularly interesting finding was that the MIS revegetation method was found to be involved in nine synergistic interactions with other drivers across four reforestation success indicators, namely MAI TV, Simpson's diversity index, decrease in soil erosion, and decrease in landslide frequency. This indicates that reforestation with mixtures of highly productive species (in our case introduced species) can have multiple benefits for reforestation projects, enhancing not only forest productivity (i.e. MAI TV) but also environmental success (i.e. species diversity, soil erosion and landslide reduction).

The article by Le et al. (2014) published in Global Environmental Change (see Section 11.2 of this report) provides a more detailed presentation of the results of this study.

8.3. Pilot testing initiatives to improve watershed rehabilitation outcomes

8.3.1. Pilot testing the evidence-based smallholder best practice in a community reforestation program

The crucial issues and constraints experienced by stakeholders in implementing community-based reforestation programs are summarized in Appendix 12.8. These issues are largely a recurrence of problems that led to unsuccessful outcomes in past reforestation programs in the Philippines (see Estoria, 2004; Pulhin et al. 2007; Carandang et al. 2010; Israel and Lintag, 2013; Le et al. 2014). Also, these issues are interlinked as either causes or effects. For example, the issue of 'limited participation' of PO members in the maintenance of the plantation is attributed to the issues on 'unclear rights and responsibilities' of PO members and 'weak leadership'. These two latter issues are results of the 'lack of social preparation'. Also, the 'low quality of seedlings' is a function of 'lack of skills', 'limited production period', 'delayed release of funds', 'limited access to high quality germplasm' and 'ineffective seedling quality control policy'.

A number of interventions have been implemented in the pilot community-based reforestation project. These were mainly adopted from suggestions provided by stakeholders during the planning workshop (listed in Appendix 12.8) and guided by results of scientific investigations of past ACIAR research projects. These interventions include adequate social preparation; improved supply of high-quality germplasm; implementation of appropriate livelihood projects for food and income; production and planting of high-quality seedlings of species that match the social preference, site conditions, and potential market; application of best practice in planting and post-planting silviculture; testing policy changes at the local level and advocating national adoption; and suitable and effective project monitoring.

While the pilot reforestation project is still in its early stages, it has generated key lessons that will potentially address the common shortcomings of past community-based reforestation programs. We found that for a community-based watershed rehabilitation project to succeed, it should be timely and should match the needs and interests of the community; be holistic; provide sustainable socio-economic benefits; and be participatory and evidence-based. There should be adequate social preparation and community organising. Capacity building of PO members is a necessity and a one-off training event is ineffective. The support of extension officers in building the capacity of the PO is essential.

In terms of project management, it is imperative to have an honest, visionary and charismatic leader of the PO. Transparency of handling project funds is also essential. A timely release of adequate project funds together with implementation of appropriate and sustainable livelihoods is essential in maintaining active participation of PO members. In as much as reforestation programs are largely carried out on public lands, security of tenure is a requisite. Lastly, the role of women in the designing, implementing and monitoring of a community-based reforestation program should never be discounted.

Further results of the pilot community-based reforestation program are discussed in Gregorio et al. (2015a), which is an article that featured in IUCN's manual on forest landscape restoration (see Section 11.2 of this report).

8.4. Influence of reforestation on watershed health

8.4.1. Impacts of reforestation on baseflow

The study has generated important findings that help answer the long-standing debate about whether trees have positive or negative effects on stream baseflow. It was found that surface run-off generation in fire-climax grassland was much greater than in reforested areas due to the combination of low topsoil permeability and increased landslide incidence in deforested terrain once deep tree roots have disappeared. Figure 1 shows that grassland has lower soil organic carbon and higher bulk density than the forested site.

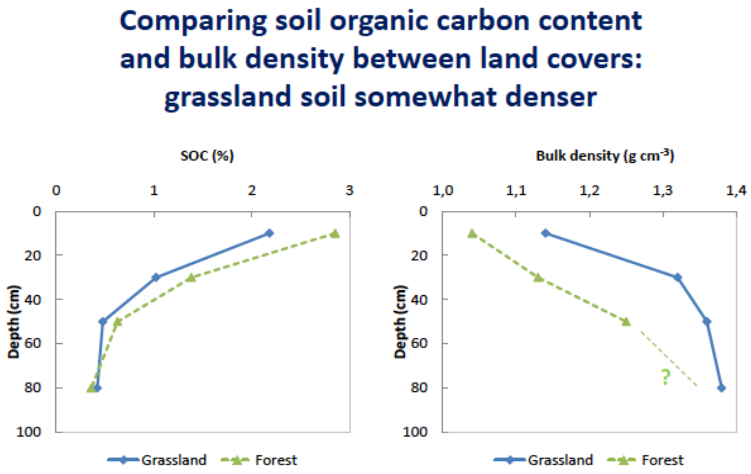


Figure 1. Bulk density and soil organic carbon of Imperata grassland and forested site

It was found that the annual water use of the semi-mature aided regeneration forest was estimated to be much higher than the *Imperata* grassland. Despite the higher water use of the forest, rainfall infiltration under the plantation was higher than the grassland, causing an overall net positive effect on stream baseflows. Figure 2 shows that the amount of moisture stored in active soil layer is higher in grassland than in forested site confirming the beneficial role of reforestation in reducing landslide and stormflow.

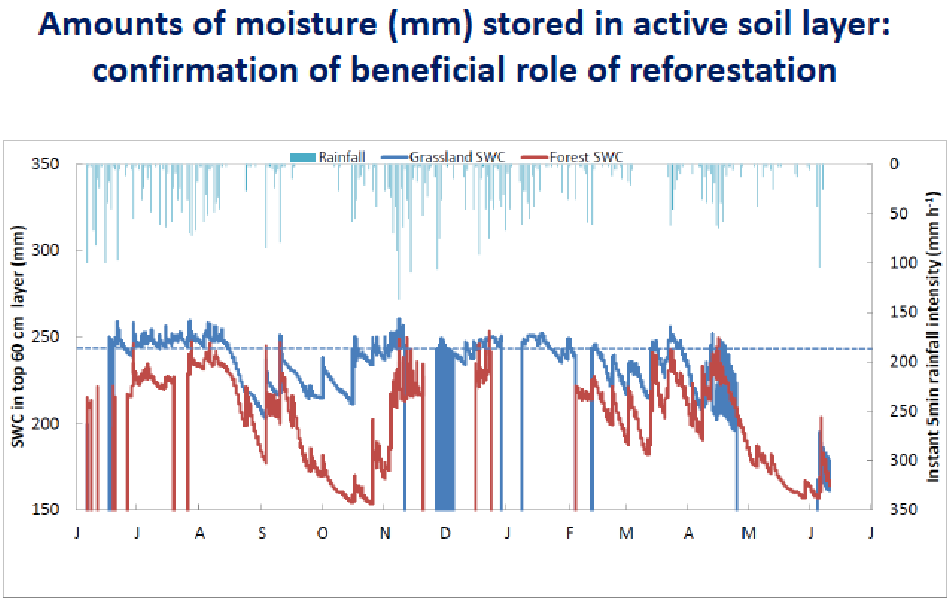


Figure 2. The amount of moisture stored in active soil layer in grassland and forested site

The study also confirmed that 23 years after the start of reforestation, the soil was capable of absorbing even the highest rainfalls on record (>200mm during Typhon Haiyan), thereby limiting the stormflow response and adhering to the classic notion of the ‘forest sponge’. The macropore development is considered key to optimum soil hydrological functioning and may take at least 10 years of undisturbed soil recovery to develop. The basic site hydrological functioning can be reliably assessed by comparing changes in soil hydraulic conductivity with depth against median and 95th percentile rainfall intensities.

Further information about the results of this research are presented in various research articles by Zhang et al. (in prep.) listed in Sections 7 and 11.2 of this report.

8.4.2. Results of the avifaunal diversity assessment

A total of 35 avifauna species were recorded in Kawayanon Watershed (Appendix 12.9). These species belong to 12 orders and 26 families. Order Passeriformes was the most represented with 17 species. Most of these birds inhabit bushes, trees, shrubs and grasses. Some are forest dwellers and are common from sea level to mountainous terrain. The second most represented orders were Columbiformes and Coraciiformes. Order Columbiformes was represented with 6 species all within the Family Columbidae. This order is a homogeneous group of arboreal and terrestrial birds with several unique anatomical and physiological features. Order Coraciiformes was represented with five species in three families. Orders Anseriformes, Apodiformes, Falconiformes Ciconiiformes, Cuculiformes, Falconiformes, Gruiformes, Piciformes, Psittaciformes and Stringiformes were represented with one species each.

Of the 35 species recorded, 7 (20%) are endemic to the Philippines. The most represented family was Columbidae, with 3 species of doves and 2 species of pigeons. These include the common emerald dove, spotted dove, white-eared brown fruit dove, thick-billed green pigeon and green imperial pigeon. They are important game species for the commercial trade (Collar et al. 1994).

Family Alcedinidae, Artamidae, Bucerotidae, Nectariniidae, Pycnonotidae and Sturnidae were represented by two species each. Worth noting from these groups are the two species of hornbills from the Bucerotidae family, the Rufous and Tariktik Hornbills. These are considered forest interior species and are excellent indicators of forest health and quality. Being important game species, they face a continuous threat. Another important species is the Colasisi of the family Psittacidae. It is usually collected for the commercial pet trade by local inhabitants of Kawayanon and neighboring barangays. Strikingly unexpected is the occurrence of the Philippine Mallard, a secretive water bird that normally forages in inconspicuous water habitats.

The recorded birds are distributed among four categories based on habitat affinity - the generalists, woodland generalists, forest specialists and water birds (Table 4). The result shows that the proportion of generalist species is higher than woodland generalists and forest specialists. This indicates that even if the avifaunal composition is not diverse, the reforestation project is very important for conservation because it harbors substantial numbers of forest dependent and forest specialist species. The protection zone of the pilot reforestation project is an important ecosystem that will eventually link to the adjacent natural forest in the community. The result provides support for the calls to protect the remaining secondary forest at the site for the benefit of highly sensitive forest bird species. Other vegetation types such as tree plantations, coconut plantations and areas of natural regeneration should, however, not be discounted as they also support a good number of avian species that are dependent on forest ecosystems.

Table 4. Avifaunal distribution in Kawayanon Watershed based on habitat affinity

Category	Number	Percent
Generalist	22	63
Woodland Generalist	8	23
Forest Specialist	4	11
Water Bird	1	3
Total	35	100
Index of Diversity (H’)	2.9139	

Although the forest landscape at the study site is generally fragmented, the heterogeneous elements are connected by a common gully corridor. This corridor is connecting the various ecosyststems namely grassland, natural forest, tree plantations and smallholder crop farms, and is harboring a wide array of avifaunal species ranging from generalists to forest specialists. The presence of forest specialists and woodland generalists even in the lower gully corridors would suggest that there has been a continuous flow of materials and energy among various fragments, thus connectivity is becoming more evident at this stage. This would justify intensification of the current protection efforts for the secondary forest and the young tree plantation.

8.4.3. Findings on the evaluation of soil dynamics after restoration using *Acacia mangium* and *Pretocarpus indicus*

The plant biomass of *A. mangium* and *P. indicus* significantly increased one year after reforestation but the magnitude is similar between these species. This could be due to the relatively similar growth of seedlings of the two species at young ages which is consistent with the report of Clark and Clark (1999). It was found that at similar soil depths, the reforested sites had significantly lower bulk density compared to the grassland site. The significantly lower bulk density in reforested sites could be attributed to higher root biomass. Roots influence bulk density through formation of root channels.

The chemical properties of the 0-5 cm soil depth appeared to be statistically similar between the grassland and reforested sites, except for N and this was significant especially in the *P. indicus* site (Appendix 12.10). The relatively faster turnover of *P. indicus* litter explained the significantly higher total N under that site. Given the limiting influence of N on ecosystem recovery, the significantly higher total N under the one-year old *P. indicus* stand could provide a headstart in the recovery of the soil.

Similar trends were also observed for the bulk density and total N of the 5-10 cm soil depth (Appendix 12.11). A significant difference between the grassland and the reforested sites was observed in the organic carbon. The *P. indicus* site had significantly higher P, exchangeable K and Ca, and base saturation compared to the grassland. At this soil horizon, the amount of P, K, and Ca was not statistically significant between *A. mangium* and grassland. The slow rate of leaf decomposition of mangium could be the reason for this observation.

This study found that except for the total N, the changes in the physico-chemical properties of the soil one year after reforestation are similar between *A. mangium* and *P. indicus* at the 0-5 cm and 5-10 cm layers. The significant negative change in total N at the *A. mangium* site and the positive change of N at the *P. indicus* site suggests that despite both tree species being able to form a symbiosis with N-fixing bacteria, accumulation of soil total N varies. With nitrogen being one of the major limiting nutrients in a degraded soil, the use of *P. indicus* could be more advantageous over *A. mangium* in rehabilitating degraded sites.

The magnitude of change in microbiological properties one year after the establishment of *A. mangium* and *P. indicus* is significantly different only in the basal respiration rate and microbial metabolic quotient (qCO_2) at the 0-5 cm soil depth. The positive changes in the basal respiration rate and qCO_2 of the *A. mangium* site implies an active but carbon-inefficient microbial community while the negative changes at the *P. indicus* site suggests the opposite. Low nutrient availability can stimulate the activity of microorganisms to acquire the limiting nutrient (Craine et al. 2007). While the high lignin content of *A. mangium* litter had limited the litter decomposition resulting in the low turnover of nitrogen, the relatively lower soil total N under the *A. mangium* site could have contrastingly stimulated microbial activity. Aside from the stimulation of microbial activity, low nutrient availability was also reported to cause an increase in qCO_2 such that more energy is expended in the acquisition of the limiting nutrient (Spohn and Chodak, 2015). This could explain the significantly higher qCO_2 at the *A. mangium* site compared to the *P. indicus* site.

The study revealed an insignificant increase in soil carbon stock one year after reforestation and carbon sequestration was observed only in the plant biomass. The absence of a significant difference in soil carbon stock one year after reforestation corroborates with the reports that increases in carbon stock in the soil occurs over decades (Paul et al. 2002).

8.5. Developing policy recommendations

8.5.1. Developing the implementing guidelines of the national policy on Forest Nursery Accreditation

Convincing top officials of DENR to integrate research results into national policies is not straightforward. It is imperative to provide concrete evidence that the proposed policy or amendment of the policy will provide tangible positive results. The pilot-testing of the nursery accreditation guidelines at the local level proved to be highly useful in getting the attention of the top DENR officials. Also, the advocacy of policy amendment led by DENR officials at the local level who have witnessed the effectiveness of the tested interventions was found to be very important in persuading the top DENR officials at the national level to consider the project's recommendations.

The long process to transform research results into a national policy is a major challenge experienced by the research team. It has been almost three years since the ACIAR research team started the advocacy to amend DAO 2010-11 to incorporate the nursery accreditation implementing guidelines. The road towards realization of the policy amendment has had considerable turns, and has required time and patience. Bureaucracy, limited time availability of key DENR officials to examine recommendations from the project, and less prioritization of suggested policy improvements are among the many reasons for the prolonged waiting period before a research result will become a national policy.

With the change of administration, USec Mendoza, the new USec for Field Operations, sent a formal communication to the management of the project stating that the proposed amendment of DAO 2010-11 advocated by project researchers has been forwarded to the Forest Management Bureau for review. He also emphasized that any policy recommendation from the ACIAR research team that will be helpful to further the success of DENR reforestation programs will surely be given a timely attention under his administration.

8.6. Field trials and plantation experiments

8.6.1. Mixed-species trial in the pilot community-based reforestation project in Caibiran, Biliran

The mixed-species trial experienced El Nino conditions in 2015 to 2016, one year after its establishment. This resulted is substantial mortality of seedlings. It was observed that climax species particularly white lauan (*Shorea contorta*) was severely affected. Ipil (*Intsia bijuga*), a slow-growing species of high wood density, and mahogany (*Swietenia macrophylla*) and gmelina (*Gmelina arborea*) also had significant numbers of seedling mortality. Bagras (*Eucalyptus deglupta*) had the lowest mortality.

Replanting of dead seedlings has been carried out. Data on seedling growth were collected and are being processed. Data collection and management of the field trial will continue under the new ACIAR ASEM 2016/103 project. Updated results of the trial will be presented under this project.

8.6.2. Effects of mycorrhiza and fertiliser on the growth of *Paraserianthes falacataria* seedlings

The study indicated that the application of chemical fertiliser had the greatest influence on the growth of *P. falcataria* seedlings. The fertiliser enhanced the growth, nodulation, biomass production, shoot and root K concentration, and AMF infection of four-month-old seedlings. Amending soil with rice hull had only improved the photosynthetic rate, nodulation, shoot biomass production, and shoot and root N and P concentration of four-month-old seedlings. Interaction between the types of potting media and chemical fertiliser application was observed on nodule number. Twice as many nodules were formed in the fertilised soil plus rice hull potting mix, but there was only a slight improvement in nodulation relative to the fertilised pure soil medium.

The potting mix had greater influence on seedling growth and biomass production. Carbonized rice hull in the potting mix provides greater benefits for seedling growth, biomass production and nutrient uptake than raw rice hull. On the other hand, AMF alone failed to promote growth and biomass production but it did improve total N and total P in shoots, and total K in roots. Interaction between the type of potting mix and inoculation influenced the total N in shoots. When seedlings were grown in soil plus raw rice hull, inoculation at either 5 or 10g of mycovam seedling^{-1} resulted in higher total N in shoots. However, no added benefit on total N in shoots was obtained from inoculation. The varied responses to inoculation of seedlings grown in two types of potting mixes suggest that fertility of the potting medium can influence the benefits of AMF inoculation.

Details of the results of this research are presented in the IUFRO Conference paper by Ferraren et al. (2015) listed in Section 11.2 of this report.

8.6.3. Tree characteristics and wood quality for determining the best end-use of smallholder tree farms

The preliminary inventory of all five stands found that the trees appeared to be even-aged, with some younger regrowth. In all five stands, tree density varied greatly, ranging from patches of densely stocked forest to scattered individuals. The incidence of wind damage (broken tops), fungal decay and curved trunks was high, resulting in a reduction of gross bole volume from 112 m^3ha^{-1} to merchantable (i.e. defect free) bole volume of 70 m^3ha^{-1}.The volume of branches greater than 10 cm diameter, which may be useful for firewood, was estimated at 43 m^3/ha. Hence, approximately 85 m^3/ha of wood which is non-merchantable as sawlog would also be available for use as firewood. These estimates did not include leaves and small branches. Except for the stand at Sitio Cansiso which was situated on a road, log haulage distance from the stand to a road varied between 1 and 1.5 km.

Despite a high incidence of typhoon damage in the sample of 50 trees, merchantable volume increased markedly with tree diameter. The sawn lumber recovery rate was 37% and also increased markedly with tree diameter. The recovery was high because the sawmill was required to maximise recovery by cutting boards with end dimensions as small as 2x2", but also ranging up to 1x10". Only 24% of the boards were of the smallest size (i.e. 2x2"), and 43% were 6" wide or more. However, a consequence of maximising recovery to satisfy local requirements was that 58% of the boards included some decay or wane.

Measured as a percentage of lumber length, bow was low, being less than 1% for lumber sized either 2x4" or 2x6". Twist was also low, being less than 0.25% for boards of either size. For boards which had been dried for two months, end splitting was more serious at an average of 6.6% of the volume of boards sized 2x4" and 2x6". Few boards suffered severe cell collapse during drying, Overall, the net recovery of defect-free lumber which had been re-cut to eliminate end-splitting and then re-sized to standard dimensions, would be approximately 13%. It was not possible to quantify the extent of fungal decay in tree boles, but decay was found in almost half of all trees, occurring in trees 30 cm DBH or larger.

Our research illustrates the importance of log quality for the development of sustainable livelihood activities from community-managed forests. Poor log quality limits the options available for either sale or value-adding. From a financial perspective, selling the trees to a sawmiller would appear to be the worst option. The price offered by local sawmillers was low and the required sawn timber dimensions on which royalty would be paid was large. Small diameter logs were effectively unsaleable. Consequently, the volume of lumber on which a royalty would be paid would be very low compared to the 37% found in this harvesting trial.

From a merchandising perspective, it is difficult to envisage the rough-sawn boards produced in the trial harvest being processed into furniture. A combination of shrinkage, wane, fungal decay, end-splitting and imprecise cutting would drastically reduce the volume of lumber which could be processed into furniture-grade material. In the Philippines, the increased prices paid for furniture-grade compared to rough-sawn lumber have led to suggestions (e.g. Mangaoang and Harrison, 2003) that furniture manufacture may provide an outlet for forest owners to enter the value-adding chain. However, there is little evidence of markets for these products being developed by capital-poor communities similar to the CFP-BA.

For the stands examined here, using chainsaws to convert trees into rough-sawn lumber appears to be the best technically feasible and financially viable option. Within many communities in the Philippines, low-quality lumber is acceptable for housing construction. The rough sawn low-quality lumber produced from the stands in this study would be suitable for such community use. This study has shown that for this market, sawn timber recovery can be relatively high even for poor quality logs. The 37% recovery rate is similar to the 39% recovery reported for chain-sawn *Gmelina arborea* logs on the nearby island of Leyte (Cedamon et al. 2013) and to the 35% recovery reported in Peru by Giudice et al. (2012).

This study indicates that log quality is a major influence on whether community forestry initiatives can help communities to develop sustainable livelihoods. Poor quality logs and the resulting high proportion of low-quality lumber greatly reduce the capacity for communities to access established lumber markets or to use lumber for value-adding activities within the community.

The article by Baynes et al. (2014) published in Small-scale Forestry (see Section 11.2 of this report) provides more information on the results of this research.

8.6.4. Effects of regeneration types on recruitment of species and functional diversity

We found that the understories of the different forest types shared some common species, e.g. *Glochidion album*, *Fagreae racemose* and *Ficus septica* Lour. We also found consistent trends with seedling diversity, functional diversity and canopy species diversity being negatively correlated with both soil nitrogen and phosphorus levels. The mechanism responsible for this relationship is unclear. However, it may be the result of differences in pre-planting soil treatments including fertiliser additions between forest types, litter nutrient differences depending on canopy composition, and higher diversity forests being more efficient at nitrogen and phosphorus cycling compared with less diverse systems (Richards and Schmidt, 2010).

The choice of the overstorey species impacts heavily on understorey seedling recruitment. As such, the characteristics of the species selected should be carefully considered if planting is designed to achieve biodiversity and production objectives (Le et al. 2014). The species used within our monoculture forests; *Swietenia macrophylla,* is a wind-dispersed, shade-intolerant but long-lived pioneer, with fruit that is of limited attractiveness to animal-dispersers. However, this species can provide canopy refuge (Slocum and Horvitz, 2000; Grogan et al. 2014). Elsewhere, Parrotta (1992) found the highest recruitment beneath monocultures of *Leucaena leucocephala*, possibly because of its overall structure and leaf litter traits, but did not recommend this species for planting because of invasion potential. Overstorey fruit bearing species (e.g. *Ficus*) can also accelerate understorey development within plantations, even when located long distances from seed sources (Peña-Domene et al. 2013).

The family Moraceae maintained similar levels of diversity across forest types. These were species belonging to the genera *Artocarpus* and *Ficus,* which were described by the comparable richness of the syncarpous fruit type between forest types (Laliberté et al. 2010). Other studies have found a similar prevalence of this functional group in *Artocarpus* (Quimio, 1999) and *Ficus* (Ingle, 2003).

Growing evidence suggests that human activities have a strong legacy on forest structure and composition within the tropics (Bhagwat et al. 2008). Monoculture understories had more species belonging to the largest fruit size class (6 = “>100mm”). These species included *Mangifera indica* Blume (mango), *Theobroma cacao* L. (cacao), *Citrus maxima* (Burm.) Merr. (pomelo), *Artocarpus altilis* (Parkinson) Fosberg (bread fruit), *Chrysophyllum cainito* L. (star apple), *Psidium guajava* L. (guava) and *Swietenia macrophylla*. People likely dispersed these species into plantations and the vast majority of the individuals observed were wildlings. This suggests, that exotic species can fulfil a ‘utilitarian role’ within small-scale forestry by regenerating and producing NTFPs once the canopy species has been selectively harvested, and that mahogany monocultures can provide conditions conducive for seedling recruitment.

We found wind-dispersed richness in the understorey of the monoculture forest types was threefold less than in the regenerating selectively logged forests. Only one individual of a wind-dispersed native species (*Alstonia macrophylla* Wall.) was found within the monoculture forests. Dipterocarpaceae species have been estimated to have a routine dispersal distance of ~100 m, with some experimental data suggesting the majority of seeds are dispersed less than 40 m from the mother tree (Ingle, 2003; Corlett, 2009). In the present study, possible seed sources occurred at distances between 160 m to 5.5 km from the plantation locations. These distances are likely too large for wind-dispersed tree species to recruit into the understorey of plantations, at a time-scale relevant for small-scale reforestation projects.

Seedling recruitment beneath small-scale community and smallholder plantations is an important factor in determining the longer-term sustainability and success of reforestation efforts (Le et al. 2014). This study highlights the value of reforestation in general, providing that exotic monocultures can recruit diverse understories that contain some species valued by the forest-dependent local communities. However, from a conservation perspective, it is a concern that wind-dispersed seedlings are absent, as this functional trait included ecologically important tree species such as *Octomeles sumatrana*, *Cratoxylum sumatranum* and several species of Dipterocarpaceae. Our results suggest that more active means of facilitating the establishment of species with this functional trait is required to sustain recruitment of future emergent trees in diverse tropical forests.

The article listed in Section 11.2 by Wills et al. (2016) published in Journal of Applied Ecology details the results of this study.

8.6.5. Key findings of biodiversity and carbon stock assessment in the post-kaingin secondary forests in the upland Philippines with implications for land-use policy development

We found higher SOC concentrations in all soil depths in our oldest fallow sites followed by young fallow sites and in new fallow sites. A similar pattern was found at all soil depths examined (i.e. 0-5 cm, 6-15 cm and 16-30 cm). The differences in SOC distribution was not significant in the case of the topsoil layer (i.e. 0-5 cm), whilst the distribution in the middle (6-15 cm) and bottom (16-30 cm) soil layers were significantly (p<0.05) different across the sites. The relative contribution of the SOC (at the different soil depths) to total SOC stock, however, varied across the sites of different fallow categories and forest, with relatively higher SOC concentrations in the topsoil layer (i.e. 0-5 cm) in our control forest sites (49.8%) followed by the middle-aged sites (48.98%). In the case of the oldest fallow secondary forest sites, the relative contribution of SOC in the bottom layer was comparatively higher (27.1%) than all other site categories.

We found high SOC, soil N and soil P recovery in our fallow sites when compared with the control old-growth forests. In most cases the recovery was higher in young fallow sites and in oldest fallow sites. Among the soil nutrients, soil K recovery was lowest across all site categories. The pattern of soil K recovery was different to soil carbon and N and P, with relatively higher recovery in middle-aged sites. Interestingly, soil K recovery was lowest in the oldest fallow sites. Despite relatively higher variability within the sites in recovery of carbon and nutrients, there was no significant difference between sites (of different fallow categories) in the recovery of selected soil parameters.

We found patch size (*PS*) explained the highest amount of variation in soil carbon and nutrients availability (in relation to the control old-growth forest) in regenerating secondary forests (Appendix 12.12). Other site factors important in explaining the variations were slope (*SL*) and fallow age (*FA*). There was no influence of the distance from nearby control old-growth forest (*DIS*) to the recovery of the soil carbon and nutrients across our sites. Patch size was found to be consistently important in explaining the variation in recovery for all the soil parameters and soil depths we examined (Appendix 12.13). In the case of soil P recovery, we also found that the slope of the sites was equally important as the patch size in explaining the variation.

We did not find a clear or consistent influence of shifting cultivation land-use on the stocks of SOC, N and P in regenerating secondary forests in the upland Philippines, but there was a relatively greater influence on soil K concentrations. The higher levels of SOC and nutrients (i.e. N and P) in young fallow sites could be due to the initial release of carbon and nutrients from plant materials to the soil following burning (Giardina et al. 2000; Tanaka et al. 2001). Heating of soil during burning acts as an important mechanism of nutrient release and the initial burning associated with shifting cultivation is reported to increase SOC by the addition of organic matter in soil via ash (Tanaka et al. 2001). Burning can also result in losses of soil-available N due to increased volatilization, although, the losses of soil P to the atmosphere due to volatilization is relatively low (Giardina et al. 2000; Romanyá et al. 2001). In shifting cultivation landscapes, burning also results in a decrease in microbial activity and associated biomass in the soil at the initial stage that may negatively influence organic carbon in soil (Tanaka et al. 2001).

The relatively lower concentration of SOC and P at our middle-aged sites could be due to increasing nutrient uptake by regenerating vegetation during successional development. Similarly, relatively greater concentrations of soil carbon, N, and P in our oldest fallow sites could be due to higher litterfall, litter decomposition and microbial activity in sites (Lange et al. 2015; Paudel et al. 2015; Sayer et al. 2011). Soil K was consistently low at all our sites and fallow categories, although Yang et al. (2003) reported an increase in soil K after fire and shifting cultivation use at sites in China.

We found that site environmental parameters, mainly patch size, have the greatest influence on the recovery of SOC, soil total N and P; and we have found that the same factors influence aboveground biomass carbon and forest structure recovery in regenerating secondary forests after shifting cultivation (see Mukul et al. 2016a). As mentioned earlier the higher levels of soil carbon and nutrients in our fallow sites could also be due to the initial release of carbon and nutrients following burning, and may not represent the actual recovery in young fallow sites. In the case of soil K, both patch size and slope were found to be equally important for its recovery.

Our study found that shifting cultivation may not be as detrimental to soil quality as suggested in the literature, at least on the soil type and climate we studied, and that geographic and site-specific conditions may be important in determining the impact that shifting cultivation has on soil properties. The concentrations of soil carbon, N and P were significantly higher in the young fallow secondary forests, while soil K concentration was lower compared to old-growth forest. We also found greater availability in the soil stocks of SOC, soil N and P in tropical secondary forests compared to old-growth forests after shifting cultivation use. In young fallow areas, this may be attributed to the release of nutrients from slashing and burning of the plant biomass available at the site. Patch size together with the slope of the site and fallow age were significant explanatory factors associated with the recovery process.

Further information regarding the results of this research is detailed in Mukul et al. (2016) and Mukul and Herbohn (2016) listed in Section 11.1, and Mukul (2016) in Section 11.2.

9. Impacts

The project has provided an understanding of the complexities of implementing the community-based watershed rehabilitation program in the Philippines. The research activities have threshed out the implementation challenges and constraints, which have mostly recurred for over two decades of undertaking people-based forestry in the country. Interventions were undertaken to improve the reforestation system, which provided scientific impacts and also contributed to improving the technical capacity and socio-economic condition of smallholders involved in reforestation programs. Further, the research interventions have promising impacts for upland communities and the environment in the long-run.

9.1. Scientific impacts – now and in 5 years

A number of project activities are showing very promising signs of creating substantial scientific impacts. In particular, the results from the assessment of past reforestation programs has the potential to substantially influence the design and implementation of reforestation projects both in the Philippines and in other tropical countries. In addition, the assessment of the impacts of reforestation on stream baseflow, water quality and water movement within reforested watersheds has the potential to change the way in which the impacts of reforestation are viewed. Further, data collected during Typhoon Haiyan are unique and have indicated that the reforested areas in the Manobo study area acted as a buffer for massive peak flows of water through the catchment compared with the non-forested Basper watershed. The data add substantially to our understanding of the potential of tropical reforestation for buffering extreme rainfall events – for which to date there has only been very limited evidence. In addition, the post-typhoon assessment of damage to smallholder and community forests should allow for a much better understanding of the typhoon-resistance of key species. The field trials on mixed-species planting will also provide useful information in regards to appropriate combinations trees of various species within the stand.

The protocol on seedling quality assessment as part of the implementing guidelines of the Forest Nursery Accreditation Policy in DAO 2010-11 will improve the uptake of high-quality seedlings in reforestation programs in the Philippines. Also, the set of criteria on mother tree selection developed under the project will promote the identification of phenotypically superior trees, which will improve the quality of germplasm for reforestation programs in the country. The identified mother trees from the natural forests will improve the supply of high-quality germplasm especially for native species, which is increasingly promoted in watershed rehabilitation programs in the Philippines.

The design of the pilot community-based reforestation project in Biliran has provided a model for the local DENR office in designing the new NGP projects in other communities in the province. This includes subdividing the land into planting zones and incorporating fuelwood planting in the implementation plan. Zoning land into production, protection, and agroforestry, and planting fuelwood along the boundary of the plantation was initiated in designing the pilot community-based reforestation program in Biliran.

The project was invited to participate in the Forest Landscape Restoration Workshop at the IUCN Office in Washington DC to present the best practice and evidence-based community-based watershed rehabilitation research that has been pilot tested in Biliran province as part of the project's research activities. This research was selected by IUCN as one of the seven out of 118 submissions regarding forest landscape restoration initiatives in tropical countries. A paper presenting the process of designing the program; the implementation schemes and monitoring strategies; and outcomes and impacts of the pilot community-based watershed rehabilitation program has been developed. This formed part of the IUCN handbook to catalyse and inform dialogues of policymakers around the world on the roles forest landscape restoration can play to enhance food security. In addition, the lessons from the project were presented at the SYSYNC workshop on governance held in Annapolis in March, 2017 and will be incorporated into a special issue of Land Use Policy. Following the SYNSYNC workshop, and in recognition of the important implications of the research undertaken by the project, the project leader has been invited to present key results and their implications to the FAO group responsible for the implementation of the Bonn Challenge. The research undertaken in this project thus has the potential to influence the manner in which Forest and Landscape Restoration is implemented in many tropical countries.

Articles published in leading journals are the most likely to have a substantial scientific impact. As such, we can use indicators of quality of the journals in which project results have been published as a leading indicator of the likely scientific impact of the project. The Thompson ISI impact factor is an accepted, but albeit imperfect, measure of journal quality. The average impact factor of forestry journals is around '1'. As can be seen from Figure 3, the 21 of the 28 papers published by project researchers were in journals with impact factors double the average for forestry. Importantly, 32% of publications were in the top 10% of journals in their respective Thompson ISI fields, and 64% of publications were in the top 25% of journals in their respective Thompson ISI field of research.

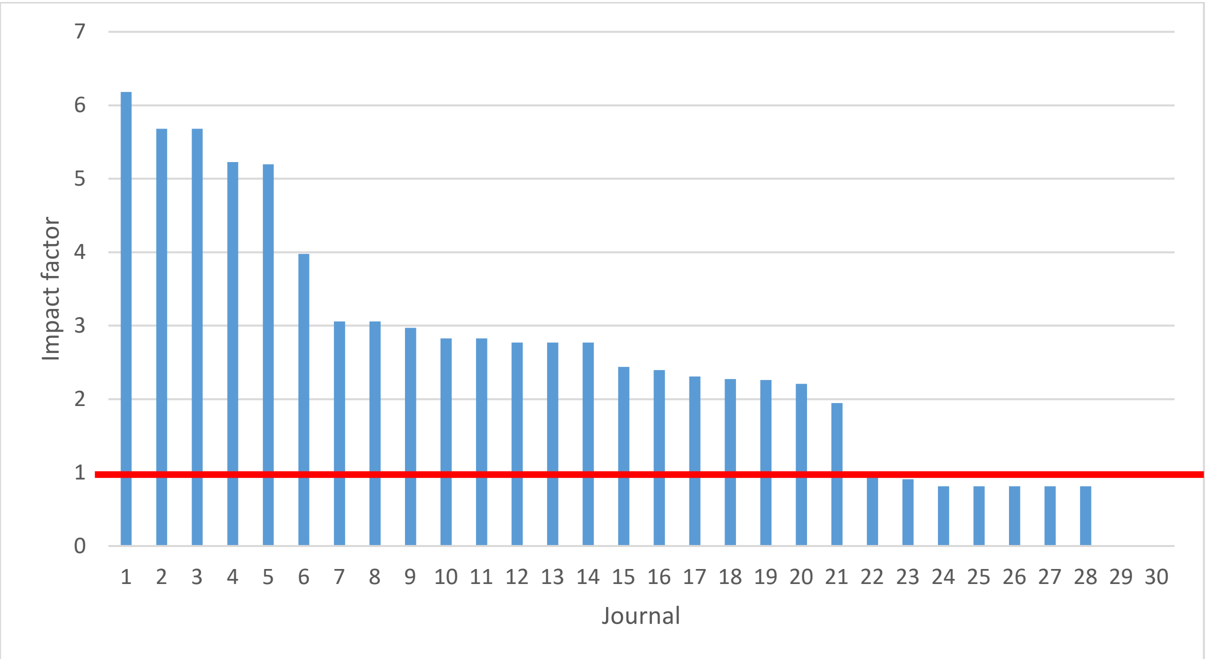


Figure 3. Impact factors of the journals in which the project's research has been published. The red line indicates that average Thompson ISI impact factor of 'forestry' journals.

9.2. Capacity impacts – now and in 5 years

The project has significantly contributed to the capacity development of research partners in the Philippines including communities, DENR staff at the local level, and VSU researchers. DENR personnel were trained about the nursery accreditation process. Selected members of the PO were also trained in methods of high-quality seedling production. Selected DENR staff and members of the PO who attended the training sessions delivered by project researchers themselves became trainers for the rest of the PO members. Training sessions on plantation establishment, maintenance and protection were also carried out in communities for enhancing the knowledge of farmers on best practice reforestation. The nursery and communal plantation of KFAI served as a demonstration site for other POs in the province implementing the NGP. Some POs in the province have adopted the best practice in seedling production and plantation silviculture demonstrated in the project's pilot community-based reforestation program.

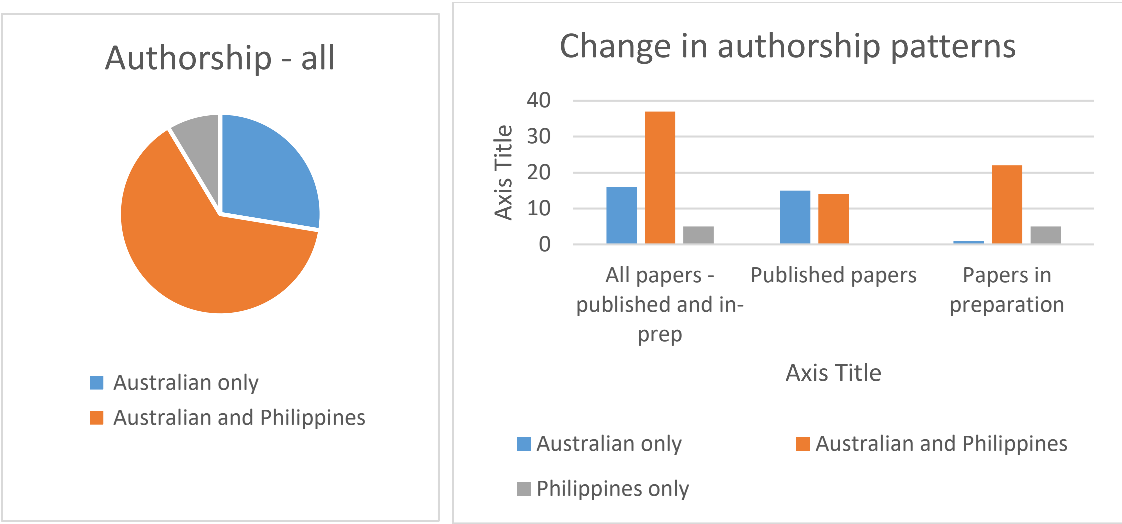
The project has contributed to enhancing the technical capacity of local DENR personnel in designing, establishing and monitoring field trials. Relevant personnel of local DENR offices in Regions 8 and 10 were involved in the establishment and management of several of the project's field trials. Ths has enhanced their knowledge of experimental designs, methods of data collection, and data analysis. They were also exposed to using research instruments that are not commonly available in forestry research agencies in the Philippines including the infrared gas analyser, laser hyspometers, canopy analyser, and leaf area meters.

Project researchers were requested by DENR Region 8 to evaluate the phenotypic qualities of about 3,000 potential mother trees of native species that the department has identified from the natural forest in three municipalities in Region 8. The evaluation process also served as hands-on training of DENR personnel on assessing mother trees of timber species. The mother tree identification is part of DENR's program to promote the use of high-quality germplasm in the NGP, diversify tree species in reforestation projects, and address the shortage of seeds to satisfy the planting targets of the NGP.

The manuals and other extension materials disseminated by the project have also served as reference materials in undertaking various activities relevant to watershed rehabilitation. The collaborative efforts of the project and DENR Region 10 in establishing field trials have substantially improved the knowledge of DENR personnel in undertaking scientific silvicultural investigations. DENR staff explicitly stated this during the planning and establishment of the experiments.

Selected members of the PO were trained to assess the physical quality of mother trees. These PO members conducted the inventory of mother trees in the natural forest of the community. The mother trees will serve as the sources of germplasm for the PO's nursery seedling enterprise.

The capacity of partners from VSU to undertake research has been improved. This is exemplified by VSU researchers undertaking most of the socio-economic and policy research, and the increase of primary authorship of VSU researchers in research articles developed from the project's research activities. The analytical laboratory at VSU established by the project has improved the capacity of VSU research partners in undertaking water, soil and plant tissue analyses as part of the research activities. The training and mentoring of VSU staff members by Australian researchers has dramatically enhanced the knowledge and skills of our Filipino partners in operating and managing the analytical laboratory. Importantly, there has been substantial co-authorship of scientific papers (Figure 4a), with both the level of co-authorship between Philippines and Australian authors increasing over the course of the project (Figure 4b).



(a) (b)

Figure 4. Authorship of journal articles originating from the project's research activities.

9.3. Community impacts – now and in 5 years

The implementation of the pilot community-based reforestation program in BIliran has provided positive impacts to partner communities and those that are not directly involved in the project. The adoption of best practice seedling production and plantation establishment demonstrated in the pilot community-based reforestation program in Biliran has improved the knowledge and skills of the partner communities and provided direct and indirect economic benefits including reduced reforestation cost due to limited seedling mortality and fast seedling growth in the field. Community residents who are not members of the PO have realised the desirable practices of the pilot community-based reforestation, which they have not witnessed in past reforestation projects in the area. The failure of past reforestation programs in the community provided an initial negative impression towards the project by most households. Accordingly, only few families decided to participate. As implementation of the pilot reforestation progressed, community residents started to realise the stark difference in regards to the approach, strategies and technologies adopted in the pilot reforestation from the past reforestation programs in the community. The recent survey on the impacts of the pilot reforestation program indicated that there is increasing interest of community residents to become involved in the reforestation program. It is expected that the membership of the PO will continue to increase over the next five years.

Fire was a major cause of the failure of past reforestion projects at the site. It was reported that the site was burned at least twice every year. However, since the implementation of the pilot community-based reforestation project, the plantation has not been burned. It was surmised that the combined initiatives of the project including the appropriate information campaign, the participatory approach in program design and implementation, and showcasing the potential of the project in providing food and income has prompted community appreciation. Hence, a collaborative effort to protect the established plantation from fire has developed.

Having demonstrated the benefits of smallholder-based best practice in seedling production and plantation establishment, it is perceived that the pilot community-based reforestation program will improve the performance of NGP projects in other communities in Biliran Province. The implementation of a DENR PENRO MC regarding the adoption of the protocol for forest nursery accreditation advocated by the project will also improve the quality of seedlings in reforestation projects of communities in the province. The institutionalization of the protocol and criteria promoted by the project for national implementation will impact communities in several regions of the country. Also, the article regarding the pilot community-based reforestation program in Biliran Province published by the IUCN as part of their case studies promoting food security through forest landscape restoration will benefit communities across the globe that are engaged in forest landscape restoration.

9.3.1. Economic impacts

The training on high-quality seedling production has largely improved the skills of communities to produce high-quality seedlings and encouraged the DENR-PENRO to adopt a robust set of seedling quality assessment criteria. With these, seedlings from community nurseries are expected to be of high quality, hence resulting in high seedling survival and fast growth in the field. High survival of outplanted seedlings means higher economic returns to communities. In the NGP implementation, communities are paid to produce seedlings and plant the seedlings in the field. The payment is made on a package price of PhP12 per seedling. Communities are paid once the seedlings are planted. When there is mortality during the field inventory by DENR, the communities are required to replant. However, during this stage, the communities are not paid to grow and replant the seedlings. The likely economic impact of improved seedling quality through training will be assessed as part of the project's monitoring activities. The high quality of seedlings produced by KFAI and their low-cost nursery set-up has been promoted by the local DENR office in other community seedling production projects. Members of POs in other communities visited the KFAI communal nursery.

The pilot reforestation system in Biliran will promote effective and efficient implementation of reforestation programs such as the NGP. With a high survival rate of plantations and high growth performance of seedlings attributed to the use of high-quality planting materials and following best practice plantation establishment, maintenance and protection, farmers will incur less cost in implementing watershed rehabilitation projects and realise early returns from trees. While the plantation in the pilot community-based reforestation project in Biliran experienced severe El Niño for over a year in 2015 with a recorded average monthly rainfall of only 40mm, the seedling survival of the two-year-old plantation was over 70%. After 2.5 years from planting, the average height of *A. mangium* was over 3 m while for native trees it was almost 2 m.

The project provided substantial funds to implement the pilot reforestation project in Biliran. The funds have been used to cover the costs of seedling production, plantation establishment and plantation maintenance for three years. The mode of payment and timing of funds release were designed to promote efficient and effective implementation of the reforestation project. Delayed release of funds and very low budgets to carry out reforestation activities were explicitly mentioned by PO members during the planning workshop in Biliran as major impediments to the timely undertaking of reforestation activities. This issue has been addressed in the pilot reforestation project.

Recognising the early success of the pilot community-based reforestation program in Biliran, in mid-2015, the DENR PENRO provided substantial funds to assist the PO establish the communal agroforestry farm. The funds were used to purchase planting materials for crops including cassava, sweet potato, banana, abaca and coffee. Also, the PO was able to purchase two buffaloes for cultivating the agroforestry farm and other livelihood benefits. One of the buffaloes produced a calf in May 2016.

The knowledge and skills of PO members in applying best practice in nursery seedling production and plantation silviculture has dramatically improved. This is exemplified by the high quality of seedlings the PO has been producing and the high survival rates and considerable growth of trees in the pilot reforestation. This has been a major factor for the DENR PENRO to award another 63 ha of new NGP project to the PO with a budget of about PhP1.3 million, the largest among the few new NGP projects in Biliran Province in 2016.

9.3.2. Social impacts

A major component of implementing the pilot reforestation project in Biliran is community organising. This is an essential aspect of community-based reforestation programs which has typically been neglected or given less emphasis by implementing agencies. For example, the recent NGP does not include community organising as a component of the program because the POs were previously organised during the implementation of previous community-based reforestation projects (e.g. CBFM). However, most of the POs disbanded for various reasons particularly conflicts among members and their poor experiences in implementing reforestation projects. The community organising process undertaken by the project in implementing the pilot reforestation in Biliran has resolved conflicts among PO members, which has largely improved the dynamics of the group.

The application of the appropriate method of implementing community-based forestry in the pilot reforestation program including the use of a systems approach in program design; the use of genuine participatory planning, implementation and monitoring; and the adoption of best practice nursery and plantation silviculture. This has broadened the knowledge and understanding of the community about the rationale, importance and benefits of a community-based forestry program, and their responsibilities in implementation. Most of the PO members did not understand the rationale behind previous community forestry projects. They viewed themselves as contract workers to establish the plantations. The long-term commitment to voluntary management of the plantation was absent because there was no appreciation of project ownership. Surveys undertaken to determine the impacts of the pilot reforestation two years post-implementation revealed that there were significant changes in the views, attitudes and outlook of the community towards community-based forestry projects. This has broadened the understanding of the PO regarding the essence of the reforestation program – transforming their mental construct as reforestation ‘contractors’ (who are simply paid to grow seedlings and plant trees) to plantation ‘owners’ (who have access to utilise plantation resources but with the responsibility of appropriately managing the trees).

The training event on high-quality seedling production and assessment of seedling quality conducted by the project has improved the knowledge of communities in terms understanding the importance of high-quality seedlings in watershed rehabilitation programs. The training has also enhanced the skills of community organisations in producing high-quality forestry seedlings. The learning and application of best practice plantation establishment, maintenance and protection has broadened smallholders’ knowledge and skills in undertaking watershed rehabilitation. With improved awareness and skills, the smallholders have become empowered and more motivated to implement the NGP.

Forest fires intentionally set by land claimants and other disgruntled community residents were reported as a major reason why previous reforestation projects in the community did not succeed. It was reported that the site was burned several times every year. The pilot community-based reforestation project site has not been burnt since its establishment in October 2014 while adjacent NGP plantations were burned several times each year. The El Nino in 2015 to 2016 resulted in burning of most NGP plantations in Biliran and elsewhere in the Philippines.

9.3.3. Environmental impacts

The field trials and investigations of the RF approach to reforestation have provided information on appropriate species mixtures, and this has been integrated in the design of the pilot community-based reforestation program. The pilot reforestation project is currently only 2.5 years old. The prevention of forest fire at the site, and the initial establishment of trees should contribute positive environmental effects but this has not been thoroughly studied at this stage.

The survey on avifaunal species composition in the research site indicated that while the generalist bird species exceeded the woodland generalists, there is an indication of connectivity of the reforestation project with the adjacent natural forest. This established connectivity of corridors is expected to increase as the trees mature. A floristic description in the riparian zone of a stream that traverses the pilot reforestation site has been conducted and the result revealed important native tree species that could become sources of germplasm for subsequent natural enrichment of flora and fauna diversity at the site.

The identified mother trees from the natural forests in Biliran and Leyte Islands will improve the supply of high-quality germplasm and increase the species diversity of indigenous trees in future reforestation programs.

9.4. Communication and dissemination activities

In view of the participatory approach adopted by the project in designing, implementing and monitoring research activities, ensuring active stakeholder engagement and an established communication pathway with stakeholders is paramount. A well-structured system for communication among project implementers and the dissemination of project results and findings to stakeholders has been developed. Meetings, workshops, public fora, and focus group discussions are among the methods adopted to communicate with project implementers and stakeholders, particularly the DENR and other government agencies. Extension materials developed from the findings of reseach activities were also disseminated during farmer field days at VSU. Publication of research results in high-quality journals enabled the project to convey important findings to a wider international audience.

The VSU research team has held monthly meetings to discuss updates to project activities. Annual meetings with DENR at the national level have also been undertaken to convey salient findings of the project to the top officials of the department. There have also been a number of meetings and workshops with DENR officials at the local level.

Project staff members have also worked hard to develop communication channels with members of the Kawayanon Farmers Association Inc. (KFAI), our partner PO. Monthly meetings were held to discuss various topics including project activities, issues arising from the implementation, and updates to PO income and expenses. Developing rapport and trust with the POs has been facilitated with the appointment of a community liaison officer.

A large number of communication and information dissemination activities including meetings and workshops have been conducted for the past 5 years of the project's implementation. Some of the key meetings and workshops are listed in Table 5.

Table 5. Some of the key meetings undertaken during the course of the project implementation

Title	Date	Venue	No. of participants
Meeting with DENR-PENRO Biliran to discuss improving the production and use of quality seedlings in Biliran.	7 Jun 2013	DENR PENRO Office, Naval, Biliran	11
Meeting with local officials of Caibiran regarding the conduct of research activities.	10 Jun 2013	Caibiran Municipal Hall, Caibiran, Biliran	7
Meeting of research team with DENR Region 8 officials regarding the conduct of hydrology research in Tacloban.	9 Jul 2013	DENR Regional Office, Tacloban	12
Meeting with DENR PENRO-Biliran to discuss harvesting of mature mangium trees in Kawayanon as part of the KFAI livelihood project.	19 Jul 2013	DENR PENRO Office, Naval, Biliran	9
Meeting with RTD Jocson of DENR ERDS regarding the application of the seedling quality evaluation protocol developed by the ACIAR Project.	31 Jul 2013	DENR Regional Office, Tacloban	8
Meeting with staff of DTI and DOLE in Biliran for potential capacity-buliding support for these agencies to assist the PO in Kawayanon.	15 Aug 2013	DTI and DOLE Offices, Naval, Biliran	10
Meeting with the Technical Working Group to present results of project activities including NGP assessment, nursery survey, and timber harvesting trial.	20 Aug 2013	DENR Regional Office, Tacloban	11
Meeting with the community (Manobo Tribe) to present hydrology research plans and explain the purpose of the study.	3 Sept 2013	Manobo Tribe, Bagacay, Tacloban	21
Meeting with the residents of Kawayanon for the implementation of the pilot community-based reforestation program.	20 Nov 2013	Kawayanon, Caibiran, Biliran	108
Meeting to brief FASPO and ERDB officials on the progress of research activities.	21 Feb 2014	FASPO Office, DENR, Manila	13
Meeting with DENR-PENRO Biliran for the issuance of DENR Memorandum to apply the Forest Nursery Accreditation protocol of ACIAR in Biiliran.	5 Mar 2014	DENR-PENRO, Naval, Biliran	15
Planning workshop with DENR, KFAI members and Kawayanon	24-25 Mar 2014	Kawayanon, Caibiran, Biliran	98

residents to design the pilot reforestation program in Kawayanon.			
Workshop with DENR and PO officials in Biliran to present the results of the NGP assessment and nursery survey in Regions 8 and 10, and discuss interventions to address the identified issues.	2 April 2014	Marvin's Inn, Naval, Biliran	37
Cross-site visit of KFAI officials to YESIDA to learn about useful experiences of YESIDA in undertaking community forestry project with auspice from GIZ.	4 April 2014	Maasin, So. Leyte	10
Meeting with land claimants of the proposed pilot reforestation site to design and agree on terms in regards to the use of their claimed lands for the pilot reforestation program.	11 April 2014	DENR PENRO Office, Naval, Biliran	18
Presentation of hydrology research findings to Manobo Tribe members.	20 Jun 2014	Manobo, Bagacay, Tacloban	32
Meeting of VSU Research Team to discuss project activities to be presented in the University In-house Review.	18 July 2014	College of Forestry, VSU, Visca, Baybay, Leyte	10
Meeting with DENR R10 regarding the field trials in Mindanao; field visit to potential experiment sites.	16-20 Oct 2014	DENR-ERDS, Malaybalay, Bukidnon	8
Assessment of KFAI nursery by DENR Nursery Accreditation Team.	6 Nov 2014	KFAI Nursery, Kawayanon, Caibiran, Biliran	13
Cross-site visit of KFAI members to YESIDA to learn about useful experiences of YESIDA in undertaking community forestry project with auspice from GIZ.	14 Nov 2014	Maasin, So. Leyte	32
Lecture with primary school students about watersheds and the importance of the pilot reforestation project in Kawayanon.	12 Feb 2015	Kawayanon Community School, Caibiran, Biliran	36
Meeting with DENR R8 officials to provide updates on the project.	17 Mar 2015	DENR Region 8 Office, Tacloban	12
Meeting with top officials of DENR to provide updates on the project and discuss new developments in DENR reforestation programs.	23 Mar 2015	DENR Main Office, Manila	13
Meeting with KFAI and DENR to design the agroforestry system as part of the pilot reforestation project.	2 July 2015	Kawayanon, Caibiran, Biliran	45
In-house review at VSU to present	7-8 Oct 2015	College of Forestry,	26

research results of the project to VSU faculty and staff.		VUS, Visca, Baybay, Leyte	
Presentations of research results at the IUFRO Conference in Australia.	18-19 Oct 2015	Sunshine Coast, Australia	180
Meeting with ERDB officials to present the proposed Technical Bulletins on seedling quality assessment and mother tree accreditation as part of implementing guidelines of DAO 2010-11.	25 Nov 2015	ERDB Main Office, Los Baños, Laguna	12
Presented project research activities and key results during a conference on using native trees for reforestation.	27 Nov 2015	Quezon City, Manila	68
Meeting with the PO in Biliran in relation to the CARP project and land claimants.	18 Dec 2015	Kawayanon, Caibiran	29
Meeting with top officials of DENR to brief about the proposed new ACIAR ASEM/2016/103 project and obtain letter of support.	10 Jun 2016	DENR Main Office, Manila	8
Meeting with top officials of DENR-ERDB to brief about the proposed new ACIAR ASEM/2016/103 project and obtain letter of support.	13 Jun 2016	ERDB Main Office, Los Baños, Laguna	10
Meeting of VSU project researchers to discuss project development and updating of research activities.	4 Aug 2016	VSU Guesthouse, Visca, Baybay, Leyte	10
Meeting with DENR R8 officials and PO representatives to present the important findings and implications of the pilot community reforestation project in Biliran.	30 Sept 2016	Marvin's Inn, Naval, Biliran	62
Meeting with newly appointed USec for DENR Field Operations USec Montejo to brief him on the Watershed Project activities and key results, and presented the project extension materials.	9 Nov 2016	DENR Central Office, Manila	6
End-of-project review.	13 Mar 2017	VSU, Visca, Baybay, Leyte	22
End-of project review continuation.	15 March 2017	Sabin Resort, Ormoc City	48
International invitation only workshop on "The landscape of restoration governance: The role of incentives, regulations and information	April 20 & 21 2017	Annapolis, USA	16

10. Conclusions and recommendations

10.1. Conclusions

The implementation of the ASEM/2010/050 project was very timely, coinciding with the institutionalization of the National Greening Program in the Philippines. The project's research activities and key findings corresponded with a number of recurring issues in people-based reforestation programs in the Philippines.

The project's application of a systems approach in analysing community forestry programs, and its use of genuine participatory processes among stakeholders for designing, implementing and monitoring intervention measures has proven to be effective in improving watershed rehabilitation outcomes. The project is one of only a handful of studies to investigate the impacts of reforestation on water movement in a degraded tropical catchment. In the case of our paired catchments, the gains in water flows through increased infiltration associated with reforestation exceed the losses from transpiration, thus resulting in increased stream baseflow. This is a significant contribution to the on-going debate about whether planting trees reduces streamflows as a consequence of additional water losses through transpiration. Our research also found that shifting cultivation may not be as detrimental to soil quality in upland watersheds as suggested in the literature, at least on the soil type and climate we studied, and that geographic and site-specific conditions may be important in determining the impact that shifting cultivation has on soil properties. The field trials established and the research conducted on existing tree plantations have provided crucial silvicultural information including that regarding appropriate mixtures of tree species, adequate spacings, and the importance of germplasm sources and fertilising regimes. Unfortunately, many of our field trials were badly damaged by Typhoon Haiyan in 2013 and most had to be abandoned. However, the typhoon provided an opportunity to undertake a study on typhoon damage. This study has revealed that in general, native species are more resilient to typhoon damage than exotic species, and that mixtures of between six and eight species are less prone to wind damage than monocultures. These results have important implications for the design of reforestation systems in typhoon-prone areas and are now being incorporated into the design of NGP plantings.

The project has identified factors that contribute to the success or failure of reforestation programs in the Philippines and analysed the interactions among these factors. The analyses led to the identification of drivers and indicators of reforestation success. We developed a Bayesian Belief Network and used this model to identify intervention points for improving community-based watershed rehabilitation outcomes. One of the crucial findings was the critical importance of livelihoods as a driver of reforestation success. While livelihood projects have previously been incorporated into community-based reforestation programs in the Philippines, most of these projects have failed to provide benefits to communities. A major activity of the project was to draw on our research to design and implement a 'best practice' pilot reforestation project in Biliran in partnership with the community and local DENR staff. This pilot community-based reforestation project has demonstrated that a critical key to the success of people-based forest landscape restoration programs is addressing the socio-economic and food security issues of smallholder farmers. The social landscape is equally as important as the biophysical landscape of a reforestation project site. The lessons learnt from the Biliran pilot project have wide application in the Philippines and the site is now being used by DENR as an exemplar of how to implement successful projects as part of the NGP. With the strong linkage and support of DENR at the local and national level, there is a substantial opportunity to incorporate the key findings of the ACIAR ASEM/2010/050 project into national policies to improve the outcomes of forest and landscape restoration programs throughout the Philippines.

10.2. Recommendations

While the Biliran pilot reforestation project provided many important insights into how reforestation can be best implemented, there remain important unanswered questions as to how these can be applied in other situations. It is recommended that further research be undertaken into what approaches work best to implement landscape-scale community-based reforestation.

Our research has clearly shown that livelihood projects are fundamental to the success of reforestation, both in the Philippines and elsewhere in developing tropical countries. However, there is still much to be learnt about what types of livelihood projects are best suited to being incorporated into reforestation projects in different settings. We recommend that further research should be undertaken to identify and develop livelihood initiatives that can be built into reforestation projects and which generate both short-term cash income and long-term material benefits for communities and smallholders involved in reforestation.

The research undertaken in the paired catchments at Manobo and Basper has revealed that reforestation can improve infiltration rates and baseflows in highly degraded ultramafic soils. That study is one of a very small number which have been conducted on degraded soils in the tropics and the results potentially change the way the impacts of reforestation on stream baseflows in catchments with degraded soils are viewed. It is recommended that further research be undertaken to address how broadly these results apply to other soil types and soils which are less degraded.

Influencing policy and practice in the Philippines requires an ongoing commitment and the maintenance of relationships between researchers and DENR officials, especially those at the national level. In order for the more recent project results to be integrated into national policy, and to change practices within the National Greening Program, it is recommend that ACIAR consider a mechanism to ensure that there are ongoing interactions between researchers at VSU and national policymakers and local implementers. This may be through ongoing funding of research or through support from the ACIAR Philippines country office.

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11.2. List of publications produced by project

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B. OTHER PUBLICATIONS

1. Technical report

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2. Postgraduate research project

Abulencia, M. Soil Dynamics of Degraded Land One Year After Restoration Using Acacia mangium Willd. and Pterocarpus indicus Willd

Gudmundsson, C. The influence of edge effects on wood density and sapwood area of tropical tree species: evidence from small-scale plantations in the Philippines

3. Workshop/conference proceedings

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1. Conference Presentations

Ferraren, A., Gregorio, N. Agne, L., Avela, M., and Pasa, A. 2015. The effects of rice hull potting mix, chemical fertilizer, and arbuscular mycorrhizal fungi inoculation on the growth, nutrient uptake and mycorrhizal infection of *Paraserianthes falcataria* Seedlings in the Nursery. In: Meadows, J., Herbohn, J. and Harrison, S. (eds.) Small-scale and community forestry and the changing nature of forest landscape. IUFRO Research Group 3.08 Small-scale Forestry Conference 11-15 Oct 2015, Sunshine Coast, Queensland, Australia.

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2. Extension and training materials

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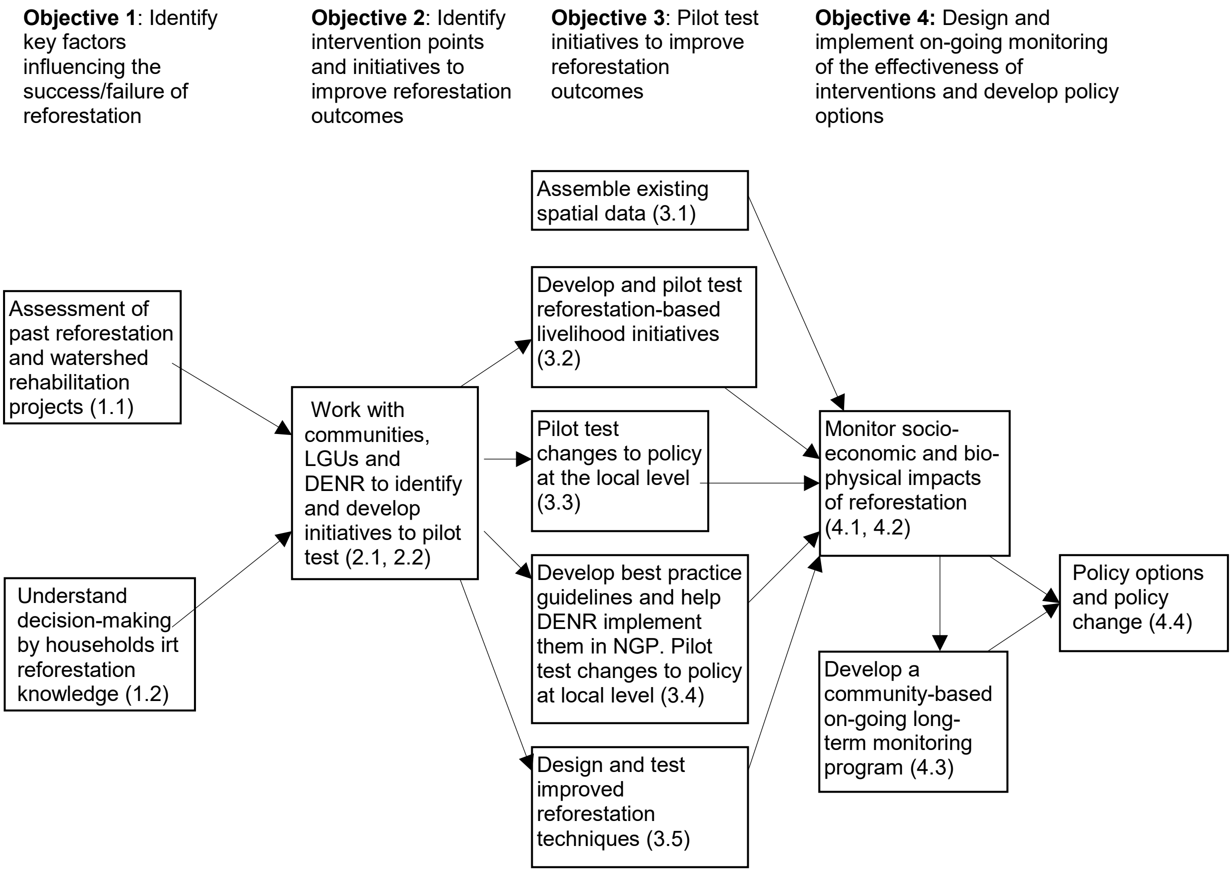
Mangaoang, Y. 2016. Common Tree Nursery Pests and Diseases in Biliran Province. ACIAR Watershed Project, VSU, Leyte

Pasa, A. What is Watershed? 2014. ACIAR Watershed Project, VSU, Leyte

12. Appendices

12.1. Outline of the research process



12.2. List of tree species planted in the mixed-species trial

Common name	Scientific name	Origin	Legume or non-legume	Succession status
Bagras	*Eucalyptus deglupta*	Native	Non-legume	1
Bagalunga	*Melia dubia*	Native	Non-legume	1
Bahai	*Ormosia calavensis*	Native	Legume	2,3
Bitanghol	*Calophyllum blancoi*	Native	Non-legume	2
Dao	*Dracontomelon dao*	Native	Non-legume	2,3
Gmelina	*Gmelina arborea*	Exotic	Non-legume	1
Hindang	*Myrica javanica*	Native	Non-legume	2,3
Ipil	*Intsia bijuga*	Native	Legume	3
Kalumpit	*Terminalia microcarpa*	Native	Non-legume	1,2
Kamagong	*Diospyros discolor*	Native	Non-legume	2,3
Mahogany	*Swietenia macrophylla*	Exotic	Non-legume	1

Manggachapui	*Hopea acuminata*	Native	Non-legume	4
Mayapis	*Shorea palosapis*	Native	Non-legume	4
Molave	*Vitex parviflora*	Native	Non-legume	1,2
Narra	*Pterocarpus indicus*	Native	Legume	2,3
Nato	*Palaquium luzoniense*	Native	Non-legume	3
Toog	*Petersianthus quadrialatus*	Native	Non-legume	3
White lauan	*Shorea contorta*	Native	Non-legume	4
Yakal	*Shorea astylosa*	Native	Non-legume	
Yakal saplungan	*Hopea plagata*	Native	Non-legume	3,4

Successional Status: Pioneer (1), Early Secondary (2), Late Secondary (3), Mature (4)

12.3. Assessment of NGP tree planting in Misamis Oriental

Four 2011 and four 2012 NGP plantations on land managed under CBFMAs and managed by a PO in the province of Misamis Oriental were surveyed. The plantations are located in the barangays of Don Gregorio Pelaez, Mat-i, Lanise and Manibay in the municipality of Claveria. All eight plantations were planted with falcata and virtually all of them were intercropped with vegetables or corn. Weed control and fertilising for these crops has had a very beneficial effect on tree growth. All plantations are small in area, the largest being 2.4ha. The most notable characteristic of these plantations is that all of the 2011 plantings are infected with gall rust (Figure 12.3a) and where trees have been replanted in 2012, the new seedlings are also becoming infected. Consequent severe pruning to remove the galls reduces tree growth and further impairs the poor form of this species (Figure 12.3b).

a b

Figure 12.3. Gall rust infection of falcata trees planted in 2011 (a) and consequent severe pruning to control it (b)

One of the most successful aspects of the NGP in Misamis Oriental is that engagement of the local population is high, e.g. in one PO, membership has increased dramatically from 20 to 125 with the advent of the NGP. This may have occurred because tree planting has been integrated with the farming system through intercropping, providing a nurse crop for coffee or as a SALT form of erosion control. At Mat-i, the NGP has reinvigorated interest in SALT technology and contour tree planting.

The least successful aspect of the NGP in Misamis Orienal has been that at high elevations (circa 1000 masl) the local provenance of falcata has proved very susceptible to gall rust, resulting in infection rates of up to 90%. Despite heavy infestations of gall rust, a PO contractor, the Paglaum Upland Agricultural Development Farmers Cooperative (PAGUADCo.) has grown another 140,000 falcata seedlings for planting in 2013 (Figure 12.3c). The quality of nursery stock is variable, i.e. some very poor red lauan seedlings have been out-planted, resulting in excessive mortality. At Lanise, planting has also been carried out underneath a dense tree canopy of secondary forest (Figure 12.3d). These seedlings are highly likely to become suppressed. A minor related problem is that the planted areas are stated as the area of each holding, rather than the actual net area planted. This results in inflated planted area estimates.

Figure 12.3c. Newly germinated and ready-to-plant falcata seedlings at the PAGUADCo Nursery

Figure 12.3d. Falcata seedlings planted underneath residual secondary forest

12.4. Summary of issues in implementing the NGP as provided by stakeholders

Activity	Issues
Site selection	No consultation with the community No consultation and agreement with land claimants
Organizational preparation	The PO was advised of the project, but there was no discussion on the roles the PO would take on in the implementation, conditions or benefits Only few PO officers were aware of the project, not other members No efforts to inform the PO members of the potential benefits PO members do not attend PO meetings Claimants are not included in project planning Limited guidance from extension officers
Empowering the PO	No community organising occurs in the NGP, unlike in previous CBFM projects Lack of identification of training needs of PO members and absence of training and capacity building Lack of support from extension officers
Implementing livelihood projects	There are no livelihood projects in the NGP except planting of coffee, cacao and in some areas, rubber tree PO generates revenue from seedling production and plantation maintenance but the budget for these activities is low
Nursery seedling production	PO not involved in species selection Some seedlings were supplied by DENR, and the PO was only assigned to plant No training on high-quality seedling production Seedlings were inspected by DENR, but low quality seedlings were accepted High mortality of wildlings in nurseries Insufficient seedling production period Limited sources of seeds and wildlings of premium species Delayed payment for seedlings
Plantation design	Not a landscape approach; no delineation of area for production, protection and agroforestry
Plantation establishment, maintenance and protection	Inappropriate practices i.e. planting layout along the slope; small planting holes to accommodate the root ball; polybags not removed when seedlings are planted Firebreak was established but not maintained due to lack of funds Weeding and strip brushing delayed due to late release of funds No fertilizer applied Very small budget for plantation maintenance
Project monitoring	Inappropriate basis for auditing reforestation success i.e. limited to seedlings produced, area planted and labour employed Limited amount of funds to implement the project and support effective monitoring of established plantations

12.5. Species of plus trees identified by the team during the inventory in Burauen, Leyte

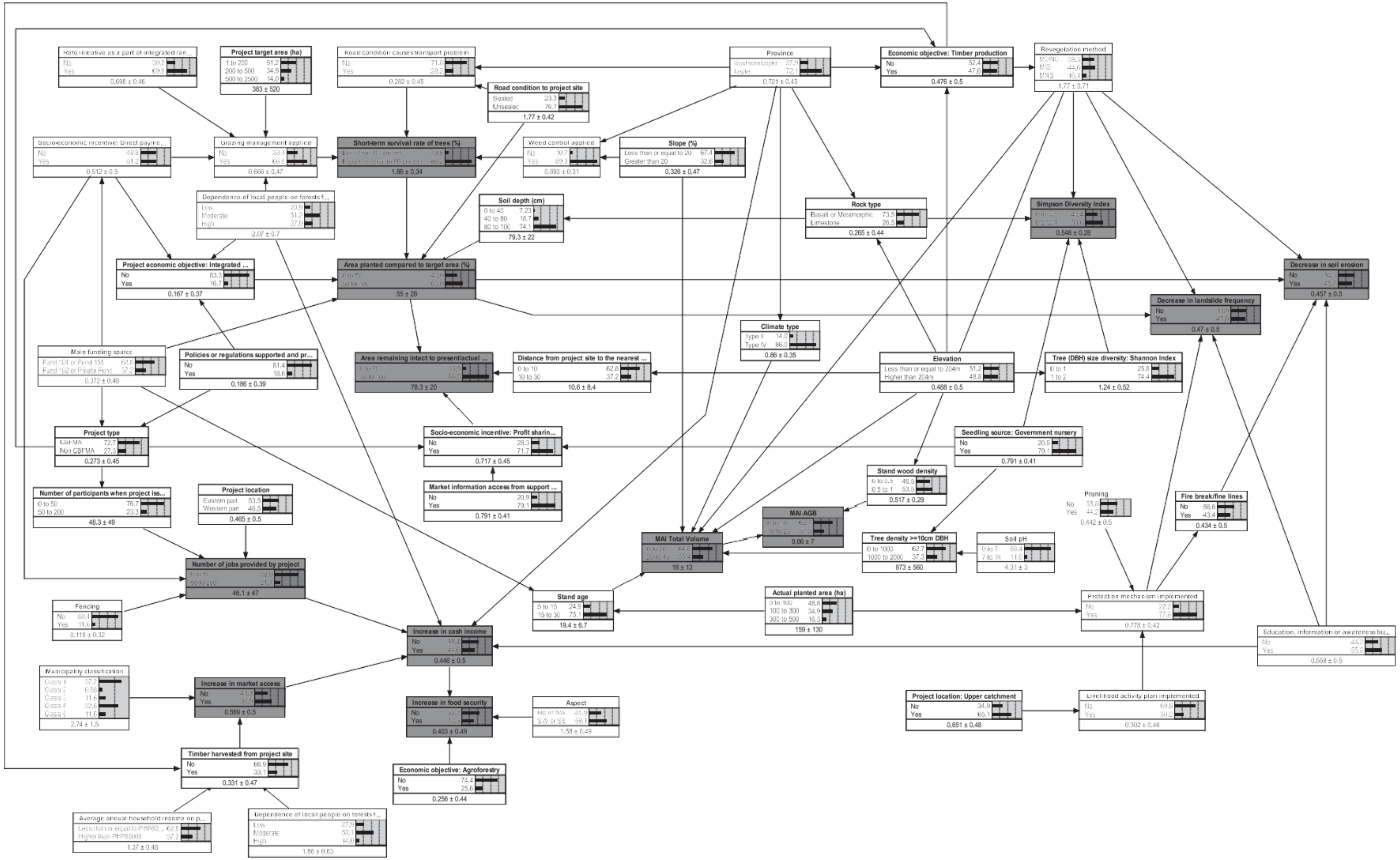
Local names	Scientific name	Family	Mean height (m)	Mean DBH (cm)
Alauihau	*Aglaia cumingianna*	Meliaceae	20.3	37.6
Bagang-aso	*Anaxagorea luzonensis*	Annonacaea	17.2	30.1
Bagtikan	*Parashorea malaanonan*	Dipterocarpacaea	24.0	64.2
Balukanag	*Chisocheton cumingianus*	Meliaceae	9.3	48.0
Banato	*Mallotus philippensis*	Euphorbiaceae	11.7	28.2
Bitanghol	*Calophyllum blancoi*	Clusiaceae	11.24	25.2
Bunguas	*Homalium gitingense*	Flacourtiaceae	17.7	30.6
Ficus spp	Unidentified	Moraceae	12.0	20.8
Hindang	*Myrica javanica*	Myricaceae	15.6	38.7
Laglag	Not known		13.1	64.4
Lanete	*Wrightia pubescens*	Apocynaceae	13.4	26.0
Kalantas	*Toona calantas*	Meliaceae	17.5	65.1
Lingo-lingo	*Viticipremna philippinensis*	Lamiaceae	17.3	38.0
Malatambis	*Syzygium hutchinsonii*	Myrtaceae	12.4	32.0
Manggasuro	Not known		18.0	33.9
Mayapis	*Shorea palosapis.*	Dipterocarpaceae	22.9	47.5
Milipili	*Canarium hisutum*	Burseraceae	13.1	31.6
Narra	*Pterocarpus indicus*	Leguminosae	16.8	49.6
Palaspas	Not known		14.3	24.3
Pili	*Canarium*	Burseraceae	14.6	30.0
Sagimsim	*Syzygium brevipaniculatum*	Myrtaceae	15.9	30.4
Syzygium spp	Unidentified	Myrtaceae	13.2	22.5
Tamayuan	*Strombosia philippinensis*	Olacaceae	20.0	61.9
Tangile	*Shorea polysperma*	Dipterocarpaceae	14.7	38.0
Ulaian	*Lithocarpus llanosii*	Fagaceae	22.0	51.2
Whilte Lauan	*Shorea contorta Vidal*	Dipterocarpaceae	19.8	40.7
Yau-yau	*Litsea micrantha Merr.*	Lauraceae	20.3	37.6

12.6. Species of potential plus trees that were identified in Villa Consuelo, Biliran

Common Name	Scientific name	Family name	Mean height (m)	Mean DBH (cm)
Alauihau	*Aglaia cumingianna*	Meliaceae	16.7	30.0
Almaciga	*Agathis philippinensis*	Araucariaceae	15.4	32.4
Almon	*Shorea almon*	Dipterocarpaceae	20.3	36.8
Amahuyan	Unidentified	Unidentified	18.8	31.0
Antipolo	*Artocarpus blancoi*	Moraceae	18.3	41.1
Apanang	*Neotrewia cumingii*	Euphorbiaceae	16.8	36.0
Bagtikan	*Parashorea malaanonan*	Dipterocarpacaea	23.5	40.4
Bahai	*Ormosia calavensis*	Fabaceae	17.5	32.0
Balobo	*Diplodiscus paniculatus*	Tiliaceae	16.8	30.0
Banai-banai	*Unidentified*	Unidentified	21.7	30.0
Bitanghol	*Calophyllum blancoi*	Guttiferae	16.7	33.1
Bunod	Unidentified	Unidentified	15.9	30.0
Cacao-cacao	Unidentified	Unidentified	18.7	31.0
Gabon-gabon	Unidentified	Unidentified	30.8	32.0
Guisok	*Hopea philippinensis*	Dipterocarpaceae	19.9	41.8
Hagakhak	*Dipterocarpus validus*	Dipterocarpaceae	19.7	34.7
Hindang	*Myrica javanica*	Myricaceae	16.7	34.3

Ilang-ilang	*Cananga odorata*	Annonaceae	20.8	38.5
Kalumpit-gubat	*Terminalia microcarpa*	Combretaceae	20.7	40.1
Kamagong gubat	*Diopyros montana*	Ebenaceae	15.9	32.0
Kaningag	*Cinnamomum mercadoi*	Lauraceae	16.1	30.0
Katmon	*Dillenia philippinensis*	Dilleniaceae	17.6	30.0
Kiya-kiya	Unidentified	Unidentified	18.5	38.0
Kulipapa	Unidentified	Unidentified	16.6	37.0
Lako-lako	Unidentified	Unidentified	18.9	33.0
Lanete	*Wrightia pubescens*	Apocynaceae	16.8	30.3
Lanipga	*Toona ciliata*	Meliaceae	18.4	35.3
Lolasona	Unidentified	Unidentified	16.9	34.5
Magsilago	Unidentified	Unidentified	17.4	43.5
Magtalisay	Unidentified	Unidentified	15.3	41.0
Mala-toog	Unidentified	Unidentified	19.2	40.0
Malapanau	*Dipterocarpus kerii*	Dipterocarpaceae	20.1	32.0
Malaputat	*Terminalia darlingii*	Combretaceae	18.9	53.0
Malasantol	*Sandoricum vidalii*	Meliaceae	16.8	30.0
Malatambis	*Syzygium hutchinsonii*	Myrtaceae	16.2	36.2
Manga-manga	Unidentified	Unidentified	17.5	41.7
Mangachapoi	*Hopea acuminata*	Dipterocarpaceae	20.9	39.2
Mangasinoro	*Shorea assamica.*	Dipterocarpaceae	18.6	34.0
Matang-araw	*Melicope triphylla*	Rutaceae	26.1	40.0
Mayapis	*Shorea palosapis*	Dipterocarpaceae	20.6	38.2
Milipili	*Canarium hirsutum*	Burseraceae	15.1	44.0
Nato	*Palaquium luzoniense*	Sapotaceae	17.6	34.8
Nino	Unidentified	Unidentified	19.8	38.7
Paguringon	*Cratoxylum sumatranum*	Guttiferae	14.9	35.0
Putian	*Alangium meyeri*	Alangiaceae	20.8	39.0
Red lauan	*Shorea negrosensis*	Dipterocarpaceae	22.1	44.9
Sagimsim	*Syzygium brevistylum*	Myrtaceae	16.9	33.0
Salay	Unidentified	Unidentified	17.6	31.0
Salngan	*Blumeodendron philippinense*	Euphorbiaceae	16.9	31.0
Tagubinlod	Unidentified	Unidentified	16.5	33.0
Tamayuan	*Strombosia philippinensis*	Olacaceae	20.2	36.7
Tanguile	*Shorea polysperma*	Dipterocarpaceae	20.2	36.7
Tiga	*Tristaniopsis micrantha*	Myrtaceae	14.8	30.0
Tuai	*Bischofia javanica*	Euphorbiaceae	17.8	40.3
Ulaian	*Lithocarpus llanosii*	Fagaceae	18.0	37.1
Watingan	Unidentified	Unidentified	18.0	36.4
White lauan	*Shorea contorta*	Dipterocarpaceae	22.1	42.3
Yakal	*Shorea astylosa*	Dipterocarpaceae	18.2	34.8

12.7. The Bayesian Nework of drivers of reforestation success



12.8. Issues and problems in implementing community-based reforestation projects and suggested corresponding interventions

Issue or problem	Cause of the issue or problem	Intervention
Beneficiaries are poorly selected	Limited timeframe for social preparation; no funds for community organizing	Adequate timeframe to prepare for program implementation; adequate resources to organize the community
Unclear rights and responsibilities of stakeholders	Lack of a sound management plan; feeling of being a contractor rather than owner of the project	Management plan that clearly indicates the rights and responsibilities of stakeholders including the PO and land claimants
Weak PO leadership	Inappropriate community organising; weak support from supporting agencies; lack of capacity building	Capacity-building; strong support and guidance from community organisers
Site-species mismatch	No consultation; absence of long-term plan (no zoning); limited germplasm sources; limited seedling production period; delayed release of funds	Site survey (vegetation and site characteristics); PO should also select the species to plant; blocking must be done to guide species selection and facilitate plantation management
Low quality seedlings	Lack of knowledge and skills; limited funds; limited germplasm sources, limited production period; delayed release of funds; ineffective implementation of seedling quality control policy; seedlings purchased from other nurseries	Training on production of high-quality seedlings; more stringent seedling quality control, e.g. nursery accreditation; inventory of mother trees; planting schedule to allow ample time for seedling production
Lack of participation of members	Only few members are involved in seedling production	Equal distribution of job opportunities and capacity to benefit financially especially in seedling production where bulk of the budget is allotted
Planting in the wrong season	Limited germplasm supply; delayed release of funds	Inventory of mother trees; improve germplasm access; timely release of funds so as not to delay the implementation of project activities e.g. seedling production scheduling
Inappropriate site preparation	Limited funds; lack of knowledge on best practice	Training on appropriate plantation establishment, maintenance and protection
Inappropriate post-establishment silviculture including absence of weeding and fertiliser application	Limited funds; lack of community participation; lack of knowledge on best practice	Training on appropriate plantation establishment, maintenance and protection; increase funds for plantation maintenance including firebreak construction; timely release of funds; application of appropriate amount of fertiliser
Limited participation and involvement of locals; only few farmers maintain and protect the trees	Inappropriate community organising; no consultation with the community; absence of livelihood projects and other socio-economic incentives	Public consultation; there must be equal distribution of job opportunities especially in seedling production where bulk of the budget is allotted
Low seedling survival rate	Site-species mismatch; low quality seedlings; inappropriate nursery, planting and post-planting silviculture; lack of maintenance; seedling damage	Appropriate site-species matching using existing scientific information and local knowledge; seedling quality regulation; training on best practice in plantation establishment, maintenance and protection

	during hauling; delayed release of funds; planting off season	
Pests and diseases	Lack of knowledge for pest and disease identification and control; limited monitoring of the plantation	Training to improve knowledge on pest and disease identification and control
Poaching of trees	Limited or absence of plantation monitoring; lack of information campaign; limited participation of the community	Collaboration with community residents and leaders; *barangay* policy to help protect the plantation; information campaign on importance of the project
Damage of plantation by stray animals	Lack of information campaign; absence of local policy; lack of involvement and participation of the community	Collaboration with community residents and leaders; *barangay* policy to help protect the plantation; information campaign on importance of the project
Forest fire	No firebreak; insufficient plantation monitoring and maintenance	Establishment of firebreak; regular monitoring and maintenance of the plantation
Unclear harvesting policies	Lack of sustained information; lack of long-term management planning including zoning according to plantation use	Development of long-term project plan; zoning of plantation to delineate production, protection and agroforestry zones; educate the PO members on the harvesting process
Sharing of benefits	Lack of organization and internal policy on sharing of benefits	Develop internal policy regarding the sharing of benefits among PO members
Inappropriate livelihood projects	Livelihood that does not match the preference and capacity and circumstance of the PO; no consultation with community and no feasibility study	Consultation with the PO and community; feasibility study
Unsustainable livelihood projects	Limited knowledge of business ventures and financial management	Training and capacity building
Corruption	Improper auditing; lack of transparency; weak organisational structure	Proper community organising; regular reporting of expenditures and income to DENR and PO members. POs accountable for reporting to DENR as mandated in the program
Ineffective governance	Unsupportive policy; loopholes in implementation of policies resulting in ineffectiveness and corruption	Assessment of policies, their appropriateness, effectiveness and implementation; improvement of implementation of existing policies or formulation of new policies
Limited support from community organiser	Shortage of funds; improper distribution of community organiser's time	Increase budget for personnel; capacity building of PO members to operate even without the extension officer
Failure to conduct periodic monitoring	Lack of funds; weak community organsing and capacity building	Increase funds; improve capacity of POs
Delayed release of funds	Red tape and bureaucracy	Improve capacity of PO to prepare documents; strong support from the extension officer or local DENR staff
Inappropriate funds	Limited funds to implement the project and support effective monitoring of established plantations	Adequate funds should be provided and livelihood projects must come with the reforestation programme
Inappropriate basis	The size of area planted is the	The socio-economic impact of the program

for auditing of reforestation success	basis for assessing reforestation success	should also be included in the assessment rather than focusing on the size of the plantation

12.9. Avifaunal species recorded in Kawayanon, Caibiran, Biliran

ORDER	FAMILY	SCIENTIFIC NAME	COMMON NAME	HA
Anseriformes	Anatidae	Anas luzonica*	Philippine Mallard	WB
Apodiformes	Apodidae	Collocalia troglodytes*	Pygmy Swiftlet	G
Ciconiiformes	Ardeidae	Bubulus ibis	Cattle Egret	G
Columbiformes	Columbidae	Chalcophalps indica	Common Emerald Dove	WG
Columbiformes	Columbidae	Spilopelia chinensis	Spotted Dove	WG
Columbiformes	Columbidae	Phapitreron leucotis*	White-eared Brown Fruit Dove	WG
Columbiformes	Columbidae	Treron curvivosta	Thick-billed Green Pigeon	FS
Columbiformes	Columbidae	Duculea aenea	Green Imperial Pigeon	FS
Coraciiformes	Alcedinidae	Halcyon smyrensis	White-throated Kingfisher	G
Coraciiformes	Alcedinidae	Halcyon chloris	White-collard Kingfisher	G
Coraciiformes	Bucerotidae	Buceros hydrocorax	Rufous Hornbill	FS
Coraciiformes	Bucerotidae	Penelopides panini*	Tariktik Hornbill	FS
Coraciiformes	Meropidae	Merops viridis	Blue-throated Bee-eater	WG
Cuculiformes	Cuculidae	Centropus viridis*	Philippine Coucal	G
Falconiformes	Accipitridae	Haliastur indus	Brahminy Kite	G
Gruiformes	Rallidae	Gallirallus torquatos	Barred Rail	G
Passeriformes	Artamindae	Artamus leocorynchus	Woodswallow	G
Passeriformes	Artamindae	Hirundo rustica	Barn Swallow	G
Passeriformes	Campephagidae	Lalaga nigra	Pied Thriller	G
Passeriformes	Corvidae	Corvus macrorhynchos	Large-billed Crow	G
Passeriformes	Estrildidae	Lonchura mallaca	Chestnut Munia	G
Passeriformes	Muscicapidae	Rhipidura javanica	Pied Fantail	G
Passeriformes	Nectariniidae	Nectarinia jugularis	Olive-backed Sunbird	G
Passeriformes	Nectariniidae	Nectarinia sperata	Purple-throated Sunbird	G
Passeriformes	Oriolidae	Oriolus chinensis	Black-naped Oriole	WG
Passeriformes	Ploceidae	Passer montanus	Eurasian Sparrow	G
Passeriformes	Pycnonotidae	Hypsipetes philippinus*	Philippine Bulbul	G
Passeriformes	Pycnonotidae	Pycnonotus goiavier	Yellow-vented Bulbul	G
Passeriformes	Sturnidae	Sarcops calvus	Coleto	WG
Passeriformes	Sturnidae	Aplonis panayensis	Asian Glossy Starling	G
Passeriformes	Timaliidae	Macronous striaticeps	Brown Tit-babbler	G
Passeriformes	Turdidae	Copsychus saularis	Oriental Magpie Robin	G
Piciformes	Picidae	Megalaima haemacephala	Coppersmith Barbet	WG
Psittaciformes	Psittacidae	Loriculus philippensis*	Colasisi	WG
Stringiformes	Tytonidae	Tyto capensis	Grass Owl	G

*Philippine endemics; HA=Habitat affinity, WB=Waterbird, G=Generalist, WG=Woodland generalist, FS=Forest specialist

12.10. Soil physical and chemical properties of the Grassland site and one-year old A. mangium and P. indicus reforested sites at 0 – 5 cm and 5 – 10 cm depths

Soil Properties	0 – 5 cm			5 – 10 cm		
	Grassland	*A. mangium*	*P. indicus*	Grassland	*A. mangium*	*P. indicus*
Bulk density	0.83 a	0.70 b	0.70 b	0.80 a	0.69 b	0.67 b
Organic C	49.62 a	47.71 a	52.34 a	32.37 b	41.65 a	45.45 a
Total N	3.70 b	3.39 b	5.86 a	4.11 b	4.11 b	5.08 a
Bray-2 P	2.87 a	3.47 a	3.10 a	1.96 b	2.29 ab	2.45 a
pH (KCl)	3.77 a	3.80 a	3.85 a	3.73 a	3.80 a	3.83 a
Exc Al	2.13 a	2.02 a	2.11 a	2.67 a	2.76 a	2.31 a
Exc K	0.32 a	0.35 a	0.43 a	0.20 b	0.26 ab	0.35 a
Exc Na	0.12 a	0.12 a	0.11 a	0.14 a	0.14 a	0.12 b
Exc Ca	0.35 a	0.48 a	0.61 a	0.05 b	0.19 ab	0.41 a
Exc Mg	0.86 a	0.81 a	0.79 a	0.59 a	0.70 a	0.71 a
Base sat.	44.09 a	47.74 a	49.25 a	28.10 b	32.50 ab	44.73 a

Means with similar letters within the same row and soil depth are not significantly different at P<0.05.

12.11. Assessment of NGP tree planting in Misamis Oriental

Soil Properties	0 – 5 cm		5 – 10 cm	
	A. mangium	P. indicus	A. mangium	P. indicus
Bulk density	-14.33 a	-14.89 a	-13.28 a	-16.22 a
Organic C	-2.41 a	6.49 a	32.88 a	44.23 a
Total N	-6.94 b	59.50 a	2.33 a	25.99 a
Bray-2 P	21.44 a	20.44 a	20.56 a	40.33 a
pH (KCl)	0.40 a	1.93 a	1.27 a	1.21 a
Exc. Al	-1.31 a	3.73 a	8.60 a	-5.19 a
Exc. K	25.44 a	48.50 a	58.82 a	92.54 a
Exc. Na	-2.84 a	-5.03 a	-0.65 a	16.03 a
Exc. Ca	117.68 a	333.73 a	-442.08 a	-3048.80 a
Exc. Mg	-3.48 a	-7.02 a	19.70 a	21.15 a
Base Saturation	15.60 a	23.55 a	26.47 a	77.03 a

Means with similar letters within the same row and soil depth are not significantly different at P<0.05.

12.12. Summary of LMEM between soil carbon and nutrient recovery with environmental attributes obtained using the package MuMin

Soil parameter	Soil depth (cm)	Explanatory variable				*DF*	*LL*	*AICc*	*∆ AICc*	*Weight*
		FA	*DIS*	*SL*	*PS*					
SOC	0-5			X	X	6	-86.12	190.71	0.0	0.47
					X	5	-88.43	191.15	0.44	0.37
		X			X	6	-87.80	194.05	3.34	0.09
		X		X	X	7	-85.54	194.42	3.71	0.07
	6-15			X	X	6	-93.6	205.65	0.0	0.44
					X	5	-96.3	206.88	1.23	0.24
		X			X	6	-94.56	207.58	1.93	0.17
		X		X	X	7	-92.25	207.83	2.18	0.15

	16-30			X	X	6	-95.67	209.79	0.0	0.42
					X	5	-98.48	211.25	1.46	0.20
		X		X	X	7	-94.01	211.36	1.57	0.19
		X			X	6	-96.47	211.39	1.6	0.19
Total N	0-15				X	5	-88.43	191.14	0.0	0.42
				X	X	6	-86.93	192.31	1.17	0.24
		X			X	6	-87.07	192.6	1.46	0.20
		X		X	X	7	-85.01	193.35	2.21	0.14
	6-15				X	5	-101.9	218.08	0.0	0.40
				X	X	6	-100.1	218.71	0.63	0.29
		X			X	6	-100.5	219.53	1.44	0.19
		X		X	X	7	-98.65	220.64	2.56	0.11
	16-30				X	5	-106.9	228.03	0.0	0.30
		X			X	6	-104.9	228.29	0.27	0.26
				X	X	6	-104.9	228.36	0.33	0.25
		X		X	X	7	-102.8	229.0	0.97	0.18
Total P	0-5			X	X	6	-80.12	178.7	0.0	0.51
					X	5	-82.76	179.8	1.1	0.30
		X			X	6	-81.67	181.8	3.09	0.11
		X		X	X	7	-79.55	182.42	3.72	0.08
	6-15				X	5	-93.35	200.98	0.0	0.42
		X		X		6	-91.42	201.3	0.32	0.36
		X			X	6	-92.33	203.12	2.14	0.14
		X		X	X	7	-90.51	204.35	3.37	0.08
	16-30			X	X	6	-98.21	214.89	0.0	0.45
					X	5	-100.8	215.81	0.92	0.28
		X		X	X	7	-96.90	217.13	2.24	0.15
		X			X	6	-99.47	217.41	2.52	0.13
K	0-5			X	X	6	-82.95	184.37	0.0	0.76
		X		X	X	7	-82.20	187.73	3.36	0.14
				X	5		-87.04	188.36	3.99	0.10
	6-15			X	X	6	-88.49	195.44	0.0	0.82
		X		X	X	7	-87.57	198.47	3.03	0.18
	16-30			X	X	6	-89.94	198.35	0.0	0.82
		X		X	X	7	-89.02	201.37	3.02	0.18

FA = fallow age, *DIS* = distance (from the nearest control forest site), *SL* = slope, *PS* = patch size, *DF = Degree of Freedom, LL = Log Likelihood, AICc = Akaike Information Criterion corrected for small sample size; **Values in the bold indicate the most influential model describing the variation in biomass carbon recovery.

12.13. The relative importance of site environmental attributes in the final LMEM.

Soil parameter	Soil depth (cm)	Explanatory variable*				Number of candidate model
		FA	*DIS*	*SL*	*PS*	
SOC	0-5	0.16 (2)	-	0.54 (2)	1.0 (4)	4
	6-15	0.32 (2)	-	0.59 (2)	1.0 (4)	4
	16-30	0.38 (2)	-	0.61 (2)	1.0 (4)	4
Total N	0-5	0.34 (2)	-	0.37 (2)	1.0 (4)	4
	6-15	0.31 (2)	-	0.40 (2)	1.0 (4)	4
	16-30	0.45 (2)	-	0.44 (2)	1.0 (4)	4
Total P	0-5	0.19 (2)	-	0.59 (2)	1.0 (4)	4
	6-15	0.22 (2)	-	0.44 (2)	1.0 (4)	4
	16-30	0.27 (2)	-	0.59 (2)	1.0 (4)	4
K	0-5	0.14 (1)	-	0.90 (2)	1.0 (3)	3
	6-15	0.18 (1)	-	1.0 (2)	1.0 (2)	2
	16-30	0.18 (1)	-	1.0 (2)	1.0 (2)	2

FA = fallow age, *DIS* = distance (from the nearest control forest site), *SL* = slope, *PS* = patch size. *Values in the parenthesis indicate the number of models containing respective explanatory variable.