Can Small Island Communities Harness Emerging Carbon Markets for Conservation?

An Examination of Ecological Capacity in the Context of the Social, Political and Cultural Environment of Kaledupa Island in the Wakatobi National Park, Sulawesi, Indonesia

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Vita

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Preface and Acknowledgements

The research on which this thesis is based could not have been accomplished without the help of others. I want to particularly thank my primary advisor, Caroline Karp, for her support in all phases of this project. I would also like to express my gratitude for Steven Hamburg and Brian Crawford, who sat on my thesis committee and advised me during the analysis and writing stages of the thesis process. As always, I would like to acknowledge my parents, Pamela George and David Austin, for their boundless support for my whole life.

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Abstract

This study examines the potential for carbon offsets activities, related to agricultural intensification and mangrove restoration, to contribute to marine conservation on Kaledupa Island in the Wakatobi National Park, Sulawesi, Indonesia. Marine conservation in this region is of especially high importance due both to the valuable biodiversity resources of the region and the importance of marine resources for the livelihoods of local communities. Carbon offset projects, which reduce greenhouse gas emissions to the atmosphere, or sequester greenhouse gases from the atmosphere, have been shown to have valuable co-benefits in the form of provision of revenues, rehabilitation of degraded ecosystems, and revitalization of environmental services. Most carbon offset projects have focused on terrestrial forest resources for offset projects due to their high capacity for carbon storage. This study addresses whether successful carbon offset projects could be developed in coastal systems to conserve marine biodiversity and system health.

To address this research question, this study examines the potential for agricultural intensification based on existing resources use patterns in both agricultural and near-shore systems. Results indicate that there are high levels of reliance on both systems, preempting radical changes in land uses such as terrestrial reforestation. In light of these constraints, this research suggests two avenues by which offset projects could be developed for the benefit of the adjacent reef fishery. First, agricultural intensification on lands owned by fishing households could sequester carbon and provide additional income to those households that already own land, potentially reducing fishing effort. Second, mangrove restoration and management could reduce

negative effects of mangrove wood harvesting for fuel, construction, and fishing equipment uses. Similarly, the dissemination of efficient cook stoves could reduce demand for mangrove wood substantially. Agricultural intensification and reduced mangrove harvesting have the potential to improve marine and fisheries health through the provision of important nursery grounds, habitat refugia, and filtration services. However, neither mangrove-based project directly reduces fishing pressure.

Kaledupa's fringing reef flats and coral reefs are being over fished and degraded. This study examines the mechanisms by which agricultural intensification, mangrove reforestation, and efficient cook stove projects could benefit the marine environment. This could be through the provision of alternative livelihoods to fishermen, through an increase in revenue for conservation, or through indirect benefits of terrestrial and mangrove ecosystem health. When evaluating alternative project options, potential marine co-benefits are examined.

This research proposes a closed-loop system whereby Operation Wallacea, a UK-based research-tourism organization that annually brings 400 students, faculty and staff to the island, could aide in the development of carbon offset credits on Kaledupa and purchase those credits to offset the emissions from their activities, particularly travel to and from the research site. Projects that benefit the marine environment directly, or generate revenue that can be used for marine conservation, can benefit local communities. In exchange, Operation Wallacea will benefit through the provision of offsets, and the benefit to the marine system on which their research activities rely.

Introduction

In 1990, 85% of people directly involved in fishing and processing of fisheries resources were small scale or artisanal fishers in Asia (Allison 2001). In Indonesia alone, coral reef fisheries are an important source of food and income generation for 152 million people, 65% of the county's 235 million inhabitants (Darwin Initiative 2008). Additionally, Indonesia's reefs are considered biodiversity hotspots as they support one of the riches areas of marine biodiversity on the planet. Ninety percent of the world's coral species and 50% of the world's reef fish can be found in the island nation (Smith 2007). This research examines the competing pressures of resource utilization and biodiversity conservation on one island in the Wakatobi National Park in Sulawesi, Indonesia. The objectives of the research are to assess the potential of a market-based marine conservation option- the development of carbon credits as a tool for marine conservation. To do this carbon credit project options were identified, the size of the market was estimated, and the benefits to the local community and marine environment were considered.

I. Background

The island of Kaledupa is the second in a string of four islands that are included within the Wakatobi National Park (WNP) in the Province of Sulawesi, Indonesia. The park falls within the biogeographically designated Wallacea region of Indonesia, an area notable for its exceptional biodiversity (Conservation International 2007). The WNP was designated in 1996 by the Indonesian Ministry of Forestry, in cooperation with The Nature Conservancy and the World Wildlife Federation, in recognition of the coral reef, mangrove and sea grass habitat that have high conservation value (Unsworth 2007).

The WNP has a population of around 100,000 people, seventeen thousand of whom live on Kaledupa (Elliot 2001), and the majority of whom rely on these vital marine resources for food and livelihoods. Population growth, advancing technology and foreign demand for marine resources have increased pressure on the marine ecosystems in the WNP. As a result, the reef system is now in a serious state of degradation; stocks have declined over the past 5 years indicating that fishing may have exceeded maximum sustainable yield (May 2004). The importance of these threatened biodiversity resources in the region has drawn regional, national and international attention to the area. This attention has manifested in conservation strategies ranging from management at the park level, to small-scale traditionally managed areas involving periodic closures and gear restrictions (Coles 2004).

Operation Wallacea (OpWall) is a UK based research and education organization that has been conducting marine science research off Kaledupa, and the nearby island of Hoga, since 1995 and contributed to the development of the National Park. OpWall brings several hundred researchers and students to Kaledupa each year to pursue scientific and social science research projects. Additionally, OpWall plays an integral role in the development of resources management at the island level. In 2005 OpWall began a partnership with the Darwin Initiative, a British government grant making organization dedicated to the preservation of biodiversity around the world. The goal of the partnership is the development of a program for sustainable management of coastal fisheries and marine resources on Kaledupa (Coles 2004).

The goal of the fisheries management program is to reduce fishing pressure by licensing and registering boats from Kaledupa, and implementing legislation to effectively close the fishery to outsiders (Coles 2004). Outside fishers have been shown to add to fishing pressure and resource destruction (Halim 2004). The plan further seeks to reduce fishing pressure by developing alternative livelihoods for Kaledupan fishermen. Alternative income sources currently under investigation are: coral and marine ornamental fish culture for sale in western aquarist markets, wildlife conservation product development, ecotourism development, improvement of seaweed culture, and the development of marketable carbon credits (Coles 2004).

II. Carbon Offsets and Biodiversity Conservation

Carbon offsets, which represent a reduction in greenhouse gas (GHG) emissions or the sequestration of GHGs through afforestation and reforestation, can be purchased by greenhouse gas emitting entities to offset their emissions (UNFCCC 2008). Background of carbon offsets and a discussion of the fundamental criteria of carbon offsets can be found in Appendix A.

There is a significant potential for forestry-based carbon market mechanisms to conserve biodiversity resources as certain ecosystems are both major sources and sinks of carbon and areas of valuable biodiversity (Koziel 2002). There is concern, however, that this mechanism may overlook valuable ecosystems that do not sequester as much carbon as forests, such as inland coastal systems or marine systems (Koziell 2002). Even in Indonesia, where a large proportion of the population lives in coastal areas, offset project efforts have focused on terrestrial conservation rather than marine conservation because these systems have significant carbon stocks and are relatively easy to measure (Delaney 1999; Dwiprabowo 2003; Ginoga 2004; Roshetko 2007; Subaruhdi 2004; Wise 2005).

Additionally, offset projects have the ability to contribute to and catalyze rural development and ecosystem restoration in low-income countries (Caviglia-Harris 2003). Offset projects can provide direct benefits such as provision of cash income, rehabilitation of degraded ecosystems, and revitalization of local ecosystem services, or indirect benefits, including provision of resources for community investment, improvement of business and market organization, and provision of training and technical assistance (Katoomba 2008). However, recent offset projects in Indonesia under the Clean Development Mechanism, which mandates sustainable development measures in addition to carbon offsets, have not generally been geared towards local development or conservation (Appendix B).

This project explores potential for offset projects to be developed that achieve three objectives;

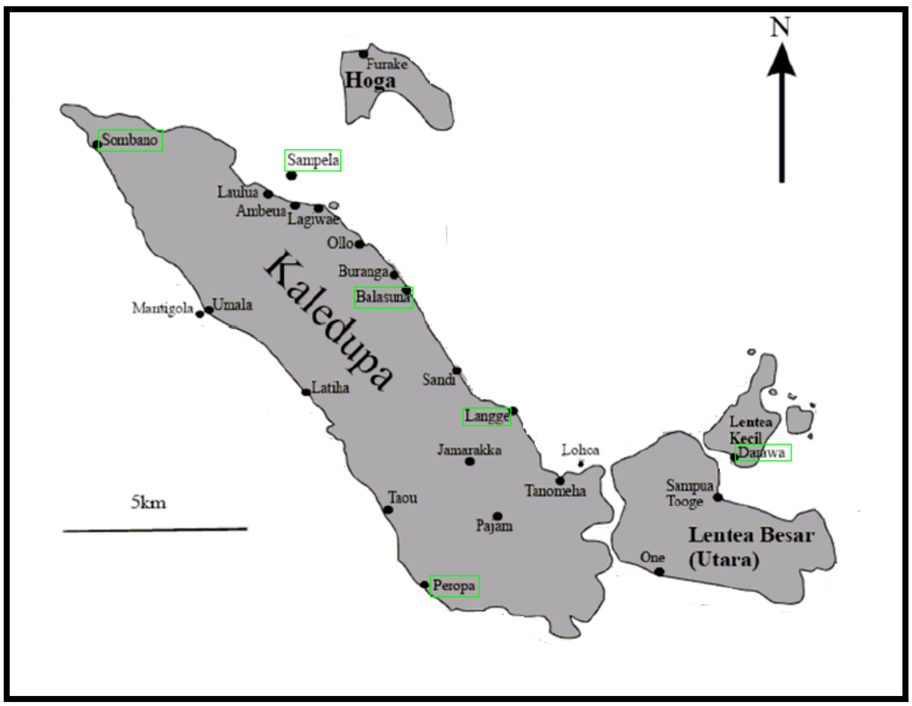
1. The generation of reliable offset credits
2. The development of benefits to local communities and sustainable development.
3. The creation of benefits to near-shore marine habitats and associated fisheries.

III. Site Description

The research was carried out on Kaledupa, an island of approximately 10,000 ha (Figure 1). The island is home to 17,000 people spread between 4,400 households in 17 villages. There are two distinct ethnic groups within the Kaledupa sub-region: 15,000 Kaledupan islanders (locally known and hereinafter referred to as the Pulo) in 14 villages; and 2,000 Bajo, a traditionally nomadic sea people who now occupy three villages constructed on stilts in the sea grass flats around Kaledupa (Cullen 2006).

The majority of both the Pulo and Bajo populations are small-scale fishermen, farmers, or traders for subsistence and income generation. The Bajo, who generally do not own land, make up almost 50% of the fishing pressure on the island (Cullen 2007). Pulo communities are generally more diverse in their sources of income: 37% rely on marine resources for their primary income generation while 25% are farmers (Cullen 2007).

Figure 1. Map of Kaledupa and Primary Villages.



High rates of deforestation in the early half of the 20th century under Dutch rule resulted in the decimation of primary teak and hardwood forests on Kaledupa (Henderson 2001). Additionally, the introduction of coconut palms for palm oil production has altered the landscape of the island

(Henderson 2001). Some heavily fragmented secondary forest is growing on the steepest slopes in the central part of the island. Mangrove forests are relatively much less degraded. Increasing pressure on mangrove forests systems, however, has led to degradation of these forests particularly in areas near population centers.

Kaledupa can be characterized as an island with highly constrained resources - there are 0.5 ha land per person on Kaledupa compared to 1.6 ha per person globally. Declining reef fish stocks indicate that the limits of the marine system may have been reached. Additionally, the Kaledupan population is currently growing at a rate of 3% per year (Kecematan 2006), nearly double the average annual Indonesian growth rate (CIA 2007). Island communities like Kaledupa exemplify the kind of resource constraints that may soon plague even large continents. According to Allison Hess: "Island futures might be likened to global futures in a microcosm: where on continents the limits are only beginning to be perceived, on some small islands they have already been reached (Hess 1990)." This exercise in determining potential for carbon credits on a small island, while specific to Kaledupa, is an exercise in assessing the appropriate balance between necessary human demands and conservation of important marine systems and biodiversity.

Research Question

Research Question: Does Kaledupa have the capacity for sustainable carbon offset projects, and, if so, which projects could most benefit the marine environment?

To answer this question, two systems were examined for their potential to develop carbon credits and benefit the marine environment; agriculture land owned by fishermen, and mangrove forests managed by the national government. These systems were selected for study due to their ability to sequester significant quantities of carbon, and the potential for project activities developed in them to have benefits for the marine fishery.

Operation Wallacea and the Darwin Initiative proposed a mechanism to reduce fishing pressure on Kaledupa that involves monitoring fish catch, developing a registration scheme, and implementing restrictions on gear type, areas where fishing is allowed, species that can be caught, and catch size allowance (Coles 2004). These regulatory mechanisms will be paired with the development of alternative livelihoods to supplement reduced income when fishing is constrained. This study examines the potential for Kaledupan fishing households to gain an alternative income from carbon credits through the development of projects that increase carbon storage on land used for agriculture.

Additionally, this research examines potential offset projects in mangrove forests. The rationale behind the examination of these systems is not to provide an alternative livelihood for individuals in an effort to reduce fishing pressure directly, but rather to conserve a habitat that is vital to the health of the adjacent reef fisheries. Mangrove forests are not individually owned but rather managed by the Ministry of Forestry (Ruitenbeek 1992). As a result, funds from offset projects in the mangrove forests will be administered at the community level and could also be used for conservation projects.

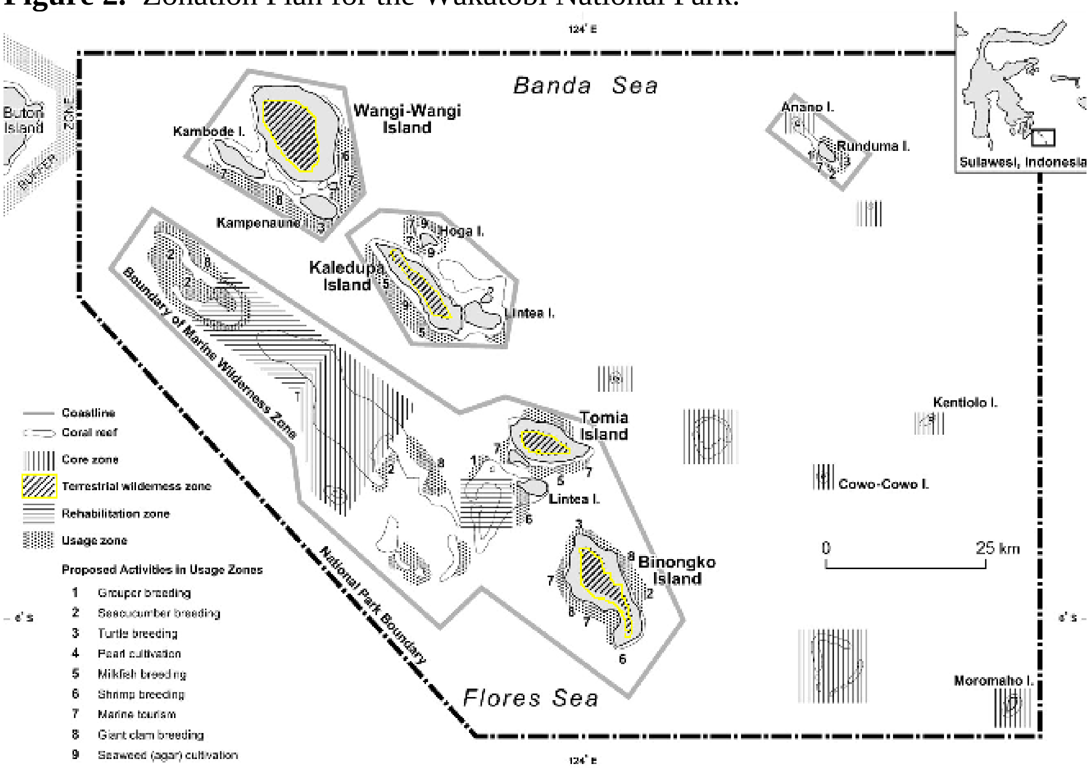
This research defines the viable scope of offset projects for conservation, identifies facilitating mechanisms for conservation, and formulates criteria for evaluating conservation project options. The results are intended to aide communities and OpWall in the formation of conservation policies that will complement basic resource use patterns, rather than conflict with them. In order to answer the fundamental research question of whether Kaledupa has the capacity for sustainable carbon offset projects, and, if so, which projects could most benefit the marine environment, two sub-questions were asked and applied to both agriculture land and mangrove forests:

1. **What are the baseline agriculture and mangrove land uses on Kaledupa and how do current levels of reliance on those land uses constrain offset project scenarios?**
2. **What are possible offset project scenarios in the agriculture and mangrove sectors, and how might they benefit communities and the marine environment?**

Due to heavy pressure on marine resources there have been recent efforts to formulate an effective management plan for the WNP. Figure 2 shows the current zonation plan for the WNP, a part of the management plant for the park (Clifton 2003). The WNP approach to marine conservation is to close designate breeding and nursery sanctuaries to fishing, and to close or regulate other reef areas. This figure below shows the proposed protected areas in the park.

The zonation plan also proposes the development of terrestrial wilderness zones on all the major island in the park. This research effort hypothesizes that a terrestrial wilderness zone like the one in the current plan will most likely fail because islanders rely heavily on terrestrial and mangrove resources. To address this hypothesis, this project describes current land uses on Kaledupa, estimates carbon in those land use systems, and quantifies the extent of reliance on terrestrial resources for food and income generation.

Figure 2. Zonation Plan for the Wakatobi National Park.



Source: Clifton, 2003. Terrestrial Wilderness Zone designated by crosshatching

After taking into account constraints on offset project options, potential offset scenarios were developed, and the possible benefits to local communities and local environments were estimated. The capacity of local institutions to facilitate the development of offset projects was taken into account, focusing on two local non-governmental actors, OpWall and the local NGO Forcani. OpWall is in a key position to facilitate this project due to its long-term investment in research tourism on the island as it has an economic interest in facilitating marine conservation, as participation is likely to decline if the marine system becomes degraded. Additionally, it may want to offset its participant's carbon emissions due to air travel to and from the project site each year. Forcani is an important stakeholder due to its history of advocating on behalf of local communities to improve access to health care, educations, and, most recently, conservation (May 2004).

Methods

The approach to the overarching research question of whether Kaledupa has the capacity for sustainable, marine-oriented, carbon offset projects required multi-disciplinary and multi-faceted methodologies. Three primary methods were used to identify resource use characteristics and further understanding of resource dependency (Table 1). These were a census of fishing households[1], in-depth interviews with farmers, and quantification of mangrove forest biomass and biomass use. Additionally, research was supported by semi-structured interviews with village leaders, NGO representatives, government officials, and OpWall experts. These interviews were used preliminarily to identify interview and issue targets, and throughout the study to further the understanding of technical, social, and legal constraints of conservation projects beyond those identified through individual household interviews.

In addition, this project estimated OpWall's GHG emissions due to airline travel in order to estimate the size of the demand for carbon offsets related to research tourism. To estimate willingness to pay for carbon offsets, a survey of 78 OpWall participants was administered to determine whether participants had purchased offsets for their flights, and whether participants could be a potential market for carbon offset projects developed on the island.

These various methods were used to optimize tradeoffs between quantity, relevance, accuracy and timeliness of the information acquired. They emphasized the importance of learning from and with local people. Additionally, the multiple approaches allowed for the comparison of

[1] This method, though truly a survey by definition, was referred to by primary implementers of the Darwin Initiative as a "census". As a result, it will be referred to as a census even though every fishing household on the island was not sampled.

results across methods, which allows for cross-check and confirmation (FAO 1997). Each method is described in Table 1 and in the following sections:

Table 1. Matrix describing the primary goals of each method, and the sub question to which each method contributes.

Sub Question	Methods Used	Primary Goals
What are baseline land uses?	Literature Review, Darwin Initiative Census, Farmer Interviews, Expert Interviews, Mangrove Forest Assessment	Identify farming system characteristics, including land area owned, crops grown, and income from agriculture
		Determine mangrove forest area and estimate Net Primary Productivity and annual biomass increment
Future Scenarios: What are limitations to future conservation scenarios?	Literature Review, Farmer Interviews, Expert Interviews, Mangrove Forest Assessment	Further understanding of resource use and dependency by determining proportion of crops sold and rates of fuel wood use
		Clarify landowner's decision-making processes regarding innovative technologies or cropping systems
		Further understanding of the constraints of traditional farming systems in order to define projects that will lead to beneficial changes in the farming community
Future Scenarios: What institutions are available to facilitate conservation projects?	Literature Review, Expert Interviews, OpWall Surveys	Identify a target market for which producers might develop a product
		Assess technical expertise available for conservation project implementation
		Identify entities with institutional and social capacity for project implementation

Source: (FAO 1997; McCracken 1988).

I. CENSUS OF FISHING HOUSEHOLDS FOCUSING ON LAND USE

Research questions were developed and incorporated into the Darwin Initiative census of all fishing households in nine representative villages between July 2007 and September 2007. A 'fishing household' is defined as an economic unit that derives its primary income from marine resources (fishing, trading or processing of marine resources). Approximately 40% of the Pulo self identify as belonging to a fishing household, while about 75% of the Bajo self identify as belonging to a fishing household (Cullen 2007). The census surveyed all 208 fishing households in eight Pulo villages, representing 14% of the estimated 1440 Pulo fishing households, and 252 fishing households in one Bajo village, representing 65% of the estimated 510 Bajo fishing households. The census was carried out by either Pulo or Bajo natives in the appropriate language and dialect to the community being surveyed.

The census focused primarily on patterns of marine resource extraction, but this research included questions regarding terrestrial resources use. The purpose of these questions was to identify the primary patterns of land ownership, use, and dependency among fishing households both in Pulo and Bajo communities. The original census questions covered basic information on family composition and ethnicity. Additional questions regarding terrestrial resource use were:

1. What is the total area of the land you use?
2. What crops do you grow on your land?
3. How much of each crop do you grow?
4. What percent of your income do you derive from the crops you grow?

Feedback from interviewers was utilized weekly in the early weeks of census operation to determine the appropriateness and utility of questions asked. Question 3 was removed after difficulties in timely response were encountered.

II. INTERVIEWS WITH FARMERS IN NON-FISHING HOUSEHOLDS

Semi-structured interviews with 47 individuals, identified by five village leaders as key farmers in their village, were undertaken to identify patterns of past, present and future land use decisions. Additional purposes of these interviews were to identify trends in land use among non-fishing households, to clarify the decision making processes among land owners regarding crop production methods, to identify the potential for future adaptation of land use, and to assess needs for technical expertise regarding land use changes.

The agriculture related interview questionnaire was formulated with Ramadika Prihartawan (Wawan), a native Kaledupan and a forestry student at the University of Kendari, and James Pepper, a geography student at University of Portsmouth. Interviews were conducted in individual, household, or small group settings. In both Pulo and Bajo households, interviews were conducted in English with an English-Pulo or English-Bajo translation by Wawan. Key questions asked are listed below.

1. How much land do you own?
2. What was the land used for before you started farming?

3. What do you use your land for?
4. What percent of your products do you sell?
5. Why did you choose to grow the crops that you grow?
6. What other crops could you grow on your land?
7. Do you have plans for expansion or diversification?

III. MANGROVE FOREST BIOMASS AND BIOMASS USE ASSESSMENT

In addition to agricultural land, mangrove forests are an important resource for Kaledupan and Bajo populations. Mangrove wood is used for cooking, heating, building materials and fishing equipment. While historically these uses have been sustainable, recent increases in demand have been shown to degrade systems and the ecological services the systems provide (Alongi 2002).

In order to rapidly assess the patterns of land use in mangrove forests, this research utilized satellite photographs and ground GPS referencing to quantify roughly the extent of mangrove forests. Additionally, direct measurements of above-ground biomass via diameter and breast height measurements were attempted but were abandoned due to safety concerns.

In lieu of direct measurements, best estimates for productivity and biomass accumulation come from four studies in the region. Mangrove forest net primary productivity in the two Malaysian studies is estimated to be between 17.7 tons C /ha /yr (Putz 1986) and 27.4 tons C /ha /yr (Hossain 2008). Using an estimate of 20% of net primary productivity stored (Duarte 1996), these studies suggest that carbon storage both above and below ground in mangrove systems is between 3.5 and 5.5 tones C / ha / yr. This estimate is supplemented by a study in the Hitchinbrook Channel, Australia, and another in the federated states of Micronesia which estimate annual above and below ground biomass at 3.5 tons C /ha /yr (Clough 1998) and 3.4 tons C /ha /yr (Devoe 1998), respectively.

Semi-structured interviews with 12 mangrove wood users in Sampela, a representative Bajo village, and Ollo, a representative Pulo village, were used to estimate the biomass extracted annually for fuel wood use. These villages were chosen based on the advice of Forcani members, who believed that they would be the most representative of mangrove wood use in communities of each ethnic group. Other uses for mangrove wood were ignored in this interview process.

Respondents were asked an open ended question of how much mangrove wood they use per day (no units were prompted). The response was always in units of number of small sticks. Measurements of a 10 stick bundle were uniformly 0.04 (± 0.01) m^3 (approximately 1m x 0.2 m x 0.2 m). These volume estimates were converted to weight using estimated densities of 800 kg / m^3 (WAC 2008). This is the average of the low estimates for density of the most abundant species of mangrove trees on Kaledupa (Analuddin 2000).

This is a conservative estimate for mangrove wood use, as mangrove wood for purposes other than fuel were not taken into account. Additionally, as mangrove wood bark is carved off before use there is a small but significant portion of the wood extracted that is not used for fuel.

Results

The results presented here indicate the baseline land uses on Kaledupa and the constraints and capacities governing future offset project scenarios. This section first presents the baseline land uses on agriculture land, and the potential projects that could be developed on agricultural land. It then presents the baseline land uses of mangroves and then potential offsets projects that could be developed in mangrove forests.

On a methodological note, about 20% of census respondents (ostensible from fishing households) claimed they derived a majority of their income from farming – likewise about 35% of the respondents from the farming survey actually self identified as primarily fishermen. These respondents were treated as if they belonged to the group that they self identified as belonging to. This experience highlights the importance of using multiple sources to triangulate trends and patterns of land use among subsistence communities.

I. Baseline Land Uses- Agricultural Land

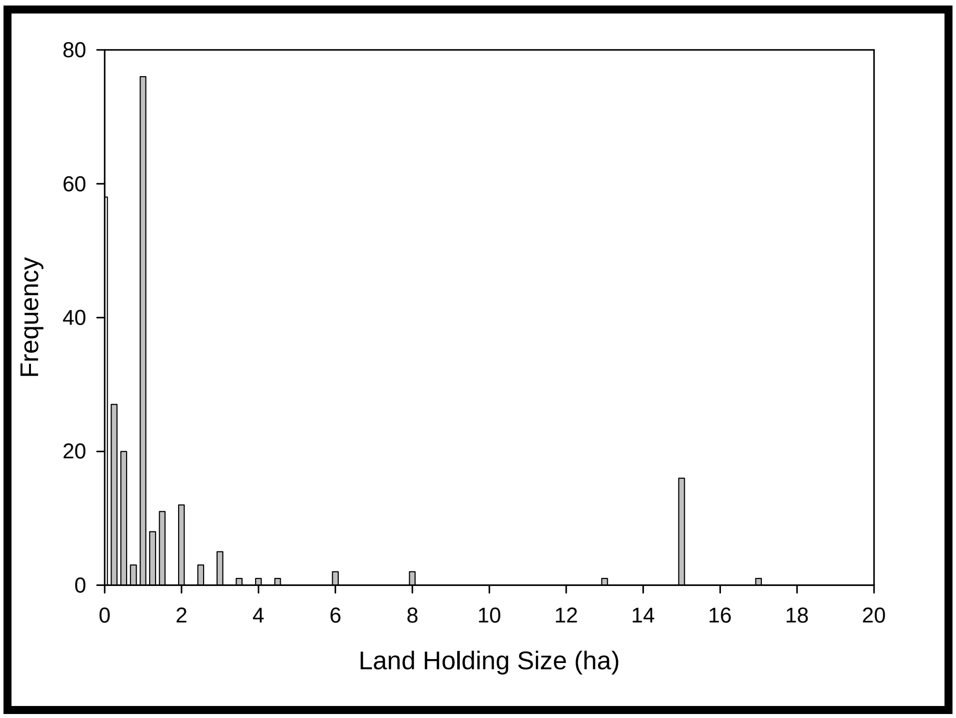
i. Agricultural Land Area

Data from the census estimated average land area owned by fishing households to be 1.1 (± 2.1) ha per household, with a median of 0.75 ha per household. This information was combined with data from the in depth interviews, which estimated that farming households own 3.5 (± 2.7) ha per household, with a median of 3 ha per household. Using an estimate of 1440 fishing households and 970 farming households, it can be inferred that Pulo fishing households utilize

1600 ha, while farming households utilize 3400 ha. Fishing and farming households thus utilize an estimated total of 5000 ha of land on Kaledupa, or 65% of the land area.

A frequency distribution of land holding sizes is shown in Figure 3 (n = 460 households). Results of the census from the village of Darawa were removed prior to the analysis as the average land holding for Darawan was much larger than that of the rest of Kaledupa, driven in part by two massive land holdings of 65 ha and 125 ha. These outliers skewed the average land holdings up significantly. The important result from this analysis is that almost 40% of households cultivate less than 0.5 ha land.

Figure 3. Frequency distribution of Land Holdings by Size (excluding outliers)



Census data was compared with data from The Southeast Sulawesi Statistics Organization (2006), the Indonesia Investment Coordinating Board (IICB 2006), and the Wakatobi census from 2000 (Table 2) (Kecematan 2000). The results demonstrate wide variance regarding land use estimates in the region; forest land estimates are particularly variable. However, agriculture land estimates are relatively uniform across previous estimates. The discrepancy between my estimates and those of the previous studies suggest that either the Darwin Initiative surveyed 9 non-representative villages to estimate total land area used for agriculture, or the classifications in the previous studies did not match those used in this research. For example, yards included in house compounds may not be easily differentiated from agricultural land.

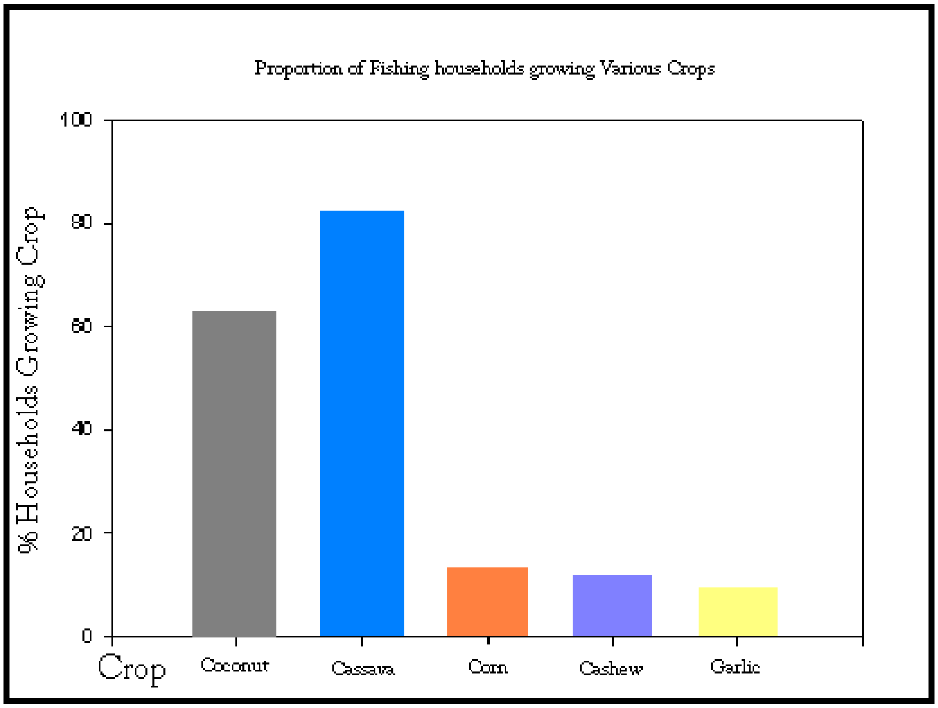
Table 2. Land Use Estimates from various organizations.

Land Use	**SSSO**	**IICB**	**Wakatobi Census**	**Current Estimates**
Yards/House compounds	1117	--	2056	--
Forest (including mangroves)	2856	6155	228	1500
Cultivated Land (and fallow)	2721	2727	3555	5000
Other	3186	992	0	2750
Total	9880	9874	5839	9250

ii. Patterns of Land Use on Agricultural land

Census data indicate that 62% of Fishing households grow coconut and 81% grow cassava. In addition, 13% grow corn, 12% grow cashews, and 9% grown garlic (Figure 4**Error! Reference source not found.**). These were the only crops reported, and represent the five major crops grown on Kaledupa according to the NGO Forcani. Forcani also noted that Cacao is grown on a few farms on Kaledupa, and fruit trees and green vegetables are grown most commonly in ‘house gardens’, or yards. Interviews with farmers and with Forcani indicate that corn and cassava are grown in a 3-5 year rotation system. Forcani staff suggest, but do not have supporting data to confirm, that fallow periods have shortened in length over the past decade.

Figure 4. Graph showing proportion of households growing coconut, cassava, corn, cashew, and garlic.



Census data also provides important information about crop diversification. Currently, almost 50% of fishing households grow only one crop - either coconut or cassava. 28% of households grow two crops, 86% of which grow coconut and cassava, and all of which grow at least one of either coconut or cassava. Twenty-one percent grow three crops, all of which grow coconut and cassava in addition to one other crop.

This research found no relationship between the size of land holdings and the percent of farming households' income derived from agriculture ($p = 0.68$, Figure 5). Research has shown that there is a positive relationship between land holding size and farm diversification (Pope 1980). This research, however, found no relationship between the number of crops grown by a household and the land area owned by that household ($p = 0.24$, Figure 6). This study did find a significant relationship between the number of crops grown and percent of farming household's income derived from agricultural activities ($p < 0.001$, Figure 7). However, very little variance was explained (R2 = 0.168). These negative findings may be due to the fact that data was not normally distributed and village samples were not random, violating some of the basic assumptions for use of parametric statistics.

Figure 5. Relationship between size of land holding and income derived from agriculture.

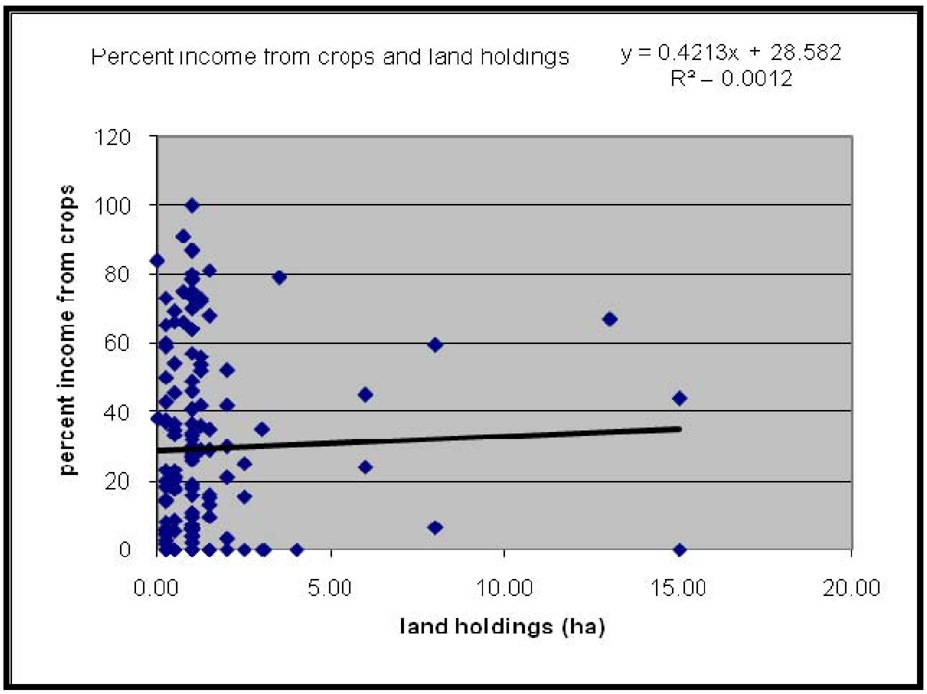


Figure 6. Relationship between land holding area and the number of crops grown

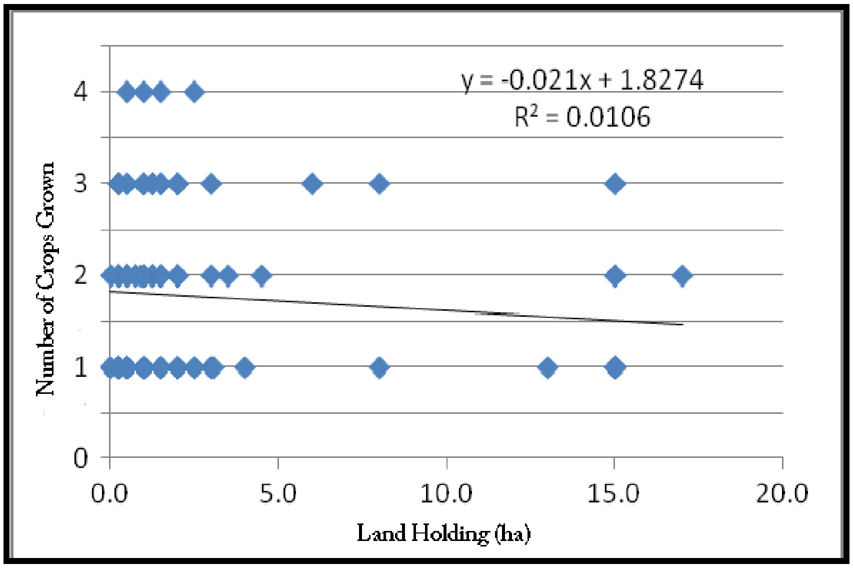
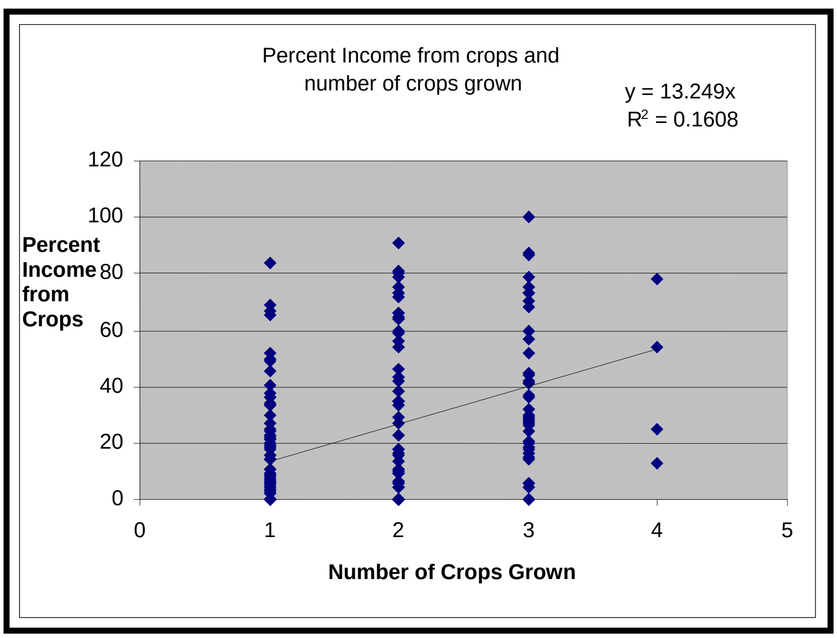


Figure 7. Relationship between number of crops grown by a household and the percent income the household derives from crops.



iii. Reliance on Agricultural land

The census and farmer interviews provide important data about income from agriculture, diversification and intercropping, and land area estimates. This information allows us to gauge reliance on land and flexibility for land use change in Pulo communities, which will define the limitations of conservation plans.

Data from the census and the in-depth interviews with farming households indicate that both Pulo fishing and farming households rely heavily on land resources, and that this reliance is primarily for household consumption rather than income generation. 77% of Pulo fishing households own land, these land owners derive 24% of their income from agriculture, selling approximately 26% of their crops and saving the rest for household consumption. Farming households, on the other hand, derive about 70% of their income from agriculture, selling approximately 51% of their crops.

Data from the in-depth interviews shed more light on the patterns of crop production and surplus generation for income. In general, both fishing and farming communities are not generating a surplus of the three main annual crops – cassava, corn and banana. These crops, in addition to rice bought from off the island, are the carbohydrate staples eaten on the island. Farming households sell only 20% of these crops while fishing households sell only 8% (Table 3). Additionally, these sales occur almost entirely on the island, indicating that there is no island level surplus of these crops.

Table 3. Proportion of agricultural produce sold, cumulatively and by type.

	Fishing Households n= 460	**Farming Households n=47**
% Produce from land resources sold	26	51
% annual produce sold	8	20
% perennial (tree crops) sold	72	73

However, the two primary tree crops – coconut and cashew – are generally sold off-island in Bau Bau as cash crops. Seventy three percent of tree crops grown by Farming households are sold and 72% of tree crops grown by fishing households are sold (Table 3). While cashew trees are grown primarily on their own, coconut trees, due to their sparse shade cover, are often intercropped with other annual crops. This allows farmers to generate income from coconut products, primarily copra, and to grow food crops such as cassava and corn (Henderson 2001).

iv. Alternative management of agricultural systems

During interviews with local leaders and farmers, questions regarding current and future crop diversification were asked. Justifications for current crop combinations included land suitability, limited knowledge of crop options, short rotations in the case of cassava and corn, and income stabilization in the case of coconut. When asked about possible diversification options, respondents listed sugar cane, cashew and teak as potential crops they could grow on their land. However, many respondents claimed that either there were no alternatives to the crops they were growing, or that they were not interested in diversification. A few respondents had plans to begin teak and cashew cultivation, but cited lack of knowledge, lack of access to seeds, and poor land suitability as limitations to successful adoption of these crops.

Farmers and local leaders explained that alternative cropping systems would need to be demonstrated as successful endeavors over a period of time before they would be adopted by villagers. A common example mentioned was a failed aquaculture project that was promising, but ultimately failed due to technological complications.

Current efforts to experiment with alternative management of agriculture land are carried out on an individual farmer basis. The risk inherent in these trials has limited the breadth of these efforts. Support, both financial and technical, needs to be coordinated on a community level. This research did not find a local organizational body already in existence on Kaledupa that would have the capacity to coordinate efforts to develop a carbon credit project in the agricultural sector. Organizations thus far have justifiably focused on the marine sector in Kaledupa and in the Wakatobi Park. The NGO Forcani, however, has the capacity to organize a farmer's cooperative, or some equivalent, to facilitate project implementation. Additionally, the status of the area as a national park draws the support of a number of regional and national governmental and non-governmental agencies which could be exploited during the development of potential carbon-credit projects.

II. Future Scenarios - Offset Project Possibilities on Agricultural Land

Due to high levels of reliance on terrestrial systems, conservation projects on Kaledupa should not conceptualize conservation as preservation of pristine natural systems. Not only are those non-existent in the terrestrial ecosystems on the island, reliance is so high on all systems that prohibiting managed use of one would only increase use of another. Instead, conservation projects should recognize agricultural production as an integral part of the terrestrial ecosystem, and one that can be sustainably managed to meet a number of objectives. Likewise, offset projects should also recognize the importance of agricultural productivity. The following section discusses the remaining project option – agricultural intensification - and its relative contribution to the three factors of interest, carbon offset capacity, social benefits, and benefits to the marine environment.

Agricultural intensification is the enhancement of agro-ecological productivity through a variety of methods, including increased fertilizer use, irrigation, or the use of machinery or draft animals. On Kaledupa, and Pacific Islands in general, agricultural intensification has predominantly occurred through the shortening of fallow periods, which has consequences on soil quality and productivity (Hamnett 1990). All of these traditional mechanisms of intensification can have negative impacts on adjacent ecosystems. Here I examine the potential for an alternative form of agricultural intensification, management for increased carbon stocks through multi-cropping and agro-forestry systems, on Kaledupa.

Despite the multiple benefits of activities that increase carbon sinks on agricultural land, there are many challenges to implementation. Often, high labor requirements, high costs of establishment, and delayed revenue returns prevent the implementation of more carbon intensive land uses (Wise 2002). High initial costs, however, ensure that the project would not have been implemented in the absence of carbon credits, thus rendering it additional. Economic returns on the initial intensification investment will also ensure that the project is permanent (see **Appendix A** for a discussion of additionality and the fundamental criteria of carbon offsets).

i. Carbon offset from Agricultural Intensification

A number of mechanisms can increase carbon sinks in agricultural systems. Kaledupa's soils tend to be poor due high levels of erosion after land clearing (Hendersen 2001). Carbon in soil organic matter and above-ground biomass on Kaledupa can be increased by:

a. using conservation-tillage or zero-tillage systems;
b. increasing biomass additions to soil through mixed rotations with cover crops, application of green manures, and application of composts;
c. adopting agro-forestry in cropping systems to increase above-ground standing biomass;
d. using soil conservation measures to avoid soil erosion and loss of soil organic matter;
e. cultivating perennial grasses (60-80% of biomass below ground) rather than annuals (20% below ground);
f. and converting marginal agricultural land to woodlands to increase standing biomass of carbon (Pretty 2002).

Table 4 lists common species used in agro forestry systems in Indonesia (Hendri 2000). These are potential crops on Kaledupa, though lower soil fertility than in other areas of the country will reduce the viability of some of these species. Much research will need to be done to determine viable species and systems for Kaledupa.

Table 4. Common Agro-forestry species in Indonesia

Resource	Species name	Common name
Timber	Dalbergia latifolia	Sonokeling
	Paraserianthes falcataria	Sengon
	Quercus sundaica	Pisang
	Tectona grandis	Teak
Fuel wood	Gliricidia sepium	Gliricidia
	Erythryna subumbrans	Erythryna
	Leucaena leucocephala	Leucaena
	Erythryna subumbrans	Dadap
Fruit	Citrus nobilis	Jeruk
	Pithecelobium jiringa	Jengkol
	Nephelium lappaceum	Rambutan
	Durio zibethinus	Durian
	Psidium guajava	Guava
	Mangifera foetida	Limus
	Mangifera indica	Manga
	Syzigium aqueum	Jambu air
	Persea americana	Avocado
	Artocarpus heterophyllus	Jack fruit
	Cocos nucifera	Coconut
Other	Ceiba pentandra	Kapok
	Bambusoideae spp.	Bamboo
	Arenga pinnata	Aren

Estimates for increased carbon storage due to increased intensification in Indonesia range widely, from 0.32 t C / ha /yr for converting traditionally managed agricultural land using reduced tillage, cover crops and compost addition (Watson 2000), to more than 20 t C / ha /yr for adopting intensive agro-forestry systems (Pretty 2002). It has been demonstrated that smallholder agro-forestry in Indonesia has moderate carbon sequestration potential (Ginoga 2002; Roshetko 2007). In multi-crop ‘home gardens’ on the island of Sumatra, Delaney and Roshetko found average above ground carbon stocks to be approximately 35 t C/ ha and soil carbon stocks of 60 t C/ ha (Delaney 1999). These results are comparable to studies estimating above ground biomass stocks of home gardens on West java between 20 and 50 t C /ha and annual Carbon increment to be between 3 – 10 t C / ha /yr (Sanchez 1999; Dwiprabowo 2003).

There are currently no baseline estimates for the amount of carbon currently stored in the agro-ecological systems on Kaledupa, though stores are probably smaller, but within the same order of magnitude, as stores reported on Java and Sumatra. In order to estimate the potential size of the market on Kaledupa, and the benefits to individual land holders, this research estimates that the increase in carbon due to agricultural intensification in the form of multi-cropping and agro-forestry activities could range from 0 to 7 t C / ha / yr, depending on the land quality and type of intensification activity (Ginoga 2002). The maximum carbon sequestration potential of 7 t C / ha / yr is the equivalent of about 25 t CO_2 / ha /yr.

One concern is that the costs of participating in the carbon market may be too high to make it worthwhile (Simon 1992). Transaction costs are discussed more fully in Appendix D. A small scale agro forestry project in the Cianjur District of West Java reported up-front costs of between 9.70 USD and 12.50 USD per ton of CO_2 sequestered (Subarudi 2004). The largest portions of these total costs were for tree planting, seedlings and farmer training (Subarudi 2004). Subsequent costs of maintaining, monitoring and reporting are expected to be much lower. This research uses and estimate of 4.00 USD based on estimates from the BioCarbon Fund of the World Bank of carbon sequestration prices between 3.00 USD and 5.00 USD per ton CO_2 (WBCFU 2008).

Intensification projects may be economically viable and could provide individual land holders with a significant source of income. Fishing households own approximately 1 ha of land used for agriculture. If this land is managed for moderate carbon storage of about 25 t CO_2 / ha, this could provide those households with an additional 300 USD per year, assuming a carbon price of 16 USD / ton CO_2, an implementation cost of 4 USD / ton CO_2, and no discernible effect on crop yields. This compares to current estimates of income from agriculture of between 220 USD / yr and 440 USD / yr (Cullen 2007).

ii. The Social and Environmental Benefits of Agricultural Intensification

Another important reason to further investigate carbon intensification on agricultural land on Kaledupa is the potential for projects to provide additional benefits to local communities. Studies have shown that agro-forestry has social, economic and environmental benefits for land users at all levels (ICRAF 2004). Additionally, there are a number of benefits of agricultural diversification such as provision of income, stabilization of incomes, reduced demand for imports, more sustainable utilization of natural resources, and sustainability (Timmer 1990; Karama 1992). While different carbon intensive systems provide different social and environmental benefits, the general benefits in these two areas are listed below (Simon 1992; Ginoga 2005).

Social Benefits:

1. Steady employment – improved distribution of labor
2. Increased total production to meet the supply deficits

3. Provision of increased income opportunities

Environmental Benefits:

1. Reduced pressure on existing forest resources through development of fuel wood resources
2. Rehabilitation of watersheds and the control of erosion
3. Increased sustainability and improved soil fertility

Agricultural small holders have an incentive to develop tree farming systems for economic reasons: to meet household needs, to produce for market demand, and/or to reduce risks through diversification of income stream (Roshetko 2007). Land owners also have an incentive to development agro-forestry systems for environmental reasons. Trees can improve productivity and sustainability of land, help prevent land degradation and increase biodiversity while still allowing for utilization of land for the production of agricultural products (Wise 2002). Interviews indicate that the challenges to implementation are diverse, although most farmers reported lack of access to information and seedlings as the primary reasons for current agricultural practices.

iii. Benefits of Agricultural Intensification for the Fishery

Agricultural intensification may benefit the marine environment through improved erosion control and reduced siltation. Additionally, the cultivation of wood resources on Kaledupa could reduce demand for wood from the mangrove forest, which could have indirect benefits for the adjacent fisheries as it would alleviate pressure on mangrove forests. Mangroves provide breeding grounds, juvenile fish refugia, filtration services, and supply nutrients to adjacent habitats (Bann 1997).

However, implementation of Agro-forestry projects on Kaledupa has no direct relationship to the improvement of fisheries resources unless it results in exit of fishers from the fishery, which is unlikely. In addition, Bajo households do not own land, but comprise almost 50% of the pressure on the fishery (Cullen 2007). Projects that aim to reduce pressure on the fishery by increasing productivity and income from terrestrial sources will leave out the entire Bajo population of over 500 households in addition to approximately 1500 Kaledupan households that do not have access to agricultural land resources.

At most, agro-forestry projects will be applicable to the 970 Kaledupan households that derive their primary income from farming, and 1150 Kaledupan households that derive their primary income from fishing but also farm (80% of Kaledupan fishing households. The estimated 2100 households with land holdings make up approximately 40% of the total pressure on the fishery from both Kaledupan and Bajo households.

Additionally, the relationship between the provision of alternative livelihoods and a reduction in fishing pressure is under scrutiny. Particularly in very poor communities, the provision of ‘alternative’ livelihoods often results in supplementing, rather than substituting for existing sources of income (Pollnac 2005). The efficacy of an alternative livelihood program depends on the application of the project, but it can be reasonably hypothesized that the implementation of an agro-forestry project among the approximately 2100 households that might benefit from an alternative livelihood will not reduce the pressure on the fishery by the full 40% applied by those land owners.

III. Baseline Land Uses - Mangrove Forests

i. Mangrove Forest Area

Information collected on the extent of mangrove forests and current fuel wood use rates contributes to understanding of the current pressures on mangrove forests on Kaledupa. The mapping of fringing mangrove forest using GPS measurements indicate that there are 1500 ha of mangrove forests on Kaledupa (Figure 8). Using a conservative estimate of 3.5 t C/ha/yr, this research estimates an annual biomass increment in all Kaledupan mangrove forests at approximately 5250 t C.

ii. Reliance on Mangrove forests

Interviews from ten families in the Bajo village of Sampela indicate that Sampelan households use approximately 12,000 (± 5000) kg mangrove wood per year for fuel wood. Assuming that Sampela is representative of all Bajo households, Bajo communities use about 6000 (± 3000) tons of mangrove wood for fuel per year. On the other hand, interviews from ten families in the Pulo village of Ollo indicate that Pulo households use approximately 4000 (± 1500) kg mangrove wood annually. Assuming this is representative of all Pulo households, Pulo communities cumulatively use about 15,000 (± 6000) tons of mangrove wood for fuel each year.

This indicates that on a daily basis, Pulo use only one-third the amount of mangrove wood that the Bajo use. However, the Pulo population is eight times the size of the Bajo population. Thus the Pulo population uses more than twice the amount of mangrove wood than the Bajo use on an annual basis. In sum, both Bajo and Pulo households use a little more than 20,000 (± 8,000) tons of mangrove wood for fuel use each year, even though harvesting of mangrove wood is illegal on the national level (Ruitenbeek 1992). Twenty thousand tons of mangrove wood is equivalent to about 10,000 tons of carbon or almost 37,000 tons CO_2 (BFIN 2008).

Pulo communities on Kaledupa are appropriating almost twice the annual biomass increment from the surrounding mangrove forests. Additionally, interviews and direct observations indicate that more easily accessible mangrove forests have higher rates of extraction and thus greater degradation, a pattern that will exacerbate degradation of forests at the village level.

Figure 8. Map of Kaledupan mangrove forests.

Mangrove Forests Designated by Cross-hatching.

iii. Alternative management of Mangrove forests

Indonesia's national government, through the Ministry of Forestry, prohibited extraction of mangrove wood for any use in 1990 (Ruitenbeek 1992). This legislation, however, had not been 'socialized' on Kaledupa until December of 2006, when the Ministry of Forestry implemented the first program to improve health of degraded mangrove forests. This project included both the socialization of the legislation, which involves an education campaign to draw attention to the importance of healthy mangrove forests, and trial reforestation of 50 ha of severely degraded mangrove forests (Suhaidin 2007).

The process of reforestation involved site identification using soil texture analysis, harvesting of Bruguiera Gymnorhiza and Rhizophora Stylosa seedlings from Kaledupan mangrove forests, and planting more than 35,000 seedlings in two 25 ha areas on the northeastern coast of Kaledupa (Suhaidin 2007). The overall success of the reforestation projects cannot yet be determined, although the local director of the program expressed consternation that only approximately 10% of planted seedlings appeared to be successful (Suhaidin 2007). Unfortunately, funding for the reforestation project was cut in spring of 2007. However, some preliminary socialization, training and capacity building among Kaledupan villages regarding the importance of mangrove forests was accomplished.

IV. Future Scenarios – Carbon offset projects in Mangrove Forests

Like agricultural land, one option for reducing mangrove degradation is to manage mangrove wood more efficiently. Unlike agricultural land, reducing damage can also be achieved by reducing demand for the resource.

i. Mangrove Reforestation

Replanting and managing forests on marginal or degraded land may be one way to meet demand for mangrove fuel wood resources and mitigate current rates of degradation. Ong demonstrated that managed, monoculture forests in Malaysia can sequester more than 6 t C / ha /yr on average (Ong 1993), an increase of 3 t C/ ha /yr over current estimated rates. Monoculture reforestation would not be as beneficial to the adjacent fishery, but would be more beneficial than severely degraded forests.

Low estimates for the up-front costs of mangrove reforestation are around 250 USD per ha (Lewis 2001). Assuming rates of carbon sequestration at around 3 t C / ha greater than before project activity, that would equate to upfront costs of about 80 USD per ton of Carbon sequestered, or about 22 USD per ton of CO_2 sequestered. However, if we assume the rate of forest productivity increase as a result of project activities stays constant, the rate of return on investment will increase over time. Carbon credits may be one way to fund the development of programs to reforest degraded areas.

ii. Moderation of Demand for Mangrove Wood

Another option is to reduce demand for mangrove fuel wood. This has been done around the world through the introduction of efficient biomass burning cook stoves. These stoves cost between 1 USD and 5 USD and can save up to 40% of the wood fuel normally consumed in open fires, and 25-35% of the fuel consumed in typical stoves (FAO 1999). If stoves are implemented in 25% of Bajo households this could save approximately 500 t C/ yr, or 1800 t CO_2 / yr, and if implemented in 25% of Kaledupan households this could save approximately 1000 t C / yr, or approximately 3600 t CO_2 / yr. Assuming stoves costs approximately 5 USD, upfront costs would be between 1 USD and 2 USD per ton of CO_2 sequestered.

iii. Implications for Community Welfare

In addition to benefits for the fishery, mangrove forests provide physical services in the form of storm protection, erosion control, and filtration services. Cumulatively, these benefits constitute an important communal resource for Kaledupans, both Bajo and Pulo. Implementation of a reforestation program in neighboring Ujung Pandang, south Sulawesi, highlights the positive benefits for local communities (Babo 1998). In this community based project about 700 ha of mangrove were replanted. Stakeholders experienced increases in ecosystem goods and services from the restored mangrove forest, in addition to benefits from increased eco-tourism.

iv. Implications for the Fishery

Both mangrove forest management and the reduction of demand for fuel wood will have positive benefits for the adjacent fishery. Mangrove forests provide breeding sites, nursery grounds, and habitat refugia for many fish species (Alongi 2002). One study estimated that for every hectare of mangrove forest cut down, there is a corresponding reduction in fish catch of 1.08 t / ha/ yr (Melana 2000). These effects are direct and well-documented. Costanza et al. (1998) estimate the ecosystem service value of mangrove forests at 9990 USD / ha / yr, up to 1/3 of this estimate is derived from the value of the benefit to the adjacent fishery. The remaining value is derived from the direct extraction of resources and the indirect ecosystem services that the forests provide. This estimate is supported by another study focusing on adjacent fisheries, which suggests that the market value of capture fisheries supported by mangroves ranges from 750 USD to 16,750 USD / ha / yr (Ronnback 1999).

V. Alternatives: Seagrass Carbon Storage

Seagrass systems on Kaledupa are vital habitat, and provide breeding and nursery grounds for important reef fish species. A credit project could be developed that generated carbon credits through the reduced degradation of seagrass habitat. It is estimated that seagrass flats sequester 0.015 to 0.15 t C / ha /yr (CITE). The area of seagrass beds on Kaledupa is estimated to be approximately 5000 ha. This means that the seagrass habitat on Kaledupa sequesters 75 – 750 tons C in total.

The benefits of reducing degradation of seagrass flat for adjacent marine systems are expected to be large. This is one project option that would ensure direct benefits to the fishery, as opposed to alternative project options examined that have only indirect benefits.

VI. OpWall Capacity and Participant Offset demand

Each year almost 400 students travel to Kaledupa to participate in research with OpWall. Most students travel from England, although there are a few students from Scotland, Ireland and the US. Most common routes from London to Kendari are through either Dubai or Singapore and then through either Jakarta or Denpasar. This research used the average round-trip distance traveled from London to Kendari through each of the possible routes, 17,000 mi (27,400 km), to represent the distance traveled by all 400 students. The CO_2 emissions due to this trip are approximately 7.5 tons of CO_2 per person, or 3,000 tons CO_2 for all 400 participants. Using a conservative estimate of between 12 and 18 USD per ton CO_2, the price of an offset for a flight from London to Kendari would be between 90 USD and 135 USD (Bowell 2007). Thus, total revenues generated for carbon offset projects could be between 36,000 USD and 54,000 USD.

None of the 78 respondents to the willingness to pay survey administered during the summer of 2007 purchased offsets for their travel to and from the project site. However, about 60% claimed they were willing to pay for a flight offset. Of those willing to pay for an offset, 22% were willing to pay the offset to the local NGO Forkani, 22% were willing to pay the offset to OpWall, and another 22% were willing to pay the offset to either organization. Thirty four percent of respondents indicated that they would want to buy offsets directly from a carbon market, many of the same respondents expressed reservations regarding the nature of potential offset projects on Kaledupa. Additionally, a few participants had questions regarding how offset projects would benefit the local community. While gauging willingness to pay is important, OpWall should consider incorporating the offset costs into their participation fee.

Conclusions and Recommendations

I. Comparing Offset Options

This research project asks the question: Does Kaledupa have the capacity for sustainable carbon sequestration projects, and, if so, which projects could most benefit the marine environment? The main finding of this project is that a variety of carbon offset projects could be established on Kaledupa in ways that contribute to marine conservation. My key findings are:

- Agricultural intensification could result in increases of carbon stocks of 0 – 7 tons C / ha / yr, resulting in net revenues of up to 300 USD / ha / yr.
- Mangrove reforestation could result in increased carbon stocks of about 3 tons C / ha / yr, resulting in revenues of up to 175 USD / ha / yr.
- Efficient cook stove implementation could reduce mangrove fuel wood use by 40%, for example from 6000 tons annually to 3600 tons annually in Bajo households. This savings in Bajo homes could generate carbon credits worth more than 70,000 USD.
- Each project option has different co-benefits (Table 5).

Agricultural intensification for carbon credits is an option that could provide individual land owners with an additional source of income. One shortcoming of this project option, however, is that it leaves out Bajo communities which don't own land, but represent 50% of the fishing pressure on the island. Additionally, there is no assurance that fishing households would be willing to leave the fishery even if income from agriculture was increased as fishing plays a significant cultural role on the island.

Table 5. Criteria for Evaluating Project Options.

		Potential Offset Project:		
Characteristics of Project:		**Agricultural Intensification**	**Efficient wood stoves**	**Mangrove restoration**
Community Welfare	**Equity**	No Bajo benefits	Both benefit	Both benefit
	Income	Positive	Positive	Neutral
	Food Security	Good	N/A	Good
Environment	**Terrestrial**	N/A	N/A	N/A
	Marine	Indirect	Good	Good
Carbon	**Additionality**	Information and Financial Barriers	Information and Financial Barriers	Information and Financial Barriers
	Leakage	Good	Good	Good
	Permanence	Depends on Economic viability of project	Depends on acceptance of technology	Depends on management
	Upfront Costs (per ton CO2)	About 10 USD, Slower rate of return	About 1-2 USD, Fast rate of return	About 20 USD, Slower rate of return

Projects in the mangrove forests may have more direct benefits to the fishery through improved habitat. However, a serious shortcoming of mangrove focused projects is that they will not reduce fishing pressure. Additionally, since mangroves are not privately owned, questions of distribution of funds are salient. In the case of mangrove forest management, community or government ownership could cause tension between various stakeholders. Mangrove cook-stoves could also generate significant funds, the use of which could have widely varying implications for project success, marine conservation, and community welfare. While this research does not attempt to clarify those questions, issues of ownership and distribution of funds will need to be addressed before project implementation.

An important consideration for all projects is the importance of visibility of project benefits to the community. Pollnac and Pomeroy (2005) demonstrate that perception of benefits influence involvement and participation in coastal management project in the Philippines and Indonesia. Involvement in management projects enhance the likelihood that project benefits are those desired by the host communities (Pollnac, 2005).

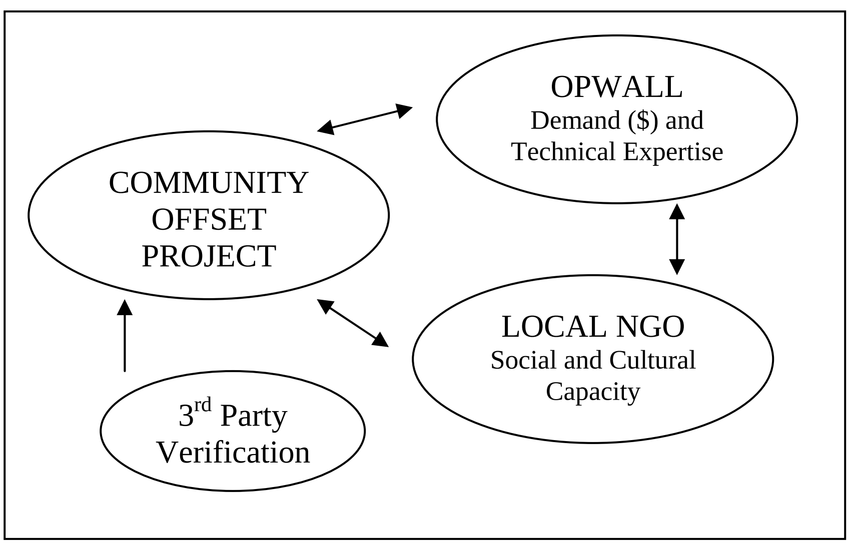
II. Recommendations

The Wakatobi's unique marine resources are under pressure from coastal communities, visitors, and pressures associated with global markets for marine resources such as sea cucumbers and sharks. The Indonesian government, via the Ministry of Forestry, is attempting to use traditional conservation methods such as mandatory licensing, seasonal bans, and closures to protect identified coral reefs, sea grass beds, and mangroves understood to be important breeding and nursery grounds (Halim 2004). These efforts can be supplemented to generate funds to support local conservation bank that could finance local conservation projects, purchase and retire fishing vessels, and purhase fishing rights. These recommendations are presented below.

i. Project Implementation and Operation

Due to high transaction costs and institutional complexity of certifying carbon offset projects with the Clean Development Mechanism of the Kyoto Protocol, a closed loop system may be a better alternative (see Appendix B for a discussion of the Clean Development Mechanism in Indonesia, and Appendix C for a discussion of transaction costs). OpWall can provide demand for carbon offsets, investment capital, and the basic research and monitoring necessary for project implementation. This research recommends that if OpWall pursues the implementation of offset project development, funds generated by those offset projects are used for community development and the conservation of the marine system. Thus, communities could benefit directly from project implementation through cash income, rehabilitation of degraded systems and revitalization of environmental services, and indirectly through community investment, business organization, and training. In exchange, OpWall will benefit through provision of carbon offsets, and potential benefits to the marine ecosystems on which their activities rely. The local NGO Forcani has the capacity to act as a facilitator of this relationship, carrying out project implementation within communities and negotiating agreements at the local and regional government level (Figure 9).

Figure 9. Proposed Organization of Credit System.



This closed-loop system has the potential to be replicated in other areas where research tourism and eco-tourism enterprises have developed. Carbon offset projects can be facilitated by tourism organizations, which visitors can purchase to offset their emissions to and from the site.

Community hosts will benefit from increased revenue from tourism, and rehabilitation of degraded ecosystems, while tourist ventures will benefit through a more pristine environment for visitors to enjoy.

ii. Project Implementation to ensure community benefits

The final recommendation of this research is that project implementation must include local community members in order to ensure socially beneficial outcomes of credit projects. While the positive benefits have the potential to be significant, many projects fail to achieve their desired environmental and social outcomes, often due to the lack of inclusionary mechanisms for local community members, who can better account for the dynamics of local resource use (CIFOR 2007).

The experience of Subarudhi et al. (2004), who established small scale carbon credit projects on 17.5 ha of land in West Java, demonstrated the challenges associated with the implementation of small scale afforestation and reforestation projects in Indonesia (Subarudi 2004). Their project followed a participatory approach, which included the consideration of local capacity, local labor, added value and other benefits. Before field implementation, training of farmers was conducted through a participatory approach, following Participatory Rural Appraisal (PRA) principles. While successful, Subarudi et al. (2004) listed a number of important characteristics of a project to ensure acceptability and success. Below I address how each would be integrated into a carbon offset project on Kaledupa:

a. Participatory Planning: For successful project implementation, participatory planning should be done properly by involving all relevant stakeholders. On Kaledupa this would mean involving the local NGO Forcani, OpWall representatives, government officials, village leaders, fishermen, and other local representatives. For agriculturally based projects, farmers and farming groups must be included.

b. Leadership: Choosing a credible person as community representative is a determining factor for the success of active stakeholder participation in the project planning process. Another factor is the selection of a good facilitator to manage group meetings.

c. Clarification of Ownership: Defining ownership is essential to project success as tenure disagreements can stall project implementation. This is the case in agriculturally based projects, but of particular significance regarding the ownership of the Sombano inland mangrove. While the fringing mangroves on Kaledupa are nationally protected, responsibility has been delegated to the regional governments or the local community in the absence of regional action. The mangroves on Kaledupa are treated as open access resources and there is no observable enforcement of harvesting prohibitions. This has led to individual extraction from the forest and the encroachment of individual agriculture activities. Clarifying the ownership of this valuable resource will be required before decision making about project implementation in that area can be accomplished.

d. Establishment and Capacity Building of Farmer Groups: For agriculture based projects, the establishment of a farmer group is very important. On Kaledupa there are informal groups that have developed in villages. Carbon credit projects will require more formal development of village level farming associations, and inter-village connections in order to facilitate the improvement of farmers' skills and knowledge in the project activity. Various activities can be conducted for capacity building, such as: (i) training, (ii) field demonstrations, (iii) study tours, (iv) forestry-extension activities, and (v) field discussions with relevant experts. Additionally, a system to ensure that farmers developing carbon credits will also reduce pressure on the fishery is important.

e. Project Monitoring and Evaluation: Monitoring allows project implementers to quantify the additional carbon benefit of project activities, and is essential to the credibility of the project. Additionally, it is a learning tool that allows project implementers to review the progress of the project, and to propose modifications to achieve objectives in the face of unexpected events. Finally, third party verification of offsets is vital to the legitimacy of project development.

iii. Future Research

The ultimate outcome of this research is to provide recommendations regarding carbon credit project options that merit further study. There is a capacity for successful carbon credit projects on Kaledupa, but these projects should be much more fully researched before credible credits can be developed. More accurate quantification of baselines and more accurate quantification of the carbon value of future scenarios must be measured. The following research should be undertaken so that projects can rely on an adequate knowledge base:

1. Estimate land uses with greater accuracy. This may involve the use of satellite imagery and remote sensing, although distinguishing degraded secondary forest from farmland and various crop patterns is difficult unless a supervised classification is conducted.

2. Determine baseline carbon stocks in agro-ecosystems. This would require the quantification of above ground biomass, particularly perennial plant and wood plant biomass, and soil carbon in current agricultural systems on Kaledupa

3. Determine viable agro forestry and carbon intensive agriculture systems, the carbon value of their increased storage capacity, and the added environmental benefits of their adoption.

4. Estimate mangrove wood use with greater accuracy. This should include better estimates for fuel wood use, in addition to estimates for other mangrove wood uses, in order to improve accuracy of baseline estimates.

5. Investigate social and environmental and political challenges to project development, and potential outcomes of different project options.

iv. Concluding Remarks

This research has attempted to define the bounds within which carbon credit projects might be developed on a small island by defining project characteristics that will develop economic opportunities while ensuring the community's sufficient access to resources. The challenges to project development are significant, but not insurmountable. As resources become similarly constrained around the world, this exercise in identifying possible carbon offset project options may become more common. It is hoped that these options can successfully improve welfare of local communities and can serve as a prototype for similar projects in the region.

Appendix A. Fundamental Criteria of Carbon Offsets (UNFCCC 2008)

Carbon offsets are behaviors that decrease the amount of carbon entering the atmosphere or biologically sequester carbon from the atmosphere. Offset types currently produced include renewable energy production, carbon sequestration or energy efficiency measures. The fundamental criteria for offsets are to demonstrate additionality, and to demonstrate no leakage, double counting, or future counting:

1. Additionality: Without demonstrating that the project would not have happened due to regulations, financial incentives, or information barriers, the project cannot be considered an offset because those behaviors are not additional to 'business as usual' patterns. The UNFCCC prescribes the following methodologies to ensure additionality:

   i. Preliminary screening based on start date of project – prove that project was initiated in anticipation of credits

   ii. Identification of alternative land use scenarios – In the absence of project, what would have happened? If there is only one option, then the project is not additional. This is also known as defining the baseline: The determination of a baseline by which to assess carbon sequestration is critical as it provides the frame of reference for determining how carbon sequestration projects are contributing to the net carbon sink at either the project or national level.

iii. Investment analysis- demonstrate that project activity would not be economically attractive in the absence of CDM funding (i.e. costs too high, profits too low)

iv. Barrier analysis – determine whether there are technological, economical, organizational, social or cultural barriers to project implementation. Barriers demonstrate additionality if they are sufficient to prevent the project without CDM funding.

v. Information analysis – determine the extent to which information regarding project activity is available to stakeholders

vi. Common Practice analysis – determination of extent to which similar project have diffused into geographical area

2. Leakage: Projects must not exhibit leakage, the deflection of carbon emitting behaviors to another location.

3. Double Counting: Clear and organized accounting must ensure that carbon resources are not counted twice, particularly in projects involving the participation of many landowners.

4. Temporal issues:

i. Permanence: A ton of avoided CO_2 emissions is a permanent concept. Permanence implies that the ton will be held out of the atmosphere "forever." Project planners must examine development trends in order to determine whether reforested areas will remain forested for the foreseeable future.

ii. Future offsets: The project must not rely heavily on future offsets because these offsets are less reliable and the carbon sequestered in the future does not equate carbon sequestered now due to the resonance time of CO_2 in the atmosphere.

iii. Accurate estimation of Project timeline: overestimation of the length of a project is a ubiquitous fault of sequestration projects. Forest ecosystems will sequester more carbon at the start of a project when trees are young and growing rapidly. However, as trees reach maturity growth functions will plateau and net carbon sequestration will become very small. At this point the project is completed- no further credits should be issued.

Appendix B – CDM in Indonesia

The Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC), commits regulated industries in developed countries to stabilize GHG emissions (UNFCCC 2008). Flexibility mechanisms were developed to allow industries to purchase offsets for their emissions from areas where the cost of emissions reductions would be much less expensive (UNFCCC 2008). The rationale was that the benefit to the atmosphere would be the same no matter the source of the emissions reductions.

The Clean Development Mechanism is one flexibility mechanisms that was developed specifically to encourage industries in developed countries to implement emissions reduction activities in developing. Carbon offsets can be used by the entities from the developed country to meet their emissions reduction requirement, and can contribute to sustainable development in the host country (UNFCCC 2008). Project activities must meet the fundamental criteria of carbon offsets; additionality, permanence, no leakage, and no double counting. Additionally, CDM mandates sustainable development as defined by the Designated National Authority in the host country. This organization oversees, approves of, and verifies CDM carbon offset projects in Indonesia.

The Clean Development Mechanism (CDM) of the Kyoto Protocol defines small-scale afforestation and reforestation (AR) project activities as those that are expected to result in net anthropogenic greenhouse gas removals by sinks of less than 8 kilotons of CO_2 per year and that are developed or implemented by low-income communities and individuals as determined by the

DNA (UNFCCC 2008). The project options outlined in this research would fall into that category. However, the institutional structure to support the CDM in Indonesia is considered underdeveloped, especially for small-scale AR projects (Murdiyarso 2003). Table 6 demonstrates the bias of CDM Projects in Indonesia towards larder scale alternative energy generation and methane capture projects.

Table 6. Current Projects Approved, and pending Approval by the National Commission on CDM in Indonesia.

APPROVED PROJECTS	# projects
Methane capture	11
Alternative energy generation	25
Co-composting	6
Industrial efficiency	3
Cook stoves	2
Total	**47**
POTENTIAL PROJECTS	# projects
Methane capture	7
Alternative energy generation	22
Co-composting	0
Industrial efficiency	1
Cook stoves	0
Total	**30**

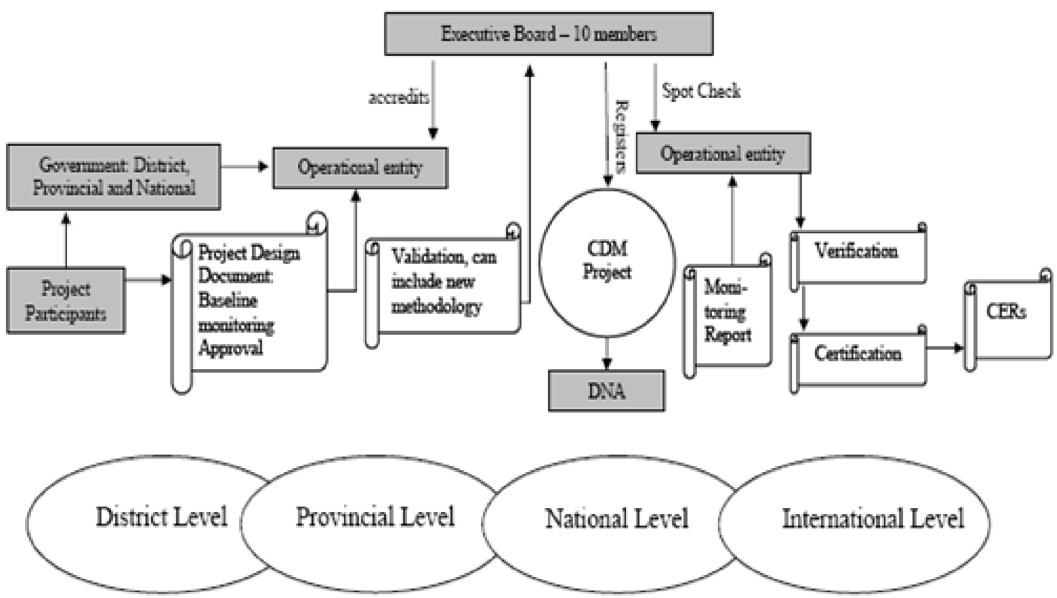
Source: (NCFCDM 2008).

One reason for this bias is the institutional complexity of implementing CDM projects in Indonesia (Figure 10). Contributing to this complexity. the recent process of decentralization of governance stipulated by Law No. 22/1999 has given responsibility of some CDM functions to provincial and local levels of government, whose roles and responsibilities regarding CDM are still unclear (Murdiyarso 2003).

Also, Government Regulation No. 34/2002 controls permits for environmental services of forests in land tenure systems defined by the Ministry of forestry as protected forest or production forests (MOF 2003). This system does not accommodate projects developed on private or communal lands (Murdiyarso 2003; Ginoga 2004).

Finally, a national board to oversee, approve of, and verify CDM projects has been developed in accordance with CDM procedure (NCFCDM 2008). However, this Designated National Authority (DNA) is in its infancy stages and as such has unclear operational mechanisms and poor coordination with project implementers (Murdiyarso 2003).

Figure 10. Institutional Features of Indonesia's CDM.



Source: (Michaelowa 2003).

Appendix C. Transaction Costs (Dudek, 1996)

Whether or not a project is CDM compliant, it will have transaction costs. Dudek and Wiener divided transaction costs into six categories:

1. Search costs are the costs of identifying and finding interested partners to the transaction

2. Negotiation costs are costs involved in coming to an agreement between partners. These costs include meetings, trainings, socialization projects, negotiations, assignment of benefits, time schedules, site visits, as well as the hiring of lawyers to draw up contracts

3. Approval costs (For CDM approval): include time delays incurred after submission of project designs for host country and Annex 1 country government endorsement. The approval costs were highlighted as a major transaction cost by investors (Lile 1998) .

4. Monitoring costs were defined as the costs necessary to ensure that participants are fulfilling their obligations, and to measure the actual greenhouse gases (GHG) abatement. They include technical expertise, training, collecting and analyzing data, and reporting. The choice of monitoring techniques will influence the level of transaction costs for the project managers. At this stage the monitoring options are:

    a. Modeling
    b. Remote sensing – suited to national level

c. Field inventories – permanent plots and ground truthing, biomass surveys or destructive sampling

5. Enforcement costs were defined as the costs of ensuring that all parties comply with the terms of contracts or agreement. This may take the form of litigation or administrative proceedings

6. Insurance costs are the costs entailed by partners in reducing or compensating for the risk of project failure through natural causes or failure of a partner to meet their obligations.

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