ECONOMIC ANALYSIS OF THE CONSERVATION & COMMUNITIES PROJECT

Photo Credit: Nathan Martinez

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ECONOMIC ANALYSIS OF THE CONSERVATION & COMMUNITIES PROJECT

FINAL REPORT

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ACRONYMS

ANGAP	-	*Association nationale de gestion d'aires protégées*
BCR	-	Benefit-Cost Ratio
CBNRM	-	Community Based Natural Resource Management
CBD	-	Convention on Biological Diversity
CEA	-	Cost Effectiveness Analysis
CF-MT	-	Conservation Farming Minimum Tillage
CF	-	Conservation Farming
CLP	-	Local Park Committee
COAP	-	Protected Area Code
COBA	-	*Communauté de base locale*
COSAP	-	Protected Area Orientation and Support Committee
CSO	-	Civil Society Organization
DEF	-	Department of Water and Forest
ECCO	-	Environment and Climate Change Office
ERR	-	Economic Rate of Return
EV	-	Economic Value
FAO	-	Food and Agriculture Organization
FEP	-	Foreign Exchange Premium
GCF	-	*Gestion contractualisée des forêts*
Gelose	-	*Gestion locale sécurisée*
GIS	-	Geographic Information System
GPF	-	*Gestion participative des forêts*
HYD	-	High-Yield
ICDP	-	Integrated Conservation and Development Project
IRR	-	Internal Rate of Return
IP	-	Implementing Partner
IUCN	-	International Union for Conservation of Nature
LEAP III	-	Learning, Evaluation and Analysis Project
LIDAR	-	Light Detection and Ranging
LULCC	-	Land Use Land Cover Change
MaMaBay	-	Makira-Masoala-Antongil Bay
MDGs	-	Millennium Development Goals

MNP	-	Madagascar National Parks
NASA	-	National Aeronautics and Space Administration
NCBA	-	National Cooperative Business Association
NEAP	-	National Environmental Action Plan
NPK	-	Nitrogen, Phosphorous, and Potassium
NPV	-	Net Present Value
NRM	-	Natural Resource Management
PA	-	Protected Area
PES	-	Payment for Ecosystem Services
RA	-	Rainforest Alliance
REDD+	-	Reduction of Emissions from Deforestation and Forest Degradation
SA	-	Strategic Approach
SAN	-	Sustainable Agriculture Network
SAPM	-	*Système d'aires protégées de Madagascar*
SFR	-	*Sécurisation foncière relative*
SMART	-	Spatial Monitoring and Reporting Tool
TCO2E	-	Tons of Carbon Dioxide Equivalent
TGRN	-	*Transfert de gestion de ressources naturelles*
USAID	-	United States Agency for International Development
VOI	-	*Vondron'Olona Ifotony*
WWF	-	World Wide Fund for Nature

EXECUTIVE SUMMARY

INTRODUCTION

Although Madagascar is widely recognized as the home of some of the world's most exceptional biodiversity, the island's natural landscapes are under intense pressure from unsustainable levels of human exploitation. In response, conservation and development practitioners are working together to leverage potential synergies between environmental conservation and human development goals. USAID/Madagascar supports this effort with the Conservation and Communities Project (CCP),[1] a 5-year program including the Mikajy activity, which supports both conservation and resilient livelihoods (USAID 2019a).

USAID Mikajy is working in the country's western region of Menabe and the Makira-Masoala-Antongil Bay (MaMaBay) region in the northeast. Both landscapes have high levels of biodiversity and endemism, and each faces a unique set of pressures on its ecosystems. USAID Mikajy is implementing a wide range of interventions seeking to reduce these pressures in both terrestrial and aquatic ecosystems. This study focuses on a subset of Mikajy's interventions within each landscape's terrestrial ecosystems.

Within the terrestrial landscapes, USAID Mikajy aims to reduce deforestation in Menabe by reducing the practice of slash-and-burn agriculture (*Hatsake*) through, among other activities, the promotion and adoption of conservation-friendly agriculture, reforestation, firefighting, awareness raising, updating management plans and increasing land tenure security. Likewise, in MaMaBay, USAID Mikajy aims to reduce deforestation by lessening the demand for rainforest land in communities through similar activities, one of which is supporting vanilla farmer cooperatives to achieve compliance with the Rainforest Alliance (RA) certification. In the two landscapes, USAID Mikajy is also working to help establish new community based natural resource management (CBNRM) systems and strengthen existing ones to improve outcomes for ecosystems and people in and around the Protected Areas (PAs).

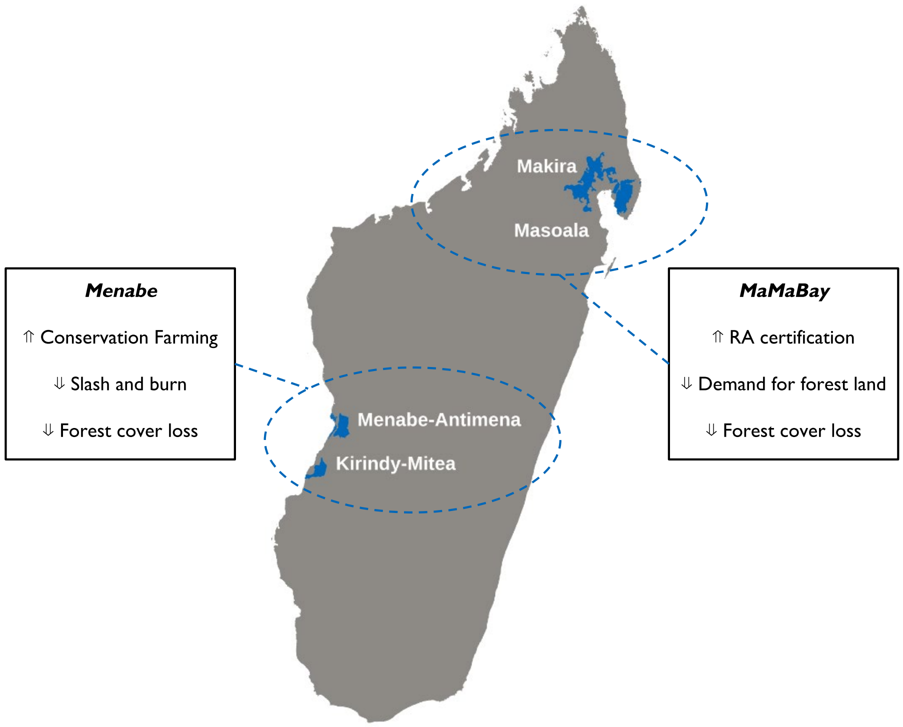
PURPOSE OF ANALYSIS

USAID/Madagascar's Sustainable Environment and Economic Development Office (SEED) requested that the Learning, Evaluation and Analysis Project (LEAP III) team carry out a financial, economic, and environmental assessment of designated interventions under the Mikajy activity. Specifically, USAID/Madagascar requested the LEAP III team to conduct:

- A cost-benefit analysis (CBA) of conservation farming (CF) of maize and groundnuts in Menabe;
- A CBA of Rainforest Alliance (RA) certified vanilla production in MaMaBay; and
- A cost-effectiveness analysis (CEA) of various approaches to conservation and natural resource management (NRM).

[1] The CCP consists of Mikajy and the Hay Tao activities. Only Mikajy is within the scope of this study.

Figure I: Mikajy Agricultural Interventions Selected for Analysis



The purpose of this study is to demonstrate which Mikajy investments have the greatest potential to generate the highest benefits for society, including development returns and environmental benefits, per dollar spent.

APPROACH AND LIMITATIONS

To collect information for the analysis, the LEAP III team used a combination of interviews and secondary evidence. In November 2019, the team conducted interviews with staff from USAID and its implementing partners (IPs) to gather the data required to complete the CBA of maize and groundnut CF and RA certified vanilla farming, and the CEA of conservation and NRM structures. Data collected in the field was supplemented with information from a detailed literature review, including USAID administrative documents, farm surveys from similar activities, and related academic and scientific research.

A model is a reflection of reality. In the best of situations, the model is built upon statistically representative samples of a target population. In other situations, a combination of secondary evidence, administrative data, and critical assumptions are needed to develop a model that can be used to identify risks, information gaps and to ask important evaluation questions that can be addressed over the project lifecycle. Due to significant limitation in the availability and access to data, this study represents the latter, which means caution should be exercised when interpreting results and making any inferences about USAID Mikajy's activities.

The approach to the study was slightly altered by the team to accommodate the knowledge gaps. The team took a forward-looking approach by highlighting the data needs and how this data can inform future decisions.

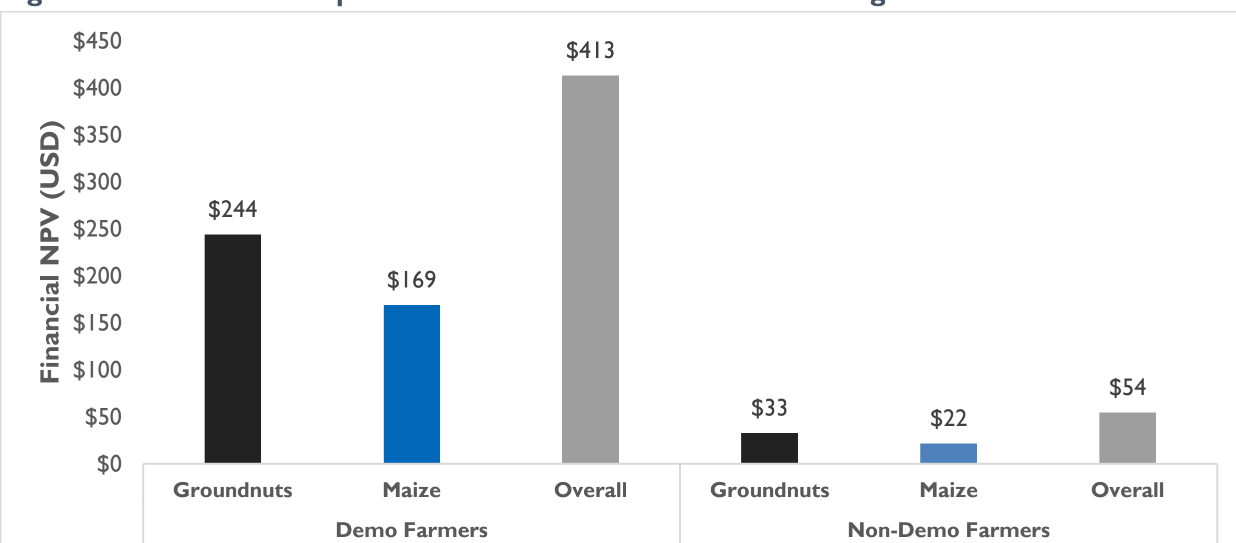
FINDINGS AND CONCLUSIONS

To conduct the CBA for an agriculture intervention, the team reports two critical investment criteria: financial net present value (NPV) and economic NPV. The financial NPV reports the net financial gain or loss from the perspective of a typical farmer. It is an important criterion as it reflects on financial attractiveness and sustainability of the intervention for farmers. The economic NPV captures a wider set of impacts beyond those that come with immediate financial implications for the farmers, including the impact of trade-based distortions (e.g. tariffs, subsidies, etc.) and externalities, (e.g. environmental or health).

CBA OF CONSERVATION FARMING (CF)

USAID Mikajy supports two types of farm groups in the Menabe landscape – 96 demonstration (demo) farmers with an average farm plot size of 0.40 hectares (ha) and 1,500 other (non-demo) farmers with an average of 0.1 ha. Each farm group devotes 50 percent of their land each to maize and groundnut production (e.g. demo farmers produce 0.20 ha of maize and 0.20 ha of groundnuts). The two key differences between demo and non-demo farmers is the area of the farm plot and USAID Mikajy's in-kind seed and fertilizer subsidies provided to demo farmers. To participate in the activity, the farmers will need to incur additional costs related to improved inputs, increased labor, and post-harvest handling in the expectation of improved yields and reduced instances of disease and pests. The financial performance of conservation farming for maize and groundnut is illustrated below with the combined incremental financial gains of groundnut and maize farming representing the overall financial impact on demo and non-demo farmers. These values represent the incremental gain of conservation farming relative to the "status quo" of performing *Hatsake* maize and groundnut production.

Figure II: Financial NPV per Farmer from Conservation Farming in Menabe



From an economic standpoint, the intervention will come with additional impacts beyond those listed above. The additional impact included in the study is USAID Mikajy's programmatic costs that are not paid for by the farmers. Furthermore, the values of some of the financial transactions are adjusted for the economic analysis to account for market distortions such as taxes and subsidies. Although the study provides illustrative values to demonstrate the potential economic impact of reducing net deforestation at the local, national, and global level, these figures have a high level of uncertainty and should be updated when more information becomes available. Other potential impacts from the economy's perspective include the expected benefits of reduced soil erosion and the impact of increased fertilizer runoff, that are excluded due to limited evidence for quantifying or monetizing them. In aggregate, acknowledging the limitations of the study, the CF intervention results in an economic gain (NPV) of $8,786, meaning the activity provides a net gain to society after factoring in economic distortions and programmatic costs. The intervention, however, is expected to result in a negative economic NPV of $4,155 for non-demo maize farmers, which is mainly being driven by the low on-farm financial gains relative to the programmatic costs per beneficiary and the adjusted economic values related to trade-based distortions.

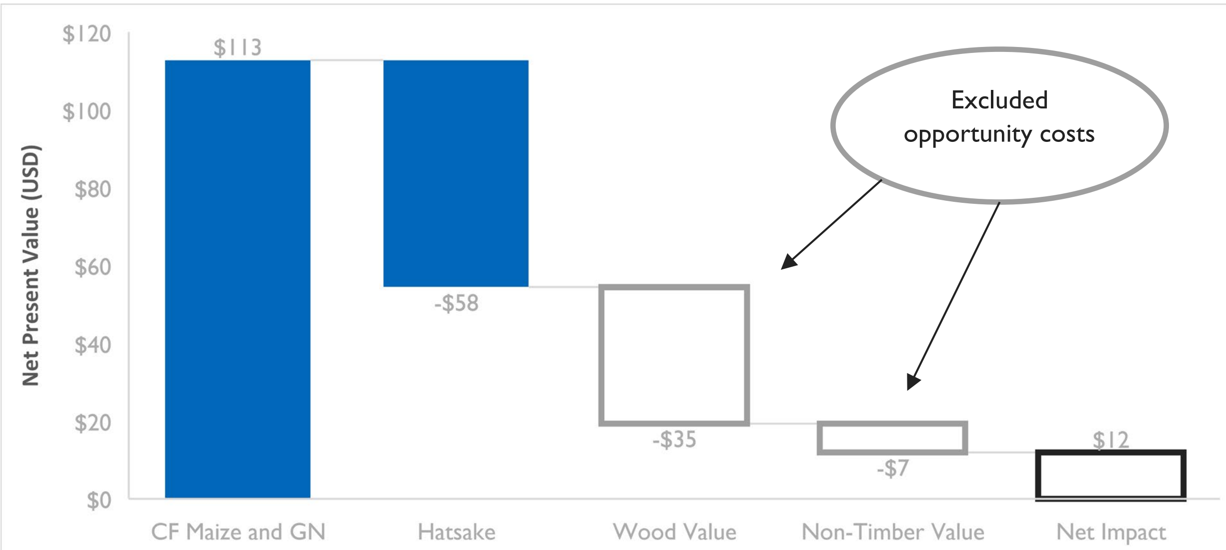
Figure III: Overall Economic NPV from Conservation Farming in Menabe

The positive incremental financial return for maize is highly dependent on assumptions regarding the source of additional organic fertilizer. The model currently assumes that 60 percent of additional organic fertilizer will be met with farm cattle. Similarly, the financial return to CF groundnut farmers is dependent on the quantity and price of high yield seed varieties. Several other adjustments would raise the incremental NPV, including a financial mechanism that would help offset inputs cost (e.g. seeds and fertilizers) and yield growth potential achieved by the first year of adoption. Additionally, while the CBA model assumes the land dedicated to CF production is fixed, farmers could increase their revenues if they expand production to other non-forested agriculture land.

The incremental financial NPV compares the costs and benefits of conservation farming with the "without intervention" values for *Hatsake* maize and groundnut production. However, farmers are likely to consider other opportunity costs when determining if they should conserve the surrounding land, including the value of wood and non-timber forest products. Since we do not have the specific geospatial coordinates of each individual farmer, we have developed illustrative ecosystem values to demonstrate the potential impact of USAID Mikajy activities and to identify information gaps that should be addressed moving forward. It should be emphasized that these values have been excluded from the financial and economic NPV due to the high level of uncertainty.

Non-demo CF results in an NPV of $113 per 0.1 ha before accounting for the opportunity cost of *Hatsake* groundnut and maize production. From the farmer's perspective, this value drops to $12 when the opportunity cost of Hatsake ($58)[2] unsustainable wood extraction ($35) and non-timber forest products ($7) is accounted for on the same amount of land (Figure IV). We currently assume the support for CF farming could result in a 12 percent reduction in forest loss within a 50-meter radius of one Menabe community or 0.0193 ha of averted forest loss per year. Under this scenario, non-demo CF results in an incremental financial NPV of $10 per 0.019 ha, after accounting for the opportunity cost of *Hatsake* groundnut and maize production. From one community's perspective, this value drops to $6 when the opportunity cost of unsustainable wood extraction ($3.6) and non-timber forest products ($0.8) is accounted for.

Figure IV: Year 1 Opportunity Cost of Conservation Farming for a Farmer in Menabe



Similar adjustments have been made to the economic returns to maize and groundnut farmers to account for illustrative impacts of averted forest loss at 0.077 ha over a 4-year USAID Mikajy implementation period.[3] However, the study has used a range of low and high ecosystem values to account for the variability reported in secondary research.[4] Based on this approach, the study reports economic resource flows ranging from a low value (NPV) of $9,079 to a high value (NPV) of $9,089 when incorporating these illustrative ecosystem values (Table 1).

[2] After accounting for *Hatsake*, the incremental financial NPV of CF is $54. This value is represented in Figure II as the net financial NPV for non-demo farmers.

[3] Equation: 0.019 ha of averted deforestation per year * 4-year implementation period = 0.77 ha of averted deforestation.

[4] The following ecosystem values were used by category: national (low = -$2.64 per ha; high = $10 per ha); global (low = $0.08 per ha; high = $15.70 per ha); and benefits of carbon sequestration (low = $40 per tCo2e; high = $80 per tCo2e)

Table I: Illustrative Range of Ecosystem Values for Conservation Farming for 1.58 ha of Averted Forest Loss

Ecosystems Value	Low Value (USD)	High Value (USD)	Difference
Maize & Groundnut Economic Value	$8,786	$8,786	$0
National Ecosystem Value (*Source: Kremen et al 2000; Carret and Loyer 2004*)	-$1	$4	$5
Global Ecosystem Value (*Source: Hockley and Razfindralambo 2006; Carret and Loyer 2004*)	$0	$6	$6
Benefits of Carbon sequestration (*Source: Bernal et al. 2018; World Bank 2013*)	$294	$294	$0
Total	**$9,079**	**$9,089**	**$10**

CBA OF RAINFOREST ALLIANCE VANILLA PRODUCTION

USAID Mikajy RA activities support over 4,622 ha of RA certified vanilla production, 5,200 producers, and six communities in the MaMaBay landscape. To comply with RA certified vanilla production, farmers need to incur additional costs related to investments for sanitation facilities, increased labor costs for production and security, and higher wages for hired labor. In return, producers receive a guaranteed sales price, a potential price premium and advance payments throughout the year and expected yield growth associated with the adoption of Sustainable Agriculture Network (SAN) practices.[5] The financial performance of RA certified vanilla production is illustrated below.

Table II: Financial and Economic Return to RA Certified Vanilla

Producer	Financial NPV per Farmer	Overall Economic NPV
RA Certified Vanilla	$1,679	$2,538,031

From an economic standpoint, the study includes USAID Mikajy's programmatic costs and values some of the financial transactions to account for market adjusted distortions such as taxes and subsidies. Other potential impacts from the economy's perspective, such as the expected benefits of reduced soil erosion and the increased health benefits associated with building new sanitation facilities, are excluded due to limited evidence for quantifying or monetizing them. Even in the absence of these potential benefits, The RA certification activity results in an economic gain (NPV) of $2,538 million (Table III), meaning the activity provides a net gain to society irrespective of whether ecosystem services or health benefits are included.

These results are built upon the critical assumption that yields increase by 45 percent due to improved farming techniques and enhanced market connectivity. If yields increase by only 20 percent, then the incremental financial and economic NPVs turn negative. While an assumed price premium of 10 percent

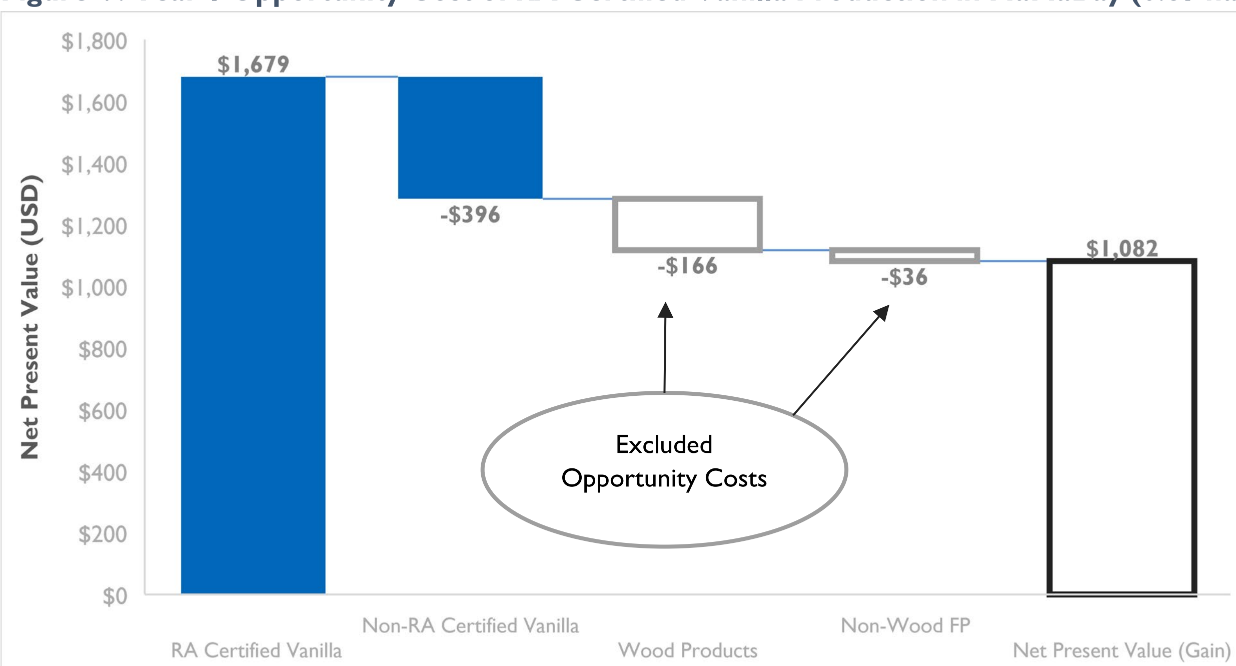
[5] At the time of this report, the market price for USAID Mikajy farmers was 221,391 per kilogram ($61 per kilogram). However, the study incorporates IMF price forecasts to reflect a 30% decline in vanilla prices over the next 3 years.

has a positive impact on the financial and economic results, the price premium is most likely critical for reasons that are not evaluated in this study, including its role in incentivizing producers to participate in RA certification and by providing consumption smoothing throughout the year.

For RA certified vanilla production, we have also developed illustrative ecosystem values to demonstrate the opportunity cost of conservation from the producer's perspective and to identify information gaps that should be addressed moving forward. RA certified vanilla producers are expected to have an incremental NPV of $1,679 per 0.89 ha. From the producer's perspective, the value drops to a financial gain $1,082 (NPV) after the opportunity cost of traditional vanilla ($396)[6], unsustainable wood extraction ($166) and non-timber forest products ($36) is accounted for on the same amount of land (Figure V).

We currently assume the support for RA certified vanilla production could result in a 12 percent reduction in forest loss within a 50-meter radius of six MaMaBay community or 0.1181 ha of averted forest loss per year. The opportunity cost of traditional vanilla production, as well as the opportunity cost of wood and non-timber resource extraction, is $79 (NPV) per 0.118ha, including traditional vanilla production ($53), wood extraction ($22), and non-timber forest products ($5). This compares to an incremental value of $223 per 0.118 ha for RA certified vanilla production, suggesting vanilla producers in the six communities would experience a financial gain of $472 relative to the opportunity cost of conservation.[7]

Figure V: Year 1 Opportunity Cost of RA Certified Vanilla Production in MaMaBay (0.89 ha)



Adjustments have also been made to the economic returns to vanilla producers to account for illustrative impacts of averted forest loss of 0.118 ha per year or 00.47 ha over a 4-year USAID Mikajy implementation

6 The value of traditional vanilla production in a protected area is considered because this study assumes that traditional vanilla plots in the MaMaBay region do not turn fallow after a cultivation period of 5-years. This value is highly dependent on assumptions regarding the baseline yield growth rates for non-RA certified vanilla.

7 This assumes the benefits of RA certified vanilla production are dependent on the conservation requirements of RA certification. In other words, producers would not receive the incremental benefits of RA certification if they do not meet the conservation goals of RA certification.

period.[8] Once again, the study has used the same range of low and high ecosystem values to account for the variability reported in secondary research. Based on this approach, the study projects economic resource flows ranging from a low value (NPV) of $2,547 million to a high value (NPV) of $2,548 million with these illustrative ecosystem values incorporated.

Table III: Illustrative Range of Ecosystem Values for RA Certified Vanilla Production

Ecosystems Value	Low Value (USD)	High Value (USD)	Difference
Vanilla Economic Value	$2,538,031	$2,538,031	$0
National Ecosystem Value (*Source: Kremen et al 2000; Carret and Loyer 2004*)	-$7	$25	$32
Global Ecosystem Value (*Source: Hockley and Razfindralambo 2006; Carret and Loyer 2004*)	$0	$40	$40
Benefits of Carbon sequestration (*Source: Bernal et al. 2018; World Bank 2013*)	$9,955	$9,955	$0
Total	**$2,547,980**	**$2,548,052**	**$72**

CEA OF VARIOUS APPROACHES TO CONSERVATION

After an extensive literature review, discussions with USAID/Madagascar and Mikajy staff and data collection from IPs, we selected the conservation interventions and the measure of effectiveness listed in Table IV for this study. The interventions listed are among those that USAID Mikajy is supporting. While there are various models of community based natural resource management, we found that Contractual forest Management (CFM) is the most adopted model in the Mikajy target landscapes. Our choice of the change in rate of forest cover loss as the measure of effectiveness was primarily dictated by data availability – most studies of conservation effectiveness in the literature focus on forest cover as an indicator of conservation outcomes. Several other potential measures of effectiveness were considered such as changes in levels of biodiversity, ecosystem fragmentation, and carbon stock levels, but data measuring these measures was either unavailable or inadequate for the purposes of this study.

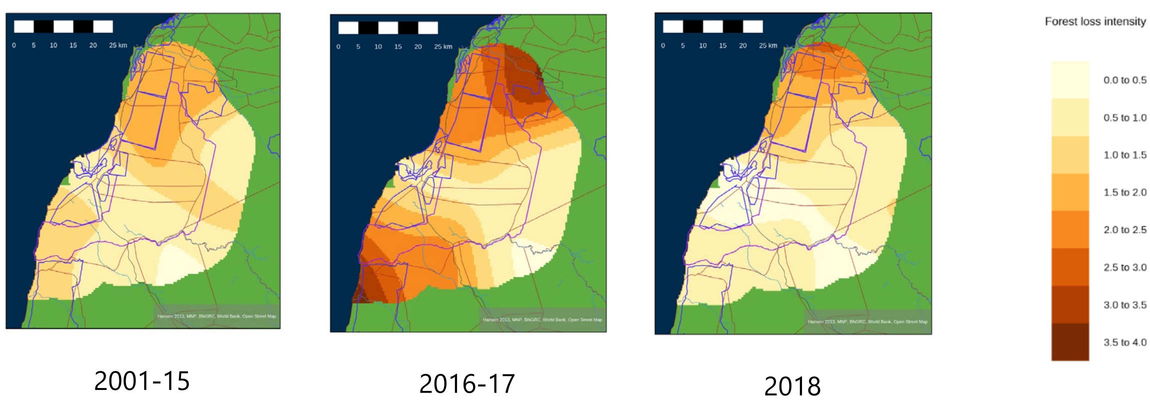
[8] Equation: 0.118 ha of averted deforestation per year * 4-year implementation period = 0.47 ha of averted deforestation.

Table IV: Conservation Interventions and Measures of Effectiveness Selected for the CEA

Interventions to be compared	Measure of effectiveness
• Protected Area – Zone of Strict Protection • Protected Area – Zone of Sustainable Use • Protected Area – Zone of Controlled Occupation • Protected Area – Special reserve or research concession • *Transfert de gestion des ressources naturelles* (TGRN) – Contractual Forest Management	• Prevented forest cover loss that is attributable to the intervention

Our ability to complete this analysis was constrained by the lack of rigorous studies that compare the effects of alternative conservation and NRM interventions. Exploratory analysis shows variation in forest cover loss intensity over space and time (Figure VI), however identifying a causal relationship between forest cover loss intensity and conservation intervention requires primary statistical analysis. Currently, it is not possible to rigorously calculate a measure of cost-effectiveness for the various conservation and NRM alternatives that Mikajy is considering supporting.

Figure VI: Forest Cover Loss Intensity in the Kirindy-Mitea Protected Area



Visualization: Authors

Data Sources: Hansen et al. 2013, MNP, BNGRC, World Bank, OpenStreetMap Humanitarian Team

RECOMMENDATIONS

1. Expand Data Tracking of Value Chain Activities

USAID is positioned to efficiently collect additional data to increase the accuracy of the CBA results reported by this paper. This effort involves the following steps:

1. expanding the current vanilla tracking database to incorporate
   a. farm-level costs,
   b. alternative benefit flows (e.g. cooperative loans and health insurance coverage), and
   c. programmatic costs.

This database could be informed by annual farm-level surveys for beneficiaries that are structured on similar vanilla surveys conducted in the SAVA region.

2. Develop an indicator database for CF farmers based on the CBA model inputs used for this study and demographic information (e.g. gender, poverty levels, etc.) to quantify the incremental financial impact for individual farmers and to measure the scale (i.e. amount of land dedicated to CF production) of the intervention. This database could be based on baseline surveys for new beneficiaries and mid-term surveys for existing producers.

Data collected from both databases can be incorporated into the CBAs to more accurately reflect the financial and economic impact of the activity. Moreover, these databases can be used to improve quarterly and annual reporting, as well as monitoring and evaluation plans.

2. RECOGNIZE THE IMPORTANCE OF FINANCIAL VIABILITY FOR FARMERS

Acknowledging the limitations of this study, the results suggest that USAID should prioritize conservation farming of groundnuts or alternative crops over maize to increase the financial return to farmers and to improve the economic return to USAID's investment. Although the resources may not be available to identify a more profitable alternative, switching from maize to a more profitable crop would improve both financial and economic returns, and further incentivize farmers to support conservation efforts. To properly inform the decisions, USAID can

1. improve the accuracy of the CBA results,
2. assess the financial and economic viability of alternative crops, and
3. ensure Menabe farmers have access to a loan mechanism that helps offset the investment and input costs required of CF production to help increase adoption and ensure the sustainability of farmer involvement. Adopting CF practices involves certain recurring costs that may limit participation. For example, CF groundnut and maize production requires significant increases in input costs. Offsetting these costs with a financial mechanism would provide farmers with the necessary means to incur these costs. Although RA certified vanilla producers recently gained access to micro lending, there was no data available at the time of the analysis to incorporate the loan terms in the CBA. This is something that can be considered in an updated analysis.

3. BRIDGE THE KNOWLEDGE GAPS THAT RESTRICT COST-EFFECTIVENESS ANALYSIS

Based on the extensive literature review performed by the team, it is clear that the existing conservation and NRM reporting frameworks are non-standard across interventions and do not produce the type of high-resolution data required to undertake causal and comparative analysis on the impacts and costs of conservation and NRM management systems. USAID/Madagascar can work with Madagascar National Parks, other Protected Area managers and community-based natural resource managers to establish a framework to bridge these knowledge gaps by supporting the following activities:

1. Clearly identifying high-priority conservation outputs (ex: forest cover area, forest fires counts, endangered species populations) that can be measured and meaningfully compared at fine resolution across time and space (ideally at the VOI or fokontany level);
2. Conducting customized image processing of Landsat imagery using land cover classification algorithms that are locally tailored to the Mikajy target landscapes to generate more accurate estimates of forest cover loss. Many such analyses have already been undertaken in Madagascar,

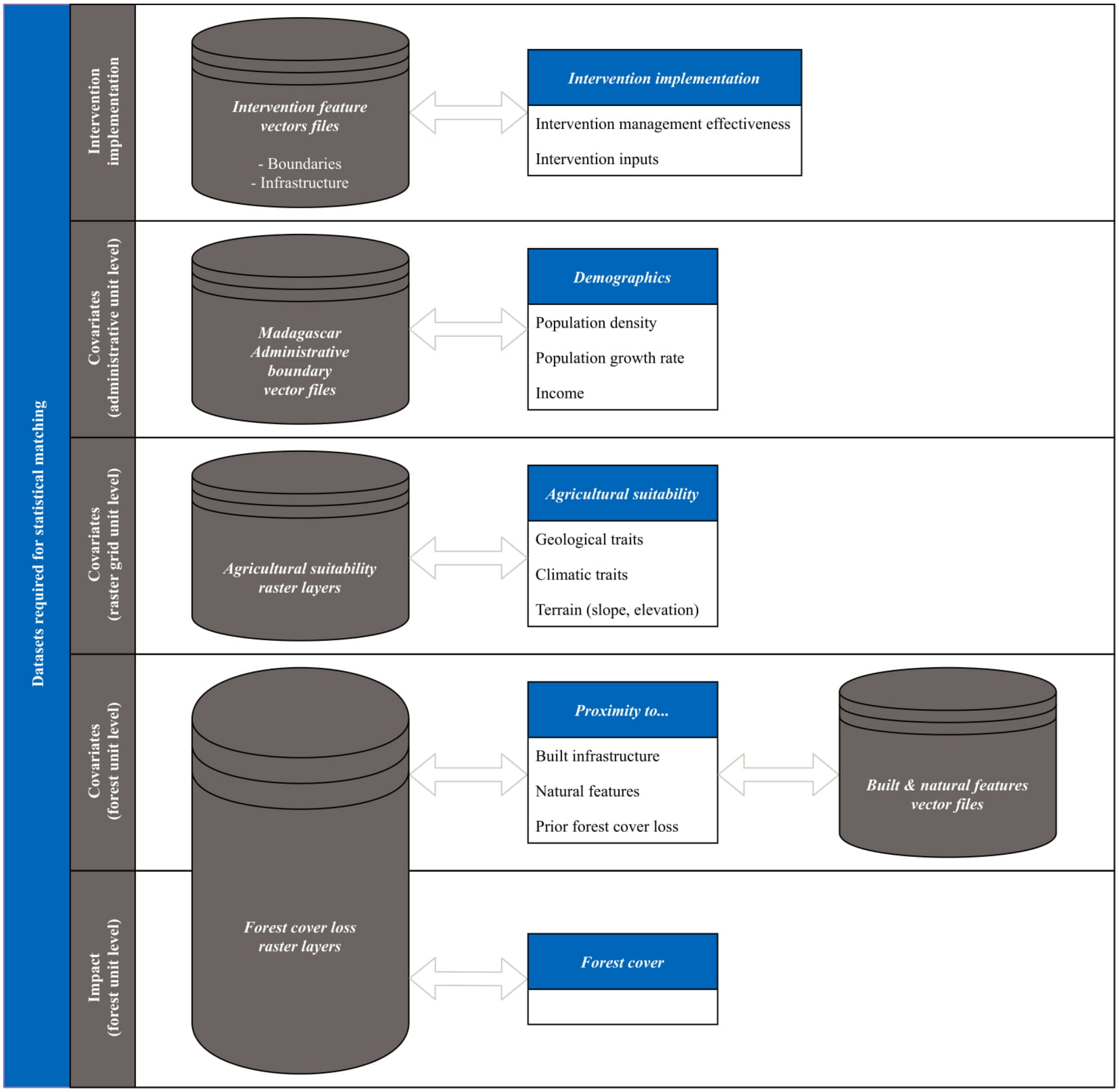
so achieving this could simply be a matter of establishing a partnership with researchers who have already developed image-processing algorithms that are tailored to the Mikajy landscapes;

3. Creating or compiling existing geospatial databases including
    a. Geospatial vector files outlining intervention areas (TGRN administrative boundaries, CF or RA farm plots), with associated date-referenced attribute information. For TGRN areas, relevant information includes the date the TGRN contract was signed, VOI management effectiveness scores, details about what natural resource exploitation activities are permitted under the contract, VOI membership levels and investments made in the intervention area such as VOI management budget, development project funds and payments for ecosystem services (PES). For CF or RA farm plots, attribute data could include yields and prices received by farmers for their crops;
    b. Other geospatial vector files describing intervention area infrastructure (ex: physically demarcated park boundaries, firewalls, nurseries etc.) and activities (realized patrol routes, community sensitizations etc.) with date-references indicating when the infrastructure was installed or when the activity took place.

The forest cover and intervention area datasets can be combined with secondary data describing observable covariates of conservation outcomes. Figure IV provides a visual summary of all the datasets that are required. By accounting for variation in intervention implementation and variation in important covariates of conservation outcomes, statistical matching can be applied to estimate the causal effects of the interventions on the target conservation outcome – in this case, forest cover loss. Statistical matching is a method that has been used in several studies to generate causal estimates of the effect of conservation and NRM interventions. The estimated intervention effects can then be compared with the intervention costs to produce measures of cost-effectiveness for different interventions

The statistical matching approach can also be used to assess the conservation impacts of Mikajy's support to maize, groundnut and vanilla farmers by verifying if there is a correlation between communities receiving the intervention and conservation outcomes, compared to communities who do not. Although these findings will not prove definitively any causation between Mikajy's interventions and improved conservation impacts, they will offer indicative values which can be incorporated into USAID/Madagascar's GIS reports and a future CBA to estimate the impact of the activity on ecosystem services.

Figure VII: Data Requirements for Cost-Effectiveness Analysis



1. INTRODUCTION

Madagascar is widely recognized as the home of some of the world's most exceptional biodiversity. The island country is rich in biodiversity with high levels of endemism in both its terrestrial and aquatic ecosystems (O. Waeber et al. 2020). However, the country is also characterized by high rates of population growth and multidimensional poverty, and a large rural population (Fritz-Vietta et al. 2011 and "Global Multidimensional Poverty Index 2019" 2019). Rural populations depend on subsistence agriculture and natural resource extraction for their livelihoods, which has put pressure on natural landscapes and been the primary driver of environmental degradation for decades (O. Waeber et al. 2020).

Activities such as slash-and-burn agriculture, land clearing for pasture, fuel wood collection, selective logging, illegal hunting and artisanal mining are among the most significant anthropogenic causes of deforestation and forest degradation ("Makira Forest Protected Area Project Design Document" 2008). These activities result in ecosystem fragmentation and biodiversity loss which put the survival of many of the country's species at risk. This situation has brought Madagascar to the point where it is considered one of the top "biodiversity hotspots" in the world (Fritz-Vietta et al. 2011).

USAID has a long history of implementing environmental projects in Madagascar. The most recently established of these interventions is the Conservation and Communities Project (CCP), which seeks "to conserve biodiversity and secure natural resources while promoting resilient livelihoods" (USAID 2019a). The CCP is comprised of USAID Hay Tao,[9] a project advancing national conservation policies and information sharing, and USAID Mikajy,[10] a five-year project (2018-2023) advancing biodiversity conservation, strengthening community-based natural resource management capacity, and promoting sustainable economic growth and land tenure rights for resource-dependent communities surrounding Madagascar's protected areas. Mikajy was designed with five strategic approaches (SAs) outlined in Table 1-1 below.

Table 1-1: USAID Mikajy's five Strategic Approaches

#	Theme	Strategic Approach
1	Nature	Work with communities, NGOs, CSOs, and government to improve protected area and natural resource management.
2	Wealth	Support community-based, conservation-friendly enterprises and livelihoods.
3	Resilient Communities	Interface and synergize with other development programs delivering services to target communities.
4	Action	Operationalize community-based land and resource tenure policy in landscapes/seascapes.
5	Power	Strengthen community, CSO, private sector, and government capacity in targeted landscapes to advocate for and engage in improved community-based land and natural resource management.

[9] In Malagasy, Hay Tao means "know how."
[10] In Malagasy, Mikajy means "taking good care of."

The CCP is working in two distinct landscapes of High Conservation Value (HCV). The first of these landscapes is in the Menabe region in the country's west, with interventions in Ambondrobe Protected Landscape and Ramsar Site; Menabe-Antimena Protected Landscape; Allée des Baobabs; Kirindy-Mitea and Belo-sur-Mer National Park and Biosphere Reserve; and coastal Locally Managed Marine Areas (LMMAs) at various locations between Belo-sur-Tsiribihina and Belo-sur-Mer. The second landscape is the Makira-Masoala-Antongil Bay (MaMaBay) region in the country's north-east. The ecosystems of the two target landscapes are distinct; Menabe's terrestrial ecosystem is characterized largely by dry deciduous forest and some spiny forest, whereas MaMaBay is covered by rainforest. Both landscapes are high in their levels of biodiversity and endemism, and each faces a unique set of pressures on its ecosystems.

USAID/Madagascar's Sustainable Environment and Economic Development Office (SEED) requested that the Learning, Evaluation and Analysis Project (LEAP III) team carry out a financial, economic, and environmental assessment of designated interventions under the Mikajy activity. The purpose of this study is to demonstrate which investments made under Mikajy might generate the highest development returns and environmental benefits. To this end, this study includes a cost-benefit analysis (CBA) of conservation farming (CF) and rainforest alliance (RA) certified activities, and a cost-effectiveness analysis (CEA) of conservation and natural resource management systems. Figure 1-1 shows how CCP's activities, interventions and target landscapes relate to one another, while Table 1-2 describes how the two methods of economic analysis were applied. Figure 1-2 shows the location of the terrestrial landscapes in which Mikajy is implementing the agricultural interventions selected for analysis.

Figure 1-1: Hierarchy of activities within the CCP selected for analysis in this study

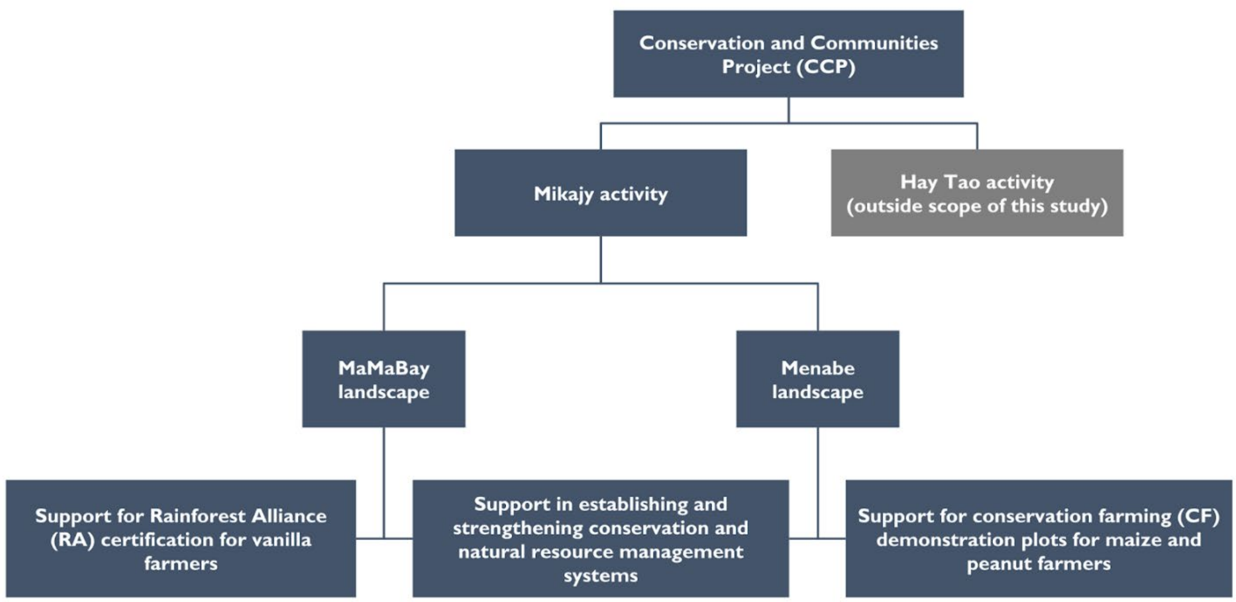
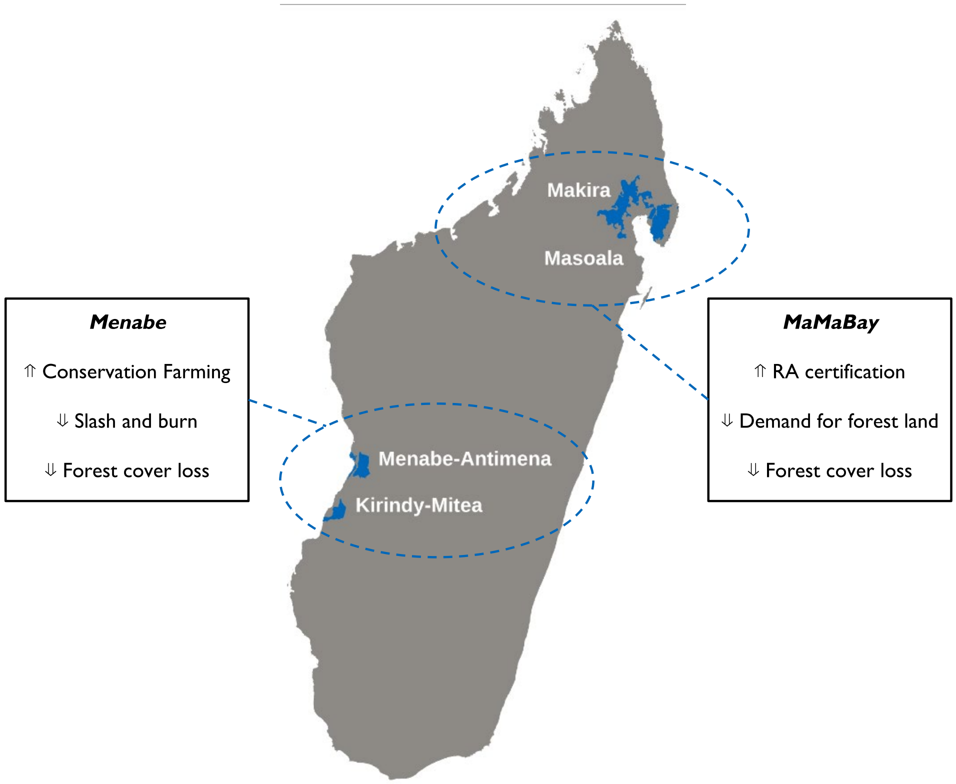


Table 1-2: Overview of Economic Analyses

Type of analysis	Relevant strategic approaches	Description
Cost-Benefit Analysis (CBA)	SA #1 – Nature SA #2 – Wealth SA #3 – Resilient Communities	The Mikajy activity is supporting demonstration maize and groundnut plots in Menabe that use conservation farming techniques, to convince farmers to adopt these practices. CF is designed to reduce pressure on ecosystems while increasing farmers' incomes through higher yields. Mikajy is also supporting vanilla farming cooperatives in MaMaBay to become RA certified, with similar objectives to conservation farming. CBA is applied to quantify the monetary value of the financial, economic and environmental costs and benefits associated with adopting the CF or RA approach. The CBA considers how these interventions affect farm budgets over time and, by quantifying the net impact of adopting CF or RA, demonstrates whether or not CF or RA will succeed in simultaneously reducing environmental degradation and poverty.
Cost-Effectiveness Analysis (CEA)	SA #1 – Nature SA #3 – Resilient Communities SA #4 – Action SA #5 – Power	Mikajy is contributing to efforts to establish and strengthen community based natural resource management (CBNRM) systems in and around protected areas (PAs). There are a variety of different approaches to CBNRM involving partnerships between a managing institution (Madagascar National Parks, an NGO or some other academic or private institution) and a local community management committee. CEA is a way of comparing different interventions with similar outcomes. This study compares the cost-effectiveness of various approaches to sustainably managing natural resources in and around terrestrial PAs in the Menabe and MaMaBay landscapes.

Figure 1-2: Mikajy agricultural interventions selected for analysis



This study begins with a description of the methodologies used to carry out the analyses. This section is followed by a presentation of the results of the analysis, which includes conclusions and recommendations to guide USAID Mikajy in its project implementation moving forward.

2. BRIEF LITERATURE REVIEW

Historically, the primary conservation instrument for mitigating anthropogenic degradation of wilderness areas has been the creation of Protected Areas (PAs). However, given that environmental degradation is often largely being driven by unsustainable use of natural resources by rural citizens, in recent decades conservation efforts have shifted towards establishing and strengthening natural resource management (NRM) systems in and around PAs. In Madagascar, this approach is known as transfer of management of natural resources (*transfert de gestion des ressources naturelles*, or TGRN). The policy of TGRN has established a Community Based Natural Resource Management (CBRNM) paradigm throughout the country.

The theory behind CBRNM is that, if rural people are given the responsibility of managing the natural resources upon which their livelihoods depend, they will ensure not to unsustainably deplete the supply of those natural resources (Casse 2012). In practice, the effectiveness of CBRNM in curbing environmental degradation and improving rural livelihood outcomes can vary widely and depends on many different factors. The detailed literature review in Annex I provides an in-depth discussion of the history and current state of conservation and CBNRM in Madagascar. This summarised literature review focuses on the factors that influence the effectiveness of conservation interventions and CBNRM systems.

CONSERVATION FARMING AND SUSTAINABLE AGRICULTURE

Given that many smallholder farmers are responsible for much of the destruction of Madagascar's natural landscapes, many development organizations working on ICDPs promote conservation farming (CF) and other sustainable agriculture practices to relieve anthropogenic pressure on ecosystems. The theory of change for CF is based on the notion that certain agricultural practices enhance natural biological processes, supporting soil fertility, and nutrient and hydrological cycling. As a result, these practices can increase farm profitability through higher yields and reversed land degradation (Milder et al., 2011). Although CF is practiced in many forms, it is typically comprised of agronomic practices that minimize soil disturbance (e.g. no or limited tillage), maintain permanent soil cover (e.g. straw or cover crops), and diversify crop rotations to include nitrogen-fixing crops (FAO, 2019). Similarly, Sustainable Agriculture Network (SAN) promotes the responsible use of inputs and agricultural practices to increase productivity while protecting the environment, including agroforestry shade cover, vegetative ground cover, soil erosion control, and soil/crop fertilization (Rainforest Alliance, 2016).

In general, there are potential on-farm benefits of adopting CF and SAN practices. For instance, these practices have the potential to increase soil structure and soil organic matter, enhance oxidation, and intensify phosphorus levels (Hobbs et al. 2008 and Milder et al. 2011). There are also benefits associated with water management and water use efficiency, such as increased water infiltration and water holding capacity. For example, Bombelli and Valentini (2011) note that for each percentage increase in soil organic material results in an additional 150 m3/ha of water that can be stored in the soil.

Conservation and sustainable agriculture practices also have the potential to control and reduce soil erosion. For example, there is evidence that wheat and maize residue coverage reduced soil loss by 62 percent and 97 percent, respectively (Giller et al., 2009 and Gilley 2005). Conservation and sustainable agriculture also have potentially indirect effects on biodiversity and ecosystem services including positive effects on agricultural landscapes, vegetation connectivity, and non-domesticated species, such as insects, birds, and bats providing pollination and pest control services. However, there is mixed evidence regarding these impacts because the key drivers of deforestation, such as migration, drought and land availability, are not directly tied to CF and sustainable agriculture practices.

There is some evidence pertaining to the reduction in deforestation rates associated with conservation efforts and promotion of sustainable agriculture practices. For example, a geospatial analysis of USAID's Central Africa Region Program (CARPE) shows a 27 percent reduction in deforestation rates in areas surrounding the villages receiving sustainable agriculture and land use planning interventions compared to those not receiving the intervention (USAID 2019b). In Colombia, Reuda et al. demonstrate a 12 percent reduction in forest loss for RA certified coffee producers relative to non-RA certified coffee producers in the region (2014). In Ethiopia, Takahashi and Todo (2013) use propensity score matching to show a 1.7 percentage point reduction in the probability of deforestation for RA certified coffee producers versus non-RA certified producers.

COMMUNITY BASED NATURAL RESOURCE MANAGEMENT

Conservation decision-makers need to decide how best to implement a CBNRM system in a specific threatened area. Are some approaches to CBRNM relatively more effective than other approaches? Under what conditions is CBRNM likely to be most effective? What are the key moderators of effectiveness that should be accounted for when designing and implementing a CBRNM system? Some of these moderators are described below, with an emphasis on the implementation of TGRN contracts.

Compatibility with socio-cultural aspects

Fritz-Vietta observes that Western notions of and approaches to environmental conservation are fundamentally different from, and often incompatible with, traditional Malagasy land use governance systems. The degree to which a conservation project succeeds or fails can thus be said to depend in part on the compatibility of the conservation project with the local socio-cultural aspects that inform land use decisions. (Casse 2012 and Fritz-Vietta et al. 2011) If the governance structures and social dynamics introduced by a conservation project are incompatible with traditional governance structures and social dynamics, local people are likely to abandon the new structures and dynamics in favor of tradition. This principle is embodied in several of Elinor Ostrom's celebrated 8 principles of governing a commons (Ostrom, 1990).

In some cases, the incompatibility of conservation efforts with local socio-cultural aspects can exacerbate rather than rectify environmental degradation. Casse shows an example of such a situation when he describes situations where *Gestion locale sécurisé (Gelose)* contracts undermined existing land tenure rules, thereby intensifying land ownership conflict between locals and migrants and subsequently increasing deforestation (Casse 2012). These types of perverse outcomes can arise when a conservation project fails to consider the role of existing socio-cultural aspects in land use decision-making.

In an effort to ensure compatibility of TGRN systems with existing socio-cultural structures and dynamics, the *Gelose* law allows for the establishment of a *dina* specifically designed to govern natural resource management.[11] This *dina* is the community-level social code that establishes both the requirements of the TGRN and the consequences of non-compliance to the requirements within the framework of traditional

[11] Establishing the *dina* allows for 'Congruence between appropriation and provision rules and local conditions' and a 'conflict-resolution mechanisms,' which Ostrom 1990 identifies as principles of effectively governing a common pool of resources (CPR).

socio-cultural structures. To be effective, the *dina* must be tailored to the local community such that the restrictions and non-compliance penalties are neither too restrictive/harsh nor too lenient[12] (Randrianarison et al. 2009). The effectiveness of the *dina* plays a large role in the overall effectiveness of the TGRN.

The balance of competing objectives

Each conservation project varies along the protection-production spectrum - that is, the restrictions imposed on local peoples' use of natural resources versus the rights of local people to make productive use of natural resources within the project area (Neal J. Hockley 2007). The point along this spectrum at which a TGRN contract lies is the result of a negotiation process between parties with different (often competing) objectives. Local community members seek to maximize the production rights embodied in the contract, while PA/TGRN managers seek to maximize the protection powers of the contract.

The trade-off between protection and production can have a significant impact on whether or not the contract will be an effective mechanism to achieve conservation and human development goals. If a contract leans too heavily toward production, natural resource pools will be degraded and the TGRN will not achieve its conservation objectives. If the contract is more biased towards protection, the opportunity costs to community members of conservation (e.g. foregone agricultural activity, firewood collection, bush meat etc.) may outweigh the perceived benefits, leading community members to reject the terms of the contract and return to prior levels of environment-degrading activity (Randrianarison et al. 2009).

> *'[There is] a growing body of recent research which finds little evidence for the effectiveness of community-based, extractive resource management in conserving biodiversity in terrestrial, developing world contexts, primarily due to the differences in objectives between local resource users and conservationists, and the inability of resource users to satisfy their needs through permitted sustainable uses. Likewise, there is mixed evidence for the effectiveness of multiple use (category V) protected areas in conserving biodiversity.' (Gardner et al. 2018)*

Contracts may become biased more towards one party or another during the negotiation process for a variety of reasons. There may be power imbalances between negotiating parties and/or under-representation of members of marginalized groups. (Gardner et al. 2018). One possible scenario is if the PA manager has the upper-hand over the local community during the community engagement and negotiation process, the terms of the negotiated contract might fail to meet local peoples' economic needs, and/or fail to consider the perspectives of key traditional leaders (Randrianarison et al. 2009). Alternatively, there may have been little to no community engagement at all, resulting in a generic contract that is ill-suited to a community's circumstances.[13]

Another possible scenario is the consolidation of power by an elite group within the community, resulting in improved circumstances for the elite but unchanged or worsened conditions for marginalized members of the community (Casse 2012). Table 2-2 lists some of the key factors that interact to either stabilize or destabilize a TGRN contract.

[12] 'Graduated sanctions' is another one of Ostrom 1990's principles of effective CPR management.

[13] Yet another of Ostrom's principles of effective CPR management is ensuring community participation in the process of defining the rules of the CPR management system.

Table 2-2: Dynamics of TGRN Contract Stability

Key metrics	Stabilizing factors	De-stabilizing factors
• Ecosystem intactness • Biodiversity • Community wellbeing	• Natural resource exploitation privileges • Equitable distribution of TGRN benefits within community • Accessible livelihood alternatives	• Natural resource exploitation constraints • Power imbalances between community and external parties • Power imbalances within community

Socio-spatial scope

TGRN systems are voluntary, opt-in institutions. This means that, while a TGRN may be actively managed by a COBA, the protection offered by the COBA depends on the level and extent of buy-in from community members. The level and extent of community buy-in begins with the community consultations and negotiations that take place when the TGRN is being established. There must be clearly demonstrable benefits of participating in the TGRN, and these benefits must be equitably accessible by everyone within the jurisdiction of the TGRN whose livelihood depends on natural resource exploitation. Once initial buy-in is established, the sustainability of the community's buy-in depends on the degree to which the anticipated benefits of the TGRN are actually realized and accrue to the community, and that the benefits exceed the costs (Randrianarison et al. 2009). Sustainability also depends on the degree to which the realized benefits align with the community members' expectations. Hockley and Andriamarovololona found that gaps between 'oral contracts' and official TGRN contracts established between external stakeholders and community members can produce a divergence in expectations that ultimately undermines the stability of a TGRN contract (Neal J. Hockley 2007).

Management capacity

COBAs must be sufficiently capacitated both technically and financially if the TGRN system is to be effective. TGRN arrangements are unlikely to be successful if the community members and COBA managers are ill-informed and capacitated to implement the management system (Randrianarison et al. 2009). This may seem obvious, but in the rush to implement TGRN on a national scale in Madagascar many contracts were signed without ensuring that the local capacity was in place to ensure the system's success.

On the financial side, COBAs must be able to generate enough revenues to cover the cost of TGRN activities. In theory, COBAs are designed to achieve financial self-sufficiency through membership fees and levying taxes on forest products (Randrianarison et al. 2009). In practice, many COBAs have been unable to cover their costs, and in some cases external financial commitments imposed by the TGRN have created a net outflow of money from the community (Neal J. Hockley 2007). In some cases, communities were essentially 'bought off' with significant front-end investment from development agencies as a form of quid-pro-quo for abandoning deforestation and natural resource extraction. In these cases, when the initial funding was depleted, communities returned to the status quo of environmental degradation (Freudenberger 2010).

Enforceability of TGRN contract

One of the most challenging moderators of the relative effectiveness of a conservation project is the degree to which conservation requirements can be enforced. Gardner notes:

> *"Law enforcement is a major challenge for PAs worldwide, particularly in developing countries with limited resources for surveillance and enforcement and widely-dispersed, resource-dependent rural populations and/or organized criminals seeking to illicitly extract natural resources. The problem is exacerbated in Madagascar because neither MNP nor new PA promoters have authority to apply the law: instead serious infractions require managers to organize and fund field missions by a 'mixed brigade', comprising members of the gendarmerie, MEEF agents, local and municipal authorities and members of the PA management committee." (Gardner et al. 2018)*

Thus, law enforcement represents a bottleneck in the decentralization of conservation and natural resource management. Only the DEF has the legal authority to enforce conservation laws, but it lacks the resources to effectively apply and uphold these laws at a large scale throughout the SAPM. TGRN arrangements have adopted patrolling and enforcement systems that leverage cooperation between community-level and central enforcement institutions. However, non-communication and mistrust between State officials and community representatives can hinder the effectiveness of the patrolling and enforcement system (O. Waeber et al. 2020). In the Menabe region, the prospect of violent encounters with the *Dahalo* (highly armed cattle-rustlers who meet in the forest to plan raids) jeopardizes the safety of community patrollers and the willingness of community members to engage in patrolling.

Securing land tenure rights through "*Sécurisation foncière relative*" (SFR) can either enhance or diminish the enforceability of TGRN contract requirements, depending on whether pre-existing community conflicts are resolved prior to securing land tenure rights (Randrianarison et al. 2009 and Casse 2012). This is one of many ways in which the enforceability of conservation laws is also closely linked with the socio-cultural aspects of the community described previously. Other such linked factors include the degree to which the community members view the TGRN *dina* as legitimate, and the degree to which COBA members are willing to effectuate the *vonodina* (sanctions) against their neighbor in the event of an infraction. It is useful to distinguish between the enforcement of an agreement on the communities and giving communities the tools with which to enforce agreements among their own members.

3. METHODOLOGY

The methodology section has two subsections. The first subsection discusses the approach and assumptions for the cost-benefit analysis (CBA) of conservation farming (CF) and Rainforest Alliance (RA) activities. The second subsection covers the cost-effectiveness analysis (CEA) of conservation and natural resource management systems.

3.1 COST-BENEFIT ANALYSIS OF CONSERVATION FARMING AND RAINFOREST ALLIANCE ACTIVITIES

Cost-benefit analysis (CBA) is the systematic cataloguing of benefits and costs, in monetary terms, and the determination of net impact by comparing the costs and benefits of the investment to the costs and benefits of the "business-as-usual" situation with the investment (Boardman et al. 2006, 1). In simpler terms, it is the comparison between the costs and benefits "with investment" to the costs and benefits "without investment". To measure the overall impact of an investment, CBAs can be conducted using an integrated approach to include financial, economic, risk, and stakeholder analysis.

One objective of this CBA is to assess USAID Mikajy support of conservation farming for groundnut and maize production in Menabe. CF or conservation agriculture is a set of soil management practices that minimize the disruption of the soil's structure, composition and natural biodiversity. Additionally, the CBA assesses USAID Mikajy support for MaMaBay vanilla farmers and cooperatives seeking to gain and maintain RA certification, which ensures farming practices meet desirable social, environmental and economic criteria.[14] The analysis is unique from many previous USAID CBAs in that it considers the economic value of ecosystem services that may be impacted by USAID's investment activities. An economic valuation of ecosystems services seeks to measure the benefits of ecosystem services in monetary terms (De Groot et al. 2010).

The approach for this analysis adheres to USAID's *CBA Guidelines for Conducting Cost-Benefit Analysis (CBA)* (2015), USAID's *Integrating Ecosystem Values into Cost-Benefit Analysis: Recommendations for USAID and Practitioners* (2018), and other guidance material provided by the Food and Agriculture Organization (FAO), World Bank, and other subject matter experts. Given that USAID Mikajy is beginning its second year of implementation, and many activities have just started, this study uses an ex-*ante* CBA to project the likely impact of specific activities and to provide recommendations for key indicators that should be monitored and evaluated over the project lifecycle. In this section, there is a description of the activities that will be assessed by this analysis and a summarized literature review of the effectiveness of similar investments. In Annex III, there is a brief overview of each step for conducting a CBA

3.1.2 USAID MIKAJY ACTIVITIES FOR ASSESSMENT

The scope of this CBA focuses on USAID Mikajy support for RA certification activities for vanilla producers in the northeast region of MaMaBay and conservation farming (CF) activities in Madagascar's southwest region of Menabe. These interventions are aligned with Mikajy's SA #1 (Nature), #2 (Wealth) and #3 (Resilient Communities). Below is a brief description of each activity.

[14] https://www.rainforest-alliance.org/business/resource-item/rainforest-alliance-sustainable-agriculture-standard/

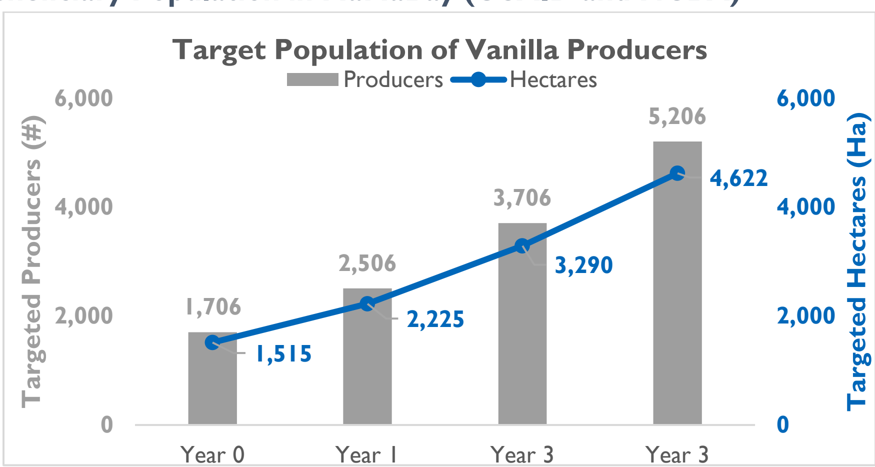
USAID RAINFOREST ALLIANCE CERTIFICATION ACTIVITIES IN MAMABAY

MaMaBay's terrestrial habitats are threatened by illegal logging of rosewood and increased deforestation of land for rice and vanilla production. Local communities' profit from vanilla production that strengthens social welfare and increases household wealth. In fact, volatile global demand has pushed global vanilla prices to a value point that exceeds the price per kilogram for silver (Ledur and Naidu, 2019). Rising demand has, in turn, increased the demand for two key factors of vanilla production – labor and land. As a result, deforestation is being undertaken to meet demand for increased vanilla production.

USAID Mikajy aims to protect MaMaBay forests by supporting farmers who adopt vanilla production processes and conservation practices compliant with RA certification. Adoption of RA certification can improve conservation outcomes by requiring the protection of local ecosystems, promoting tree coverage in agroforestry plots, and by increasing productivity and profits through the adoption of Sustainable Agriculture Network (SAN) practices.[15] In return, producers receive a guaranteed price premium, cash advances, and potential SAN-relative productivity gains (Rainforest Alliance, 2017).

USAID Mikajy supports this effort by increasing the technical capacity of farmers to comply with RA certification, improving sustainable agriculture practices, and by strengthening the administrative capacity of RA certified cooperatives.[16] This support takes place over a 4-year period, from 2019 to 2022, and includes training and technical support for 5,165 producers and 4,622 hectares (ha) of vanilla production (Figure 3-1).[17] Through this activity, USAID Mikajy hopes to incentivize communities to reduce deforestation, while increasing productivity and household wealth.

Figure 3-1: Beneficiary Population in MaMaBay (USAID and NCBA)



[15] Vanilla producers are also required to build latrines and wash basins to prevent wastewater runoff.

[16] Separate USAID activities are helping these cooperatives establish Village Savings and Loan Association (VSLA) and the provision of health benefits. However, these are not part of this CBA study.

[17] The average size of a vanilla producer receiving USAID assistance is 0.99 ha.

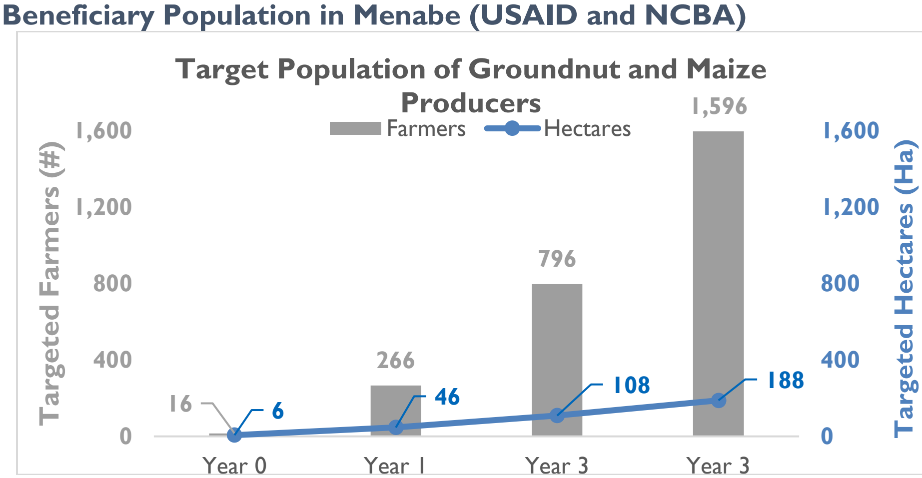
USAID CONSERVATION FARMING ACTIVITIES IN MENABE

Menabe's terrestrial habitats are primarily threatened by the demand for slash-and-burn or swidden agriculture (*Hatsake*), which is driven by population growth, immigration, and economic hardship created by recent closures for sugar, sisal, and shrimp businesses. Subsistence farmers in Menabe use two stages of *Hatsake* to prepare the land for maize and peanut cultivation. The first stage occurs in the dry season (June to September) when woody undergrowth is cut and stacked around the base of trees. The second stage happens at the beginning of the growing season (October) when the undergrowth is ignited, destroying all vegetation except for tree trunks (Frank and Schäffler, 2019).

Hatsake requires limited labor, and ashes provide the necessary soil nutrients for two to five years of cultivation. After this period, the land is typically left fallow (*monka*) and abandoned or less profitable crops are grown for a short period of time and then the land is abandoned (Sandy, 2006). Although most tropical degraded soils require a minimum of 10-years fallow period before forest regeneration, in Menabe the soil requires a longer recovery period (e.g. 20-years) or never recovers, resulting in the transition of forest ecosystems into savannahs (Gay-des-Combes JM et al., 2017). Farmers who have degraded the land through *Hatsake* and other unsustainable agricultural practices[18] then move on to other wooded areas to repeat *Hatsake*. These practices contribute to a continuous cycle that puts enormous pressure on local ecosystems and is not sustainable.

To help mitigate this destructive cycle, USAID Mikajy is promoting the use of Conservation Farming Minimum Tillage (CF-MT) practices as an alternative to *Hatsake*. This support includes training of CF-MT practices for 1,596 farmers and the direct purchase of seed and chemical fertilizer inputs for 96 demonstration plot farmers (Figure 3-2). In total, targeted farmers control 188.4 ha, including 38.4 ha of demonstration plots and 150 ha for other farmers.[19] After scaling the use of CF-MT, USAID Mikajy aims to increase productivity, raise profits, and extend the life of the land indefinitely. If these goals are met, the activity will demonstrate how improved inputs and CF-MT groundnut and maize production techniques can reduce deforestation by lessening the aggregate demand for *Hatsake* in forested areas (National Cooperative Business Association, 2019)

Figure 3-2: Beneficiary Population in Menabe (USAID and NCBA)



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[18] National Cooperative Business Association (NCBA), a sub-contractor for USAID Mikajy, site cereal mono-cropping and continuous soil disturbance as other practices that degrade Menabe lands.

[19] The average size of a demonstration farm plot is 0.4 ha, including 0.2 ha each for groundnuts and maize. Non-demonstration farm plots dedicate 0.1 ha to groundnut and maize with 0.5 ha dedicated to each crop.

3.1.3 KEY CBA INPUTS AND ASSUMPTIONS

In the absence of a detailed baseline survey of the beneficiary population, this study uses financial information from the project, secondary research from local studies and surveys, and agronomist estimates from the implementing partner to build financial cash flow statements for producer households. The study also uses macroeconomic and financial indicators to adjust for economic distortions, such as subsidies and taxes for tradable commodities. The analysis uses evidence gathered from in-country interviews and secondary research to identify and measure the impact on ecosystem services. A summary of key data sources is summarized in Table 3-1. Furthermore, a list of critical assumptions is provided in the sensitivity analysis section of this report. Since a good portion of this data is not statistically representative of the target population, the results should not be viewed as a statistical representation of the intervention's impact. An updated CBA study can depict a more accurate picture of the results when more data becomes available.

Table 3-1: Key Data Sources by CBA Topic

Benefit Profile	Topic of Analysis	Main Data Sources
Groundnut Farmers Maize Farmers	Farm Production, Revenues, and Costs	Maison des Paysans (2008) NCBA production and cost data (2019) Sahanala (2019) Focus group discussions (2019)
Vanilla Producers	Farm Production, Revenues, and Costs	USAID production and revenue data (2019) Hänke (2016) Hänke (2018) Focus group discussions (2019) Université D'Antananarivo (2005)
Ecosystem Services	Ecosystem Values	Carret and Loyer (2004) Neudert (2016) Kremen et al. (2000) Hockley and Razafindralambo (2006)

There are several specifications that farmers need to follow in order to properly adopt CF and sustainable agriculture practices. Farmers, for example, must establish exact spacing patterns between crops, dig planting stations at the precise depth, and plant seeds at the right time of year. Moreover, the regenerative benefits of farm soil structure often take several seasons to materialize. Due to these factors, the benefits of CF and sustainable agriculture adoption typically follow four pathways: quick and complete adoption over a 3-5-year period; stepwise adoption; periodic adoption; and long-term failure (Baudron 2007; Corbeels 2014). For this analysis, the CBA is assuming quick and complete adoption that will occur incrementally over a three-year period from the start of the intervention. This means maximum yield potential will be reached 3-years after farmers start adopting CF and sustainable agriculture practices and then maintained in perpetuity thereafter.[20]

[20] It typically takes several years for farmers to reap the benefits of adopting conservation farming practices because the structure of the soil takes several years to regenerate. Therefore, the CBA model is assuming that the full benefits of CF or RA production could occur a few years after the implementation period.

There is mixed evidence regarding the potential yield gains that can be achieved with the adoption of CF and sustainable agriculture practices. A meta-analysis of conservation farming found that the weighted mean difference between non-tillage with mulch and traditional agriculture is 487 kilograms (kg) per ha for grain crop yields, yet there were instances where yield gains were much greater (Corbeels et al., 2014). In Malawi, a comparison between farmers adopting the CF treatment with a control group showed an average yield increase between 1,152 and 1,172 kg per ha (Thierfelder et al. 2015). A separate study reported yield gains ranging from 20 percent to 120 percent higher, although local conditions, such as weather conditions and disease, can have considerable impacts on the variability of yield increases (Milder 2011).

The analysis is assuming a 100 percent increase in yields for groundnuts and an 80 percent increase in maize yields. These assumptions are based upon the NCBA agronomist's estimates and evidence from the aforementioned studies.[21] For vanilla production, the sustainable agriculture practices do not include a change in inputs so the adopted techniques could theoretically represent an improvement to vanilla plot ecosystems. The analysis is assuming a potential yield increase of 45.2 percent, which is based on findings from two surveys assessing the difference between average yields for Fairtrade contract vanilla producers and non-contract farmers (Hänke et al. 2018 and Hänke 2016). The importance of these assumptions will be tested using sensitivity analysis.

In addition to greater agricultural yields, there are potential on- and off-farm benefits associated with reductions in soil erosion and reduced wastewater runoff for RA certified vanilla producers constructing latrines. Sophisticated models use inputs about the physical landscape to estimate soil loss over spatial and temporal factors, including the following: soil erodibility, rainfall runoff erosivity, cover management, slope steepness and length, erosion sinks, and conservation practices.[22]

In the absence of detailed information about the current topographies of farmers and surrounding communities, as well as uncertainty regarding the expected level of erosion reduction in each landscape, the CBA analysis does not attempt to measure the benefits of reduced runoff on local communities. In this respect, there are potential benefits to agriculture, water supply, electric power generation and coastal ecosystems that are not captured in the model. At the same time, CF groundnut and maize production require the additional use of chemical fertilizers so some potential benefits may be offset by an increase in chemical runoff.

USAID Mikajy aims to reduce deforestation in Menabe by lessening the aggregate demand for *Hatsake* in forested areas by promoting the adoption of agriculture practices that raise incomes and extend the life of the land indefinitely. Under the status quo or the "without project" scenario, farmers produce maize and corn using *Hatsake* until the land goes fallow after three to five years of production. Based on focus group discussions and discussions with the implementing partner, farmers engage in *Hatsake* once their original land turns fallow. Since we do not have geospatial coordinates for each farmer, we will show how a percentage of averted deforestation would impact the economic NPV of the activity and run a sensitivity analysis on this variable.[23]

21 An original projection of 200 percent for groundnuts and 100 percent for maize was deemed too optimistic.
22 For information about measuring soil loss, reference the Universal Soil Loss Equation (USLE) at https://milford.nserl.purdue.edu/weppdocs/overview/usle.html.
23 The benefits of averted deforestation will begin in year 5 after the original land has presumably turned fallow.

USAID Mikajy aims to reduce deforestation in the MaMaBay landscape by lessening the demand for rainforest land in communities complying with RA certification. Producer communities need to comply with certain RA measures to secure and maintain certification. A major component of RA certification requires producer communities to protect local ecosystems. According to performance documents, communities comply with this mandate in 93 percent of supported areas (Rainforest Alliance, 2016). We use secondary research to show how a reduction in deforestation rates would impact the economic NPV of the activity.

The key assumptions made in the CBA model are summarized in Table 3-2 below.

Table 3-2: Key assumptions made in the CBA

Parameter	Value chains	Value	Implications	Sources
Adoption pathway	Maize Groundnuts Vanilla	"Quick and complete"	Adoption will occur incrementally over a three-year period from the start of the intervention. This means maximum yield potential will be reached 3-years after farmers start adopting CF and sustainable agriculture practices and then maintained in perpetuity thereafter.	Baudron 2007; Corbeels 2014
Increase in yields	Maize Groundnuts	80% 100%	The importance of these assumptions will be tested using sensitivity analysis.	NCBA (Implementing partner for the Mikajy intervention); Corbeels et al., 2014; Thierfelder et al. 2015; Milder 2011
	Vanilla	45.2%		Hänke et al. 2018; Hänke 2016
Reduced soil erosion and runoff	Maize Groundnuts Vanilla	N/A	Potential benefits to agriculture, water supply, electric power generation and coastal ecosystems are not captured in the model.	N/A
Increased pollution from chemical inputs	Maize Groundnuts	N/A	Potential costs of increased chemical runoff are not captured in the model.	N/A

3.2 COST-EFFECTIVENESS ANALYSIS OF CONSERVATION AND NATURAL RESOURCE MANAGEMENT SYSTEMS

The management of PAs and natural resources is an exceedingly difficult task, and highly complex systems have evolved over time as governments and NGOs struggle to simultaneously achieve conservation and human development objectives. In soliciting this study, USAID, like many other development agencies, is seeking to determine where and how support should be given to strengthen PAs and NRM in the Menabe and MaMaBay landscapes. This section outlines a methodology designed to identify the most cost-effective approach for PA and NRM.

As illustrated in the formula below, the cost-effectiveness (CE) for intervention i over time t is calculated by comparing its cost ($C_{i,t}$) to its effectiveness ($E_{i,t}$) in a relative way. The most cost-effective intervention has the highest measure.

Formula 3-1: Generic cost-effectiveness measure for intervention i over time t

$$CE_{i,t} = \frac{E_{i,t}}{C_{i,t}}$$

After an extensive literature review, discussions with USAID/Madagascar and Mikajy staff and data collection from IPs, we selected the conservation interventions and the measure of effectiveness listed in Table 3-3 for this study. The interventions listed are among those that USAID Mikajy is supporting. While there are various models of community based natural resource management, we found that Contractual forest Management (CFM) is the most adopted model in the Mikajy target landscapes. Our choice of the change in rate of forest cover loss as the measure of effectiveness was primarily dictated by data availability – most studies of conservation effectiveness in the literature focus on forest cover as an indicator of conservation outcomes. Several other potential measures of effectiveness were considered such as changes in levels of biodiversity, ecosystem fragmentation, and carbon stock levels, but data measuring these measures was either unavailable or inadequate for the purposes of this study.

Table 3-3: Conservation Interventions and Measures of Effectiveness Selected for the CEA

Interventions to be compared	Measure of effectiveness
• Protected Area – Zone of Strict Protection • Protected Area – Zone of Sustainable Use • Protected Area – Zone of Controlled Occupation • Protected Area – Special reserve or research concession • *Transfert de gestion des ressources naturelles* (TGRN) – Contractual Forest Management	• Prevented forest cover loss that is attributable to the intervention

The chosen measure of conservation and NRM effectiveness is the amount of prevented forest cover loss that is attributable to the intervention over a specified time period. In other words, it is the difference between the amount of forest cover loss (FL) that would have occurred without the intervention and the amount of forest cover loss that occurs with the intervention during the time period of interest. Formula

3-2 expresses this term mathematically, where the subscript o denotes the counterfactual situation. The effectiveness measure is positive if the intervention is successful (i.e. if forest cover loss under the intervention is lower than it would have been without the intervention). Lower forest cover loss under the intervention relative to the counterfactual means a larger effectiveness measure, meaning a larger numerator in Formula 3-1, and a higher (i.e. better) cost-effectiveness measure.

Formula 3-2: Effectiveness Measure of Conservation Intervention i over Time t

$$E_{i,t} = FL_{o,t} - FL_{i,t}$$

Each conservation intervention bears different costs, some of which are listed in Table 3-4. Depending on the configuration of the intervention, these costs may be shared by several different parties including the government, local community members, NGOs and donors. When calculating the total cost of an intervention, care must be taken to avoid double counting where there are transfers between parties who share the costs. For example, community patrol staff in a TGRN area may incur costs by purchasing materials for patrolling. If the co-managing party (MNP or an NGO) provides a transfer to the community to cover the cost of patrol materials, the cost is borne by MNP or the NGO and should only be counted once.

Table 3-4: Costs Associated with Conservation Interventions

#	Cost	Example activities
1	Up-front investment in establishing the intervention	Intervention design, community engagement, drafting documents
2	Ongoing investments in managing the intervention	Management meetings, patrolling, processing conservation infractions, reporting
3	Investment in projects that are planned as part of the intervention[24]	Investments in community infrastructure, support for alternative livelihoods, payments for ecosystem services
4	Net costs incurred by community members in the intervention area[25]	Increased costs: foregone income or utility from natural resource exploitation Compensation: increased income from support received through intervention

[24] For example, establishing a TGRN may be predicated on a commitment to implement a project to improve education or health facilities in the community. Since the conservation intervention would not have been established without this project, the cost of the project must be considered as part of the cost of the intervention.

[25] This is the difference between the opportunity cost of foregone natural resource exploitation and any compensation provided for by the intervention; failing to account for this cost category can result in an intervention appearing to be a 'great deal' for external stakeholders (Neal J. Hockley 2007)

The costs in Table 3-4 area the total costs for an intervention over the time period of interest. The cost measure for each intervention is then given by Formula 3-3.

Formula 3-3: Cost Measure for Conservation Intervention i over Time t

$$C_{i,t} = C_{1,i,t} + C_{2,i,t} + C_{3,i,t} + C_{4,i,t}$$

Bringing together Formulas 3-2 and 3-3, the cost-effectiveness measure can be re-written as shown in Formula 3-5.

Formula 3-5: Cost-effectiveness Measure for Conservation Intervention i over Time t

$$CE_{i,t} = \frac{FL_{o,t} - FL_{i,t}}{C_{1,i,t} + C_{2,i,t} + C_{3,i,t} + C_{4,i,t}}$$

An intervention can be more cost-effective compared to another because it comes at a lower cost (lower denominator) or has a larger effect on preventing forest losses (higher numerator). The cost-effectiveness measure is interpreted as '*units of forest cover loss prevented per Ariary (or USD) invested*.'

The following subsection discusses the sources of information that were used to select these interventions and measures of cost-effectiveness for analysis.

3.2.4 ANALYTICAL APPROACHES TO MEASURING CONSERVATION EFFECTIVENESS

Conservation projects seek to create impact across large areas over extended periods of time. As such, geospatial analysis is inherently well-suited to assess the impacts of conservation projects. Geospatial analysis might simply involve exploratory analysis (the 'what' of conservation), it may seek to also answer the 'why' through causal analysis. As discussed earlier in this section, data limitations have restricted this study's focus to the first of these two types of analysis, but we present a methodology that can be applied to carry out a causal analysis given the necessary input data.

EXPLORATORY ANALYSIS WITH KERNEL DENSITY SMOOTHING

Geospatial methods were applied to conduct an exploratory analysis of trends in conservation indicators in the four PAs receiving support from USAID Mikajy. Of all the available datasets, only the Hansen et al. 2013 forest cover dataset provides the level of granularity required to carry out a detailed spatial point pattern analysis. As such, despite its limitations, it has been used to observe trends in forest cover loss over space and time.

Geospatial analysis has some specific nomenclature that is useful to define here:

- A **spatial point pattern** is, as its name suggests, some pattern of events distributed in space and time.
- A **spatial point process** is the underlying mechanism that produces a spatial point pattern.
- The **window** is the defined space within which the spatial point process takes place.
- A **point** is any location within the window.

- An **event** is a point within the window where something of interest takes place. In the context of deforestation, the events are originally forested areas.
- A **mark** is an attribute assigned to an event.
- A point pattern with a binary mark consists of **case** and **non-case** (i.e. control) events. In this context, an event (an originally forested area) is a 'deforested' case if it is cleared during the timespan of the analysis, or it is a 'forested' case if it remains undisturbed.

One technique used to analyze spatial point patterns is kernel density analysis. Kernel density analysis takes a spatial point pattern and applies a kernel function to produce a smoothed surface of the estimated intensity of the underlying spatial point process at each point within the window. By calculating the kernel density of case (i.e. forest cover loss) and non-case (i.e. forest cover) events within a window, and plotting the ratio of these densities, the estimated intensity of case events can be observed. This technique was applied to compare the intensity of forest cover loss within each of the four PAs before and after PA designation.

CAUSAL ANALYSIS WITH STATISTICAL MATCHING

The effectiveness measure defined above by Formula 3-2 requires causal analysis for forest cover loss differences between intervention and non-intervention areas. Several recent studies have applied statistical matching to estimate the impact of conservation projects on deforestation rates (Rasolofoson et al. 2015 and Eklund et al. 2016). Recalling Formula 3-5:

$$CE_{i,t} = \frac{FL_{o,t} - FL_{i,t}}{C_{1,i,t} + C_{2,i,t} + C_{3,i,t} + C_{4,i,t}}$$

The goal is to determine whether or not the rate of forest cover loss is lower in an intervention area than would be the case if these areas had not been granted protection. The problem is that the unprotected zones do not provide a valid comparison group. There are two main reasons for this:

1. There are many confounding factors that influence any given forest unit's propensity to lose its forest cover. Protected and unprotected zones might not be comparable based on differences in the values that these confounding factors take in each type of zone.
2. Unprotected areas adjacent to protected zones are exposed to 'leakage' – that is, pressure that was formerly applied forest in a zone that is now protected moves into forest in the adjacent unprotected zone.

To solve these two problems, a process called statistical matching can be applied. A high-level description of statistical matching is as follows:

1. Define the window for analysis, and associate attribute variables with each forest unit within the window. A 'forest unit' in this case is a pixel of forested area (e.g. the Hansen et al. 2013 global forest cover data is approximately 30m x 30m resolution). The attribute variables should include all factors that are expected to confound the impact of the intervention on the conservation outcome (i.e. whether the forest unit will be deforested).
2. Group forest units into two areas – the intervention area (i.e. area under PA or TGRN management during the time period of interest) and the control area (i.e. the area outside PA or TGRN management during the time period of interest).

3. Randomly select[26] a number of forest units within the intervention area and use statistical matching to pair each of the selected forest units with the most similar forest unit outside of the intervention area. Since each pair of points is similar in its values of the confounding factors, the unit outside of the intervention area is theoretically a valid counterfactual for the intervention effect (i.e. the difference in forest cover loss).

4. Calculate the difference in the conservation outcome observed among the matched pairs. The difference between the outcome observed among the units within the intervention area and that observed among the units outside the intervention area is the average effect of the intervention area (Rasolofoson et al. 2015).

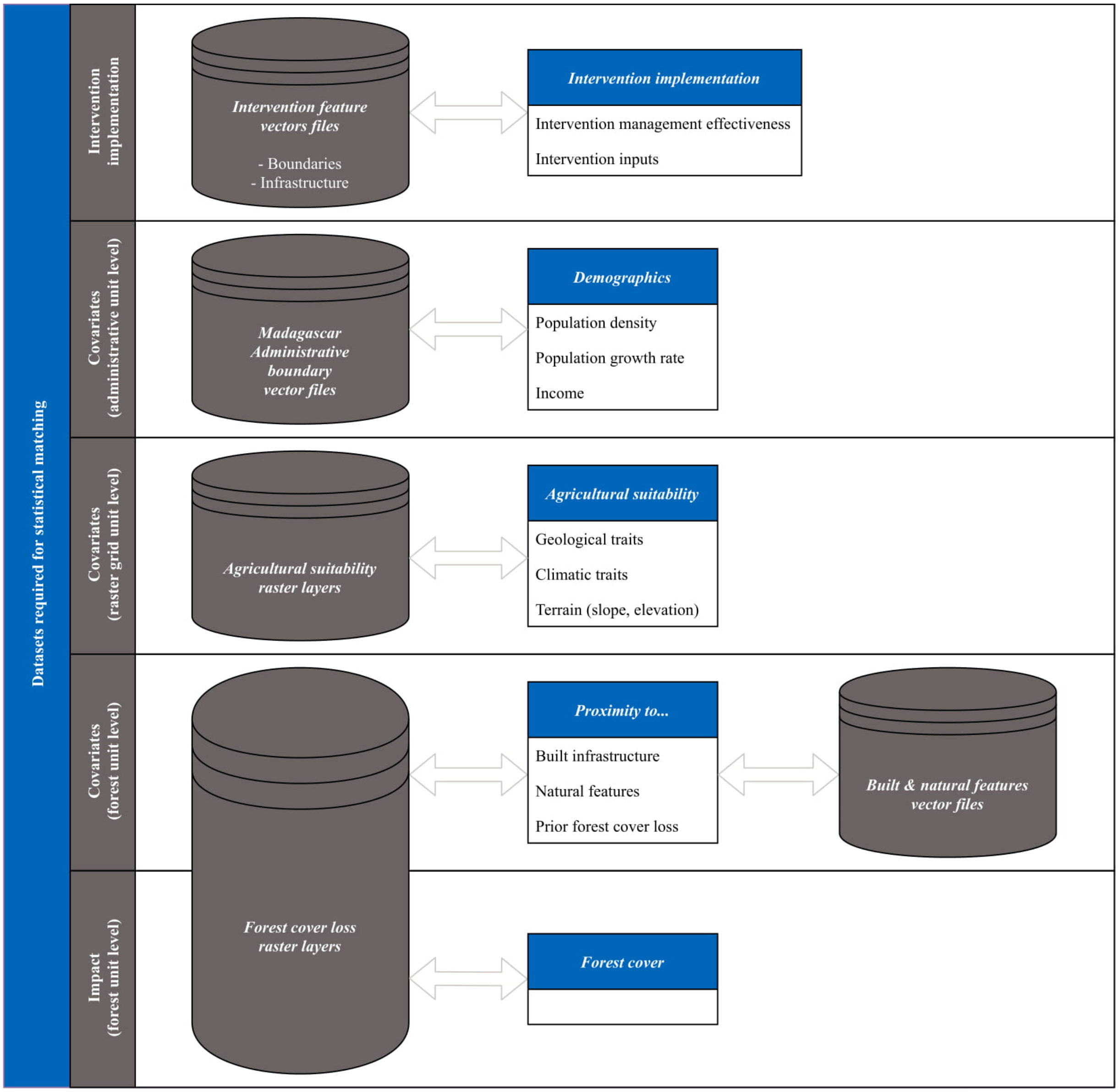
   Once the estimated treatment effect is calculated, it can be substituted into Formula **3-5** along with the intervention costs to determine the cost-effectiveness measure.

   Figure **3-3** provides a visual summary of all the datasets that are required to implement statistical matching. By accounting for variation in intervention implementation and variation in important covariates of conservation outcomes, the process produces an estimate of the causal effects of the interventions on the target conservation outcome – in this case, forest cover loss. Statistical matching is a method that has been used in several studies to generate causal estimates of the effect of conservation and NRM interventions. The estimated intervention effects can then be compared with the intervention costs to produce measures of cost-effectiveness for different interventions.

   The statistical matching approach can also be used to assess the conservation impacts of Mikajy's support to maize, groundnut and vanilla farmers by verifying if there is a correlation between communities receiving the intervention and conservation outcomes, compared to communities who do not. Although these findings will not prove definitively any causation between Mikajy's interventions and improved conservation impacts, they will offer indicative values which can be incorporated into USAID/Madagascar's GIS reports and a future CBA to estimate the impact of the activity on ecosystem services.

[26] The random selection process needs to account for the fact that forest units are spatially autocorrelated and that there may be pseudoreplication in the sample due to unaccounted for administrative level confounding factors (Rasolofoson et al. 2015).

Figure 3-3: Data Requirements for Cost-Effectiveness Analysis



4. FINDINGS

4.1 COST-BENEFIT ANALYSIS RESULTS

4.1.1 OVERVIEW

The cost-benefit model reflects the core logic of project alternatives by comparing the incremental results of USAID Mikajy interventions with the "business-as-usual" or "without intervention" scenario, over a 10-year time horizon. For this model, the "business-as-usual" is defined as farmers in the targeted MaMaBay and Menabe regions who would not receive U.S. Government or other technical assistance that would substantially alter current agricultural activities over the 10-year time horizon.

Moreover, there are key characteristics of the beneficiary profiles that shape the analysis. The beneficiary profile in MaMaBay includes vanilla producers from 4 different communities who have an average farm plot of 0.88 ha. This analysis measures the financial impact of the investment from the perspective of vanilla producers adopting SAN practices and complying with RA certification.[27] USAID support for vanilla farmers includes technical assistance and RA certification training so the incremental financial analysis compares the returns to producers with and without RA certification. However, the financial results are presented with a 30 percent price reduction over the next three years. This scenario is based on a projected one-third price reduction for vanilla (IMF 2019).[28] The economic analysis only reports on the price scenario where there is a 30 percent reduction.

The beneficiary profile in Menabe is separated into demonstration (demo) and non-demo farmers. Demo farmers are groundnut and maize farmers who have an average farm plot of 0.40 ha with 50 percent of land devoted to each crop. USAID Mikajy supports demo farmers by providing training and helping offset the additional cost for seeds and chemical fertilizer inputs. Non-demo farmers have an average farm plot of 0.10 ha with half of production going to groundnut and maize. These farmers only receive support in the form of technical training. For both farm groups, the CBA compares the incremental cash inflows and outflows of groundnut and maize farmers to measure the impact of its promotion of CF adoption and improved input usage.

4.1.2 FINANCIAL RESULTS

VANILLA PRODUCERS

Based on no change in assumed movements in vanilla prices, the average vanilla producer has a real financial NPV of 10.09 million Ariary ($2,775 USD). Under this scenario, vanilla producers would incur the same level of costs, which are primarily associated with labor[29], while continuing to experience small productivity gains at 2.0 percent per year.[30] Under the scenario with declining vanilla prices, farmers experience a real financial NPV of 1.44 million Ariary ($396 USD). Declining vanilla prices result in a slightly negative real cash flow in the 4th and 5th year but turn positive in remaining years as productivity

[27] All financial numbers are presented in real terms, meaning the numbers have been adjusted for inflation to represent 2019 values.
[28] This projection is based on increased supply from other vanilla producing countries.
[29] Family labor makes up the majority of assumed labor expenses.
[30] Yields from FAO Stats are around 1.4% (2012-2017). We are using 2% based on Fairtrade surveys, focus group discussions and to reflect a conservative estimate regarding the relative potential gain in vanilla yields under RA production.

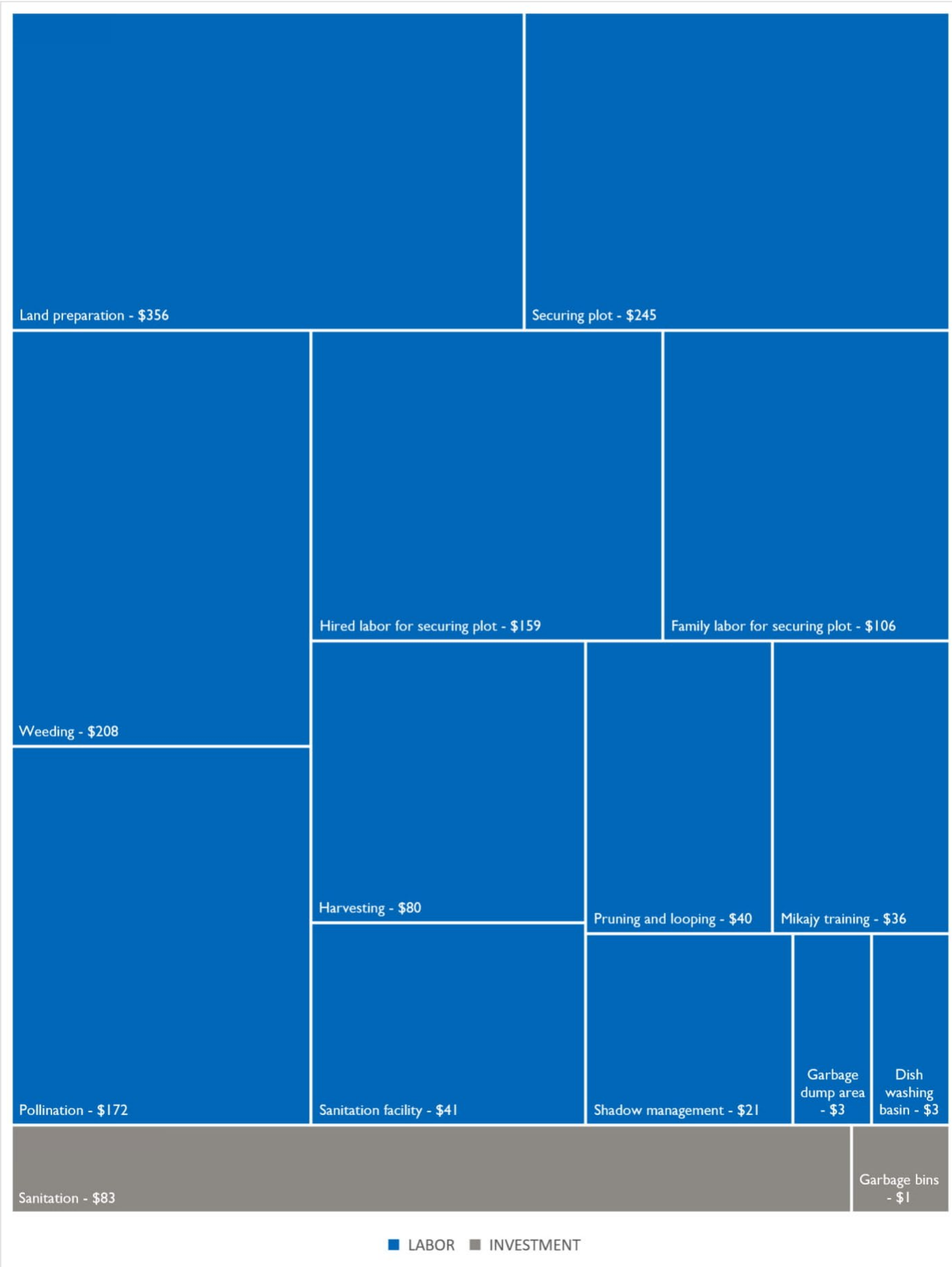
gains are realized. A decline in vanilla prices by 30 percent results in net loss of $2,379 when compared to the scenario where there are no price movements.

Table 4-1: NPV of Vanilla Production without Intervention

Price movement	Real financial NPV	
	Ariary	USD
0 percent	10.09 million	$2,775
-30 percent in first three years	1.44 million	$396

Vanilla producers incur certain upfront and recurring costs as part of the RA certification process (see Annex III for a full list of the costs). RA certification requires material costs related to sanitation, including washing facilities and garbage bins. RA certification also includes higher labor rates for hired workers as part of efforts to promote a "living wage." This variable has the most significant impact on vanilla producer costs and is tested in the sensitivity analysis section of this study. There are also opportunity costs for producers attending RA certification and SAN training and extra labor days are needed to protect the vanilla plot and comply with contracted sales dates. Figure 4-1, a tree map with incremental costs shown by value, represents a financial NPV of $1,553 in incremental costs.

Figure 4-1: Tree Map of Incremental Vanilla Costs by Activity



The CBA study quantifies two potential on-farm benefits of acquiring RA certification and SAN practices. First, this analysis assumes a 10 percent price premium. Additionally, farmers may experience increased productivity due to the adoption of SAN practices. While there is some evidence to suggest productivity gains can rise by 80 percent (Hänke 2016), the analysis is assuming a 45.2 percent productivity increase, from 37.66 kg/ha to 54.7 kg/ha.[31] These production estimates are adjusted for assumed crop theft to include 10 percent of overall production. In total, the incremental revenue from RA vanilla production is NPV $3,232.

Under the scenario where there is a 0 percent movement in projected vanilla prices, the incremental financial NPV is 9.56 million Ar ($2,631 USD), meaning farmers are $2,631 wealthier than they would be without USAID support (Table 4-2). When there is a 30 percent decline in vanilla prices, producers have an incremental NPV of 6.10 million Ar ($1,679 USD). Perhaps the most positive result from this second scenario is that the cash flow does not turn negative in the fourth and fifth year as prices decline. An important assumption of this model is that non-RA certified vanilla producers continue to experience small productivity gains, while RA-certified producers hit a maximum yield ceiling after the third year after SAN adoption.[32] The SAN practices that could increase vanilla yields include increased agroforestry shade cover, improved on-farm water management, and the structured placement of vanilla vines throughout the plot, among other SAN practices that could increase production.

Table 4-2: Incremental NPV of Vanilla Production with Intervention

Price movement	Real financial NPV	
	Ariary	USD
0 percent	9.56 million	$2,631
-30 percent in first three years	6.10 million	$1,679

GROUNDNUT AND MAIZE FARMERS

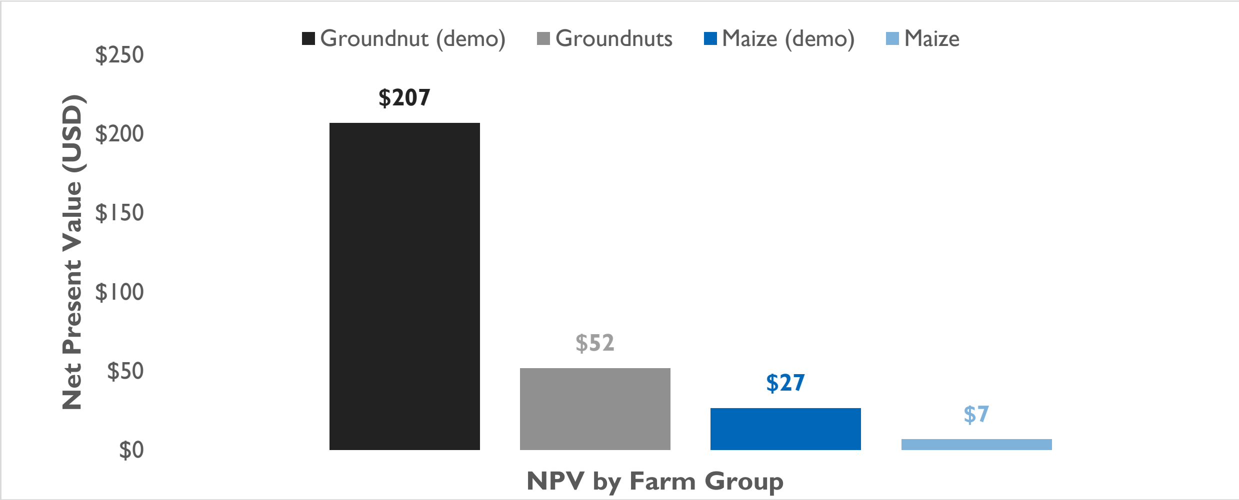
This study assumes that under the "business-as-usual" scenario, groundnut and maize farmers engage in *Hatsake*, meaning productivity starts to decline in the third year and by the fifth year farmers move on to forested land.[33] Based on this assumption, farmers have an NPV of 752,683 Ariary (USD $207) for 0.2 ha of groundnut production and an NPV of 96,483 Ariary (USD $27) for 0.2 ha of maize production (Figure 4-2). For farmers with 0.1 ha of land dedicated to groundnut and maize production, the analysis projects that farms would earn a financial NPV of 188,171 Ariary (USD $52) for groundnut production in the absence of USAID Mikajy (Figure 4-2). For maize, the analysis expects farms to earn a financial NPV of 24,121 Ariary (USD $7).

31

32 Fairtrade has provided some evidence that adopting more sustainable agriculture practices correlates with increased yields. However, we have no statistical evidence that yields will increase or decrease, so we have used sensitivity analysis to test this assumption.

33 Focus group interviews suggest that maize production is the primary cause of land degradation, so the model assumes that maize cultivation occurs until the financial cash flow turns negative.

Figure 4-2: Financial Return for Farmer without the Intervention



USAID Mikajy will subsidize the use of high-yielding variety (HYV) seeds and fertilizers to offset the costs to show how CF practices and improved inputs can increase yields. Additional costs to groundnut and maize producers include increased input costs (e.g. chemical and organic fertilizers) and increased labor costs. For both value chains, the key assumed benefits include increased production and reduced incidences of diseases and pests. For groundnuts, the study assumes a 100 percent increase in yields, and the study assumes an 80 percent increase in yields for maize. Annex III provides a list of the key cost and benefit assumptions used in this study.

Figures 4-3 shows the incremental cash flow for groundnut and maize farmers. The cash flow for demo farmers remains positive throughout the CBA study time horizon. For non-demo groundnut farmers, however, the incremental cash flow is negative in the first year and then turns positive in the second year as yield increases are realized. Similarly, non-demo maize producers experience negative incremental cash flows in the first two years of adoption and then start experiencing positive financial gains in the following years.

Figure 4-3: Incremental Cash Flows for CF Maize and Groundnuts (Author calculations)

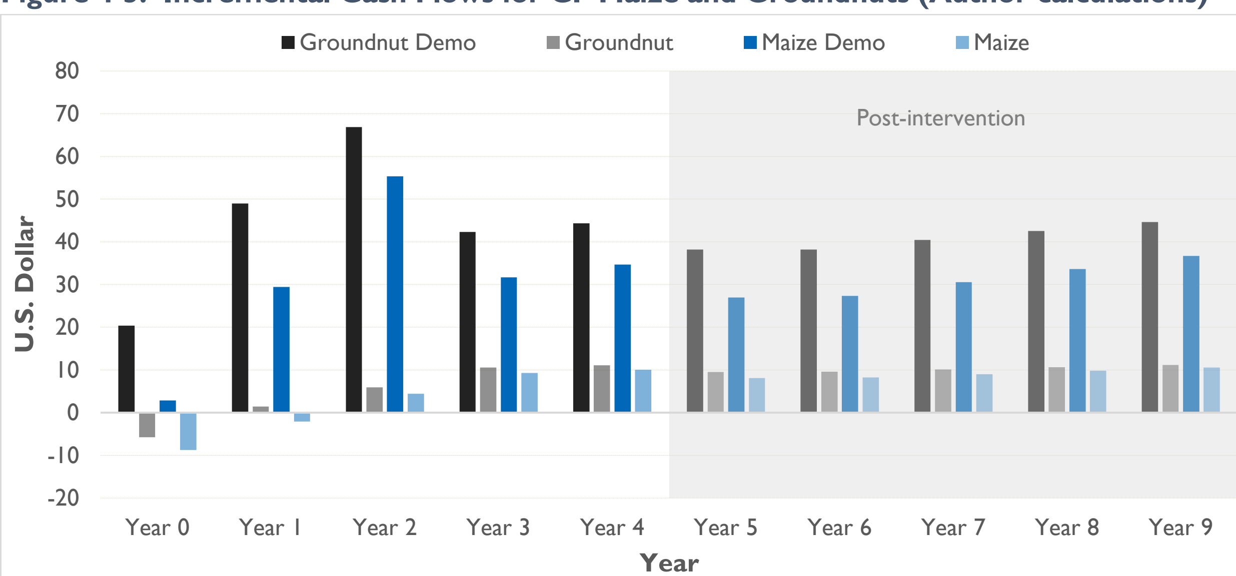
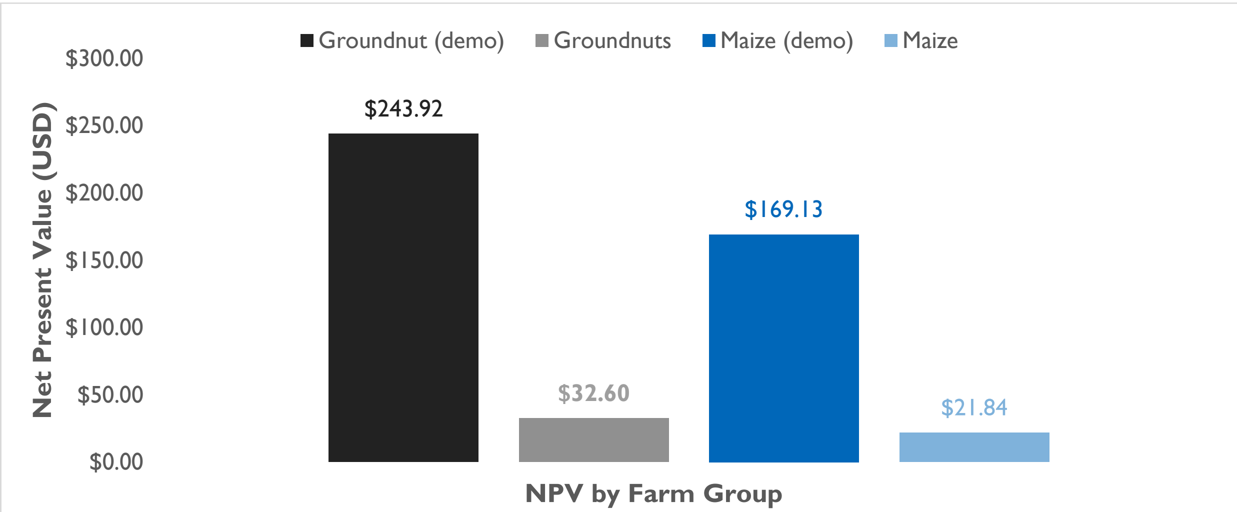


Figure 4-4 provides a summary of the incremental financial NPV that an average farmer is projected to experience. Under current model assumptions, demo groundnut farmers have a financial NPV of $244 (886,806 Ar), while non-demo farmers have an NPV of $33 (118,516). Meanwhile, demo maize farmers have an NPV of $169 (614,892 Ar), compared to $22 (79,396) for non-demo farmers. Taken as separate groups, demo farmers have a financial NPV of $413 (1,501,698 Ar) and non-demo farmers have financial NPV of $54 (197,912 Ar).

Figure 4-4: Incremental NPV for CF Maize and Groundnuts (Author calculations)



With regards to non-demo maize production, a positive NPV is heavily dependent on the assumptions that producers will experience an 80 percent increase in maize yields and source 60 percent of increased organic fertilizer usage from farmer owned livestock. The financial NPV turns negative if either of these assumptions fall. Likewise, the positive financial NPV for groundnut production is heavily dependent on the assumption that producers will experience a 100 percent increase in groundnut yields, as well as assumptions regarding the price of HYD seed varieties.

4.1.3 ECONOMIC VALUES

Per *USAID CBA Guidelines* (2015), conversion factors (CF) are used to convert financial cash flows to economic resource flows. Specifically, a CF is a ratio comparing the economic value (EV) of a good to the financial value (FV) of a good. The CF ratio is represented by the following formula:

Formula 4-1: CF Ratio

$$CF = \frac{EV}{FV}$$

The financial values for each of the value chains were developed in the financial cash flow statements, while the economic value is adjusted for economic distortions, such as foreign exchange premium (FEP),[34] and tariffs. Imported inputs, including chemical fertilizers (NPK; Urea), have been adjusted using the FEP while

[34] The foreign exchange premium (FEP) represents the amount that traded goods are mispriced relative to non-traded goods. This analysis uses an FEP of 8.70 percent based on the World Trade Organization weighted average tariff for Madagascar. This means non-traded goods are over-valued by 8.7 percent relative to other goods.

importable outputs (i.e. import substitutes), such as groundnuts and maize, have been adjusted for import tariffs and FEP.[35] Vanilla, an exportable good, is adjusted for the FEP (note: will provide CF table in the Annex).

Both NPK and Urea have a CF of 1.09, representing a higher economic resource cost and a higher incremental cost as a result of the intervention. Groundnuts and maize have CFs of 0.85 and 0.90, respectively. This means the market value (price) is higher than the true economic value due to import tariffs and FEP. Vanilla has a CF of 1.12, indicating economic benefits greater than the financial gain due primarily to the economic gain from the foreign exchange premium.

USAID Mikajy did not have the full program costs for each of the value chains. As a result, the model assumes an average cost of USD $100 per vanilla producer per year and $25 annual cost per groundnut/maize farmer over the implementation period. The higher training cost for vanilla producers is based on the level of knowledge and compliance factors that go into RA certification. Both costs are tested in the sensitivity analysis. In addition, NCBA spent $18,567 for seeds and fertilizer inputs for groundnut and maize production. The CBA assumes these subsidies are distributed to farmers over the implementation period. All USAID costs are included in the economic resource flow.

After comparing the net economic resource flows to the program costs[36], the economic NPV for vanilla is $9.22 million under the scenario 2 – vanilla prices fall by 30 percent. If the net benefits are based on a one-third split between all investment parties, then this value falls to $2.53 million that can be attributed to USAID's support (Table 4-3). The intervention for groundnut producers results in an economic NPV of $6,157 and $3,740 for demo and non-demo farmers respectively. The intervention for maize producers results in an economic NPV of $3,044 and -$4,155 for demo and non-demo farmers, respectively. In total, the CF intervention is expected to create an economic NPV of $8,786 indicating that society is $8,786 wealthier as a result of the USAID Mikajy intervention

Table 4-3: Economic Decision Criteria

Decision Criteria	Vanilla	Groundnuts – Demo	Maize – Demo	Groundnuts	Maize
Economic NPV	$2,538,031	$6,157	$3,044	$3,740	($4,155)
Economic Internal Rate of Return (EIRR)	150 percent	48 percent	25 percent	15 percent	9 percent
Modified Economic Rate of Return (MERR)	45 percent	26 percent	18 percent	13 percent	11 percent

[35] Importable outputs are goods that are, on balance, imports into the country. In this case, the economic value of the good is set by the interaction of international supply and demand.
[36] The program costs for vanilla include expenditures by USAID, RAMEX, and McCormick.

4.1.4 ECOSYSTEM VALUES

As previously mentioned, this study does not have the necessary inputs to calculate the likely benefits from reduced soil erosion. To make this calculation, we would need the necessary variables for the Universal Soil Loss Equation, including the following: average annual soil loss in tons per acre; rainfall erosivity index; soil erodibility factor; topographic factors; cropping factor; and conservation practice factor. While we were not able to incorporate these potential benefits, we use empirical deforestation rates calculated from the Hansen et al. global forest cover dataset and evidence of reduced deforestation from other evaluations of RA certification and CF practices impact on conservation outcomes to show what might be achieved through USAID Mikajy's activities. Table 4-4 provides a summary of the ecosystem values that were and were not included in this analysis. Furthermore, In Annex IV, there is a full description of the techniques and data sources used to make these calculations.

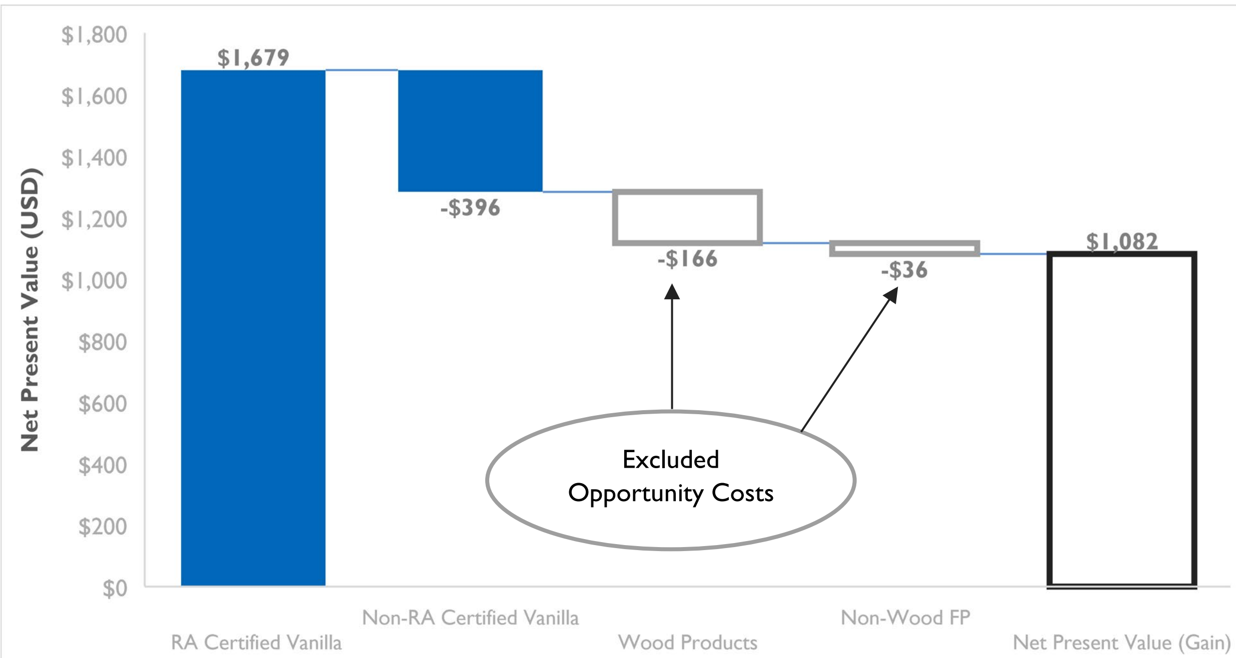
Table 4-4: Ecosystem Values by Activity and Analysis Status

Activity	Potential Impact	Technique
On-Farm CF Techniques	Reduced Erosion	Not estimated
On-Farm CF Techniques	Reduced Water Quality	Not estimated
On-Farm RA Practices	Reduced Erosion	Not estimated
On-Farm RA Practices	Improved Water Quality	Not estimated
Conservation	Carbon Sequestration	Based on projected benefits of averted forest cover loss
Conservation	Local Opportunity Costs (Vanilla; Maize; Groundnuts)	CBA estimates
Conservation	Local Opportunity Costs (wood extraction)	Secondary data
Conservation	Local Opportunity Costs (non-timber forest products)	Secondary data
Conservation	National Estimates (incl. costs of conservation, water, tourism, etc.)	Sensitivity analysis only
Conservation	Global Estimates	Sensitivity analysis only

For beneficiaries in MaMaBay, we estimate that the activity could avert 0.0124 ha of forest cover loss per year for each of the six communities or 0.1181 ha per year for all communities receiving USAID support. Over the 4-year implementation period, this would amount to 0.4724 ha of averted forest cover loss. In Menabe, we only assess the benefits that could potentially accrue to one community because of the small size of the maize and groundnut farm plots. The result is 0.019 ha of averted forest cover loss per year or 0.077 ha over the implementation period.

The CBA considers three perspectives when estimating the potential value of ecosystem services impacted by the project, including local producers, the country of Madagascar, and globally. From a local's perspective, the opportunity cost of vanilla, groundnut, and maize production, as well as the value of wood and non-timber products, will be used to estimate an average opportunity cost per ha that local communities would "give up" with the intervention.

Figure 4-5: RA Vanilla vs. Opportunity Costs of Conservation (NPV at 0.89 ha)



For RA certified vanilla production, we have also developed illustrative ecosystem values to demonstrate the opportunity cost of conservation from the producer's perspective and to identify information gaps that should be addressed moving forward. RA certified vanilla producers are expected to have an incremental NPV of $1,679 per 0.89 ha. From the producer's perspective, the value drops to a financial gain $1,082 (NPV) after the opportunity cost of traditional vanilla ($8369)[37], unsustainable wood extraction ($166) and non-timber forest products ($36) is accounted for on the same amount of land (Figure 4-5). It should be noted that the opportunity cost for vanilla production assumes that vanilla prices will fall by 30 percent over the next several years. If vanilla prices only drop by 5 percent, then the opportunity cost of conservation is greater than the value derived from RA certified vanilla.

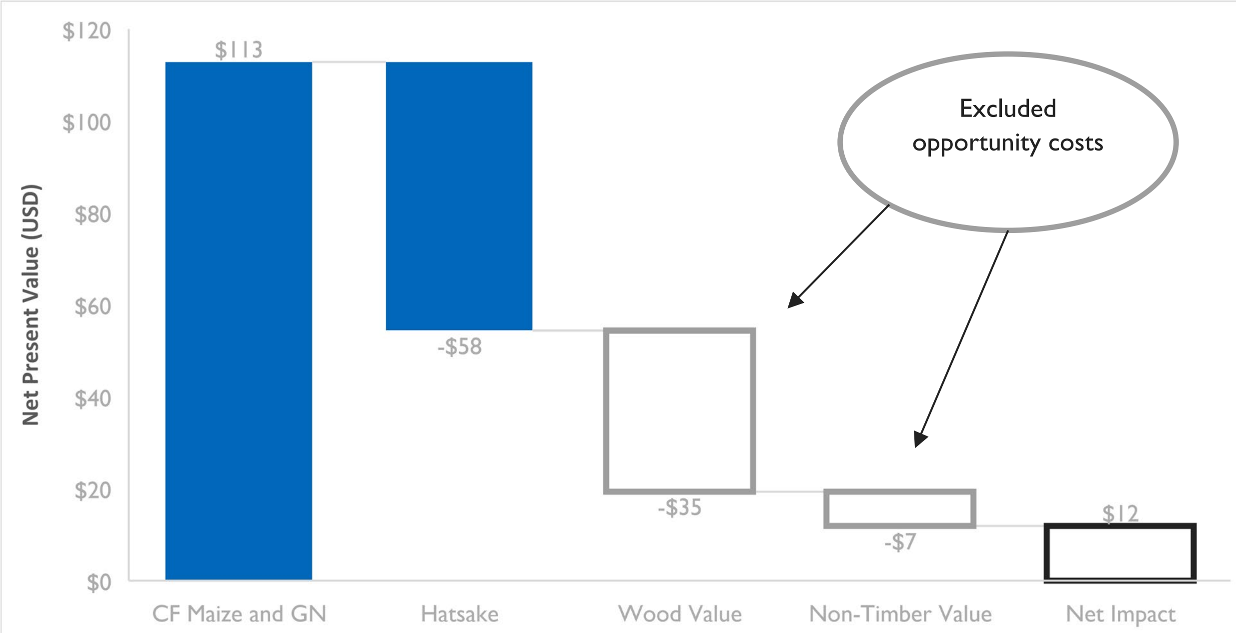
37 The value of traditional vanilla production in a protected area is considered because this study assumes that traditional vanilla plots in the MaMaBay region do not turn fallow after a cultivation period of 5-years.

We currently assume the support for RA certified vanilla production could result in a 12 percent reduction in forest loss within a 50-kilometer radius of six MaMaBay community or 0.1181 ha of averted forest loss per year. Over a 4-year implementation period, this would amount to 0.4724 ha of averted forest cover loss. The opportunity cost of traditional vanilla production, as well as the opportunity cost of wood and non-timber resource extraction, is $261 (NPV) for 0.4724 ha, including traditional vanilla production ($173), wood extraction ($73), and non-timber forest products ($16). This compares to an incremental value of $733 per 0.472 for RA certified vanilla production, suggesting vanilla producers would experience a financial gain relative to the opportunity cost of conservation.[38] The incremental financial NPV compares the costs and benefits of conservation farming with the "without intervention" values for *Hatsake* maize and groundnut production. However, farmers are likely to consider other opportunity costs when determining if they should conserve the surrounding land, including the value of wood and non-timber forest products. Since we do not have the specific geospatial coordinates of each individual farmer, we have developed illustrative ecosystem values to demonstrate the potential impact of USAID Mikajy activities and to identify information gaps that should be addressed moving forward. It should be emphasized that these values have been excluded from the financial and economic analysis due to the high level of uncertainty.

Non-demo CF results in an NPV of $113 per 0.1 ha before accounting for the opportunity cost of *Hatsake* groundnut and maize production. From the farmer's perspective, this value drops to $12 when the opportunity cost of *Hatsake* ($58), unsustainable wood extraction ($35) and non-timber forest products ($7) is accounted for on the same amount of land (Figure 4-6). We currently assume the support for CF farming could result in a 12 percent reduction in forest loss within a 50-kilometer radius of one Menabe community or 0.077 ha over the 4-year implementation period. Based on the assumption that the intervention will reduce forest cover loss, the NPV of groundnut and maize production is $36.95 per 0.077 ha of averted forest cover loss. Using the same values from Carret and Lovey (2004), wood has a one-time cost of $11.877 per 0.077 ha of averted forest cover loss and non-forest timber products have a one-time cost of $2.53 per 0.077 ha of averted forest cover loss. The total opportunity cost of foregone forest exploitation is estimated at $51.35 for 0.0771 ha of averted forest cover loss. This compares to an incremental value of $71.40 per 0.077 for CF production (before considering incremental cash flows), suggesting CF producers would experience a financial gain relative to the opportunity cost of conservation.

[38] This assumes the benefits of RA certified vanilla production are dependent on the conservation requirements of RA certification. In other words, producers would not receive the incremental benefits of RA certification if they do not meet the conservation goals of RA certification.

Figure 4-6: CF vs. Opportunity Costs of Conservation (NPV at 0.1 ha)



Secondary evidence was used to estimate the national and global impact of the two interventions. However, due to the variability of research findings, the low figures provided within the literature research and the limited projection for averted forest cover loss per year, these estimates were only tested in the sensitivity analysis. For example, Kremen et al. (2000) estimate an NPV range from $0.002 to $0.005 per ha of protected land and a national NPV range between -$2.64 to -$0.82 per ha of protected land, while Hockley and Razfindralambo (2006) estimate local values ranging from an NPV of -$0.24 to $0.02 per ha of protected land and a national range between $0.05 to $0.22. Carret and Loyer (2004) estimate national benefits of $10 per ha of protected land, including $3 from biodiversity conservation, $4 from eco-tourism, and $3 from the protection of watersheds.

The total potential global value of conservation also varies depending on the source. Carret and Loyer (2004) estimate an NPV of $15.70 per ha of protected land without accounting for carbon sequestration. Hockley and Razfindralambo (2006) estimate values ranging from an NPV of $1.18 to $6.45 per ha of protected land with carbon sequestration while Hockley and Razfindralambo (2006) estimate positive values ranging from an NPV of $0.08 to $0.35 per ha of protected land. Both studies included the benefit of carbon sequestration in their calculations.

While national and global estimates are considered in the sensitivity analysis section, we also add a carbon value scenario to account for the potential benefits of increased carbon sequestration. Specifically, the intervention is projected to reduce forest cover loss by 0.47 ha in MaMaBay (0.118 ha per year for 4 years) and by 0.077 ha in Menabe (0.0193 ha per year for 4 years). The study accounted for the benefits of carbon using two techniques. First, the amount of carbon that can be sequestered per year is calculated using estimates from Bernal et al. (2018), including 7.9 tons of carbon dioxide equivalent (tCO2e) per ha and 3.1 tCO2e per ha for dry forests.[39] Second, the study accounts for the

[39] The humid forest estimate is based on a calculation for humid forests in Africa and dry forests in South America.

tCO2e that is "saved" as a result of averted deforestation, including 90 tCO2e per ha in Madagascar's humid forests and 17 tons of carbon per ha of dry forest (World Bank 2013). Based on these assumptions, the value of carbon sequestration in MaMaBay and Menabe is $9,955 and $294, respectively.

4.1.5 SENSITIVITY ANALYSIS

To build cost-benefit models, it is necessary to make certain assumptions. The uncertainty inherent in those assumptions impacts the level of validity attributed to the result, which is why it is essential to analyze the sensitivity of the model to those assumptions. This is done using one-way and two-way tables that show how the result changes with modifications to the values of certain parameters, everything else being held constant.[40]

Annex III provides a summary of the key variables tested in the sensitivity analysis. Below is a list of these assumptions followed by a short summary of the main variables driving the results.

- Percentage change in agricultural yields due improved methods and inputs (groundnuts, maize)
- Timeline for reaching maximum yield gains
- Percentage movement in price premium for RA certified vanilla
- Annual production losses attributed to pests and disease
- Potential natural disasters (e.g. cyclones and droughts)
- USG costs per beneficiary
- Financial discount rate
- Percentage reduction in current deforestation rates
- Local, national, and global values for conservation

Of these assumptions, slight movements in the following variables caused the most significant impact: yield growth, organic fertilizer costs for maize farmers, HYD seed prices for groundnut farmers, and training costs per beneficiary. The program should closely monitor these assumptions, especially those pertaining to yields and input costs, to ensure positive returns. We tested movements in national and global ecosystem values but these variables did not have a significant impact on the financial or economic returns of the model.

[40] Monte Carlo analysis can be used when primary data (i.e. surveys) allows for the estimation of probability distributions around key input variables.

4.2 COST-EFFECTIVENESS ANALYSIS RESULTS

The secondary data obtained for the CEA (summarized in Table 4-5 below) were insufficient to determine causal estimates of the effectiveness of the various conservation and NRM structures that were selected for comparison. In general, the PA annual reports and databases provide aggregate summaries of intervention inputs (eg: number of training sessions hosted, number of patrols carried out) and outputs (eg: number of community members trained, number of logging incidents reported) and compare realized values with target values. While these aggregated data are useful for PA managers to assess operational performance and inform planning decisions, causal analysis requires these data to be disaggregated to as fine a spatial and temporal level as possible, such as the TGRN or fokontany level on an annual basis.

Given that the provided PA budgetary and effectiveness data is aggregated at the PA level, we cannot comment on how variations in spending and management effectiveness are related to conservation outcomes at the sub-PA level (i.e. within individual TGRN areas, or specific zones within the Pas). Due to these constraints, we are unable at this time to present any concrete conclusions about the cost-effectiveness of different types of conservation and NRM interventions.

Given the described limitations, we have taken a modified approach to the CEA to lay the foundation for the type of causal analysis that is required to produce rigorous estimates of the cost-effectiveness of various conservation interventions. In this section we outline the steps that were taken to lay this foundation, and we identify what information gaps need to be addressed to enable a causal analysis of conservation and NRM cost-effectiveness. Through this process we also completed an illustrative exploratory analysis of forest cover loss intensity over space and time based on known conservation intervention timelines in the Menabe and MaMaBay landscapes.

We used the Hansen et al. data to identify units of land that were forested in the year 2000, both inside and within a 10 km distance from the boundary of each of the four target terrestrial areas. The Hansen et al. data uses the year 2000 as the base year for forest cover and describes each pixel of land by its estimated percent canopy closure of vegetation higher than five meters in height. (Hansen et al. 2013) For this study, 'forest cover' was defined as 50% or greater canopy closure in Makira and Masoala PAs, and 10% or greater canopy closure in Menabe-Antimena and Kirindy-Mitea PAs. These thresholds were chosen based on similar studies in these landscapes (Bastin et al. 2017 and WCS 2012). Hansen et al. define forest loss as "a stand-replacement disturbance, or a change from a forest to non-forest state," and identifies the year in which a unit area of land was deforested.

Table 4-5: Conservation Indicator and PA Management Data

Indicator	Source	PA				Comments
		KRM	MAK	MAS	MA	
Forest cover loss	Hansen et al. 2013	✓	✓	✓	✓	May not be suitable for Western dry forests of Kirindy-Mitea and Menabe-Antimena.
	WWF aerial surveillance 2018				✓	May not display relatively small cleared or burned areas.
	Annual reports from PA managers	✓	✓	✓		Not geospatially referenced, aggregated at PA level.
Forest cover gain	Hansen et al. 2013	✓	✓	✓	✓	Only covers 2000-2012.
Biodiversity level	Ecological monitoring patrols	✓				Dated GPS coordinates of endangered species sightings from ecological monitoring patrols 2013-2016.
Environmental pressures / conservation infractions	Annual reports from PA managers	✓	✓		✓	Includes counts of environmental pressures such as logging and hunting incidents. Data is not geospatially referenced and is aggregated variously at the community level (MA), PA sector level (MAK) and PA level (KRM).
PA boundaries	Protected Planet	✓	✓	✓	✓	Outer limit of PA.
	Madagascar National Parks	✓				Shapefiles of the TGRN areas. No attribute data associated with shapefiles.
	Fanamby				✓	Shapefiles of zones within the Menabe-Antimena PA.

Indicator	Source	PA				Comments
		KRM	MAK	MAS	MA	
PA management funding and costs	Annual reports from PA managers	✓	✓	✓	✓	Aggregated to the PA level.
PA management effectiveness	PA Management Effectiveness Tracking Tool reports	✓	✓	✓	✓	PA-level information about management effectiveness.
	VOI Management Effectiveness evaluations				✓	Evaluations conducted in 2018 of the effectiveness of four VOIs in the Menabe-Antimena PA. Scores are assigned based on subjective categorical rankings.

To identify which forest units fall in which type of area, shapefiles of the PA boundaries were downloaded from the Protected Planet website. Unfortunately, the categorization is not as simple as distinguishing between inside and outside the PA boundary, because there can be several different classifications of land within a PA that offer varying degrees of environmental protection. These categories include:

- **Strict protection zone (*noyau dur*)** - no exploitation of natural resources is permitted.
- **Zone of controlled occupation (*zone d'occupation contrôlée, ZOC*)** - area in which pre-existing human settlements are situated; exploitation of natural resources may or may not be permitted.
- **Zone of sustainable use (*zone d'utilisation durable, ZUD*)** - area in which sustainable exploitation of natural resources is permitted.

The PA boundaries may also encompass special reserves, forest concessions and other special categories of land that influence the degree of pressure on the landscape within the PA.

Shapefiles received from MNP show the location of the TGRN zones around Kirindy-Mitea PA, and shapefiles received from Fanamby show several different categorizations of land within Menabe-Antimena. Since we did not receive shapefiles from MNP or WCS for Masoala and Makira PAs respectively, we were unable to distinguish between different land categories within the boundaries of these PAs. PA project documents provided by PA managers were reviewed to determine the when PA and TGRN areas were established. Table 4-6 summarizes the different land categories in which forest units were categorized in and around each of the four PAs. In the table, the category 'unprotected' refers to any area within 10km outside the PA boundary[41] that does not fall in one of the other land categories, during the timescale during which that land category is relevant. For example, if a forest unit was deforested in one of Kirindy-Mitea's TGRN zones in the year 2001, then the deforestation took place in an unprotected zone since the TGRN zones were not established and contractualized until 2017.

[41] Based on the Protected Planet shapefiles of the PA boundaries.

Table 4-6: Grouping of Forest Units in and around the Four Target PAs

PA	Land category	Relevant timescale
Kirindy-Mitea	PA	2000-2018[42]
	TGRN	2017-2018
	Unprotected	2000-2018
Makira	PA	2012-2018
	Unprotected	2000-2018
Masoala	PA	2000-2018
	Unprotected	2000-2018
Menabe-Antimena	Zone of Strict Protection	2015-2018
	Zone of Sustainable Use	2015-2018
	Special reserve or research concession	2000-2018
	Unprotected	2000-2018

We identified several observable factors that are potential covariates of forest cover loss, which are listed in Table 4-7. We searched for data sources for each covariate at the finest level of spatial aggregation available. The finer the level of spatial aggregation, the more accurate and precise the estimate of the value of the covariate will be at the location of each forest unit. The finest level of spatial aggregation considered is a forest unit (i.e. a pixel in the Hansen et al. data). Where a dataset for a covariate could not be identified, the data source is listed as *N/A* in Table 4-7. Each forest unit was assigned a value for all covariates with available data using geospatial methods.

[42] Kirindy-Mitea was originally designated a PA in 1996, but its boundaries were redrawn in 2015, and the TGRN areas were established at this time as well. However, project documents shared with the study team by MNP indicate that the TGRN areas were not contractualized until 2017 and 2018.

Table 4-7: Observable Covariates of Forest Cover Loss

Covariate	Spatial level	Data source	Rationale
Demographics			
Population density	100m x 100m grid unit	WorldPop 2020	People are the primary agents of deforestation and forest degradation, so forest cover loss patterns are related to the number and distribution of people in a forested area.
Population growth rate	100m x 100m grid unit	WorldPop 2020	An influx of people into a forested area in a given year may induce higher levels of forest cover loss as people establish new infrastructure and agricultural plots.
Income per capita	Fokontany or Commune	*N/A*	Landscapes in areas where the average income per capita is relatively low might face higher pressure from natural resource exploitation, as people extract greater quantities of resources for subsistence.
Agricultural suitability			
Temperature	Forest unit	*N/A*	Agricultural yields are dependent on climate conditions. When climatic conditions are not conducive to agriculture, yields will be lower, which might induce farmers to clear more land to increase production through expansion.
Precipitation	Forest unit	*N/A*	
Soil type	Forest unit	*N/A*	Certain soil types are better suited for agricultural development; areas with such soil types are thus more desirable for agricultural cultivation.
Elevation	Forest unit	Shuttle Radar Topography Mission (SRTM) 1 Arc-Second Global Digital Elevation Model (DEM)	Asner et al. 2012 found that "Forests found at higher elevations were less likely to be deforested or degraded," which intuitively makes sense as these areas are more difficult to access.
Slope	Forest unit	Shuttle Radar Topography Mission (SRTM) 1 Arc-Second Global Digital Elevation Model (DEM)	In MaMaBay, farmers practice *tevy-ala*, which is the process of clearing hillside forest land for rice cultivation (*Tavy*). Areas with greater slope might therefore be more vulnerable to clearing and burning via *tevy-ala*.

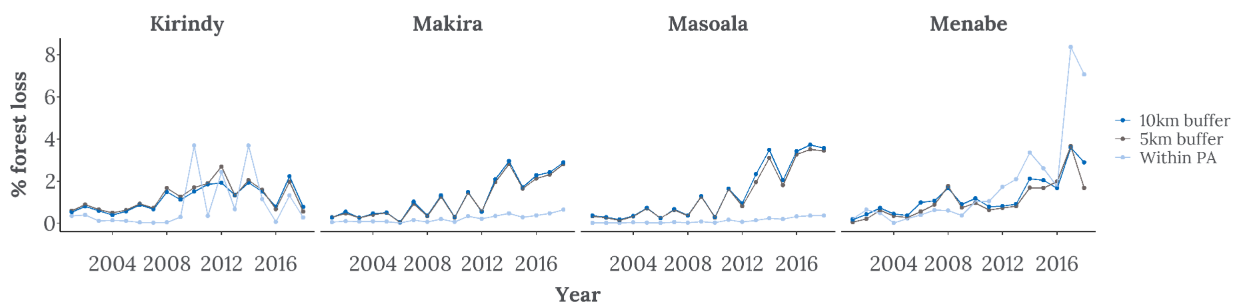
Covariate	Spatial level	Data source	Rationale
Proximity to important built and natural features			
Roads	Forest unit	Humanitarian OpenStreetMap Team	Proximity to human settlements/transportation infrastructure facilitates access to a forested unit. Forest units that are relatively easy to access are relatively more vulnerable to deforestation.
Towns	Forest unit		
Navigable bodies of water	Forest unit		
PA or TGRN administrative boundary	Forest unit	Protected Planet PA managers	Forest units deep within a PA may be less vulnerable to deforestation than forest units at the edge of the PA.
Prior deforestation	Forest unit	Hansen et al. 2013	If a farmer deforests a forest unit, she or he might subsequently deforest adjacent units.
Conservation intervention[43]			
Type of intervention (PA, TGRN, unprotected etc.)	TGRN, PA or other distinct land category	Protected Planet PA managers	Forest units should be less vulnerable to deforestation if they are situated within a PA or TGRN area than if they are within an unprotected area. This is the grouping variable for the statistical matching process.
Size of area			PA and TGRN areas that are very large and have long perimeters require relatively greater amounts of resources to effectively protect than areas that are smaller and have shorter perimeters.
Perimeter of area			
Proximity to a conservation patrol route	Forest unit	*N/A*	If a forest unit is relatively close to a patrol route, it might be less likely to be deforested if the patrols are effective at identifying and penalizing illegal deforestation events.
Proximity to a clearly demarcated PA or TGRN administrative boundary	Forest unit	*N/A*	If a boundary is to be effective, people need to be aware of where the boundary lies. Forest units in close proximity to a clearly marked boundary within a PA or TGRN might be afforded greater protection than forest units behind an unmarked boundary.
Relative effectiveness of conservation and NRM management	TGRN, PA or other distinct land category	METT reports VOI effectiveness evaluations[44]	Human pressure on natural landscapes might be lower in administrative areas in which conservation and NRM management is relatively effective.

[43] The covariates in the *Conservation intervention* category can account for heterogeneity within a type of intervention due to variations in implementation of the intervention. This can allow for impact analysis of interventions that meet certain criteria.
[44] VOI effectiveness evaluations were only provided for four VOIs in the Menabe-Antimena Protected Landscape.

To complete the causal analysis, spatially referenced data needs to be identified for the covariates that remain unquantified, and the values for these covariates associated with each forest unit in the study window. Once this is done, the statistical matching process can be implemented. Cost data also needs to be provided at the sub-PA level (ideally at the fokontany or village level); presumably cost data is available at this level of spatial aggregation, but it was not made available for this study. The cost of implementing an intervention can be compared with the estimated measure of effectiveness generated by statistical matching to produce an estimated cost-effectiveness measure for each intervention after accounting for the confounding effects of all the covariates in Table 4-7.

Although causal analysis was outside the scope of this study, we used the processed Hansen et al. forest cover data to conduct an exploratory analysis of forest cover loss trends across space and time in each of the four terrestrial PAs, based on the intervention timescales described in Table 4-7. Figure 4-7 shows forest cover loss trends within each PA and within a certain distance of the boundary outside each PA from 2000-2018.

Figure 4-7: Forest Cover Loss Trends



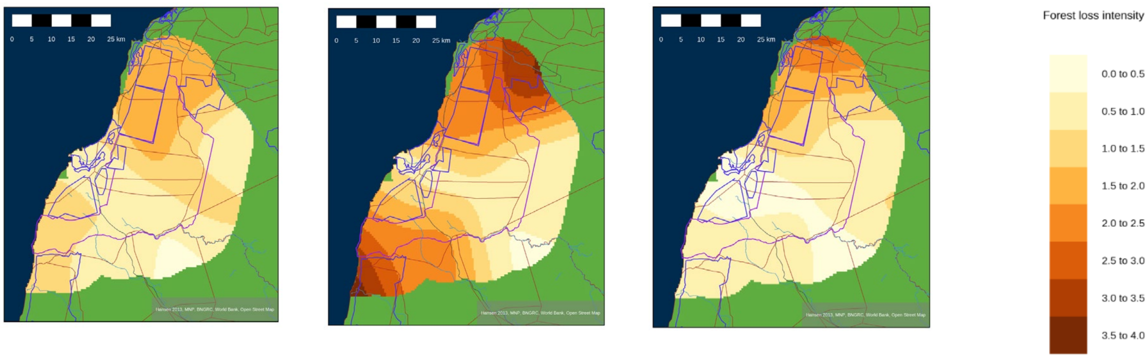
Makira and Masoala show similar trends in forest cover loss over time. Kirindy-Mitea and Menabe-Antimena show similar trends up until around the time of the political crisis in 2009. At around this time, the rate of forest cover loss begins to increase steadily in Menabe-Antimena before spiking sharply in 2016. There is a clear, biennial cyclical pattern in the forest cover loss detected within Kirindy-Mitea from 2009-2015, as well as in Makira and Masoala from 2005-2012.

The trend for Menabe-Antimena provides a useful illustration of why we cannot simply compare forest cover loss in one time period vs forest cover loss in another time period as a measure of effectiveness. The large and rapid increase in the rate of forest cover loss from 2016 to 2017 took place one year after Menabe-Antimena received its Protected Landscape status. Are we to infer from this that the Protected Landscape designation made the situation worse? Of course not; Menabe-Antimena was granted protection because the driving processes of forest cover loss were intensifying within the area. This is a clear example of how the criteria used to assign the intervention (i.e. Protected Landscape status) to Menabe-Antimena confounds our ability to observe the effectiveness of the intervention.

While this high-level perspective on the general trend in and around each PA provides some insight into the circumstances in each landscape, Figure 4-7 hides the variation in forest cover loss intensity through space within and around each PA. To observe spatial trends in each of the relevant time spans listed in Table 3-7 above, kernel density smoothed surfaces were calculated and added to maps of each PA. An example map of the estimated forest cover loss intensity in Kirindy-Mitea over time is shown in Figure 4-

8. The rest of the maps can be found in Annex IV of this report, and they display the variation in the intensity of forest cover loss through space within and around each PA.

Figure 4-8: Forest Cover Loss Intensity in Kirindy-Mitea



2001-15 | 2016-17 | 2018

Visualization: Authors

Data Sources: Hansen et al. 2013, MNP, BNGRC, World Bank, OpenStreetMap Humanitarian Team

5. CONCLUSIONS

5.1 COST-BENEFIT ANALYSIS

A model is a reflection of reality. In the best of situations, the model is built upon statistically representative samples of a target population. In other situations, a combination of secondary evidence, administrative data, and critical assumptions are needed to develop a model that can be used to identify risks and to ask important questions that should be addressed over the project lifecycle. This study represents the latter. As a result, caution should be exercised when interpreting these results or making any inferences about USAID Mikajy's activities.

For the vanilla analysis, we assume vanilla prices decline by 30 percent over the next few years as global competitors enter the market. Even with this assumption, our results suggest USAID Mikajy's vanilla intervention creates wealth at both the producer level and for the entire economy. Specifically, producers have an incremental NPV of $1,679 per household, indicating producers are $1,679 wealthier than without the intervention. Similarly, the incremental economic NPV is $2.53 million, meaning the Madagascar economy is $2.53 million wealthier as a result of USAID's support. Perhaps most importantly, producer cash flows do not turn negative, even when vanilla prices reach their nadir.

However, these results are built upon the critical assumption that yields increase by 45 percent due to improved farming techniques and enhanced market connectivity. If yields increase by only 20 percent, then the incremental financial and economic NPV turns negative. While an assumed price premium of 10 percent has a positive impact on the financial and economic results, the price premium is most likely critical for reasons that are not evaluated in this study, including its role in incentivizing producers to participate in RA certification and by providing consumption smoothing throughout the year.

USAID Mikajy supports two types of farm groups in the southwest, including demonstration (demo) farmers (0.4 ha) and other farmers (0.1 ha) who devote 50 percent of their land to each groundnut and maize production. Demonstration groundnut and maize farmers experience an incremental financial NPV of $413, including $169 for maize production and $ $244 for groundnut production. Similarly, non-demonstration farmers have an incremental NPV of $54, including an NPV of $32.60 for groundnut production and an NPV of $21.84 for maize. The entire maize and groundnut intervention results in an economic NPV of $8,786 when activity costs are considered, and economic distortions are removed from the model. These costs are being driven by assumptions regarding programmatic costs, in particular the cost per beneficiary.

The positive financial return for maize is highly dependent on assumptions regarding the source of additional organic fertilizer, while the financial return for groundnuts becomes negative with slight movements to the assumed costs of HYV seeds. Several adjustments would raise the incremental NPV, including a financial mechanism that would help offset inputs cost (e.g. seeds and fertilizers) and yield growth potential achieved by the first year of adoption. Additionally, while the CBA model assumes the land dedicated to CF production if fixed, farmers could increase their revenues if they expand production to other non-forested agriculture land

Ecosystem values are based on averted deforestation of 0.47 ha in MaMaBay and 0.077 ha in Menabe. The incremental value of RA certified vanilla producers is much greater than the opportunity cost of slash-and-burn vanilla production. This means the supported RA certified vanilla producing communities in MaMaBay should have an incentive to preserve the local protected zone. Similarly, groundnut and maize producers would be expected to get slightly higher financial returns from CF adoption relative to *Hatsake*. However, the incremental value alone is probably not high enough to incentivize farmers to conserve the local protected zones.

5.2 COST-EFFECTIVENESS ANALYSIS

Currently, it is not possible to rigorously calculate a measure of cost-effectiveness for the various conservation and NRM alternatives that Mikajy is considering supporting. Generating such a measure requires both a causal analysis of conservation and NRM effectiveness, as well as sub-PA level cost data for a particular intervention. Such granular cost data was not made available for this study, and it was beyond the scope of the study to conduct a causal analysis of the effectiveness of alternative interventions.

Remote sensing data showing forest cover at fine resolution throughout the entire country is available and can be analyzed to quantify changes in the rate of forest cover loss in an area over time. The accuracy of forest cover change estimates depends on the image processing algorithms used to classify pixels as either forested or deforested. USAID/Madagascar could make use of publicly available processed remote sensing data such as the Hansen et al. global forest cover dataset, but carrying out custom image processing of Landsat imagery using algorithms that are locally-tailored to the Mikajy target landscapes would provide more accurate estimates of forest cover loss.

5.3 RECOMMENDATIONS

1. EXPAND DATA TRACKING OF VALUE CHAIN ACTIVITIES

USAID is positioned to efficiently collect additional data to increase the accuracy of the CBA results reported by this paper. This effort involves the following steps:

3. expanding the current vanilla tracking database to incorporate
    a. farm-level costs,
    b. alternative benefit flows (e.g. cooperative loans and health insurance coverage), and
    c. programmatic costs.

    This database could be informed by annual farm-level surveys for beneficiaries that are structured on similar vanilla surveys conducted in the SAVA region.

4. Develop an indicator database for CF farmers based on the CBA model inputs used for this study and demographic information (e.g. gender, poverty levels, etc.) to quantify the incremental financial impact for individual farmers and to measure the scale (i.e. amount of land dedicated to CF production) of the intervention. This database could be based on baseline surveys for new beneficiaries and mid-term surveys for existing producers.

Data collected from both databases can be incorporated into the CBAs to more accurately reflect the financial and economic impact of the activity. Moreover, these databases can be used to improve quarterly and annual reporting, as well as monitoring and evaluation plans.

2. RECOGNIZE THE IMPORTANCE OF FINANCIAL VIABILITY FOR FARMERS

Acknowledging the limitations of this study, the results suggest that USAID should prioritize conservation farming of groundnuts or alternative crops over maize to increase the financial return to farmers and to improve the economic return to USAID's investment. Although the resources may not be available to identify a more profitable alternative, switching from maize to a more profitable crop would improve both financial and economic returns, and further incentivize farmers to support conservation efforts. To properly inform the decisions, USAID can

4. improve the accuracy of the CBA results,
5. assess the financial and economic viability of alternative crops, and
6. ensure Menabe farmers have access to a loan mechanism that helps offset the investment and input costs required of CF production to help increase adoption and ensure the sustainability of farmer involvement. Adopting CF practices involves certain recurring costs that may limit participation. For example, CF groundnut and maize production requires significant increases in input costs. Offsetting these costs with a financial mechanism would provide farmers with the necessary means to incur these costs. Although RA certified vanilla producers recently gained access to micro lending, there was no data available at the time of the analysis to incorporate the loan terms in the CBA. This is something that can be considered in an updated analysis.

3. BRIDGE THE KNOWLEDGE GAPS THAT RESTRICT COST-EFFECTIVENESS ANALYSIS

Based on the extensive literature review performed by the team, it is clear that the existing conservation and NRM reporting frameworks are non-standard across interventions and do not produce the type of high-resolution data required to undertake causal and comparative analysis on the impacts and costs of conservation and NRM management systems. USAID/Madagascar can work with Madagascar National Parks, other Protected Area managers and community-based natural resource managers to establish a framework to bridge these knowledge gaps by supporting the following activities:

4. Clearly identifying high-priority conservation outputs (ex: forest cover area, forest fires counts, endangered species populations) that can be measured and meaningfully compared at fine resolution across time and space (ideally at the VOI or fokontany level);
5. Conducting customized image processing of Landsat imagery using land cover classification algorithms that are locally tailored to the Mikajy target landscapes to generate more accurate estimates of forest cover loss. Many such analyses have already been undertaken in Madagascar, so achieving this could simply be a matter of establishing a partnership with researchers who have already developed image-processing algorithms that are tailored to the Mikajy landscapes;
6. Creating or compiling existing geospatial databases including
    a. Geospatial vector files outlining intervention areas (TGRN administrative boundaries, CF or RA farm plots), with associated date-referenced attribute information. For TGRN areas, relevant information includes the date the TGRN contract was signed, VOI management effectiveness scores, details about what natural resource exploitation activities are permitted under the contract, VOI membership levels and investments made in the intervention area such as VOI management budget, development project funds and payments for ecosystem services (PES). For CF or RA farm plots, attribute data could include yields and prices received by farmers for their crops;

a. Other geospatial vector files describing intervention area infrastructure (ex: physically demarcated park boundaries, firewalls, nurseries etc.) and activities (realized patrol routes, community sensitizations etc.) with date-references indicating when the infrastructure was installed or when the activity took place.

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ANNEX I LITERATURE REVIEW

This Annex provides a brief history of conservation and natural resource management efforts in Madagascar over the past several decades. We describe the early days of conservation and the initial focus on strictly protected areas, and how conservation projects evolved over the years into Integrated Conservation and Development Projects. We discuss various community based natural resource management systems, conservation farming and sustainable agriculture techniques and explore the evidence of and factors influencing the effectiveness of these systems and activities.

PROTECTED AREAS AND CO-MANAGEMENT

The primary conservation instrument for mitigating anthropogenic degradation of wilderness areas is the creation of Protected Areas (PAs). The first PAs in Madagascar were established during colonial times in the 1920s, and by the 1980s the number of PAs had grown to more than 30. At the 2003 IUCN World Parks Congress in Durban, the President of Madagascar made a commitment to triple the area covered by the PA network by 2008, an effort that is now referred to as the Durban Vision (Gardner et al. 2018). Today, Madagascar's System of Protected Areas (*Système d'Aires Protégées de Madagascar*, or SAPM) consists of over 100 sites covering 6.5 million hectares (11%) of the country's terrestrial area (Norris 2006 and O. Waeber et al. 2020).

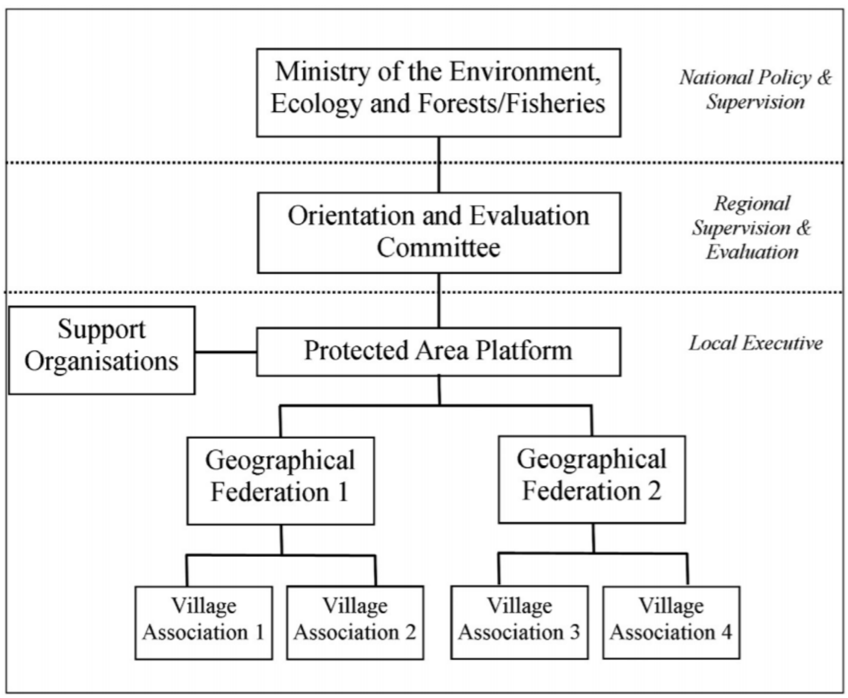
Beginning in the 1980s, the global conservation community was coming to recognize that establishing centrally governed PAs dedicated to conservation and research was failing to resolve the underlying causes of human-driven environmental degradation. Given that environmental degradation was largely being driven by unsustainable use of natural resources by rural citizens, conservation efforts shifted towards establishing and strengthening natural resource management (NRM) systems in and around PAs. In 1987-88 Madagascar drafted Africa's first National Environmental Action Plan (NEAP), which set the stage for a new approach to PA management in the coming decades (Casse 2012).

Under Phase II of the NEAP, the transfer of management of natural resources (*transfert de gestion des ressources naturelles*, or TGRN) from the government to communities was initiated. This strategy began with the introduction in 1996 of law 96-025 on the local management of natural resources (*Gestion locale sécurisée*, or *Gelose*). The policy of TGRN has established a Community Based Natural Resource Management (CBRNM) paradigm throughout the SAPM. The theory behind CBRNM is that, if rural people are given the responsibility of managing the natural resources upon which their livelihoods depend, they will ensure not to unsustainably deplete the supply of those natural resources (Casse 2012).

Gelose was the first type of CBNRM model widely implemented in Madagascar. *Gelose* consists of a tripartite agreement between a local community (*communauté de base locale*, or COBA in French; *Vondron'Olona Ifotony*, or VOI in Malagasy), the commune (administrative level similar to a municipality) and the Department of Water and Forest (DEF). An initial *Gelose* contract has a term of three years, after which time the performance of the COBA is evaluated and the contract is either renewed for 10 years, or not renewed. Another early format for CBNRM was participatory forest management (*Gestion participative des forêts*, or GPF). These early CBNRM models came to be recognized as overly complex and cumbersome to implement (Freudenberger 2010). This recognition inspired the introduction of a new model called contractualized forest management (*Gestion contractualisée des forêts*, or GCF). GCF is a simplified version of *Gelose*, where a two-party agreement is signed between the COBA and the DEF and the commune is not directly involved in the management scheme. These contracts give communities the right to access and valorize natural resources provided that they uphold contractual conservation responsibilities and restrictions (Casse 2012 and Randrianarison et al. 2009).

As mentioned previously CBNRM, and particularly GCF arrangements were widely incorporated into the management of Madagascar's New PAs created during the Durban Vision expansion. By 2009, 450 TGRN contracts had been signed in Madagascar (Randrianarison et al. 2009). PA management structures vary, but all consist of a PA manager which can be either Madagascar National Parks (MNP, formerly the National Association for the Management of Protected Areas in Madagascar or ANGAP) or a private or public institution (mostly NGOs). Figure I-1 shows a generic non-MNP PA management hierarchy. Non-MNP managed PAs have multi-level governance structures consisting of a hierarchy of committees of locally elected representatives with varying degrees of responsibility and decision-making authority. MNP-managed PAs are also adopting multi-level hierarchies consisting of Local Park Committees (CLP) and a Protected Area Orientation and Support Committee (COSAP). These organizations represent the interests of communities bordering the PAs and work alongside MNP in PA management (Gardner et al. 2018).

Figure I-1: A generic non-MNP PA management hierarchy (Gardner et al. 2018)



Incorporating human development goals into PA management objectives reflected both a growing belief in a synergy between conservation activities and rural livelihoods, as well as Madagascar's need to simultaneously meet its commitments towards the Millennium Development Goals (MDGs) and the Convention on Biological Diversity (CBD) (Neal J. Hockley 2007). Reflecting this shift in priorities, Madagascar's Protected Area Code (COAP) was updated in 2008 (and ratified in 2015) to allow the New PAs to be assigned higher International Union for Conservation of Nature (IUCN) classifications that allow for resource use within PAs, as shown in Table I-1 (Gardner et al. 2018). While Madagascar's early

PAs were dedicated solely to conservation and new research, many of the new PAs were established in areas with higher human populations and level of dependence on natural resources (Fritz-Vietta et al. 2011). These 'Integrated Conservation and Development Projects' (ICDPs) brought together environmental and development organizations to work collaboratively in priority landscapes that were occupied by significant human populations.

Table I-1: IUCN Categories (Freudenberger 2010)

IUCN Category	IUCN Management Objective	Madagascar IUCN Management Category
I	Ia) Strict Managed Reserve (primarily for scientific purposes) Ib) Wilderness area	Integral Nature Reserve (Tahirin-javaboaary)
II	National Park (managed primarily for ecosystem protection and recreation)	National Park and Natural Park (Valan-javaboaarimpirenena)
III	Natural Monument (managed primarily for conservation of specific natural features)	Natural Monument (Tahirim-bakoka Voajanhary)
IV	Habitat/Species Management Area (managed primarily for conservation)	Special Reserve (Tahirin-javaboaary)
V	Protected Landscape/Seascape (managed primarily for landscape/ seascape conservation, recreation, or culture)	Protected Harmonious Landscape (Tontolo Mirindra Voaaro)
VI	Managed Resource Protected Area (managed primarily for the sustainable use of natural ecosystems)	Natural Resource Reserve (Tahirin-karena Voajanahary)

CONSERVATION FARMING AND SUSTAINABLE AGRICULTURE

Given that many smallholder farmers are responsible for much of the destruction of Madagascar's natural landscapes, many development organizations working on ICDPs promote conservation farming (CF) and other sustainable agriculture practices to relieve anthropogenic pressure on ecosystems. The theory of change for CF is based on the notion that certain agricultural practices enhance natural biological processes, supporting soil fertility, and nutrient and hydrological cycling. As a result, these practices can increase farm profitability through higher yields and reversed land degradation (Milder et al., 2011).[45] Although CF is practiced in many forms, it is typically comprised of agronomic practices that minimize soil disturbance (e.g. no or limited tillage), maintain permanent soil cover (e.g. straw or cover crops), and diversify crop rotations to include nitrogen-fixing crops (FAO, 2019). Similarly, Sustainable Agriculture

[45] There is mixed evidence regarding the net change in fertilizer use and labor.

Network (SAN) promotes the responsible use of inputs and agricultural practices to increase productivity while protecting the environment, including agroforestry shade cover, vegetative ground cover, soil erosion control, and soil/crop fertilization (Rainforest Alliance, 2016).

In general, there are potential on-farm benefits of adopting CF and SAN practices. For instance, these practices have the potential to increase soil structure and soil organic matter, enhance oxidation, and intensify phosphorus levels (Hobbs et al. 2008 and Milder et al. 2011). There are also benefits associated with water management and water use efficiency, such as increased water infiltration and water holding capacity. For example, Bombelli and Valentini (2011) note that for each percentage increase in soil organic material results in an additional 150 m3/ha of water that can be stored in the soil.

Conservation and sustainable agriculture practices also have the potential to control and reduce soil erosion. For example, there is evidence that wheat and maize residue coverage reduced soil loss by 62 percent and 97 percent, respectively (Giller et al., 2009 and Gilley 2005). Conservation and sustainable agriculture also have potentially indirect effects on biodiversity and ecosystem services including positive effects on agricultural landscapes, vegetation connectivity, and non-domesticated species, such as insects, birds, and bats providing pollination and pest control services. However, there is mixed evidence regarding these impacts because the key drivers of deforestation, such as migration, drought and land availability, are not directly tied to CF and sustainable agriculture practices.

There is some evidence pertaining to the reduction in deforestation rates associated with conservation efforts and promotion of sustainable agriculture practices. For example, a geospatial analysis of USAID's Central Africa Region Program (CARPE) shows a 27 percent reduction in deforestation rates in areas surrounding the villages receiving sustainable agriculture and land use planning interventions compared to those not receiving the intervention (USAID 2019b).[46] In Colombia, Reuda et al. demonstrate a 12 percent reduction in forest loss for RA certified coffee producers relative to non-RA certified coffee producers in the region (2014). In Ethiopia, Takahashi and Todo (2013) use propensity score matching to show a 1.7 percentage point reduction in the probability of deforestation for RA certified coffee producers versus non-RA certified producers.

CONSERVATION: IS IT WORKING?

Today, Madagascar's vastly expanded SAPM faces significant challenges in meeting its conservation and human development objectives. The speed and scale of the expansion increased the system's complexity, which seems to have had negative implications for the efficiency and effectiveness of PA management (O. Waeber et al. 2020). Thirteen of the country's PAs don't have a manager and are therefore referred to as 'paper parks,' and 29 other 'orphan' PAs were abandoned by managers during Madagascar's latest political crisis from 2009-2014. The SAPM network faces a significant funding shortfall which, combined with broadening mandates, limits managers' abilities to competently manage PAs and jeopardizes the stability of the SAPM (Gardner et al. 2018).

It is in this context that there is a growing need for evidence that will enable stakeholders to prioritize investments in PA and CBNRM management to make the best use of scarce resources. Casse 2012 notes that there is a gap in the literature on the relative cost-effectiveness of various NRM structures. This study

[46] To determine deforestation rates, the analysis compared the 17-year average of annual tree coverage from 2001to 2017. USAID's CARPE program was implemented between 2010 and 2015.

seeks to contribute to filling this gap, by assessing the cost-effectiveness of the NRM management systems in and around the four terrestrial PAs located in the two landscapes in which USAID Mikajy is operating. The first step in this effort is to articulate a definition of 'effectiveness' and discuss the challenges of accurately measuring the effectiveness of conservation and NRM systems.

DEFINING AND MEASURING 'EFFECTIVENESS'

The mandate of conservation projects has broadened over the past several decades to encompass a range of environmental, social and economic objectives. Therefore, the effectiveness of a conservation project may be measured through a variety of environmental and social indicators. Environmental indicators of the effectiveness of a conservation project might include levels and rates of deforestation and reforestation, population counts of species of interest and the degree of fragmentation of ecosystems. Socioeconomic indicators of effectiveness could include the incomes and health of local people affected by the conservation project. The effectiveness or impact of a conservation project is the change in the level of an indicator that can be attributed to the conservation project, assuming the difficult statistical requirements for establishing the direction of causation can be satisfied.

Many evaluations of conservation projects focus on only one indicator of effectiveness, but Casse 2012 objects to this approach when evaluating CBNRM systems:

> *"We believe no analysis, in a scientific paper or as a more practical exercise, should narrow the scope of evaluation to just one main criterion. The local management of forest resources is about how to identify practical tools to obtain conservation in some simultaneously with increasing the social and economic benefits accrued to local people (resource access). If binding these two ends together is impossible in a given setting, the researcher or the practitioner ought to state it clearly and not conceal the stalemate by only favoring one single aspect in his/her analysis." (Casse 2012)*

Unfortunately, 'binding these two ends together' to create a comprehensive picture of conservation effectiveness often proves to be quite difficult. Casse 2012 goes on to note that spatially relating social indicators to conservation activities is a significant challenge. The reasons for this argument largely stem from a lack of evidence that offers scientifically rigorous understanding of the effectiveness of conservation efforts (Ferraro and Pressey 2015 and Burivalova et al. 2019).

There are two different questions that one can attempt to answer when assessing the effectiveness of a conservation project. The first question is: 'Does it work?' This is a question about the absolute effectiveness of a conservation project - that is, the effectiveness relative to the alternative of doing nothing to protect the natural environment. The second question that can be asked is: 'Is this the most effective conservation option?' This is a question of the relative effectiveness of a conservation project compared to other conservation alternatives.

ABSOLUTE EFFECTIVENESS

Gardner et al. 2018 suggest that the present-day challenge of measuring conservation effectiveness is due to the fact that "many PA establishment projects were launched without sufficient understanding of the socio-ecological contexts in which they are embedded, and have continued to be managed without an evidence base or adequate monitoring systems to ensure that implemented actions are effective." This inadequacy or absence of monitoring systems means there is a dearth of data with which to assess the effectiveness of conservation efforts within the framework of a traditional scientific experimental process. Historically, this has limited many studies of conservation effectiveness to 'simply document[ing] the conditions in and around protected areas and how they change over time' (Ferraro and Pressey 2015).

One example of a finding from a study on conservation effectiveness is 'The deforestation rate decreased by 0.5% within the PA boundaries in the first five years after the PA was established.' This example provides an inadequate measure of effectiveness because, as described above, the effectiveness of a conservation project is the change in the level of an indicator which is attributable to the project. The above example finding fails to tell us anything about what would have happened to the deforestation rate over the same time period in the absence of the PA. Perhaps the deforestation rate would have decreased within the PA boundaries even if the PA hadn't been established. Another example: 'The deforestation rate within the PA is 2% lower than the area outside the PA and within 10km of the PA boundary.' In this case, the finding *could* suggest a causal effect of the PA on the deforestation rate, but only if the study was designed to account for what likely would have happened without the PA. Perhaps the area within the PA would have experienced lower rates of deforestation than the surrounding areas even without PA designation (this is plausible if, as was the case with many of Madagascar's original PAs, a PA is established in an area that is relatively remote and unsuitable for human exploitation) (Fritz-Vietta et al. 2011).

The problem with the example findings above is that they fail to present a valid counterfactual scenario against which we can compare the observed outcome and assign attribution of the outcome to the establishment of the PA. A valid counterfactual for a conservation project must meet two main criteria:

1. The conservation outcomes observed in the counterfactual area once the conservation project has been implemented must not be influenced by the conservation project. In other words, the conservation outcomes in the counterfactual area would be the same regardless of whether the conservation project was implemented.

2. The counterfactual area must have baseline (i.e. before the conservation project) characteristics similar to the baseline characteristics of the PA. The characteristics of interest are those that are related to (i.e. co-vary with) the conservation indicator(s) of interest. These characteristics are referred to as moderators of conservation indicators (Ferraro and Pressey 2015).

Criterion #1 poses a major challenge in establishing a valid counterfactual for a conservation project due to the need to account for an effect referred to as 'leakage.' Leakage, as its name suggests, refers to the spillover effect that arises in areas adjacent to a conservation project. For example, if an area receives PA designation, people who normally would have harvested wood from the new PA may now go to an area just outside the PA to harvest wood. In this case, while deforestation within the new PA would decrease, deforestation in the area adjacent to the PA would increase. Thus, even if the adjacent area had comparable baseline (i.e. prior to PA designation) characteristics to the PA, the deforestation observed in the area adjacent to the PA is not representative of the deforestation that would have occurred had the PA not been established. The counterfactual scenario is confounded by the leakage effect.

Meeting Criterion #2 can also be very difficult because the moderating characteristics by which the target and counterfactual areas should be compared can be difficult to observe and measure. The following sections describe some of the potentially influential moderators of conservation indicators. Some of these moderators are relatively easy to measure (such as aspects of the physical context) whereas others are more difficult to measure (aspects of the socio-cultural context).

Socio-cultural context

The local socio-cultural context of an area can have a large impact on land use decisions, thereby impacting conservation indicators. Fritz-Vietta et al. list five aspects of traditional Malagasy culture that influence land use (Fritz-Vietta et al. 2011):

- Kinship (*fihavanana*)
- Social codes (*dina*)
- Taboos (*fady/faly*)
- Traditional leaders
- Beliefs in supernatural spirits/beings

The comparability of one area to another, in terms of conservation indicators, is thus partially dependent on the comparability of these socio-cultural aspects in each area. For example, if the people in one area are forbidden by *fady* to hunt a specific species of animal for bushmeat, then this area is not comparable with an area in which people are permitted to hunt that species for bushmeat, on the basis of population counts of this species (i.e. the conservation metric).

Defining a quantitative relationship between socio-cultural aspects and a conservation indicator within a jurisdiction can be difficult, if not impossible. Moreover, given that socio-cultural traditions tend to be highly adapted to the local context, defining a quantitative relationship between socio-cultural aspects and a conservation metric across multiple jurisdictions might only be achievable through empirical analysis of data from a large number of areas with detailed information on socio-cultural aspects and conservation indicators in each area.

Physical context

The physical attributes of an area which might affect a conservation indicator are relatively straightforward to observe and measure. Since anthropogenic environmental degradation of an area depends on people being capable of and motivated to degrade the area, the physical attributes of interest are those that determine the accessibility of an area of land, as well as its suitability as a site for human exploitation. Such attributes include climate (precipitation, temperature etc.), elevation, slope, soil type, presence of valuable resources and proximity to infrastructure such as roads, paths, navigable waterways and towns.

Different types of 'ecoregions' (e.g.: humid vs. dry forests vs. spiny forests, etc.) vary in the species they host, the pressures they face and their ability to recover from degradation, so conservation indicators cannot be meaningfully compared across ecoregions (Eklund et al. 2016). Ecoregions also vary in their history, their biodiversity and the current level of 'intactness' of the natural environment. If a natural environment is almost completely degraded, a conservation effort in the area might be irrelevant (Casse 2012). If a conservation project were established in a highly degraded area, a subsequent decrease in environmental degradation could simply be attributed to the fact that there are no remaining resources to exploit within the area.

Socioeconomic and political context

The economic and political aspects of an area are perhaps the most volatile moderators of conservation indicators. Freudenberger notes that the populations that put the highest pressure on forested areas tend to face significant barriers to access the necessary agricultural inputs (labor and material) for intensive agriculture, and lack opportunities to add value to and sell their products through formal, legal markets.

(Freudenberger 2010) Areas that host such populations are thus more vulnerable to the application of unsustainable agricultural methods and illegal natural resource extraction. On the other hand, high exposure to external markets and elevated prices for cash crops can also intensify pressure on forested areas as local farmers clear more land to produce more crops (Casse 2012).

Political instability at the national level has been a constant problem that has undermined Madagascar's economic growth and development, particularly in rural areas. The country has gone through three political crises since 1990, during which times conservation enforcement and monitoring have halted, resulting in 'a free-for-all, open access situation where pent up demand for resources is liberated and massive amounts of irreversible damage can be done in a very short time' (Freudenberger 2010). This political stability has been coupled with corruption and rent-seeking behavior, where powerful interests find ways to circumvent land use rules to obtain permits to exploit the land's resources. When local people witness this type of corrupt exploitation taking place, they often respond by increasing their own exploitation of the land so that they might benefit from the land's resources before the powerful outside interests deplete the resource base. Thus, areas that host high-value natural resources that are desirable to politically influential outside actors might not be comparable with areas that lack any natural resources of interest to powerful outside actors.

Another important political factor to consider is the level of conflict between locals and migrants over land use in an area. In areas where migration rates are high, conflict can arise between residents and 'outsiders' (e.g.: migrant farmers, charcoal makers, loggers, miners) over land access and ownership (Casse 2012). In many parts of Madagascar, clearing forested land for slash-and-burn agriculture (known as *tavy* in the north, as *Hatsake* in the south-west) is a traditional way of asserting ownership of land (Freudenberger 2010). This drives up deforestation rates in areas where there is a high degree of conflict between residents and outsiders. As such, an area of high conflict over land use might not be comparable with an area of low conflict over land use on the basis of deforestation rate.

RELATIVE EFFECTIVENESS

Despite the limited rigorous evidence that PAs and TGRN work in an absolute sense (i.e. compared to the alternative of doing nothing), decision makers have begun to shift away from asking 'Does it work?'[47] and they are now asking 'What works best?' Measuring the relative effectiveness of one conservation project compared to another adds another layer of complexity to effectiveness analysis. In addition to accounting for the moderators of absolute effectiveness, a relative effectiveness analysis must account for moderators that produce heterogeneity in the conservation outcomes achieved by different implementations of the same type of approach (e.g. heterogeneity between different implementations of GCF) (Randrianarison et al. 2009 and Ferraro and Pressey 2015). Some of these moderators are described below, with an emphasis on the implementation of TGRN contracts.

Compatibility with socio-cultural aspects

Fritz-Vietta observes that Western notions of and approaches to environmental conservation are fundamentally different from, and often incompatible with, traditional Malagasy land use governance

[47] It is not enough to simply compare two alternative conservation approaches to one another and adopt the one that is relatively more effective. If both alternatives are less effective than the 'do nothing' option, then either of the proactive alternatives is a suboptimal approach. Thus, even an analysis of relative effectiveness should consider the 'do nothing' scenario as an alternative.

systems. The degree to which a conservation project succeeds or fails can thus be said to depend in part on the compatibility of the conservation project with the local socio-cultural aspects that inform land use decisions. (Casse 2012 and Fritz-Vietta et al. 2011) If the governance structures and social dynamics introduced by a conservation project are incompatible with traditional governance structures and social dynamics, local people are likely to abandon the new structures and dynamics in favor of tradition. This principle is embodied in several of Elinor Ostrom's celebrated 8 principles of governing a commons (Ostrom, 1990).

In some cases, the incompatibility of conservation efforts with local socio-cultural aspects can actually exacerbate rather than rectify environmental degradation. Casse shows an example of such a situation when he describes situations where *Gelose* contracts undermined existing land tenure rules, thereby intensifying land ownership conflict between locals and migrants and subsequently increasing deforestation (Casse 2012). These types of perverse outcomes can arise when a conservation project fails to consider the role of existing socio-cultural aspects in land use decision-making.

In an effort to ensure compatibility of TGRN systems with existing socio-cultural structures and dynamics, the *Gelose* law allows for the establishment of a *dina* specifically designed to govern natural resource management.[48] This *dina* is the community-level social code that establishes both the requirements of the TGRN and the consequences of non-compliance to the requirements within the framework of traditional socio-cultural structures. To be effective, the *dina* must be tailored to the local community such that the restrictions and non-compliance penalties are neither too restrictive/harsh nor too lenient[49] (Randrianarison et al. 2009). The effectiveness of the *dina* plays a large role in the overall effectiveness of the TGRN.

The balance of competing objectives

Each conservation project varies along the protection-production spectrum - that is, the restrictions imposed on local peoples' use of natural resources versus the rights of local people to make productive use of natural resources within the project area (Neal J. Hockley 2007). The point along this spectrum at which a TGRN contract lies is the result of a negotiation process between parties with different (often competing) objectives. Local community members seek to maximize the production rights embodied in the contract, while PA/TGRN managers seek to maximize the protection powers of the contract.

The trade-off between protection and production can have a significant impact on whether or not the contract will be an effective mechanism to achieve conservation and human development goals. If a contract leans too heavily toward production, natural resource pools will be degraded and the TGRN will not achieve its conservation objectives. If the contract is more biased towards protection, the opportunity costs to community members of conservation (e.g. foregone agricultural activity, firewood collection, bush meat etc.) may outweigh the perceived benefits, leading community members to reject the terms of the contract and return to prior levels of environment-degrading activity (Randrianarison et al. 2009).

[48] Establishing the *dina* allows for 'Congruence between appropriation and provision rules and local conditions' and a 'conflict-resolution mechanisms,' which Ostrom 1990 identifies as principles of effectively governing a common pool of resources (CPR).
[49] 'Graduated sanctions' is another one of Ostrom 1990's principles of effective CPR management.

'[There is] a growing body of recent research which finds little evidence for the effectiveness of community-based, extractive resource management in conserving biodiversity in terrestrial, developing world contexts, primarily due to the differences in objectives between local resource users and conservationists, and the inability of resource users to satisfy their needs through permitted sustainable uses. Likewise, there is mixed evidence for the effectiveness of multiple use (category V) protected areas in conserving biodiversity.' (Gardner et al. 2018)

Contracts may become biased more towards one party or another during the negotiation process for a variety of reasons. There may be power imbalances between negotiating parties and/or under-representation of members of marginalized groups. (Gardner et al. 2018). One possible scenario is if the PA manager has the upper-hand over the local community during the community engagement and negotiation process, the terms of the negotiated contract might fail to meet local peoples' economic needs, and/or fail to consider the perspectives of key traditional leaders (Randrianarison et al. 2009). Alternatively, there may have been little to no community engagement at all, resulting in a generic contract that is ill-suited to a community's circumstances.[50]

Another possible scenario is the consolidation of power by an elite group within the community, resulting in improved circumstances for the elite but unchanged or worsened conditions for marginalized members of the community (Casse 2012). Table I-2 lists some of the key factors that interact to either stabilize or destabilize a TGRN contract.

Table I-2: Dynamics of TGRN Contract Stability

Key metrics	Stabilizing factors	De-stabilizing factors
• Ecosystem intactness • Biodiversity • Community wellbeing	• Natural resource exploitation privileges • Equitable distribution of TGRN benefits within community • Accessible livelihood alternatives	• Natural resource exploitation constraints • Power imbalances between community and external parties • Power imbalances within community

Socio-spatial scope

TGRN systems are voluntary, opt-in institutions. This means that, while a TGRN may be actively managed by a COBA, the protection offered by the COBA depends on the level and extent of buy-in from community members. The level and extent of community buy-in begins with the community consultations and negotiations that take place when the TGRN is being established. There must be clearly demonstrable benefits of participating in the TGRN, and these benefits must be equitably accessible by everyone within the jurisdiction of the TGRN whose livelihood depends on natural resource exploitation. Once initial buy-in is established, the sustainability of the community's buy-in depends on the degree to which the anticipated benefits of the TGRN are actually realized and accrue to the community, and that the benefits exceed the costs (Randrianarison et al. 2009). Sustainability also depends on the degree to which the

[50] Yet another of Ostrom's principles of effective CPR management is ensuring community participation in the process of defining the rules of the CPR management system.

realized benefits align with the community members' expectations. Hockley and Andriamarovololona found that gaps between 'oral contracts' and official TGRN contracts established between external stakeholders and community members can produce a divergence in expectations that ultimately undermines the stability of a TGRN contract (Neal J. Hockley 2007).

Management capacity

COBAs must be sufficiently capacitated both technically and financially if the TGRN system is to be effective. TGRN arrangements are unlikely to be successful if the community members and COBA managers are ill-informed and capacitated to implement the management system (Randrianarison et al. 2009). This may seem obvious, but in the rush to implement TGRN on a national scale in Madagascar many contracts were signed without ensuring that the local capacity was in place to ensure the system's success.

On the financial side, COBAs must be able to generate sufficient revenues to cover the cost of TGRN activities. In theory, COBAs are designed to achieve financial self-sufficiency through membership fees and levying taxes on forest products (Randrianarison et al. 2009). In practice, many COBAs have been unable to cover their costs, and in some cases external financial commitments imposed by the TGRN have created a net outflow of money from the community (Neal J. Hockley 2007). In some cases, communities were essentially 'bought off' with significant front-end investment from development agencies as a form of quid-pro-quo for abandoning deforestation and natural resource extraction. In these cases, when the initial funding was depleted, communities returned to the status quo of environmental degradation (Freudenberger 2010).

Enforceability of TGRN contract

One of the most challenging moderators of the relative effectiveness of a conservation project is the degree to which conservation requirements can be enforced. Gardner notes:

> *"Law enforcement is a major challenge for PAs worldwide, particularly in developing countries with limited resources for surveillance and enforcement and widely-dispersed, resource-dependent rural populations and/or organized criminals seeking to illicitly extract natural resources. The problem is exacerbated in Madagascar because neither MNP nor new PA promoters have authority to apply the law: instead serious infractions require managers to organize and fund field missions by a 'mixed brigade', comprising members of the gendarmerie, MEEF agents, local and municipal authorities and members of the PA management committee." (Gardner et al. 2018)*

Thus, law enforcement represents a bottleneck in the decentralization of conservation and natural resource management. Only the DEF has the legal authority to enforce conservation laws, but it lacks the resources to effectively apply and uphold these laws at a large scale throughout the SAPM. TGRN arrangements have adopted patrolling and enforcement systems that leverage cooperation between community-level and central enforcement institutions. However, non-communication and mistrust between State officials and community representatives can hinder the effectiveness of the patrolling and enforcement system (O. Waeber et al. 2020). In the Menabe region, the prospect of violent encounters with the *Dahalo* (highly armed cattle-rustlers who meet in the forest to plan raids) jeopardizes the safety of community patrollers and the willingness of community members to engage in patrolling.

Securing land tenure rights through "*Sécurisation foncière relative*" (SFR) can either enhance or diminish the enforceability of TGRN contract requirements, depending on whether pre-existing community conflicts are resolved prior to securing land tenure rights (Randrianarison et al. 2009 and Casse 2012). This is one of many ways in which the enforceability of conservation laws is also closely linked with the socio-cultural aspects of the community described previously. Other such linked factors include the degree to which the community members view the TGRN *dina* as legitimate, and the degree to which COBA members are willing to effectuate the *vonodina* (sanctions) against their neighbor in the event of an infraction. It is useful to distinguish between the enforcement of an agreement on the communities and giving communities the tools with which to enforce agreements among their own members.

CONSERVATION DATA AVAILABILITY AND QUALITY

Measuring ecosystem and biodiversity indicators can be difficult and expensive due to the large geographic scale of PAs and TGRN areas. Given that these areas are 'natural' (or the intention is for them to be kept as natural as possible) it can also be inherently difficult to access these areas for patrolling and surveillance due to a lack of transportation infrastructure. Moreover, as has been discussed previously, PA and TGRN managers are often faced with resource constraints that limit their ability to implement effective environmental monitoring programs and information management systems. What data is collected can be sparse and aggregated to such high levels that using the data to make strategic planning decisions at the local level is not possible.

Advances in mobile technologies have brought promising improvements in conservation indicator monitoring systems. One such advancement is the roll-out of use of the Spatial Monitoring and Reporting Tool (SMART) by Madagascar's PA managers, an effort which USAID Mikajy has been supporting. SMART is a Geographic Information System (GIS) software designed to help conservation decision makers design and manage information systems. SMART provides an integrated platform that allows field patrols to collect required information and instantaneously upload data to a server, where the information is accessible by decision makers for analysis, reporting and planning. Unfortunately, the implementation of the SMART system in the areas of interest for this study has only recently begun, meaning that limited SMART data was available for analysis.

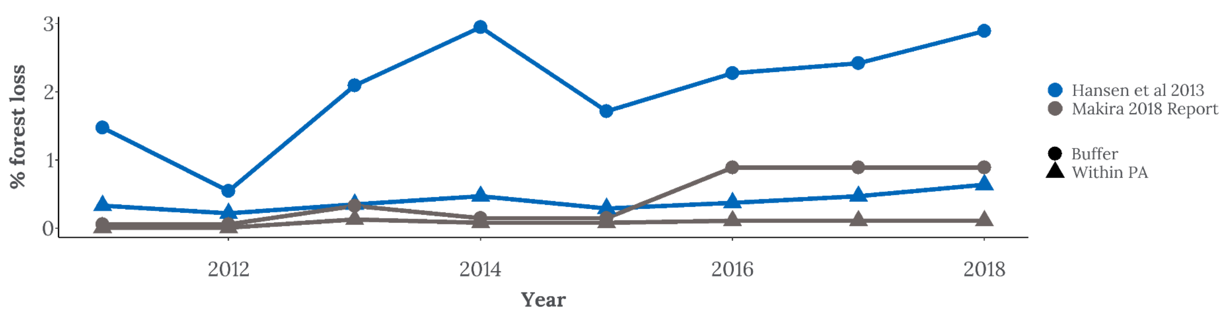
Another source of data that is widely used in the literature to monitor conservation indicators is remote sensing data. Remote sensing is the process of collecting information about the surface of the Earth using sensors fixed to a satellite or aerial vehicle. One of the most commonly used remote sensing datasets is the National Aeronautics and Space Administration (NASA) Landsat image gallery, which is commonly used to detect Land Use Land Cover Change (LULCC) at a larger scale than would be economically viable through field data collection.

The most common conservation indicator measured with remote sensing data is forest cover loss. However, the forest cover loss detected and reported through remote sensing data analysis can vary widely depending on differences in data resolution, mapping methods, image categorization algorithms and what is defined as 'forest cover.' This variability between estimates makes it difficult to compare forest cover estimates and assess the reliability of any given estimate (Bastin et al. 2017).

A global forest cover loss dataset published by Hansen et al. in 2013 and updated annually was used to estimate forest cover loss in the focus areas from 2000-2018. Here, it is important to comment on some of the limitations of using the Hansen dataset for this study. In general, remote sensing data analysis is a valid monitoring tool for deforestation – that is, relatively large areas of cleared forest land. Burivalova et al. concluded that the Hansen dataset offers a useful account of illegal slash and burn agriculture within Masoala National Park, despite substantially underestimating the level of deforestation compared to ground-truth observations (Burivalova et al. 2015).

Comparison of the forest cover loss detected by the Hansen data and that reported in the 2018 activity report for the Makira PA shows large differences between the two sets of estimates, as seen in Figure I-2. Differences in the magnitude of the estimates could be in part due to differences in definition of 'forest cover.'[51] However, not only are the individual point estimates different, but the trends do not always mirror one another – for example, the Makira activity report estimates show a decrease in the rate of forest loss from 2013 to 2014, while the Hansen estimates show an increase. Given that the estimates reported in the Makira activity report are based on a locally tailored analysis, it seems reasonable to assume that the estimates from the Makira activity report are the more accurate of the two sets of estimates. However, this comparison runs counter to Burivalova's findings in Masoala (which neighbors Makira and is a similar ecoregion) where the Hansen data underestimated forest loss relative to ground-truth comparison locations.

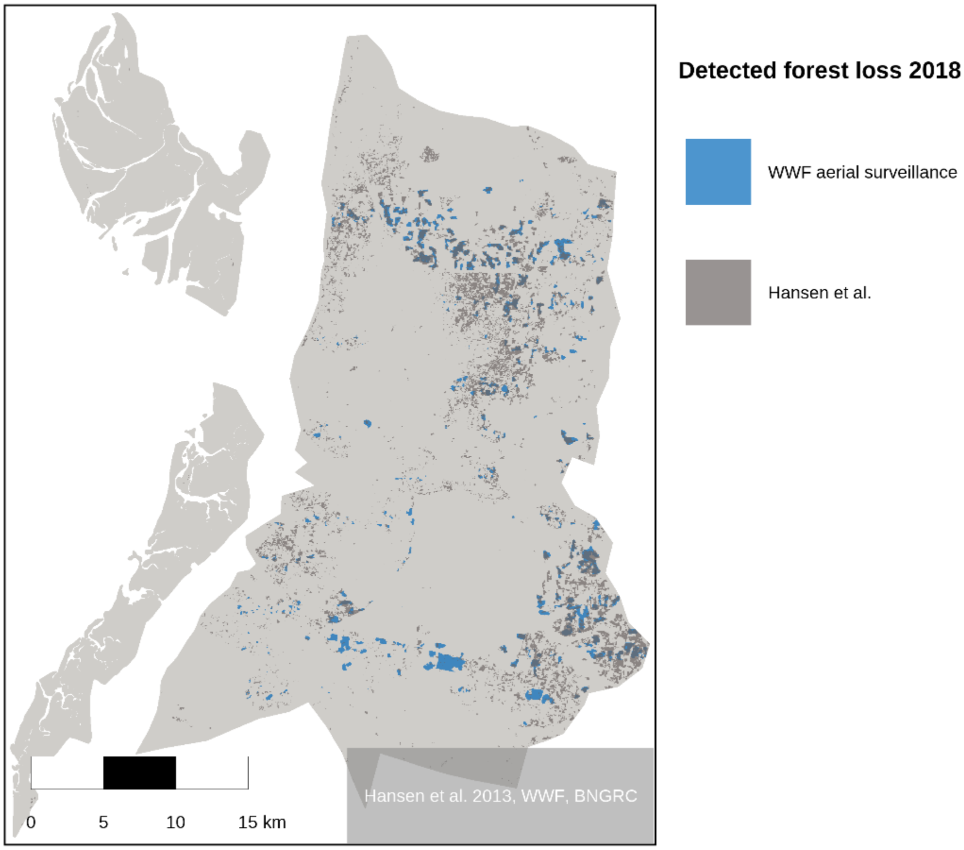
Figure I-2: Comparison of Forest Loss Estimates in the Makira PA



Similar discrepancies between the Hansen estimates and locally collected data are apparent in the Menabe-Antimena PA. The closest data we have to ground-truth observations in Menabe-Antimena is the 2018 aerial surveillance data for forest clearings and fires collected by the World Wild Fund for Nature (WWF) in November and December 2018. Comparing this data with the Hansen forest loss data raises concerns about the validity of the Hansen data in Menabe's context. Figure I-3 shows the locations within Menabe Antimena PA where WWF and Hansen each detected forest cover loss in 2018. It is evident from the map that there are many areas where the two datasets do not overlap. Analysis shows that 78% of the forest loss detected by Hansen was not detected by WWF (i.e. 78% of the Hansen forest loss estimates do not overlap with the WWF forest loss observations), and 51% of forest loss detected by WWF was not detected by the Hansen et al. data.

[51] Forest cover was thresholded at 50% or greater canopy cover for Makira using the Hansen data.

I-3: Comparison of 2018 Forest Loss Estimates in the Menabe-Antimena PA



Remote sensing data has traditionally been less useful in detecting forest degradation – that is, relatively small areas of forest clearing and/or selective logging. This is because the resolution at which conventional remote sensing analysis methods detect forest cover change is not fine enough to detect small-scale (i.e. sub-pixel) level disturbances (Yesuf, Brown, and Walford 2019 and Harris et al. 2012). This means that remote sensing data analysis is likely to underestimate forest cover loss in areas that are vulnerable to small-scale forest degradation processes such as selective logging, fuel wood collection and artisanal mining. (Allnutt et al. 2013 and Casse 2012). Recent studies have applied advanced image process techniques involving pixel-unmixing to better account for the effects of degradation in remote sensing data analysis. These methods offer promising enhancements to forest cover estimation.

One of the problems with relying on remote sensing data to monitor conservation indicators is that it can lead to an over-reliance on forest cover as a measure of conservation effectiveness. Casse rightfully points out that successful conservation 'is broader than calibration of deforestation rates,' (Casse 2012) but in practice deforestation rates are relatively straightforward to monitor and as such are widely reported as a proxy for biodiversity and habitat loss and fragmentation. Burivalova warns that this over-reliance on forest cover monitoring is dangerous because forest cover is not always a reliable proxy for levels of biodiversity (Burivalova et al. 2019).

Illegal hunting, logging and mining all negatively impact biodiversity, so levels of these activities may be used as proxy variables to measure biodiversity loss. This is where tools such as SMART are beginning to play a critical role in diversifying the range of conservation indicators that can be monitored. In the PAs in which USAID Mikajy is providing support, patrol staff look for and report signs of illegal hunting, such as presence of traps, animal carcasses, hunting platforms/camps etc. For illegal logging/mining they look for skid tracks, small clearing areas and other signs of illegal activity. These indicators are used as proxies to monitor the level of illegal activity that is taking place in the area. For this data to be useful, important questions must be answered. There is a poor understanding of the linkages between natural resource exploitation and biodiversity loss – what level of exploitation is 'sustainable?' (Freudenberger 2010 and Gardner et al. 2018) As with all aspects of conservation, assigning causality of biodiversity outcomes to conservation activities is another challenge.

Another problem with remote sensing data analyses is that they tend to be biased more towards forest loss than forest gain (Yesuf, Brown, and Walford 2019). Forest gain is an equally important conservation indicator, and there is evidence that secondary tropical forest gain is responsible for higher carbon uptake from the atmosphere than old-growth forests (Poorter et al. 2016). This makes forest gain a particularly important factor in projects focused on Reduction of Emissions from Deforestation and Forest Degradation (REDD+). On the other hand, the ecological value of secondary forests may be lower than that of old-growth species with regards to biodiversity (Zinner et al. 2013). The Hansen global forest cover dataset does include forest cover gain estimates, but these estimates currently only cover the time from 2000-2012.

ANNEX II CBA STRUCTURE - AN INTEGRATED ANALYSIS

USAID's CBA structure is logically organized to identify critical assumptions, reduce errors, and provide transparency. The first analytical step identifies raw data inputs in the table of parameters, including discount rates, yields, projected growth rates, etc. These inputs are needed to evaluate the investment activity and they are used in the second step to develop preparatory tables and indices for inflation, prices, and other projections. The next step is the financial analysis, which includes cash flow statements built upon expenditure, production, and sales schedules, among other variables. In the fourth step, economic formulas, such as conversion factors, consumer surplus calculations, and ecosystem valuations, are used to evaluate the total economic impact. Finally, sensitivity analysis is used to measure risk and to identify inputs that are critical to a successful investment. In both the financial and economic analysis, decision criteria are used to evaluate the investment (USAID 2015). Below are additional notes on financial and economic analysis, and decision criteria.

FINANCIAL ANALYSIS

A CBA assesses the financial costs and benefits of an intervention from several perspectives. While this would ideally include every stakeholder that is impacted by the project, the scope of the analysis is oftentimes constrained by information unavailability. In these situations, the CBA is built around the financial analysis of the primary recipients of the investment, which includes the farmers supported by USAID Mikajy. We use actual market prices and cash flow modeling techniques to reflect the incremental costs and benefits experienced by the targeted farmers.

The financial cash flow model includes an annualized cash outflow for each line item under costs, as well as a cash inflow for each line item under benefits. The net cash flow (NCF) represents the net gain or loss from farm production after comparing total benefits to total costs. These annual costs and benefit flows are developed for producers under the "with investment" and "without investment" scenarios.

The evaluation of each scenario will be based on the NPV and IRR decision criteria. To make these calculations, all cash flows are discounted to convert future cash flows into their present value. The standard practice for USAID is to simply use the prevailing borrowing interest rate for the beneficiaries whose cash flows are being modeled. While the official borrowing rate is 58 percent,[52] this study uses a financial discount rate of 15 percent based on the notion that producers would find alternative sources of financing such as micro lending.

ECONOMIC ANALYSIS

The economic analysis goes beyond the financial analysis of stakeholders to determine the net benefit or cost of the investment to society as a whole. This is accomplished by establishing economic prices for applicable inputs or outputs to correct for distortions. These prices represent the economic prices that would exist if there were no distortions. For example, a tradable good (e.g. fertilizer) that is used as an input for the investment would have its import tariff removed from the market value because it is

[52] According to the IMF, between 2014 and 2018 the average official borrowing cost was 58 percent (World Bank Development indicators 2019)

considered a transfer to other members of society. Because the economic analysis represents resource use, as opposed to actual cash transactions, we refer to these values as resource inflows and outflows. The analysis will also consider the relationship between its activities and local ecosystems that provide goods, services, and protections that are critical to social well-being.

According to the Millennium Ecosystem Assessment, an ecosystem "is a dynamic complex of plant, animal, and microorganism communities and the nonliving environment interacting as a functional unit," while ecosystem services "are the benefits people obtain from ecosystems."[53] This relationship typically flows in two directions. In one direction, USAID activities can positively and negatively impact ecosystems and the services they provide. In the second direction, ecosystems provide important services to USAID activities. We aim to identify the incremental impact of select USAID Mikajy activities on ecosystems and ecosystem services and identify dependencies that these activities may have on ecosystem services. We then assign a value to this measurement using benefit transfer, a technique where primary data collected in similar settings are used to derive an ecosystem value. A qualitative assessment will be provided when an impact cannot be quantified (USAID 2018).

DECISION CRITERIA

Cost-benefit analysis provides summary measurements of an investment's value to determine the impact on stakeholders and the economy, including net present value (NPV), internal rate of return (IRR), and the benefit-cost ratio (BCR). The NPV is the investment's discounted incremental cash flows across all the years evaluated. The IRR or economic rate or return (ERR) is the discount rate that makes the net present value of a project's incremental cash flows equal to zero. Finally, the BCR is the ratio of the present value of a future stream benefits over the lifetime of an investment with the present value of investment costs.

USAID uses NPV as the primary measurement for evaluating its investments. A positive financial NPV for a stakeholder means the beneficiary will experience a financial gain from the investment, while a positive economic NPV means society will gain from the investment. The two main limitations of using NPV are associated with the selection of a discount rate, which can be controversial, and the time horizon of the analysis. Per *USAID CBA Guidelines* (2015), this analysis uses an economic discount rate of 12 percent and an analysis time horizon of 10-years.

[53] Ecosystem services are further defined as provisioning services (food, fresh water, fuel, etc.); regulating services (e.g. disease regulation, climate protection, etc.); supporting services (e.g. soil formation and nutrient cycling); and, cultural services (e.g. educational, recreation, tourism). For further reference see www.millenniumassessment.org.

ANNEX III SUPPORTING CBA DOCUMENTATION

VANILLA

Vanilla producers incur certain upfront and recurring costs as part of the RA certification process (Table III-1). RA certification requires material costs related to sanitation, including washing facilities (e.g. latrines; washing basins) and garbage bins. Based on focus group discussions, these costs amount to 304,000 Ariary per household (USD $83.60) and labor costs of 170,000 Ariary per household (USD $46.80). In the absence of a predetermined contract sales date, many producers sell their vanilla earlier than expected to reduce the probability of theft and to take advantage of perceived pre-market price advantages.[54] As a result, post-harvest losses may be greater than expected and the quality of the vanilla product is lower. The CBA is assuming an average of 15 extra labor days to protect the vanilla plot and comply with the sales date at an average cost of 187,500 Ariary (USD $51.57). There are two additional costs worth noting. First, RA certification includes higher labor rates for hired workers as part of efforts to promote a "living wage." As a result, hired labor increases from 10,000 (USD $2.75) to 15,000 Ariary per day (USD $4.13). This variable has the most significant impact on vanilla producer costs and is tested in the sensitivity analysis section of this study. Finally, there are opportunity costs for producers attending RA certification and SAN training that is valued at 40,000 Ariary (USD $11) or 10,000 Ariary (USD $2.75) per day.

The CBA study quantifies two potential on-farm benefits of acquiring RA certification and SAN practices. First, RA certified products can experience a 10 to 20 percent price premium relative to non-certified products (Rainforest Alliance 2018). However, the price premium is predicated on the price end-users are willing to pay for RA certified products. This analysis is using a 10 percent price premium with sensitivity analysis applied to test this assumption. Additionally, farmers may experience increased productivity due to the adoption of SAN practices. While there is some evidence to suggest productivity gains can rise by 80 percent (Hänke 2016), the analysis is assuming a 30 percent productivity increase over 3-years, from 37.66 kg/ha to 54.7 kg/ha, which is the average of Fair Trade Certified vanilla production in SAVA (Hänke et al. 2018).[55]

[54] Vanilla is only supposed to be sold on a predetermined date set by the Government of Madagascar. The contract with RAMEX ensures this sales date is adhered to.

[55] This is provided by a survey of both Fair Trade Certified and other producers in the Sava region. the author suggests that the survey was potentially weighted towards Fair Trade producers therefore we have used this value as a conservative estimate.

Table III-1: Incremental Farm-Level Costs and Benefits for Vanilla Producers

Stream	Type	Description	Value	Units
Cost 1	One-time	Capital costs for sanitation facilities and garbage bins	304,000	Ar
Cost 2	One-time	Labor cost related to construction costs (sanitation; dump)	17	person days
Cost 3	Recurring	Security costs as a result of postponing harvest[56]	15	person days per ha
Cost 4	Recurring	Additional days of labor for SAN-related land preparation	8	person days per ha
Cost 5	Recurring	Family related labor costs of attending RA certification training	4	person days per year
Cost 6	Recurring	Increase in hired labor costs	5,000	Ar per ha per day
Benefit 1	Recurring	Increased yields[57]	15.86	kg per ha
Benefit 2	Recurring	Farmgate price premium[58]	10	%

GROUNDNUT AND MAIZE

With regards to groundnuts and maize production, USAID Mikajy will subsidize the use of high-yielding variety (HYV) seeds and fertilizers to offset the costs to show how CF practices and improved inputs can increase yields. USAID support comes to around $32 per demo farmer per year for the first three years of implementation. Additional costs to all groundnut production (i.e. demo and non-demo) include the following: 6 additional days of labor; the introduction of 40 kg/ha of high-yield (HYD) seeds[59]; 100 kg/ha of chemical fertilizers (75 kg/ha of nitrogen, phosphorous, and potassium (NPK); 25 kg/ha or Urea); 1,000 extra kg/ha of organic fertilizer (50 percent is assumed to be sourced from farmer); and 4 labor days spent attending CF training (Table 3). Similarly, the additional costs of CF maize adoption include the following: 9 additional days of labor; 100 kg/ha of chemical fertilizers (75 kg/ha of NPK; 25 kg/ha or Urea); and 5,000 extra kg/ha of organic fertilizer (60 percent is assumed to be sourced from the farmer).

56 On average, farmers currently sell vanilla products early to avoid thefts. By waiting for the right harvest time, farmers incur additional security labor costs.
57 Yield potential reached in 4 years with marginal yield growth in each year.
58 Price premium reached in 2nd year of production.
59 Demo farmers without the intervention would use 100 kg of lower quality seeds.

Table III-2: Incremental Farm-Level Costs and Benefits for Groundnut Producers

Stream	Type	Description	Value	Units
Cost 1	Recurring	Recurring labor costs for CF production	6	person days per ha
Cost 2	Recurring	Additional HYV seeds	40	kg per ha
Cost 3	Recurring	Chemical fertilizers	100	kg per ha
Cost 4	Recurring	Organic fertilizers	1,000	kg per ha
Cost 5	Recurring	Labor costs during activity implementation due to the opportunity cost of attending CF cert. training	4.83[60]	person days per years
Benefit 1	Recurring	Yield increase[61]	100	%
Benefit 2	Recurring	Pest and disease reduction[62]	30	%
Benefit 3	One-time	USAID subsidy for chemical fertilizers and seeds in first year of production	32	USD per year

For both value chains, the key assumed benefits include increased production and reduced incidences of diseases and pests. For groundnuts, the study assumes a 100 percent increase in yields, from 1,300 kg/ha to 2,600 kg/ha by the third year of CF adoption. For maize, the study assumes an 80 percent increase in yields from 2,000 kg/ha to 3,600 kg/ha. Both groundnut and maize production there is an assumed 30 percent reduction in pests and diseases experienced after the third year of CF adoption. For maize production, other benefits are expected for reduced non-high yield seed variety costs.

60 3 days for non-demo farmers
61 Yield potential reached in 4 years with marginally growth experienced each year.
62 Begins after second year of CF adoption, as many benefits to CF take time to material as the soil structure slowly improves.

Table III-3: Incremental Farm-Level Costs and Benefits for Maize Producers

Stream	Type	Description	Value	Units
Cost 1	Recurring	Recurring labor costs for CF production	9	person days per ha
Cost 2	Recurring	Chemical fertilizers	100	kg per ha
Cost 3	Recurring	Organic fertilizers	5,000	kg per ha
Cost 5	Recurring	Labor costs during activity implementation due to the opportunity cost of attending RA cert. training	4.83[63]	person days per years
Benefit 1	Recurring	Yield increase[64]	80	%
Benefit 2	Recurring	Pest and disease reduction[65]	30	%
Benefit 3	One-time	USAID subsidy for chemical fertilizers and seeds in first year of production	98	%
Benefit 4	Recurring	Reduction in non-HYV seed use	30	kg per ha
Cost 5	Recurring	Labor costs during activity implementation due to the opportunity cost of attending RA cert. training	4.83[66]	person days per years

ECOSYSTEM VALUES

As previously mentioned, this study does not have the necessary inputs to calculate the likely benefits from reduced soil erosion. To make this calculation, we would need the necessary variables for the Universal Soil Loss Equation, including the following: average annual soil loss in tons per acre; rainfall erosivity index; soil erodibility factor; topographic factors; cropping factor; and conservation practice factor. While we were not able to incorporate these potential benefits, we use empirical deforestation rates calculated from the Hansen et al. global forest cover dataset and evidence of reduced deforestation from other evaluations of RA certification and CF practices impact on conservation outcomes to show what might be achieved through USAID Mikajy's activities.

We use empirical deforestation rates for geographic zones within a 10 kilometer buffer of the PAs to determine what the total expected forest cover loss, in hectares, would be in the absence of USAID Mikajy. For MaMaBay, the weighted average forest cover loss between 2013 and 2018 is 0.020 ha forest

63 3 days for non-demo farmers
64 Yield potential reached in 4 years with marginally growth experienced each year.
65 Begins after third year of CF adoption, as many benefits to CF take time to material as the soil structure slowly improves.
66 3 days for non-demo farmers

cover loss per ha of initial forest cover.67 For the southwest region, the weighted average deforestation between 2023 and 2018 is 0.0119 ha forest cover loss per ha of initial forest cover.

According to research previously cited, there is evidence that RA certification and CF combined with land practices reforms can reduce deforestation rates. This evidence includes a 27 percent reduction in deforestation rates in Congo (USAID 2019b); a 12 percent reduction in forest loss for RA certified coffee producers relative to non-RA certified coffee producers in Colombia (Reuda 2014); and a 1.7 percentage point reduction in the probability of deforestation for RA certified coffee producers versus non-RA certified producers in Ethiopia (Takahashi and Todo 2013). More recently, Takahahi and Todo (2017) show that the reduction in deforestation rates are evidenced within a 100 meters (m) radius of the communities adopting RA certified coffee production. It should be noted that each of these studies used rigorous evaluation methods and geospatial techniques to reach these findings. We are merely using this evidence to show what could potentially occur in the intervention area.

USAID Mikajy's vanilla activities are being introduced in six communities in the MaMaBay region. Based on the Takahashi and Todo (2013) and Reuda (2014) studies, we assume that deforestation rates could potentially decline by 12 percent within a 50 meter radius of the boundaries of the communities. In the absence of geospatial coordinates for each community, this study is assuming that each community is a circular area with a radius of 500 meters (0.5 kilometers). The area of a 50-meter-wide radius around a circular community of 0.5 km radius is 8.05 ha. Using the formula in Table III-4, we estimate that the activity could avert 0..0124 ha of forest cover loss per year for each of the six communities or 0.1181 ha per year for all communities. The formula below represents this calculation for one community.

[67] Calculation: (65.7 percent of total forest cover in MaMaBay (Makira) * 0.0176 forest cover loss per ha forest)+(34.3 percent of total forest cover in MaMaBay (Masoala) * 0.0252 forest cover loss per ha forest)) = 0.020 hectares of forest cover loss per ha of initial forest cover within 10 km of PAs in the MaMaBay intervention area.

Table III-4: Deforestation Reduction for one Community in MaMaBay

Timeframe		
Y1 to Y5		
Inputs		
DL^{MK}	Average annual forest cover loss in Makira buffer zone	ha_{loss}/year
TL^{MK}	Initial forest cover in Makira buffer zone	ha_{cover}
DL^{MA}	Average annual forest cover loss in Masoala buffer zone	ha_{loss}/year
TL^{MA}	Initial forest cover in Masoala buffer zone	ha_{cover}
TL^{A}	Initial forest cover in entire MaMaBay landscape	ha_{cover}
HR	Area of 50 meter-wide annulus surrounding a community	ha_{land}
DR	Reduction in forest cover loss resulting from intervention	%
N	Number of years	#
Calculation (per period)		
$AD^{MAMA} = \left\{\left[\frac{\frac{DL^{MK}}{TL^{MK}}}{N} \times \frac{TL^{MK}}{TL^{A}}\right] + \left[\frac{\frac{DL^{MA}}{TL^{MA}}}{N} \times \frac{TL^{MA}}{TL^{A}}\right]\right\} \times HR \times DR$		

This same approach is used for Menabe. However, the projected area for all farmers under CF cultivation is only 188 hectares - less than the average area (290 ha) under RA cultivation for one community in MaMaBay. Therefore, we only assess the benefits that could potentially accrue to one community with the formula provided below. The result is 0.019 ha of averted forest cover loss per year or 0.077 ha over the implementation period.

Table III-5: Deforestation Reduction for one Community in Menabe[68]

Timeframe		
Y1 to Y5		
Inputs		
DL^{ME}	Average annual forest cover loss in Menabe-Antimena buffer zone	ha_{loss}/year
TL^{ME}	Initial forest cover in Menabe-Antimena buffer zone	ha_{cover}
DL^{KI}	Average annual forest cover loss in Kirindy-Mitea buffer zone	ha_{loss}/year
TL^{KI}	Initial forest cover in Kirindy-Mitea buffer zone	ha_{cover}
TL^{A}	Initial forest cover in entire Menabe landscape	ha_{cover}
HR	Area of 50 meter-wide annulus surrounding a community	ha_{land}
DR	Reduction in forest cover loss resulting from intervention	%
N	Number of years	#
Calculation (per period)		
$AD^{SW} = \left\{\left[\frac{\frac{DL^{ME}}{TL^{ME}}}{N} \times \frac{TL^{ME}}{TL^{A}}\right] + \left[\frac{\frac{DL^{KI}}{TL^{KI}}}{N} \times \frac{TL^{KI}}{TL^{A}}\right]\right\} \times HR \times RR$		

The CBA will consider three perspectives when estimating the potential value of ecosystem services impacted by the project, including local producers, the country of Madagascar, and globally. From a local's perspective, the opportunity cost of vanilla, groundnut, and maize production will be used to estimate an average opportunity cost per ha that local communities would "give up" with the intervention.

Table III-6 provides a summary of the values used to estimate the opportunity cost of vanilla from conserving land in the buffer zone surrounding the PAs in MaMaBay. Across both the Makira and Masoala landscapes, the NPV for 0.472 hectares of averted deforestation for vanilla production is \$173.[69] Ecosystem values derived from Carret and Lovey (2004) are used to value two other opportunity costs of conservation.[70] The first value represents the value of wood at \$187.50 per ha of

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[68] The equation uses the same logic as the formula in Table III-4. However, in this case *ME* represents Menabe-Antimena and *KI* represents Kirindy-Mitea.

[69] This represents an annualized value of around \$184 per ha compared to \$80 per ha for rice (Carret and Lovey 2004).

[70] The authors valued the opportunity cost of wood by using the total value of unsustainable wood collection and forest cover loss rates in the study area, and the total forested area in the intervention zone to derive a cost per ha of forested area across the entire intervention zone. For example, an opportunity cost of \$5.00 per ha of forested area, represents the average cost per ha of forested area at the annual rate of forest cover loss (e.g. 0.02 ha forest cover loss / ha of initial forest cover). In other words, the \$5.00 represents the opportunity cost for 0.02 ha of averted forest cover loss. A similar approach was taken for non-timber forest products.

forested land, which assumes 25 tons of wood per ha at a price of $7.50 per ton. At 0.472 ha, this represents a value of $73 of forest cover loss averted. The second value represents the forgone profits from non-timber forest products, such as the collection of fruits, vegetables, and medicinal products, which is valued at $40 per ha or $16 at 0.472 ha. This study assumes the wood and non-timber forest products are extracted on an unsustainable basis so these values are only valued in the year forest cover loss is averted. However, the value of vanilla production is estimated over the entire 10-year period.

Similar to the economic analysis, this study assumes that the resource flows of ecosystem values are experienced over a 10-year time horizon starting with the origin point of the intervention. For example, the opportunity cost of 0.0124 ha of forested land is estimated over a 10-year time horizon, including the recurring values of vanilla production and the one-time costs for wood and timber products. Moreover, averted forest cover loss that can be attributed to USAID's investment is only valued during the implementation period of 4 years (continued RA certification under RAMEX and McCormick would potentially result in future forest cover loss averted), so, in total, the intervention would avert forest cover loss by 0.472 ha. In total, the opportunity cost of conserving 0.472 ha is $261. In other words, the six communities would experience an opportunity cost of $261. There are several potential benefits that are not included in the local analysis, including direct and indirect effects of tourism and benefits from improved irrigation or drinking water.[71]

Table III-6: MaMaBay Community's Perspective of Conservation, NPV Calculations

Decision Criteria	Vanilla Production[72] Opportunity Cost
	0.4724 ha (4-year of implementation)
Opportunity Cost (NPV) of Vanilla Production (.88 ha) at a 10-year time horizon	$396
Opportunity Cost (NPV) of Vanilla Production at a 10-year time horizon (0.472 ha)	$173
One-time Opportunity Cost wood products (0.472 ha per year)	$73
One-time Opportunity Cost non-wood products (0.472 ha per year)	$16
Total NPV of averted forest cover loss	$261

[71] These benefits are estimated in the national/global section.
[72] The NPV represents the value of vanilla production under scenario 2 where vanilla prices decline by 30 percent.

Table III-7 provides a summary of the values used to estimate the opportunity cost of groundnut and maize production from conserving land in the buffer zone surrounding the PAs in the southwest. The value of groundnut and maize production has an NPV of $54 per 0.1 ha of averted forest cover loss per year. Based on the assumption that the intervention will reduce forest cover loss, the NPV of groundnut and maize production is $36.95 per 0.0771 ha of averted forest cover loss. Using the same values from Carret and Lovey (2004), wood has a one-time cost of $11.877 per 0.0771 ha of averted forest cover loss and non-forest timber products have a one-time cost of $2.53 per 0.0771 ha of averted forest cover loss. At an implementation period of 4 years, the total opportunity cost of foregone forest exploitation is estimated at $51.35 for 0.0771 ha of averted forest cover loss.

Table III-7: Menabe Community's Perspective of Conservation, NPV Calculations

Decision Criteria	Groundnut and Maize Opportunity Cost
	0.0771 ha (4-year of implementation)
NPV of CF Groundnut and Maize Production (.10 ha) at a 10-year time horizon	$112.83
Opportunity Cost (NPV of Groundnut and Maize Production (.0771 ha) at a 10-year time horizon	$36.95
One-time Opportunity Cost of wood products (0.0771 ha per year)	$11.87
One-time Opportunity Cost (NPV) non-wood products (0.0771 ha per year)	$2.53
Total NPV of 0.0771 ha of averted forest cover loss per year	$51.35

To estimate the benefits and costs of conservation on a per-hectare of protected land basis, researchers determine the scale of an economic activity; the value derived from this activity; and then the value this activity represents across the entire protected zone. For example, if households typically collectively clear 100 ha of land to engage in *Hatsake*, which is valued at $100 per ha of protected land[73], then the total activity is valued at $10,000. However, if the total protected zone is 8,000 ha of protected land, then the value or opportunity cost of *Hatsake* is $1.25 per ha of protected land. In this analysis, we are assuming the land surrounding the community (8.05 ha of protected land) is the protected zone that could be impacted by the intervention. For MaMaBay, the opportunity cost of vanilla production for 6 communities (48.30 ha of protected land)[74] is $5.44 per ha.[75] For Menabe, the opportunity cost of

[73] We assume that a hectare of land is valued at $100 regardless of the percentage of the hectare of land that was originally forested.

[74] Equation: 6 communities * 8.05 ha per community = 48.3 ha.

[75] Equation: $261 vanilla production / 48.3 ha = $5.44 per ha.

Hatsake groundnut and maize production for one community (8.05 ha of protected land) is $06.40 per ha.[76]

In Madagascar, research estimating the net costs and benefits from conservation vary significantly depending on the source. From the local perspective, Kremen et al. (2000) estimate an NPV range from $0.002 to $0.005 per ha of protected land and a national NPV range between -$2.64 to -$0.82 per ha of protected land. Hockley and Razfindralambo (2006) estimate local values ranging from an NPV of -$0.24 to $0.02 per ha of protected land and a national range from $0.05 to $0.22. Carret and Loyer (2004) estimate national benefits of $10 per ha of protected land, including $3 from biodiversity conservation, $4 from eco-tourism, and $3 from the protection of watersheds. Meanwhile, local estimates are provided for individual stakeholder groups (e.g. tourist operates and *Hatsake* rice farmers) but there are no aggregated estimates.

The total potential global value of conservation also varies depending on the source. Carret and Loyer (2004) estimate an NPV of $15.70 per ha of protected land without accounting for carbon sequestration. Hockley and Razfindralambo (2006) estimate values ranging from an NPV of $1.18 to $6.45 per ha of protected land with carbon sequestration while Hockley and Razfindralambo (2006) estimate positive values ranging from an NPV of $0.08 to $0.35 per ha of protected land. Both studies included the benefit of carbon sequestration in their calculations.

This study uses several approaches to determine the impact of the interventions on local ecosystems. First, a comparison between the opportunity costs of averted deforestation is compared to incremental financial gain of the intervention to determine if producers have a financial incentive to preserve the forest. Second, sensitivity analysis is applied to benefit transfers established in other studies to determine if ecosystem values have a significant impact on economic resource flows.

For vanilla, RA certified vanilla producers have an incremental financial NPV of $1,679 per producer, which represents a total financial NPV of $6.33 million or $1.05 million per community. Assuming a potential 12 percent reduction in current deforestation rates, the opportunity cost of vanilla production is valued at an NPV of $261 for 0.47 ha of averted forest cover loss. Therefore, the incremental financial value of 1 farmer would surpass the opportunity cost of conservation across all 6 communities. This means communities should have a strong financial incentive to participate in RA certified vanilla production, assuming yields increase and the price premium holds.

For groundnut and maize production, non-demo farmers with an incremental financial NPV of $54 per 0.10 ha and a gross NPV of $113 per 0.10 ha. At a current deforestation rate in Menabe, groundnut and maize producers would be expected to have an opportunity cost NPV of $51.35 per 0.0771 ha. Therefore, in the case of non-demo farmers the financial incentive for deforestation is slightly lower than the financial incentive for CF groundnut and maize production.

While national and global estimates are considered in the sensitivity analysis section, we also add a carbon value scenario to account for the potential benefits of increased carbon sequestration. Specifically, the intervention is projected to reduce forest cover loss by 0.47 ha in MaMaBay (0.1181 ha per year for 4 years) and by 0.077 ha in Menabe (0.0193 ha per year for 4 years). The study accounted for the benefits of carbon using two techniques. First, the amount of carbon that can be sequestered per year is calculated using estimates from Bernal et al. (2018), including 7.9 tons of carbon dioxide

[76] Equation: $51.5 groundnut and maize production / 48.3 ha = $6.40per ha.

equivalent (tCO2e) per ha and 3.1 tCO2e per ha for dry forests.[77] Second, the study accounts for the tCO2e that is "saved" as a result of averted deforestation, including 90 tCO2e per ha in Madagascar's humid forests and 17 tons of carbon per ha of dry forest (World Bank 2013). Based on these assumptions, the value of carbon sequestration in MaMaBay and Menabe is $9,955 and $294, respectively.

SENSITIVITY ANALYSIS

To build cost-benefit models, it is necessary to make certain assumptions. The uncertainty inherent in those assumptions impacts the level of validity attributed to the final result, which is why it is essential to analyze the sensitivity of the model to those assumptions. This is done through the use of one-way and two-way tables that show how the final result changes with modifications to the values of certain parameters, everything else being held constant.[78]

Below is a list of these assumptions followed by a summary of the key findings for each variable.

- Percentage change in agricultural yields due improved methods and inputs (groundnuts, maize)
- Timeline for reaching maximum yield gains
- Percentage movement in price premium for RA certified vanilla
- Annual production losses attributed to pests and disease
- Potential natural disasters (e.g. cyclones and droughts)
- USG costs per beneficiary
- Financial discount rate
- Percentage reduction in current deforestation rates
- Local, national, and global values for conservation

AGRICULTURE YIELDS

The study's yield growth assumptions hold there are initial gains in rates during the first 3 to 4 years after the farmers start receiving CF and RA SAN training. For vanilla producers, the model assumes that activity participants would achieve a 45-percentage increase in their yields over the first four years. If yields increase by only 20 percent, then the financial and economic NPV turns negative. Similarly, if groundnut yields increase by only 90 percent, as opposed to the 100 percent assumption, then the economic NPV turns negative.[79]

COMMODITY PRICES AND THE PRICE PREMIUM FOR RA-CERTIFIED VANILLA

While movements to an assumed price premium of 10 percent have an impact on the financial and economic results, the price premium could fall to 0 percent without the financial or economic NPV turning negative. However, if the price premium declines from 10 to 8 percent and yield gains are only 30 percent, then both the financial and economic NPV turn negative. All other movements to commodity prices have a negative impact on the incremental returns, but the effect is marginal because farmers "with" and "without" intervention are assumed to have the same exposure to market prices.

[77] The humid forest estimate is based on a calculation for humid forests in Africa and dry forests in South America.

[78] Monte Carlo analysis can be used when primary data (i.e. surveys) allows for the estimation of probability distributions around key input variables.

PROJECT PARAMETERS: ADOPTION RATES AND TRAINING COST PER BENEFICIARY

For vanilla farmers, the models assume an adoption rate of 93 percent and an attrition rate of 10 percent after the activity has concluded. Similarly, for groundnut and maize farmers the models assume an adoption rate of 90 percent and an attrition rate of 10 percent after the activity is over. While movements to these variables do not have a significant impact on 3 out of the four commodities, the economic NPV for groundnut production turns negative if the adoption rate drops to 85 percent.

The model currently assumes that farmers will attend several CF and RA training sessions, which has two impacts on the model. First, farmers incur an opportunity cost of attending training. If non-demo farmers are only dedicating 0.1 ha to CF groundnut and maize production, their cost of attending the training is higher because this expense accounts for a larger share of overall costs. Second, USAID Mikajy incurs some training cost per beneficiary, which has an overall impact on the economic results. At an assumed cost of $100 per beneficiary per year, movements in this cost have little impact on the economic results. For groundnut production, slight movements in the cost per beneficiary have substantial impacts on the economic results. For example, a $3.00 increase in the cost per beneficiary, from $12.50 to $15.50, turns the economic NPV negative for non-demo groundnut farmers.

ORGANIC FERTILIZER COSTS - MAIZE FARMERS

Organic fertilizers account for a significant portion of maize farm costs under CF production. According to talks with activity staff, CF farmers would likely need to obtain manure from farm-owned cattle to avoid paying for large quantities of manure. The model currently assumes that 60 percent of the additional supply will be provided by farm cattle. If this variable moves slightly, then the financial returns become negative for maize farmers. At the same time, farmers may be able to set up credit agreements with organic fertilizer providers. This is something that USAID Mikajy is currently exploring.

HIGH YIELD SEED VARIETIES - GROUNDNUT FARMERS

High yield seed varieties account for a significant portion of groundnut farm costs under CF production. The model currently assumes that farmers will use 40 kg of HYD seeds per ha at an estimate price of 7,500 Ar per kg. If either the seed quantity of the seed price increases, then the financial return to non-demo farms turns negative. A financial service could help offset the costs of the seeds. As an alternative, USAID might consider partnering with another organization to help subsidize seed costs for non-demo farmers.

FINANCIAL INTEREST (DISCOUNT RATE)

According to the World Bank Development indicators, between 2014 and 2018 the average official borrowing cost was 58 percent.[80] After internal discussions, it was decided that farmers would likely find alternative sources of finance (e.g. self-financing), which have much lower interest rates. In the absence of data, this model assumes an average borrowing cost of 15 percent. Movements to this rate do not impact the positive returns to vanilla producers or the negative returns for maize farmers. However, groundnut

[80] The data source for this estimate is the IMF (2010 – 2018). However, the study uses 15% to account for the likely rate provided by alternative money lenders (e.g. microfinance).

producers would start to experience negative returns if the financial interest rate or discount rates increases to around 50 percent.

ECOSYSTEM VALUES

The intent of this analysis is to consider the potential impact USAID Mikajy activities may have on ecosystems and conservation outcomes. In the absence of detailed information about each individual farm plot, the analysis uses empirical deforestation rates and secondary evidence from researchers to consider the potential reduction in deforestation rates over 6 communities in MaMaBay and 1 community in Menabe. At a hypothetical 50 m radius surrounding a community, we have modeled a 12 percent reduction in deforestation.

The impact this variable has on the economic NPV for vanilla is minimal, even when making extraordinarily optimistic assumptions. This is due to the fact that vanilla already has a substantial economic return and the averted deforestation is small in comparison to the hectares under RA certified vanilla production. However, it should be noted that in the absence of more detailed information, and without further knowledge about complementary activities, the analysis only considers marginal gains in conservation outcomes

NATURAL DISASTERS

Preliminary findings from a simple natural disaster modeling scenario that uses historical incidences of cyclones and reported vanilla crop losses of 30 percent, show that USAID Mikajy would improve the resilience of USAID Mikajy vanilla producers to withstand these events from a financial cash flow perspective. It should be noted, however, that this model does not account for the price elasticity of demand for vanilla, nor does it factor in the cyclone events that will devastate vanilla production for several years.

ANNEX IV FOREST LOSS INTENSITY MAPS

Figure IV-1: Average annual forest loss intensity in and around Kirindy-Mitea, 2001-2015

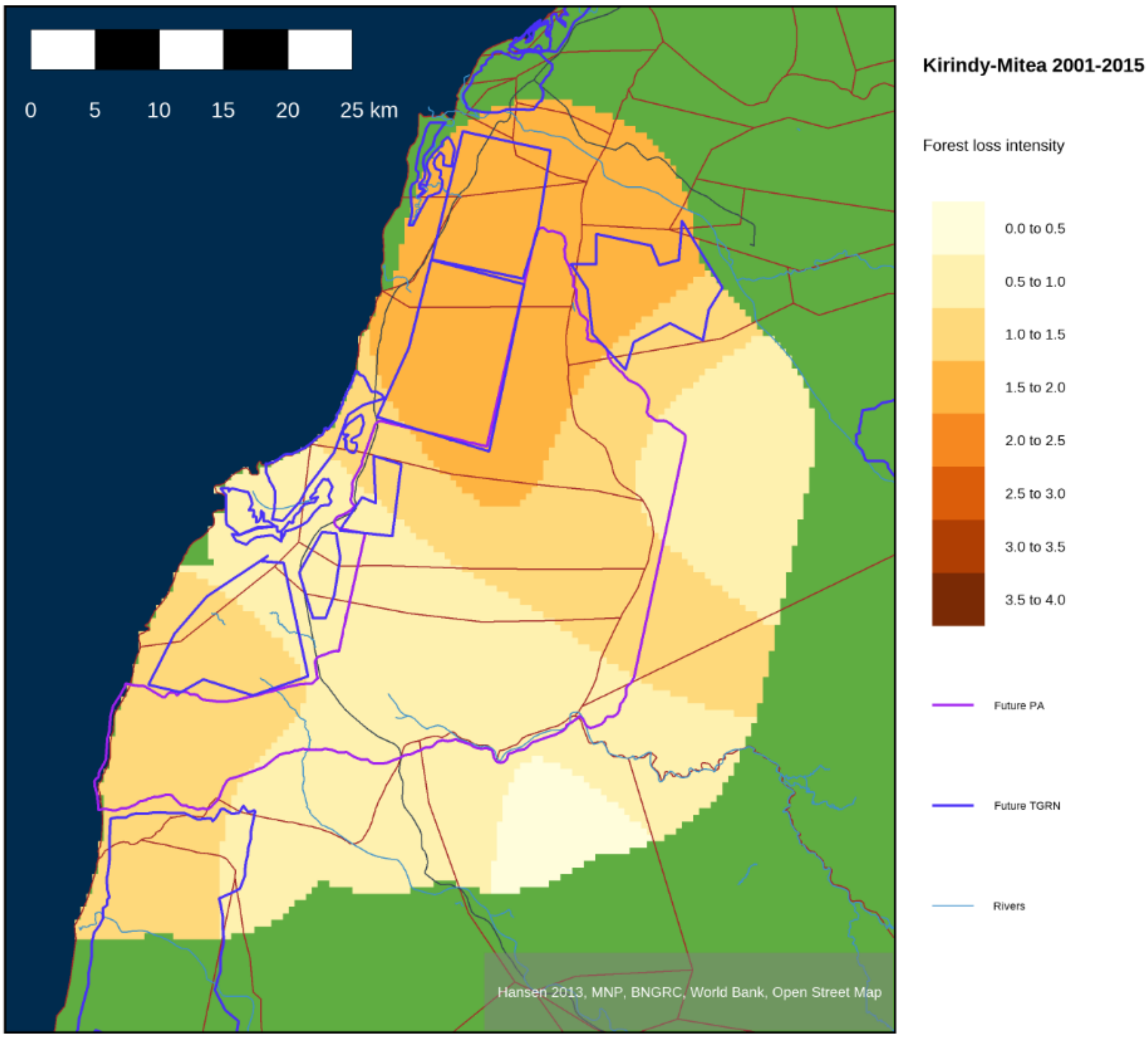

Figure IV-2: Average annual forest loss intensity in and around Kirindy-Mitea, 2016-2017

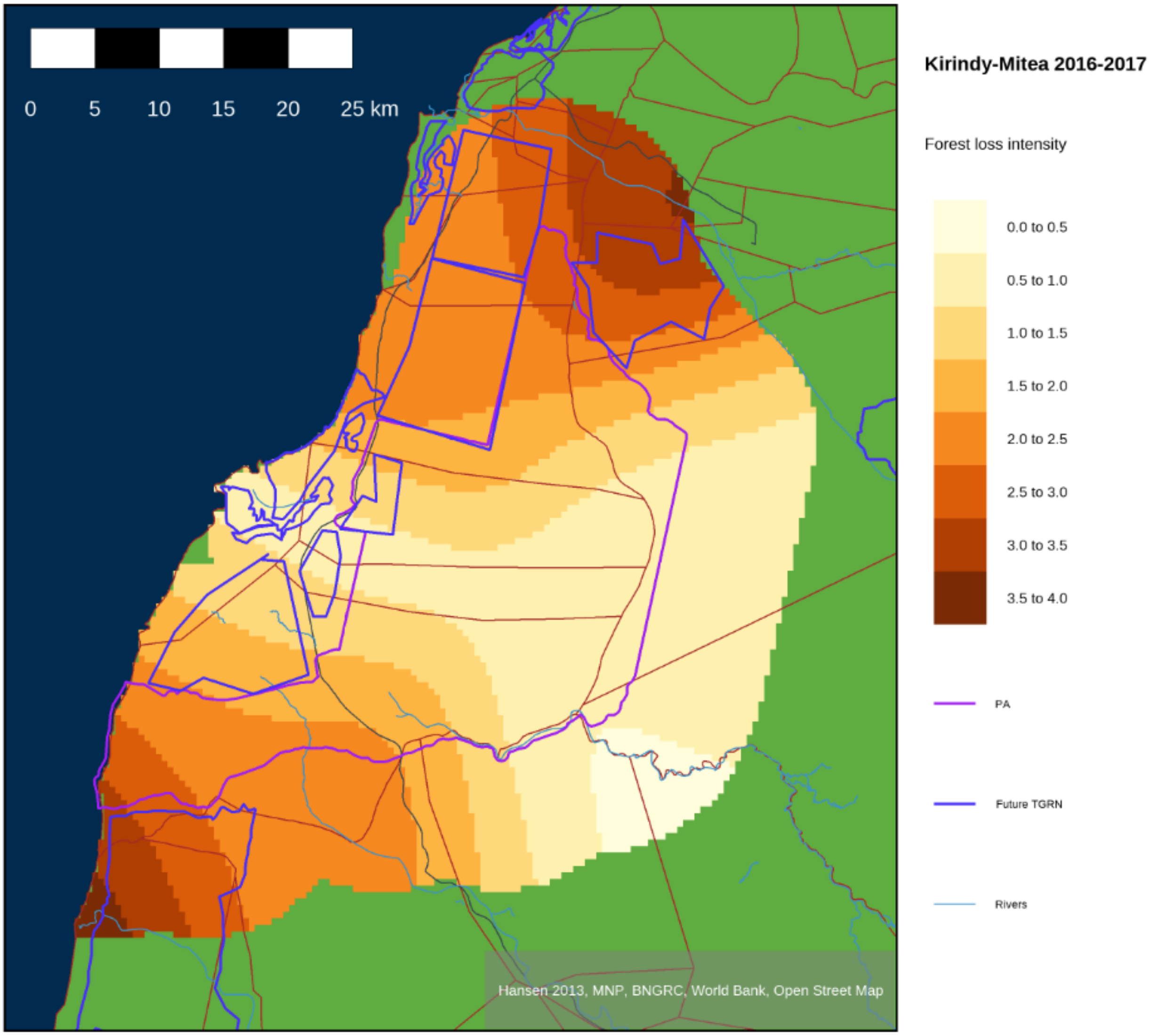

Figure IV-3: Average annual forest loss intensity in and around Kirindy-Mitea, 2018

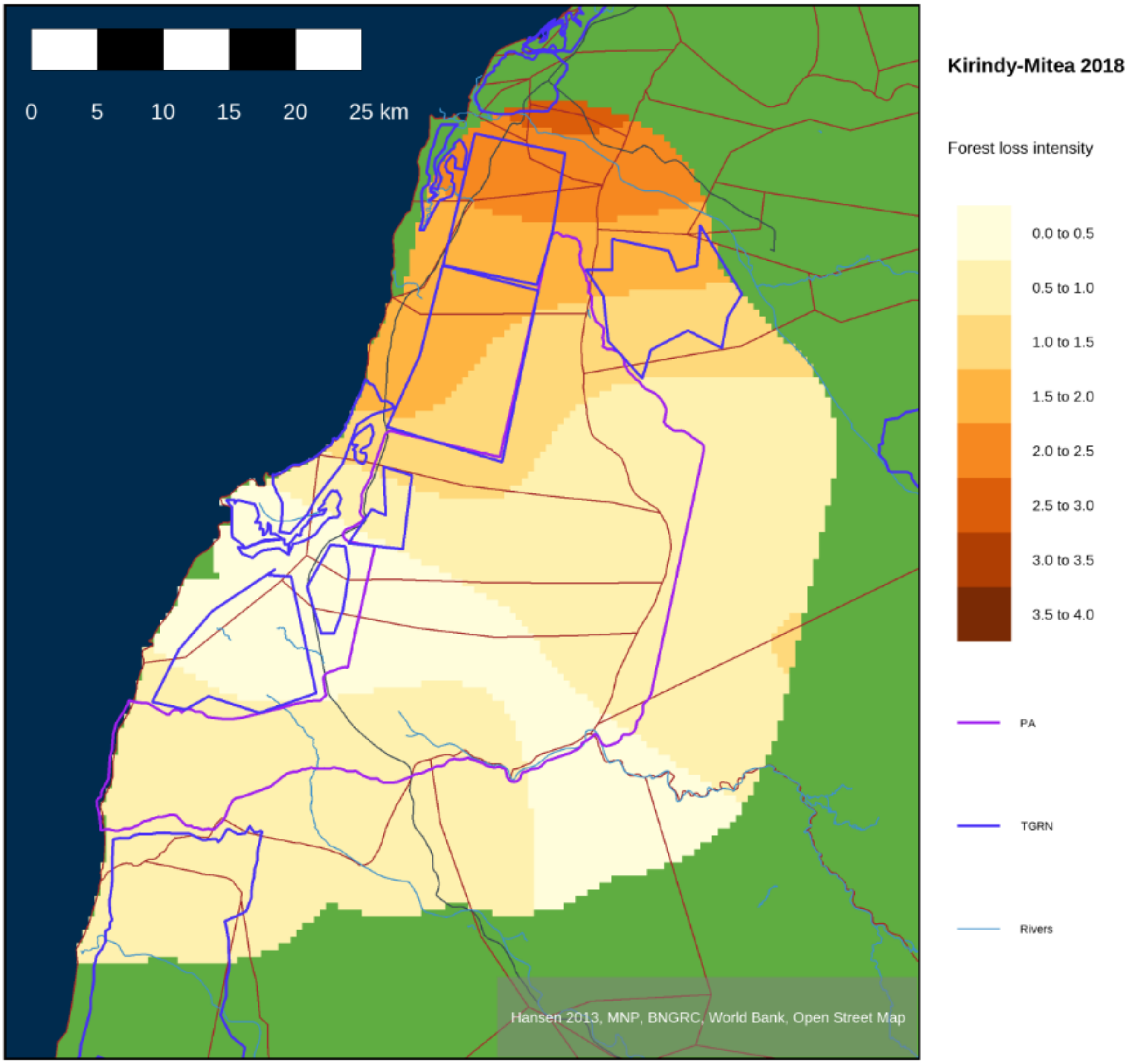

Figure IV-4: Average annual forest loss intensity in and around Makira, 2001-2012

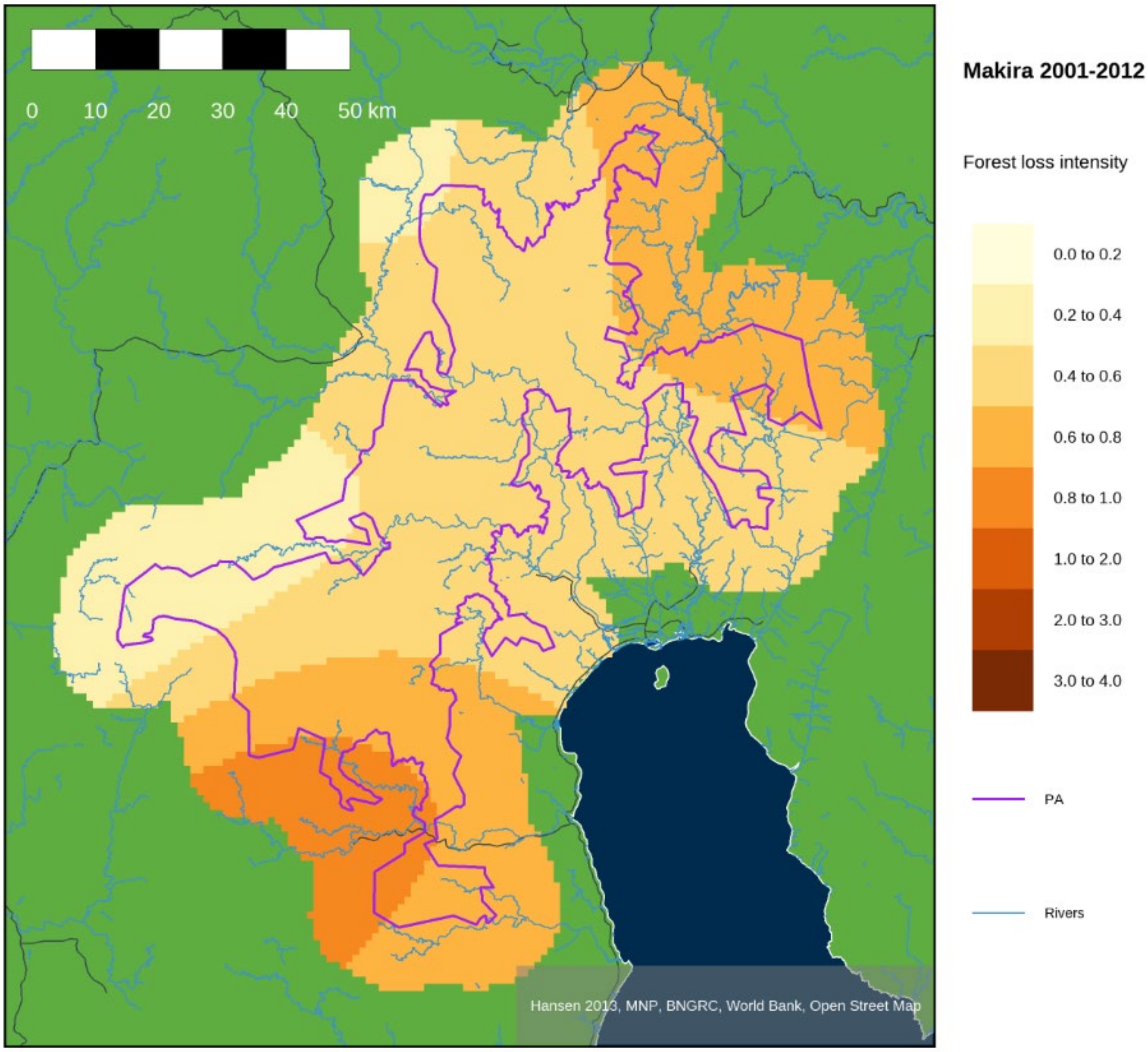

Figure IV-5: Average annual forest loss intensity in and around Makira, 2013-2018

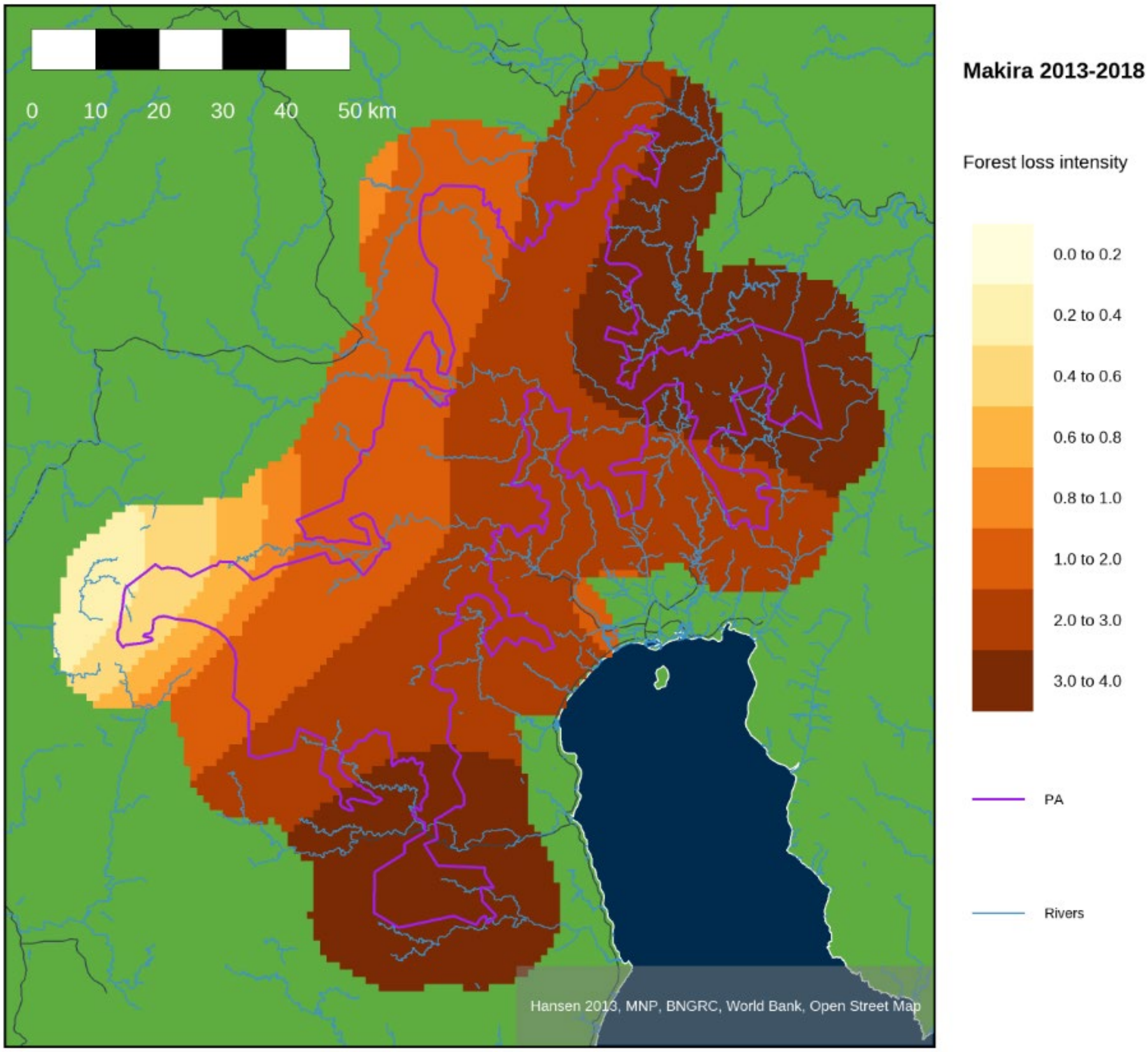

Figure IV-6: Average annual forest loss intensity in and around Masoala, 2001-2012

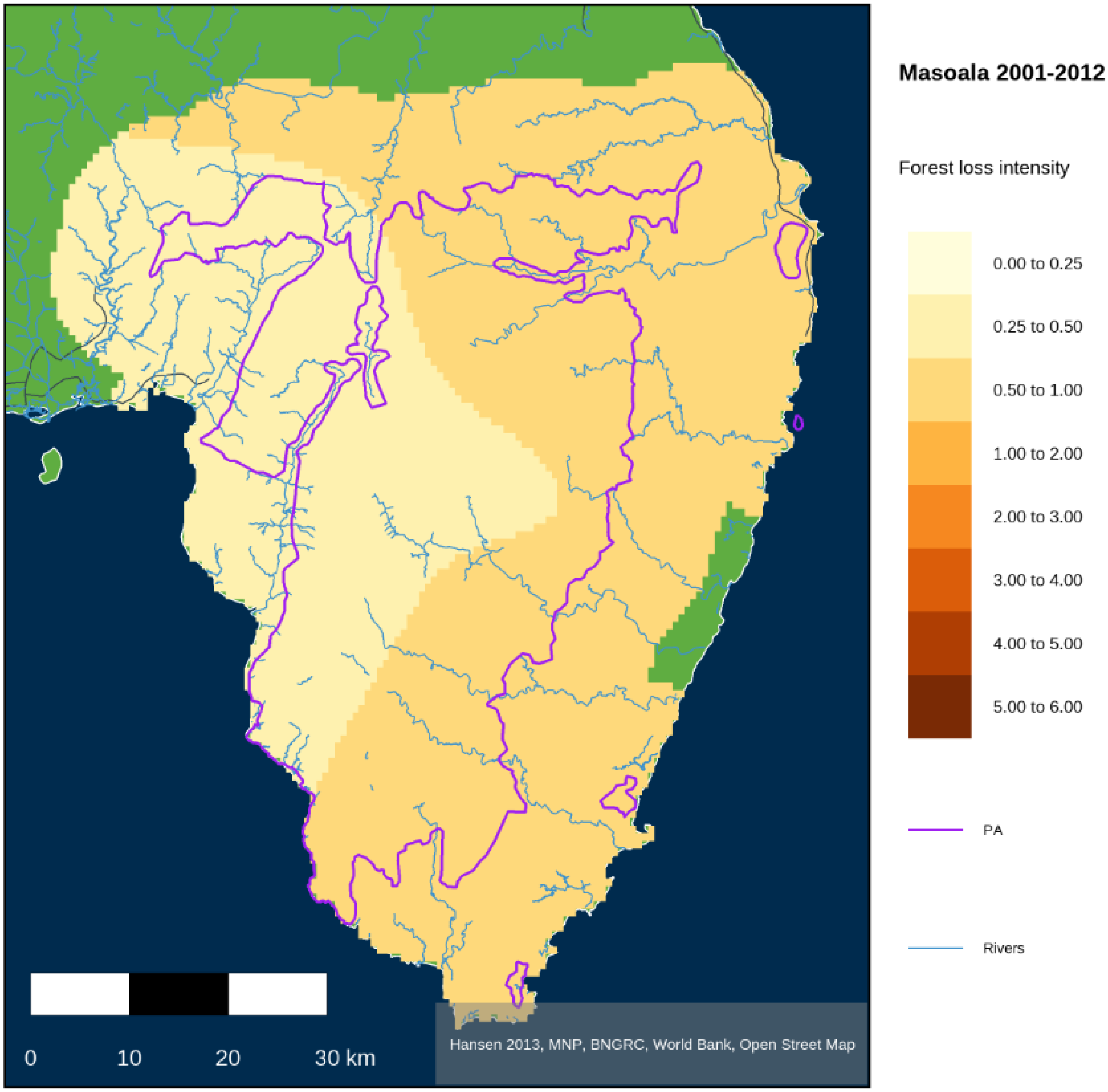

Figure IV-7: Average annual forest loss intensity in and around Masoala, 2013-2018

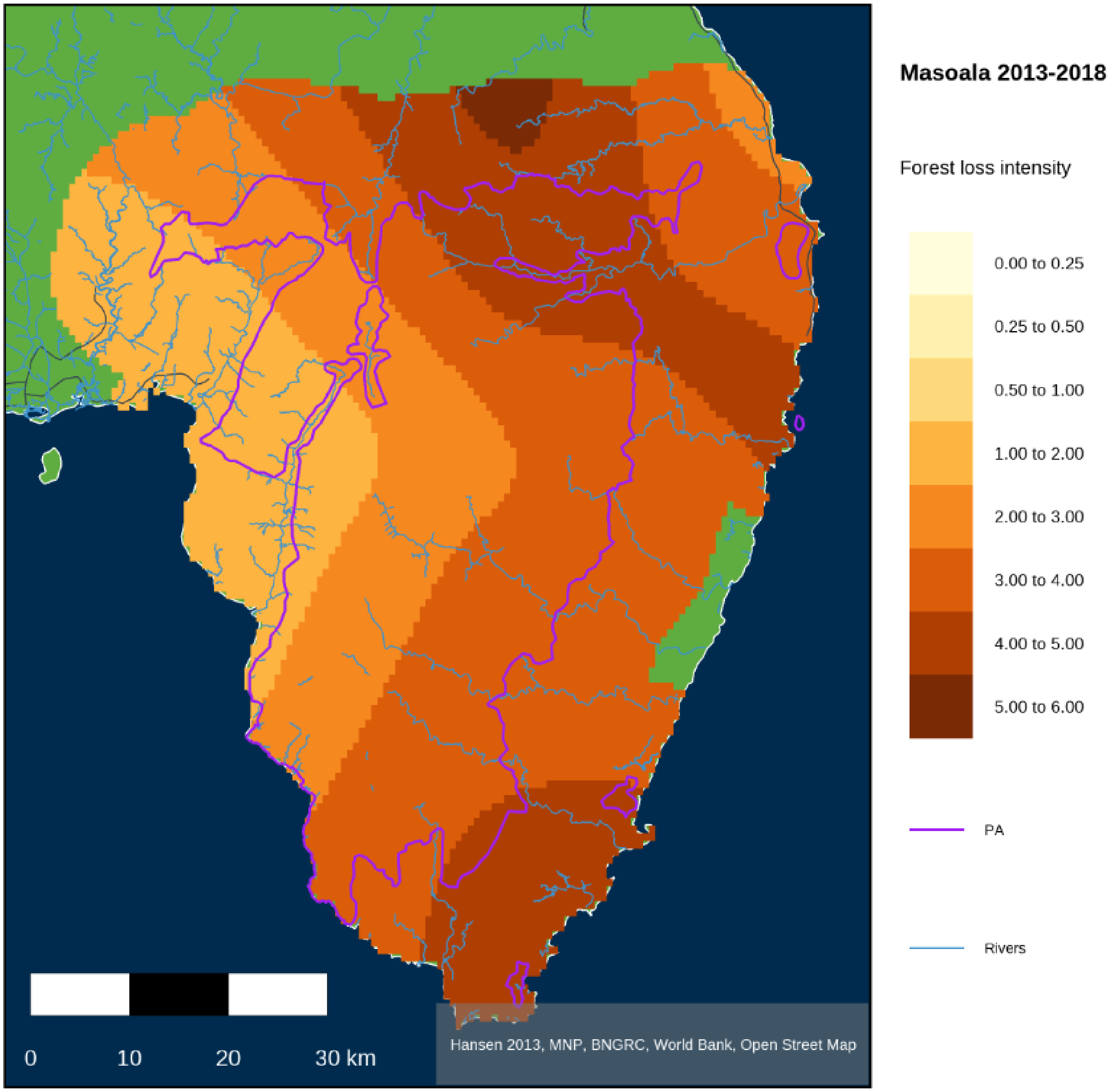

Figure IV-8: Average annual forest loss intensity in and around Menabe-Antimena, 2001-2015

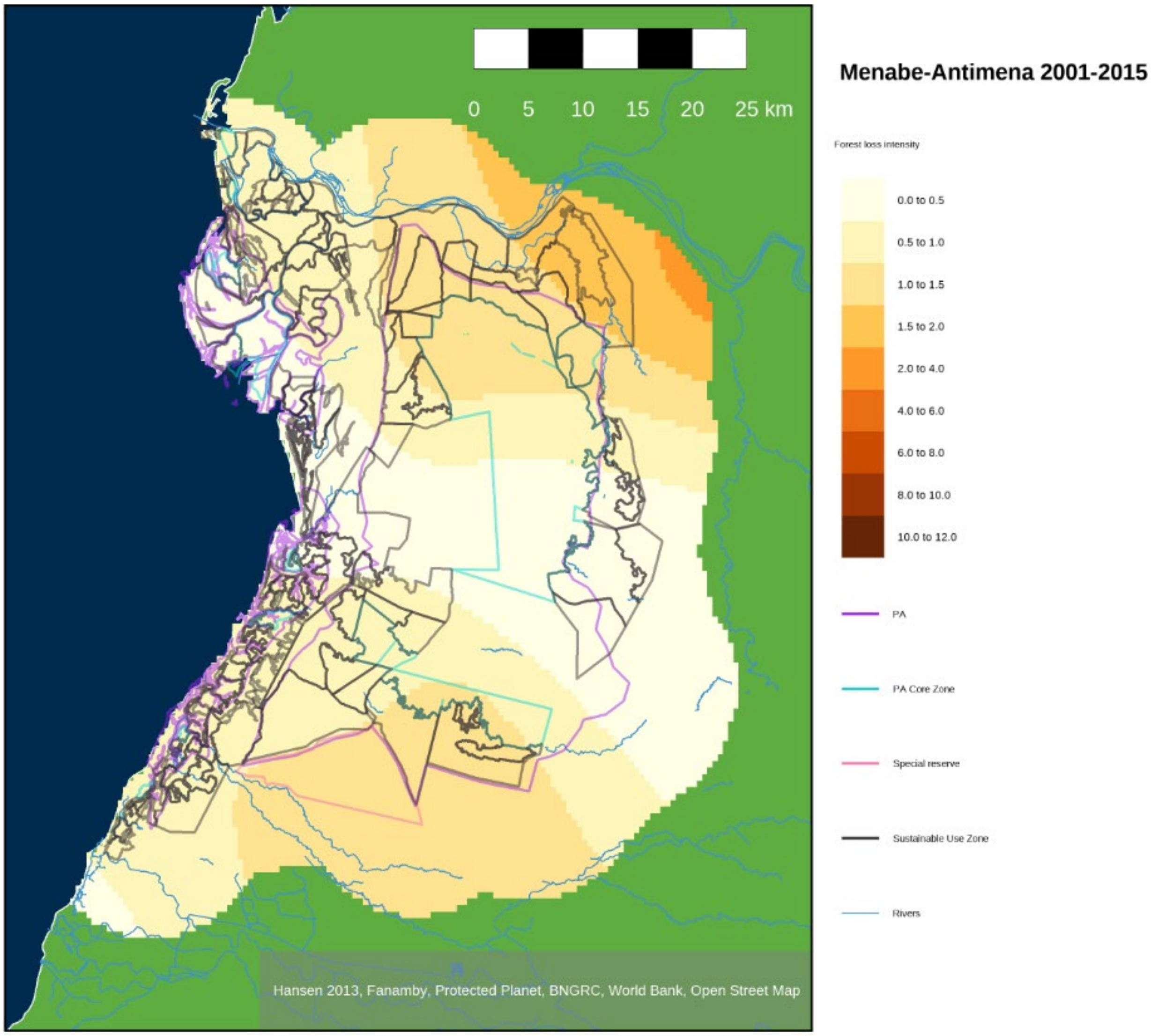

Figure IV-9: Average annual forest loss intensity in and around Menabe-Antimena, 2015-2018