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Disaggregated cost-benefit analysis incorporating ecosystem services and disservices: A case from SAI Sanctuary

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Abstract

Under private management and ownership, privately protected areas provide opportunities for *in situ* environmental conservation. These areas also provide ecosystem services and disservices for various stakeholders, but their impact on various stakeholders has not been comprehensively studied. To evaluate the economic impact of a privately protected area, a disaggregated cost-benefit analysis was conducted on SAI Sanctuary incorporating its ecosystem services and disservices on private, local, and global stakeholders over a 10-year period from 2010 to 2020. SAI Sanctuary is a privately protected area located in southern Kodagu, a district in the Western Ghats forests of Karnataka, India. To valuate costs and benefits, interviews were conducted with private and local stakeholders. A literature review integrating other valuation techniques was performed as well. Discount rates of 0% and 6% were selected, and sensitivity analysis yielded various tradeoffs born by each stakeholder group. Results indicate private stakeholders bear the greatest net costs, and local stakeholders gain the greatest net benefits largely due to pollination, a regulating service valued between $546,210 and $774,810 in the year 2020. Global stakeholders remained the least affected by SAI Sanctuary with net benefits ranging from $27,900 to $39,570 in 2020. Still, the results validate stakeholder predictions that SAI Sanctuary not only sequesters carbon dioxide, it provides a range of ecosystem services while harboring biodiversity and producing natural capital. The results also indicate that environmental conservation occasionally yields unintended tradeoffs with disproportionate costs and benefits. In sum, environmental conservation can have a multiplicity of outcomes, but it is vital to measure these outcomes and bring privately protected areas into strategies for global conservation.

Keywords: Ecosystem services, Western Ghats, disaggregated cost-benefit analysis, environmental conservation, privately protected areas, biodiversity

Author's Note

In the summer of 2015, I had the opportunity to conduct research in the Western Ghats of India through Columbia University's Summer Ecosystem Experiences for Undergraduates (SEE-U) Program. I also collaborated with researchers from the Ashoka Trust for Research in Ecology and the Environment (ATREE), an environmental conservation NGO, to help plan this project. While studying in Bangalore, I was introduced to the concept of ecosystem services and their irreplaceable economic, social, and environmental values in promoting sustainable development. To aid policymakers in fostering good governance and environmentally conscious policies, economists have begun to monetize these services creating implications for local microeconomies and the macroeconomy. Sharing our understanding of the interactions between the economy (as a subset of our environment), and ecosystems can aid individuals and governments in constructing strategies to achieve the sustainable development goals, specifically target 15.9, which calls on countries to integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts by 2020. In the future, I would like to continue researching sustainable development in South Asia along the intersections of development and environmental economics.

1. Introduction

In order to assign values to biodiversity and ecosystem services, environmental economists have used cost-benefit analysis (CBA) to evaluate their importance and impact. "Ecosystem services are the ecosystem functions of value to humans generated as emergent phenomena by the interacting elements of ecosystem structure" (Daly and Farley, 2004). Generally, ecosystem services can be categorized into four main groups: provisioning, supporting, regulating, and cultural services (Millennium Ecosystem Assessment, 2005). Humans utilize these services both directly and indirectly, but there are also option values and non-use values of services that affect ecosystem productivity and future generations (Pagiola et al., 2004). Some examples of these services include fresh water, climate regulation, nutrient cycling, and aesthetic values. The sum of all values of ecosystem services indicates the total economic value (TEV) of the ecosystem (Pagiola et al., 2004).

At the heart of all ecosystem structures is biodiversity. Biodiversity is inherently linked to all elements of ecosystem structure and ecosystem services. This means that biodiversity loss can be considered as both a decline of species and a decline of ecosystems and their services (European Chemical Industry Council, 2013). Ultimately, preserving biodiversity and sustaining ecosystems and their services are closely associated, especially in species-rich areas such as tropical evergreen forests and biodiversity hotspots.

An example of these ecosystems is SAI Sanctuary, a 300-acre privately owned and protected evergreen forest in the Kodagu district of the Western Ghats of India. Since the region is home to more than 325 globally threatened species and moderates "unique biophysical and ecological processes", the Western Ghats are recognized as a UNESCO world heritage site and one of the world's eight "hottest hotspots" of biodiversity (Western Ghats, 2012). Situated between Brahmagiri Wildlife Reserve and Nagarhole National Park, SAI Sanctuary forms a major wildlife corridor that allows organisms to move between both areas of high biodiversity concentration (Ricklefs, 2001). In sum, this area represents a critical eco-sensitive zone where wildlife and humans interact.

SAI Sanctuary, as an ecosystem, provides services in the surrounding areas for various stakeholders; however, the impact of ecosystem services from privately protected areas has not been thoroughly evaluated even though many cost-benefit analyses and ecosystem valuations have been conducted on federally protected areas. Moreover, disservices from ecosystems are hardly ever taken into account in the majority of valuation studies even though ecosystems can incur costs on stakeholders in the forms of wildlife damages, pest damages, and protection costs, among others (Lele and Srinivasan, 2013). Therefore, CBA incorporating ecosystem services and disservices from SAI Sanctuary communicates values and implications of these services to various stakeholders and policymakers.

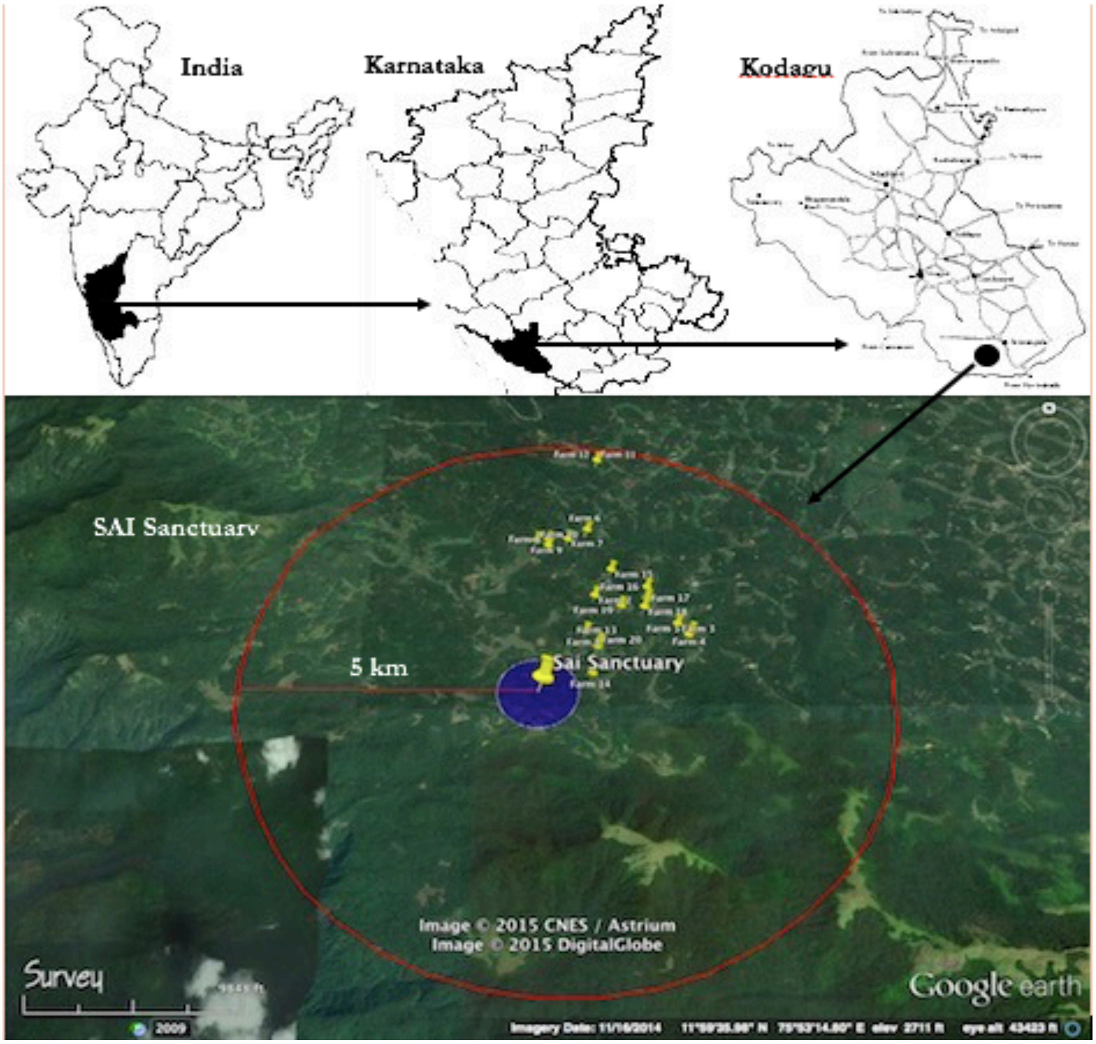
In order to analyze the impact of SAI Sanctuary, I determined the costs and benefits of its ecosystem services incurred on private, local, and global stakeholders over a 10-year period (2010-2020). I also questioned whether there was a relationship between the number of stakeholders at each stakeholder level and cost-benefit ratio. I hypothesized H_0: the amount of stakeholders at each stakeholder level will have no effect on the cost-benefit ratio, and H_1: the cost-benefit ratio will decrease as the amount of stakeholders at each stakeholder level increases (In other words, private stakeholders will have the highest cost-benefit ratio, and global stakeholders will have the lowest cost-benefit ratio). Many of the methods presented in this article are based on a previous study, "Disaggregated economic impact analysis incorporating ecological and social trade-offs and techno-institutional context: A case from the Western Ghats of India" by Lele and Srinivasan (2013).

I begin this article by describing the study site, stakeholders, methods (Section 2), and the results (Section 3). I then discuss the major findings and their implications on various stakeholders, public policy, and future research in the context of privately protected areas and conservation in the Western Ghats (Section 4). Finally, I provide a summary and concluding remarks (Section 5).

2. Methodology

2.1. Study Site

Figure 1: Maps of India, Karnataka, Kodagu (Coorg) District, and SAI Sanctuary with a 5 kilometer radius in red (Karnataka State, 2000; Kodgu District, 2015; Map of Coorg, 2015; Google Earth, 2015)



Note: The yellow pins in the map of SAI Sanctuary (bottom right) represent the various plantations that were evaluated. The blue circle represents the 300-acre plot of SAI Sanctuary. Maps not drawn to scale.

Private landowners purchased SAI Sanctuary in 1991 with the intention of restoring native forests that were previously used for agroforestry. The sanctuary is now managed by SAI Sanctuary Trust, an independently registered nonprofit organization (SAI Sanctuary Trust, 2008). "The sanctuary's rich variety of flora includes hundreds of different indigenous trees and plants—many of medicinal value—as well as numerous rare and threatened species of animals… with over 300 different kinds of birds frequenting its forest canopy" (SAI Sanctuary Trust, 2008). Currently, the sanctuary is undergoing secondary succession and remnant forests dominate the landscape.

Fragmented coffee-agroforestry mosaics characterize the area around SAI Sanctuary. Coffee agro-forests were first established in the 1850s, but since the 1970s there has been a dramatic expansion of these landscapes along with the intensified cultivation of non-native shade trees such as *Grevillea robusta* (silver oak) (Krishnan et al., 2012). Although coffee (Coffeea canephora, the robusta variety) is the main crop grown in Kodgau, pepper, tea, rice, banana, cardamom, and others are also grown usually in agroforestry systems. A 5 kilometer radius from SAI Sanctuary's coordinates (11°59'50.30"N, 75°53'9.48"E) was established as the area that represented local stakeholders that were influenced by SAI Sanctuary's ecosystem services. A total of 20 farms and 213 acres were evaluated representing 4.34% of the surrounding area under forest cover from spatial analysis using Google Earth (Google Earth, 2015).

2.2. Stakeholders

In order to assign disaggregate costs and benefits, the various levels of stakeholders had to be defined. Private stakeholders were defined as the owners and trustees of SAI Sanctuary. Local farmers and their households within a 5 kilometer radius from SAI sanctuary were ascribed as local stakeholders. Global stakeholders were also considered and defined as the total world population. The various stakeholders were assigned costs and benefits in Fig. 2. SAI Sanctuary also affects regional stakeholders downstream, but they were not included in this analysis due to time constraints.

2.3. Valuating Costs and Benefits

2.3.1. Private Stakeholders

In order to valuate costs and benefits of private stakeholders, an interview was conducted with the owners of SAI sanctuary on June 21, 2015. From the interview, the benefits from ecotourism and costs of operation from the past 5 years were determined. Data including the number of tourists per year, revenues from ecotourism, and trends for the future were obtained. The operational costs of SAI Sanctuary were broken into the categories of maintenance costs, protection costs, and labor costs. Opportunity costs were also included in the CBA because the owners could convert SAI Sanctuary and its remnant forests to coffee-agroforests like the majority of other households in the surrounding area. To monetize private stakeholders' opportunity costs, data on local farmers' average profits per acre was extrapolated from Section 2.3.2.

2.3.2. Local Stakeholders

The first step in valuating costs and benefits for local stakeholders was to select households to interview. The area limited to coffee-agroforests was predetermined using Google Earth.

The area north of SAI Sanctuary was chosen for sampling since I did not want to factor ecosystem services from Brahmagiri Wildlife Reserve and Nagarhole National Park into the analysis. The twenty households were randomly selected from dispersed communities that were scattered around roadways encompassing SAI Sanctuary (see Figure 1). The selected farms represented variation in distance from 0.84 km to 4.90 km from SAI Sanctuary with an average distance of 2.53 km. The households also varied in acreage from 2 acres to 40 acres with an average farm size of 10.65 acres. Interviews were conducted with the farmers over a three-day period from June 22-24, 2015.

Data collection was required in order to monetize pollination benefits from native pollinators, which are estimated to produce 8.826 million metric tons of coffee around the world annually (FAOSTAT, 2014). In fact, "pollination by animals is an important ecosystem service because crop plants accounting for 35% of global crop-based food production benefit from animal-mediated pollination" (Klein et al., 2007). Interviews were conducted at the households of the farmers to determine their annual profits from agriculture. A method called benefit transfer was also employed to estimate the production value of native pollinators since the production value of pollinators from SAI Sanctuary has not been evaluated.

The benefit transfer method involves estimating "the values for biodiversity or ecosystem services being transferred from studies carried out elsewhere" (Biological Diversity Advisory Committee (Australia) & Land & Water Australia, 2005). The study selected for benefit transfer was conducted by researchers who determined the status and efficiency of pollinators in a similar fragmented agroforest landscape in northern Kodagu (12°12'0.00"N, 75°48'0.00"E) located 24.3 kilometers northwest of SAI Sanctuary (Krishnan et al., 2012) According to Krishnan et al., native pollinators were responsible for 50% more coffee fruit set than by wind pollination alone in 2012. Moreover, 95.7% of all pollinators observed were bees with *Apis dorsata* (the giant honey bee) making up for 57.37% of all native pollinator fruit set (Krishnan et al., 2012). Bee populations were estimated to be declining annually at 2.5% from 2010-2015, and the rate was predicted to remain constant through 2020 (Setty, 2015). The quantification of pollination benefits could be determined using the proportion of coffee produced by pollinators and comparing it to each farmer's annual profit from coffee sales.

Pest damages and wildlife damages also had to be considered to determine the costs of wildlife disservices. The interview with the farmers included questions pertaining to crop damages from pests and crop damages from wildlife were also incorporated. The forestry department of India operates a compensation scheme that reimburses households for crop damages from wildlife, so the interview also included questions pertaining to compensation. Wildlife was defined as any medium or large-sized animals. The most widely cited were *Elephas maximus* (the Asian elephant) and *Bos gaurus* (the Indian bison/gaur). These disservices make human-wildlife conflict more likely (Distefano, 2005). Driven by India's population growth, land-use transformation, and habitat fragmentation, human-wildlife conflict is increasingly becoming a hazard to many endangered species and creates economic and social costs by undermining "human welfare, health, and safety" (Distefano, 2005).

According to Ninan and Sathyaplan, the intensity of wildlife damages is more severe "near or within forest boundaries" (2005). Accordingly, I wanted to determine if any relationship existed between severity of pest and wildlife damages and distance from SAI Sanctuary. A Garmin eTrex 10 GPS was used to plot farm locations and distances were measured using tools on Google Earth. Simple linear regressions were performed with data from both pest and wildlife damages using JMP Pro 10 statistical software.

2.3.3. Global Stakeholders

Valuating the benefits for global stakeholders included determining the price of carbon sequestration benefits and biodiversity conservation. Zero costs born by global stakeholders could be determined in the study conducted by Lele and Srninivasan (2013). In a similar manner, no costs generated by SAI Sanctuary could be determined for global stakeholders and were subsequently excluded from the valuation.

Table 1: Identified costs, benefits, and stakeholders with assigned ecosystem services

Private Stakeholders	Local Stakeholders	Global Stakeholders
1. (+) Ecotourism: Cultural Service	1. (+) Pollination: Regulating Service	1. (+) Carbon Sequestration: Regulating Service
2. (−) Operational Costs	2. (−) Wildlife Damages	2. (+) Biodiversity Conservation: Supporting Service
3. (−) Costs of Foregone Land Usage	3. (−) Pest Damages	

Note: Benefits are denoted with "+", and costs are denoted with "–". No costs could be determined for global stakeholders.

In order to determine the annual amount of carbon sequestered in SAI Sanctuary, the benefit transfer method (see Section 2.3.2.) was utilized from a global carbon sequestration study that measured annual sequestration rates of tropical forests based on the age of the forest in secondary succession. (Silver, Ostertag, and Lugo, 2000). The following algorithms from the study were used to estimate the amount of aboveground (AGC) and belowground (BGC) carbon sequestered in Mg/ha in SAI Sanctuary for the years 2010-2020 (Silver, Ostertag, and Lugo, 2000):

$$AGC = e^{\ln(0.96 * \text{Forest Age}) + 1.56}$$

$$BGC = e^{0.16 * \ln(\text{Forest Age}) + 3.65}$$

Note: The age of the forest in 2010 was calculated to be 19 assuming the forests in SAI Sanctuary began undergoing succession in 1991.

The values obtained from the amount of carbon sequestered per hectare were converted to annual amount of carbon dioxide sequestered in metric tons (tonnes/megagrams) over the 300-acre study site for 2010-2020. Prices for sequestered carbon dioxide were calculated and predicted based on market values in US\$/tCO_2 from global voluntary and mandatory markets (Diaz, Hamilton, and Johnson, 2011; Goldstein and Gonzales, 2014; Hamrick and Goldstein, 2015; Peters-Stanley, Gonzalez, and Yin, 2013; Peters-Stanley, Hamilton, and Yin, 2012).

To monetize biodiversity conservation, I utilized a meta-analysis study that aggregated the results from previous studies from 1979-2005 that gauged people's willingness to pay for the biodiversity conservation of terrestrial and marine habitats (within national jurisdictions) through the contingent valuation method

(Jacobsen and Hanley, 2008). Contingent valuation method estimates economic values by "ask[ing] people to directly state their willingness to pay (WTP) for specific environmental services, based on a hypothetical scenario" (Daly and Farley, 2004). The study found that people's WTP for biodiversity conservation is linked to income, and on average people are willing to pay 1.1257825% (based l45 WTP responses) of their income for biodiversity conservation (Jacobsen and Hanley, 2008).

Given this percentage, I calculated global stakeholders' WTP for biodiversity conservation by multiplying 1.1257825% by global gross national income (GNI) for the years 2010-2020 using the "GNI, Atlas method (current US$)" dataset (World Bank, 2015). GNI was predicted for the years 2015-2020 using the "Inflation, consumer prices (annual)" dataset (World Bank, 2015).

To determine global stakeholders' WTP for biodiversity conservation solely for SAI Sanctuary, I divided 300 acres by the total number of acres of protected terrestrial and marine area in the years 2010-2020 according to values published by *Protected Planet Report 2014* (Juffe-Bignoli et al., 2014). Multiplying each of these values by global stakeholders' WTP for biodiversity conservation for each year yielded global stakeholders' WTP for biodiversity conservation of SAI Sanctuary.

2.4. Sensitivity Analysis

For sensitivity analysis, a nominal rate of 12%, recommended by the Planning Commission of India, would be equivalent to a real rate between 3% and 6%, given current interest rates and expected inflation in India. Moreover, environmental CBA should consist of lower discount rates than monetary CBA (Lele and Srinivasan, 2013) in order to discount future generations more proportionately to present generations. I selected discount rates of 0% and 6% based on recommendations published in a review by Dasgupta (2008). Additionally, various scenarios were analyzed to account for uncertainty. I calculated the net costs born by private stakeholders without opportunity costs (Scenario 1). I also reevaluated net benefits for local stakeholders with bee populations declining annually at 5% and 0% (Scenario 2). Social costs of carbon dioxide, as determined by the White House Office of Management and Budget, were considered in calculating the net benefits for global stakeholders (Scenario 3) (Interagency Working Group on the Social Cost of Carbon, United States Government, 2015). Sensitivity analysis showed that various results change substantively depending on the modification of independent variables.

3. Results

The estimated changes in present value of the economic costs and benefits are given in Tables 2 and 3. Only the costs and benefits of the individual stakeholder groups are aggregated in accordance with the methods of disaggregated CBA, so economic impact can be analyzed for each stakeholder group. All values discussed will be in 2014 US$. I focus initially on analyzing the impact of ecosystem services and disservices. I then analyze the effects of discount rates of 0% and 6% and the time horizon of 10 years. Finally, I explain the results of sensitivity analysis and the effect of various scenarios proposed in Section 2.4.

3.1. Impact of Ecosystem Services and Disservices on Stakeholders

Of all stakeholder groups, private stakeholders maintain the highest cost-benefit ratio from 2010-2020. The majority of costs incurred result from opportunity costs of foregone land usage. Since coffee plantation owners gain large profit margins, the transferred surplus creates a considerable cost that is born by the owners and trustees of SAI Sanctuary. This cost is decreasing since the profit margin for local stakeholders is thinning (adjusted for inflation) due to bee population declines, stagnant wholesale coffee prices, and rising inflation in India (Office of the Economic Adviser Govt. of India, 2015)

Table 2: Present value of changes in economic costs and benefits of stakeholders with a 0% discount rate over 10 years (2010-2020)

	Private Stakeholders	Local Stakeholders	Global Stakeholders
Ecotourism	+ 6.35 (+ 64%)		
Operational Costs	− 15.90 (0%)		
Costs of Foregone Land Usage	− 143.47 (− 13%)		
Pollination		+ 774.81 (− 28%)	
Wildlife Damages		− 210.32 (0%)	
Pest Damages		− 278.38 (0%)	
Carbon Sequestration			+ 8.33 (− 40%)
Biodiversity Conservation			+ 31.24 (− 1%)

Net Economic Impact	− 153.02 (−14%)	+ 286.11 (− 51%)	+39.57 (− 13%)
Cost-Benefit Ratio	25.10	0.63	<0.0001

Note: Units are thousand US$ in 2014 prices, i.e. 1$ = 61INR (Board of Governors of the Federal Reserve System (US), 2015). The figures that are not in brackets reflect the value added in the year 2020. The figures in brackets reflect percent change from 2010 to 2020. Wildlife Damages are adjusted for compensation.

However, ecotourism benefits are increasing substantively, but the benefits are marginal when compared to net loss. Operational costs are expected to stay constant when adjusted for inflation. The observed percent change in net economic impact remains negative even though there is an increase in benefits and decrease in costs from 2010-2020 since the net economic impact was − $176,940 in 2010 for private stakeholders.

Due to pollinators', and particularly *Apis dorsata's* ability to fertilize between 27% and 35% of coffee flowers, local stakeholders receive the greatest net benefit (Krishnan et al., 2012). Pollination services are estimated to be valued between $546,710 and $774,810. But as expected, local stakeholders bear the highest ecosystem disservices from SAI Sanctuary. Contrasting local stakeholders' assumptions, when compensation was disregarded, pest damages still outweighed wildlife damages by 10%. When wildlife damages and pest damages were correlated with distance from SAI Sanctuary, no relationship could be determined, and linear regression yielded R^2 values of 0.000141 and 0.050234 respectively.

Global stakeholders are least affected by SAI Sanctuary's ecosystem services, and bear no ecosystem disservices. Biodiversity conservation benefits are consistently greater than the benefit from carbon sequestration. Both carbon sequestration and biodiversity conservation benefits decrease from 2010 to 2020. Although young succession forests (like the forests of SAI Sanctuary) sequester greater amounts of carbon dioxide than old-growth forests, sequestration rates still decrease annually since biomass accumulation is assumed to level off over time (Lal and Singh, 2000). Likewise, the market price of carbon remains unstable with prices currently on the decline due to recent unproductive markets predominantly in the European Union's emission trading scheme (World Bank, 2014). Biodiversity conservation benefits declined from 2010 because increasingly more terrestrial lands and marine bodies are becoming protected (Juffe-Bignoli et al., 2014). While the effectiveness of conservation management in these new protected areas can be debated, the globe is on track to meet and even surpass (by 3%) Target 11 of the Convention on Biological Diversity's Aichi

Biodiversity Targets and Sustainable Development Goal 14.3 by 2020, which call for "the effective and equitable management of at least 17% of the world's terrestrial areas and 10% of marine areas" (Juffe-Bignoli et al., 2014; United Nations, General Assembly, 2014).

3.2. Impact of Time Discounting

The use of a real discount rate of 6%, in keeping with the established CBA framework, proved to significantly impact distribution of costs and benefits on all stakeholders (see Table 3). And although absolute values change, there is no significant difference in who are net gainers and losers. This discount rate is inherently biased towards current generations, but may serve as rate revealed by the preferences of current stakeholders based on market conditions in India. Alternatively, the results in Table 2 do not discount future generations and thereby reflect equitable allocation of natural resources and capital to all generations, but this social discount rate is viewed by some economists as misrepresenting society's option values. Even so, the question of appropriately discounting future generations and continuous flows from ecosystems remains to be answered.

Table 3: Present value of changes in economic costs and benefits of stakeholders with a 6% discount rate over 10 years (2010-2020)

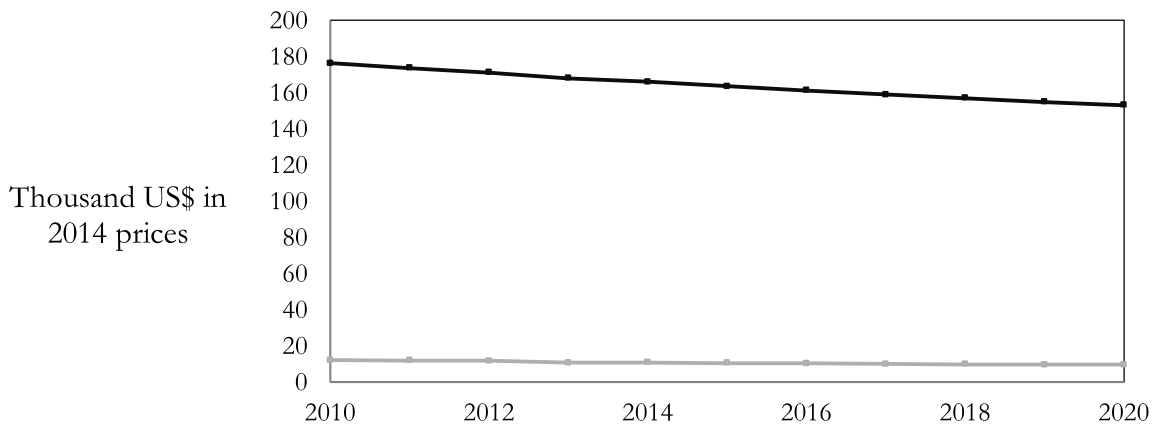
	Private Stakeholders	Local Stakeholders	Global Stakeholders
Ecotourism	+ 4.48 (+ 16%)		
Operational Costs	− 11.21 (− 30%)		
Costs of Foregone Land Usage	− 101.14 (− 38%)		
Pollination		+ 546.21 (− 49%)	
Wildlife Damages		− 148.27 (− 30%)	
Pest Damages		− 196.25 (− 30%)	
Carbon Sequestration			+ 5.88 (− 58%)
Biodiversity Conservation			+ 22.02 (− 30%)
Net Economic Impact	− 107.87 (−39%)	+ 201.69 (− 66%)	+ 27.90 (− 39%)
Cost-Benefit Ratio	25.10	0.63	<0.0001

Note: Units are thousand US$ in 2014 prices, i.e. 1$ = 61INR (Board of Governors of the Federal Reserve System (US), 2015). The figures that are not in brackets reflect the value added in the year 2020. The figures in brackets reflect percent change from 2010 to 2020. Wildlife Damages are adjusted for compensation.

3.3. Impact of Various Scenarios

Further sensitivity analysis revealed net costs decrease when costs of foregone land usage are excluded from analysis for private stakeholders as shown in Figure 2.

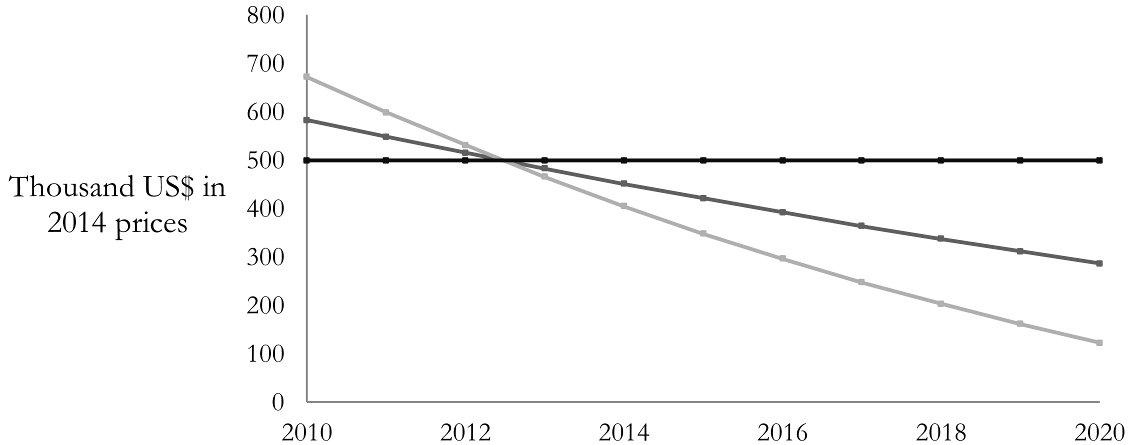
Figure 2: Present value of net costs for private stakeholders with a 0% discount rate from 2010-2020



Note: The light gray line (below) reflects net costs without opportunity costs (Scenario 1).

Since bee populations were only estimated to decrease at 2.5% annually, I designated this rate as the middle ground and chose a higher and lower rate to serve as boundaries for the actual rate of population decline. Sensitivity analysis revealed net benefits over time for local stakeholders when bee populations were estimated to be annually decreasing at 5% and when they were estimated to remain constant as shown in Figure 3.

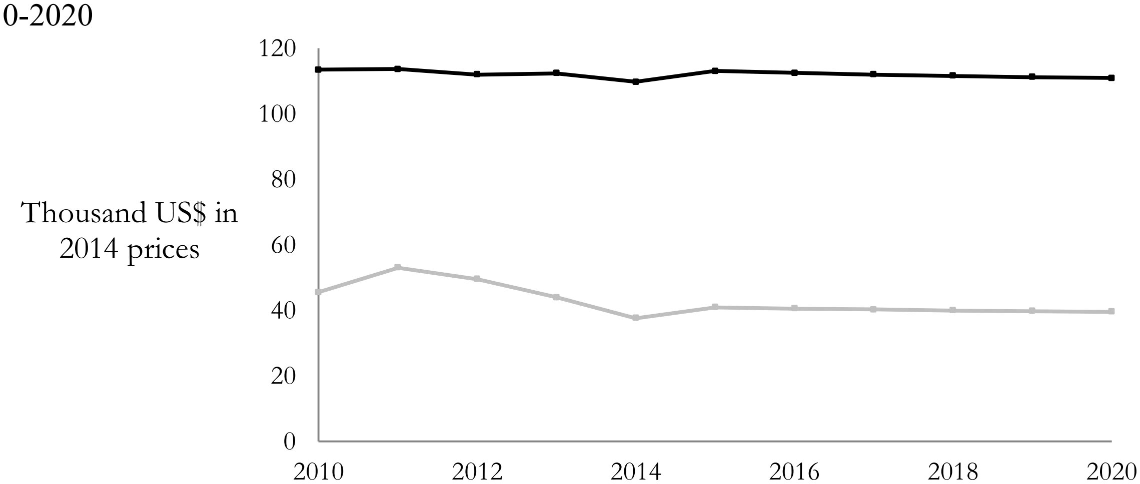
Figure 3: Present value of net benefits for local stakeholders with a 0% discount rate from 2010-2020



Note: The black line reflects net benefits when bee populations remain constant. The medium gray line reflects net benefits when bee populations decline at 2.5% annually, and the light gray line reflects net benefits when bee populations decline at 5% annually (Scenario 2). 2012 was the known base year for bee populations (Krishnan et al., 2012).

The social cost of carbon "is meant to be a comprehensive estimate of climate change damages" (Environmental Protection Agency, United States, 2015). In Figure 4, the social cost of carbon represents a high estimate of the price of carbon, and net benefits are greater when the social cost of carbon is taken into account as shown below.

Figure 4: Present value of net benefits for global stakeholders with a 0% discount rate from 2010-2020



Note: The black line reflects net benefits incorporating the social costs of carbon (Scenario 3). The gray line reflects net benefits incorporating the market prices of carbon.

4. Discussion

4.1. Trade Offs from Environmental Conservation

In the year 2020, private stakeholders are expected to bear net costs between \$107,170 and \$153,020. Reaping large profits from coffee farming would not be difficult even if bee populations decreased drastically due to native tree felling to make room for coffee plants. Although bee populations would likely lose their most suitable habitat, some pollinators will be able to locate to remnant forest mosaics surrounding the sanctuary and wind pollination will still occur (Krishnan et al., 2012; Lele and Srinivasan 2013). Fortunately, the owners and trustees of SAI Sanctuary are not seeking to profit from coffee-agroforestry.

Actually, their ability to persist in maintaining SAI Sanctuary, even while bearing a net loss and minimal benefits from ecotourism, reveals non-monetizable ecosystem services that private stakeholders value from the sanctuary. These could include cultural services such as aesthetic, spiritual, recreational, or even psychological benefits (Millennium Ecosystem Assessment, 2005). Private stakeholders may even gain a personal sense of well-being in knowing that they are safeguarding the transfer of valuable ecosystem services like evapotranspiration and biodiversity conservation to others. Ultimately, private stakeholders choose to maintain SAI Sanctuary even when a more profitable tradeoff is available.

Like private stakeholders, local stakeholders stand to lose and gain from SAI Sanctuary through wildlife and pest damages and pollination benefits. Increasing conservation efforts and sustaining populations in SAI Sanctuary would increase costs and benefits incurred on local stakeholders since bees, pests, elephants, and guar all call SAI Sanctuary home. But as previously stated, wildlife damages and pest damages may be resulting from other ecosystems even though literature suggests otherwise (Ninan and Sathyaplan, 2005). Part of the difficulty in linking wildlife and pest damages with SAI Sanctuary may result from a small sample size or the fact that the landscape consists of a mosaic of contiguous remnant forests that serves as a habitat for some species and a "highway" for species maneuvering the wildlife corridor (Ricklefs, R. E., 2001).

However, pollination benefits would likely outweigh wildlife disservices because of bees' instrumental role in coffee fruit set and, consequently, the profits gained from coffee cultivation (Krishnan et al., 2012). Still, bee populations need to be closely monitored due to local population declines and declines around the world (Setty, 2015; Potts et al., 2010). Higher bee populations from increased conservation efforts would cause a greater net loss born by private stakeholders because opportunity costs of foregone land usage would increase due to higher pollination benefits and larger profit margins in coffee cultivation.

Lastly, global stakeholders can benefit from increased conservation efforts if SAI Sanctuary expanded its 300-acre site to encompass a larger area. Global stakeholders could gain in the long term from increased carbon sequestration benefits. But minimal benefits would only be accrued in the short term from increased biodiversity conservation since the amount of protected areas worldwide is expected to steadily increase through 2020 and beyond (Juffe-Bignoli et al., 2014).

4.2. Importance of Privately Protected Areas

Privately held land is valuable for conservation in providing ecosystem services, regulating resource productivity, and curbing the effects of climate change. For example, in 2015, SAI Sanctuary stored an aggregated 77,404.69477 metric tons of carbon dioxide in total as estimated by Devagiri et al. (2012). Additionally, the net economic impact from its ecosystem services and disservices is estimated between \$274,070 and \$332,030 for 2020. As indicated, SAI Sanctuary not only acts as carbon sink, it provides a range of ecosystem services while harboring biodiversity and producing natural capital.

Privately protected areas like SAI Sanctuary "can be effective in expanding protection into under-represented or where most land is private hands" (Stolton, Redford, and Dudley, 2014). These areas can also link other large publicly protected areas functioning as wildlife corridors and habitats when the surrounding area is fragmented. But unlike publicly protected areas, these areas face different obstacles. Often privately protected areas face problems of increasing management capacity, measuring biodiversity, monitoring ecotourism impacts, acquiring funding, and poaching. Current estimates of the total amount of privately protected areas range in the tens of thousands (Stolton, Redford, and Dudley, 2014). "Millions of hectares of privately owned forest, farmland, grazing lands, and water bodies are vital for broader biodiversity conservation, not only because of their extent but because they can be located in areas in high resource productivity" like biodiversity hotspots (Stolton, Redford, and Dudley, 2014). Ultimately, privately protected areas play an irreplaceable role in conserving biodiversity and provisioning ecosystem services. Acknowledging that environmental conservation can have unintended tradeoffs (see Section 4.1) for various stakeholders, bringing these privately protected areas into the conservation conversation is vital.

4.3. Future Policy and Research Implications

As of 2015, payments for ecosystem services (PES) for carbon credits and biodiversity conservation are already under development and should be implemented in Kodagu. In particular, "[stakeholders] whose livelihoods are largely dependent on the natural forest or biodiversity need to be identified and suitably rewarded [with PES] for protecting or practicing natural farming activities that do not lead to destruction of natural ecosystem" (Devagiri et al., 2012). A revised system of compensation for wildlife disservices is also needed since damages are not fully compensated (35% of those interviewed reported losing more than 50% of their crops to pest and wildlife damages). The current system disincentivizes local stakeholders to conserve biodiversity. Local stakeholders should be instructed about the impact of pollinators, specifically *Apis dorsata* on coffee fruit set. Maintaining stable bee populations is critical for their livelihood.

For future analysis, researchers need to evaluate a larger variety and diversity of privately protected areas and their ecosystem services. By comparing the impact of these areas on different stakeholders, researchers can assemble a framework over time. Additionally, the correlation between wildlife disservices and distance from private forests needs to be evaluated with a much larger sample size and scale in order to assess the notion that these disservices increase with proximity to protected areas. Moreover, an in-depth analysis of appropriate discount rates is necessary in order to valuate ecosystem services flowing from privately protected areas over time. Depending on time, disaggregated CBA can be used to account for additional ecosystem services (reflecting a more accurate TEV) and stakeholders. Certainly, with appropriate discount rates, predictions about future ecosystem services can be carried out for to account for multiple generations.

5. Conclusion

Over time, ecological economists popularized the idea of ecosystem services with the intention of helping decision-makers assign economic values to environmental flows, but ecosystem services were hardly ever viewed as bearing costs or disservices on various stakeholders. One would presume that increased conservation efforts would improve the benefits from ecosystem services across all stakeholders; however, this is not the case in all situations as various stakeholders may face unintended tradeoffs.

Furthermore, disaggregated CBA allows one to distinguish between ecosystem services and disservices and determine the net impact on each group of stakeholders since ecosystems affect different stakeholders disproportionately.

Analyzing the economic impact of SAI Sanctuary has shown the following;

a) That the cost-benefit ratio increases as the amount of stakeholders at each stakeholder level increases, thus affirming my initial hypothesis (H_1) for this study.
b) That private stakeholders bear the greatest net costs (significantly due to costs of foregone land usage), and local stakeholders gain the greatest net benefits (significantly due to pollination).
c) That environmental conservation can occasionally have unintended tradeoffs that come with costs and benefits. Some stakeholders are not beneficiaries.
d) That economic impacts from ecosystem services change significantly with various scenarios, tradeoffs, discount rates, and ecological dynamics of the evaluated system.
e) That privately protected areas should be further researched and incorporated into global conservation strategies.

In short, ecosystem service valuation has left an impactful influence on the way humans understand natural capital and the methods of monetizing ecological flows. Ultimately, a disaggregated CBA of SAI Sanctuary benefits the biologist just as much as the decision-maker in shaping conservation strategies in the Western Ghats since both should be more economically and ecologically informed about various options and tradeoffs.

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