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Article

Challenges of Opportunity Cost Analysis in Planning REDD+: A Honduran Case Study of Social and Cultural Values Associated with Indigenous Forest Uses

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Abstract: The REDD Programme is predicated on the assumption that developed countries will provide sufficient funds to offset opportunity costs associated with avoiding deforestation. The role of non-market values in indigenous land management may challenge the efficacy of compensation schemes targeted at meeting opportunity costs as calculated in traditional opportunity cost analysis (OCA). Furthermore it is unclear how these economic incentives might affect social and cultural values linked to land-use norms, livelihoods, and local governance. This study explores the economic, social and cultural values of forest uses for a Miskito community in the Rio Plátano Biosphere Reserve in Honduras. Data were collected using household surveys, farm visits, and community workshops. OCA indicates potential for successful REDD+ payment schemes; however it is an inadequate method to account for subsistence and cultural opportunity costs associated with avoided deforestation. Compensation to change land-use practices may undermine governance institutions necessary to address deforestation in the region. Our results indicate that small-scale agriculture and other forest-based subsistence activities are important cultural practices for maintaining Miskito identity and forest management institutions. Recommendations are offered for using OCA to develop REDD+ projects that recognize the linkages between social and cultural values and forest management by focusing on approaches that consider a full range of economic, social and cultural opportunity costs.

Keywords: REDD+; opportunity cost; indigenous; subsistence agriculture

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1. Introduction

Emissions from deforestation account for up to 17% of global greenhouse gas emissions, the majority of which come from tropical deforestation [1]. A central focus of international efforts to mitigate climate change within the United Nations Framework Convention on Climate Change (UNFCCC) is the development of a program to Reduce Emissions from Deforestation and Forest Degradation (REDD+) [2]. REDD+ is likely to be structured using Payment for Ecosystem Services (PES) as the principle economic component of the carbon offset mechanism. The PES mechanism has been described as a consumer relationship founded on the principle "that those who provide environmental services should be compensated for doing so and that those who receive the services should pay for their provision" [3]. The PES mechanism proposed for REDD+ is designed to transfer funds from developed countries to pay land managers in developing tropical countries to reduce emissions from deforestation. The most significant portion of REDD+ payments will likely be spent meeting the opportunity costs (OC) associated with deforestation. OC are defined as the foregone, net benefits that would be derived from deforestation, e.g., timber, plus the net benefits of the subsequent alternative land use, e.g., cattle ranching [2]. If REDD+ payments to land users are sufficient to cover the rents derived from alternative land uses, land users seeking to maximize profit would be incentivized to alter their behavior and forego cutting down their forest. Assuming that REDD+ payments are sufficient to meet OC, REDD+ projects could provide long term societal benefits by maintaining forest cover and reducing greenhouse gas emissions [4].

While OC is central to an economic approach to changing land owner behaviors, it is just one component of overall REDD+ design and effectiveness. Creating voluntary agreements with landowners and meeting opportunity cost is contingent upon aligning the REDD+ program with national and local legal, institutional and political frameworks [5].

REDD+ offers a compelling strategy for climate change mitigation because of its potential to quickly reduce carbon emissions at a relatively low cost, while providing compensation for local forest users. Conserving forests under REDD+ projects may also bring additional benefits, including biodiversity, watershed, and soil conservation [6–8]. However, success of market-based REDD+ projects may be limited to regions where land owners are integrated into market-based economies, and where they own land in private property regimes that are protected by accountable and effective governance regimes [9–11].

Engel and Palmer [12] caution that PES, in this case REDD+, may not be a suitable solution for all locations where land management has led to a reduction in ecosystem services. The implementation of PES under unstable or corrupt governance may exacerbate deforestation and create greater social inequity. Geist and Lambing [13] identified agriculture as a proximate driver of deforestation in 96% of cases related to tropical deforestation. In Latin America, much of the agricultural expansion represents cattle ranching and colonist intrusions into low-lying tropical forests [13]. Deforestation, both legal and illegal has been difficult to curb because of underlying institutional factors such as governments' failures to enforce environmental laws, corruption, mismanagement of public lands, insecure land tenure, and relocation policies. Geist and Lambing [13] identified insecure property rights as a proximate driver of deforestation in 44% of the case studies they examined. In Latin America, nearly 60% of deforestation cases were associated with colonization, occurring primarily because of unenforced laws or undefined property rights [13]. Using these assumptions, it can be conservatively estimated that at least half of all REDD+ projects in Latin America will have to address issues of insecure land tenure.

While the REDD+ type programs may bring new sources of funding and resources to address deforestation, concern exists about the potential impacts of placing economic values on carbon in forests occupied by indigenous and forest dependent peoples, particularly for those who do not have secure land tenure over their traditional lands. In these cases REDD+ might pose a new threat to their livelihoods and rights to forest resources [14–17]. The World Resource Institute [14] estimates that 1.6 billion people are dependent upon forests to meet their basic needs, and 350 million of those are indigenous people who are highly dependent upon forests. REDD+ programs therefore need to address or take into account traditional land use practices and subsistence values derived from forest livelihoods [3,9,12,14].

Additional complexities exist when developing PES in common property regimes often associated with indigenous lands and forest-dependent peoples [2,6,15–18]. The conditions required to manage common property include acknowledging, or in many cases providing, full legal control to local users. Additionally, the ability to set and enforce rules, establish boundaries, exclude outside users, and monitor activities are functions which are essential to the effective management of common property [16–18].

While decentralization of forest management and the transfer of legal control to local communities has become increasingly popular in many topical forest regions, a legacy of States' governments ignoring indigenous institutions and rights to land, coupled with increasing migration of outsiders into these regions, has exacerbated a system of open access in many remaining frontier forests. The end result of insecure land tenure and open access forests are high rates of deforestation and the erosion of indigenous institutions that once served to sustainably maintain forest cover [18–20].

In contexts without secure land tenure and weak governance, economic incentives may be of limited efficacy to reduce deforestation and such economic incentive-based interventions will require greater investments in governance activities [21]. Wunder and colleagues [15] observed that start-up costs for establishing a new PES scheme are significant even with relatively low ongoing payments. More generally, the costs of addressing broader governance issues may be prohibitively costly, complex and time consuming. This would also require significantly more funding than OCA might indicate [15,20,21].

In Latin America, numerous studies estimate implementation costs and potential socio-economic and environmental benefits derived from REDD+ projects [10,22–24]. These studies use market-based agricultural rents to calculate OC to make baseline estimates of REDD+ program costs. Several of these studies examined the Amazon where frontier forests are being replaced by industrial soybean and cattle production. Because of variations in land uses, OC has been estimated along a price curve, ranging from \$0.10 to \$12.00 per ton of CO_2 equivalent ($tCO_2eq.$) [10,22–24]. Traditional OC are calculated using market values of foregone land use rents associated with agricultural practices. OC typically considers capital and labor investments, and the sought-after return on those investments. OC has been used to parameterize costs of fund-based and market-based PES programs.

Indigenous and non-indigenous communities alike depend upon forests for much more than income. Limited research has been conducted on how non-market or cultural values can be incorporated into the full range of costs of avoiding deforestation. When OC is applied outside of the context of a capital economy it is unknown how effective a tool it may be for capturing true foregone social benefits of agriculture and forest use [9]. It is also unclear whether targeted payments structured around OC would support or undermine communal forest management.

1.1. Calculating Opportunity Costs for REDD+

Directing financial compensation to land users to adopt alternative land use practices either through the sale of carbon credits in a market system or in a fund base approach demands that the benefits of carbon mitigation be converted into economic values. Opportunity cost analysis (OCA) has become an essential tool to determine the most cost-effective level of payment required for nations, states, communities, and individuals to accept a payment to reduce deforestation. For sellers of REDD+ credits, opportunity costs are expressed as \$/hectare and measure the net economic benefits derived from the most profitable or prevalent land-use-per-area unit of land. OCA is used throughout the literature on REDD+ and REDD+ feasibility reports to determine cost curves [25,26]. Buyers of REDD+ services purchase tons of CO_2 equivalents ($tCO_2eq.$) directly from projects or on carbon markets. Thus per-hectare opportunity costs are often converted to \$/tCO_2eq.

OCA studies indicate that REDD+ can serve as a large-scale and cost-effective means of reducing emissions over the next 20 years [25–29]. Both Kindermann [27] and Pagiola and Bosquet [28], predict that by 2020, up to 30 billion U.S. dollars could be spent on forest carbon offsets generated by REDD+ projects, reducing forest carbon emissions by as much as 50%.

A number of authors acknowledge that OCA does not provide a complete economic picture of a REDD+ project [9,30–32]. OCA does not account for additional project costs, such as implementation and transaction costs [2]. Deveny *et al*. [25] determined that these subsequent costs of REDD+ activities can vary widely from country to country; and in some cases, the additional costs of mitigating project risks may become prohibitively expensive. However, using opportunity costs provides a starting point for estimating the economic viability of REDD+ to effectively change land-use practices. OCA is an important consideration within the larger framework of governance, particularly at the national and international level, where OCA can be used as decision-making tool to compare the costs and opportunities of developing REDD+ projects across regions. OCA provides essential information to determine where and if projects should be developed, assuming secure land tenure. When employed at local levels, OCA has helped to develop payment levels for existing PES programs, such as those in Costa Rica and Ecuador [32,33]. Another important limitation of OCA lies in the difficulty of placing a value on goods, services, and social and cultural values that are difficult to quantify [9,10]. This suite of non-market social values may factor more heavily into decisions to participate in REDD+, particularly if land decisions are not motivated by short-term profits when an individual or community is deciding whether or not to participate in PES [3].

1.2. Research Objectives

The purpose of this study was to assess opportunity cost and the social and cultural values associated with an indigenous community's forest uses in Honduras's Rio Plátano Biosphere Reserve (RPBR). Furthermore we explore how incentive based payments to forego indigenous forest uses may affect societal values and local governance. The research questions we address are as follows:

(1) What are the opportunity costs associated with indigenous land uses?
(2) Are current carbon market prices sufficient to cover these opportunity costs?
(3) What values and uses are not captured in an OCA of indigenous land uses?

Using data collected from household surveys, farm visits, and community workshops we compared the values produced by OCA to subsistence values derived from agriculture and forest products, and other non-economic values associated with indigenous land uses and livelihoods.

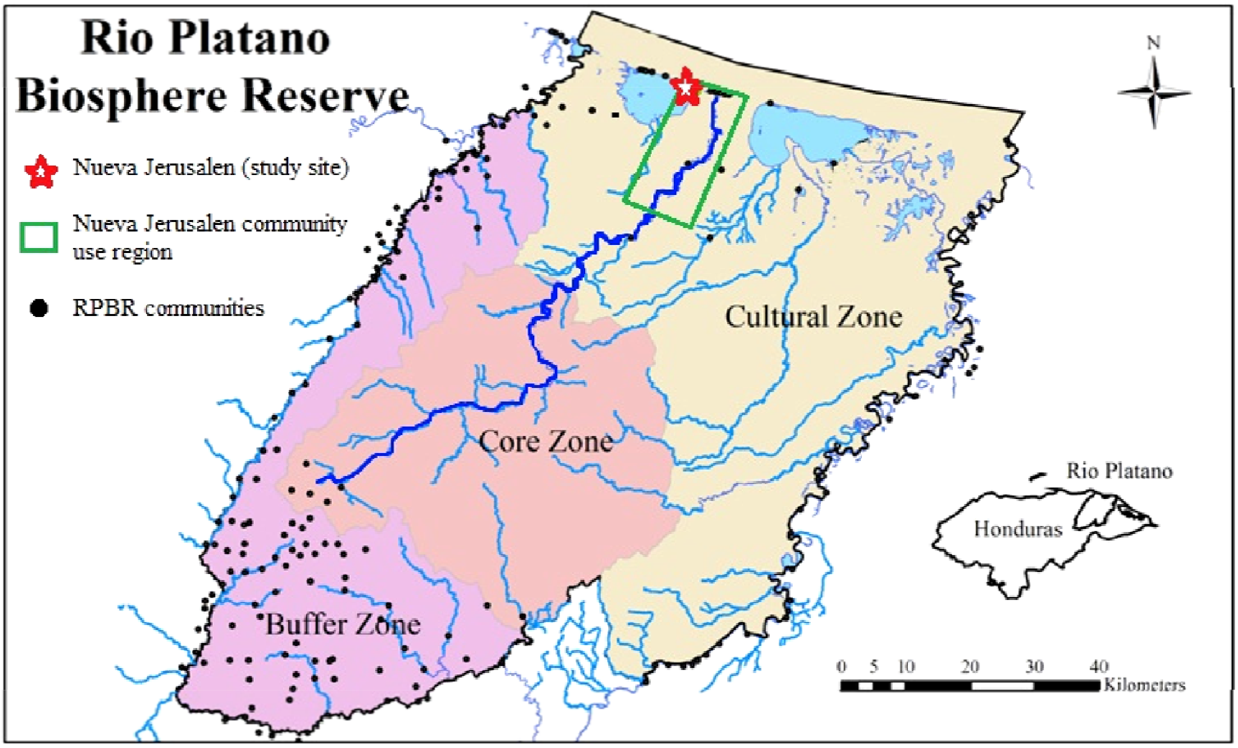
2. Methods

2.1. Case Study Site

The case study site chosen for this research is exemplary of many indigenous common-property systems in Latin America that do not have clear land tenure at the state level and are struggling to maintain local governance institutions that protect their indigenous lands from external colonization [16,18,34]. The RPBR is home to several indigenous groups, none of whom hold full legal rights to their traditional lands. Yet the RPBR region of Honduras may attract REDD+ projects because of the size of the region, extensive forest cover, and high rates of deforestation. Recent research in the region indicates that rates of deforestation have accelerated over the past two decades due to illegal colonization and cattle ranching [34]. Laws which prohibit deforestation and colonist encroachment exist, yet the Honduran Forest Service (ICF) has been unable to enforce them. These factors create the potential for a large number of carbon credits to be generated by avoiding deforestation. However, creating REDD+ projects in the region will be extremely difficult because of the presence of several different user groups, changing governance, and the many interests of international, national, and local actors [34].

Research was conducted in Nueva Jerusalen, Gracias a Dios, Honduras (Figure 1). Nueva Jerusalen is a Miskito community, which is situated between the Caribbean Sea, a freshwater lagoon (Laguna de Ibans), and a major river (Rio Plátano). It also lies within the boundaries of the cultural zone of the RPBR. The RPBR covers an area of 8000 km^2 in the isolated region of northeastern Honduras known as La Moskitia. The La Moskitia biological corridor runs southeast from Honduras into Nicaragua, and is the largest contiguous tract of rainforest remaining in Central America [35]. Most communities in the corridor are inaccessible by road. This limits market access and affects the price of products coming into and flowing out of these communities [34].

Figure 1. Map of the study area within the boundary the Rio Plátano Biosphere Reserve of Gracias A Dios, Honduras.



The RPBR is home to several ethnic groups, including the Miskito, Tawahkas, Pech, Garifunas, and Ladino populations. The Miskito Indians comprise the largest indigenous group in the RPBR, with around 35,000 people in 141 Miskito communities [36].

Most residents depend upon agriculture and fishing as means of subsistence. They also depend on lobster diving for cash income. Other than lobster diving there are few external market-based activities available to the community. In Dodds' [36] study of ecological and social sustainability of the Miskito people of Honduras, he characterizes the Miskito's society as a purchase society that is grounded in subsistence activities but that pursues opportunities for cash income. These opportunities allow residents to purchase limited market goods.

Residents of Nueva Jerusalen maintain farms along the Rio Plátano, and have practiced swidden agriculture along the river corridor for several hundred years. The Miskito swidden agriculture system operates by planting crops like rice and yuca on land which has been most recently cleared of primary forest. After one to two years of production the land is fallowed for an average of five to seven years. After a fallow period land is cleared again and replanted with less nutrient demanding crops like beans corn or inter-cropped with plantains and a variety of fruit trees [36]. By using fallow systems, agro-forestry techniques, and intercropping most Miskito communities are able to meet their subsistence food needs without using fertilizers or expanding the area under cultivation. However, according to Dodds [36], deforestation attributed to indigenous swidden agriculture is on the rise, primarily due to population growth.

Dodds [36] estimates that one half to three quarters of the Miskito diet comes from crops such as bananas, yuca, and plantains. Other crops such as rice, beans, and corn are also important parts of the

Miskito diet, but they serve as cash crops as well, and can be sold in local and regional markets.

In addition to using forest land for agriculture, the Miskito people rely heavily on forests for consumable goods like medicinal plants, firewood and game. They also depend on forests to supply durable goods like roof thatching materials, lumber for constructing houses, and large diameter trees for constructing canoes, their primary means of transportation.

The Miskito people manage their lands through an informal system of communal property norms [34,36]. All land is considered common property, which allows all residents to have equal access and use rights to the land. A principle rule of the Miskito common property system prohibits the selling of land. Cultivated land may be passed down through familial ties, yet ownership remains communal [34]. These rules served to keep extensive tracts of primary forest under the control of Miskito communities. In the last two decades these rules have been challenged by colonists who hold private property norms and ignored the indigenous form of common property management [34]. These pressures and the ensuing social changes and environmental impacts resulting from logging, deforestation for agricultural expansion, poaching, and raiding of archaeological sites prompted international response that brought funding for conservation and new state and international agencies [37].

Rio Plátano Biosphere Reserve

The cultural diversity, ecological significance, and presence of unique archeological sites, and the threats to these resources prompted the RPBR to be designated as a "Man and the Biosphere Reserve" in 1980 and as a United Nations Educational, Scientific and Cultural Organization (UNESCO) "World Heritage Site" in 1982. In 1996, the RPBR was listed as a UNESCO World Heritage Site in Danger due to continued deforestation and colonization pressure. Despite an increase in international support to protect this area, deforestation and colonization persist within the RPBR boundaries [34,36,37]. Hayes [34] identifies two major colonization fronts; one along the western boarder of the cultural zone moving east from the Rio Sico, the other moving northward from the Southeastern bordering the cultural zone.

The cultural zone of the RPBR was designated for use by indigenous peoples who occupied the region when the reserve was created (Figure 1). In 1997, when the Honduran government expanded the boundaries of the RPBR, colonization of the cultural zones was prohibited, but to date, these laws have not been effectively enforced. The lack of state presence and the state's refusal to recognize and title communal indigenous land has created a system of open access [34]. Land use change studies examining deforestation rates between the cultural zone and the non-indigenous inhabited buffer zone indicate significant differences in the impacts of land-use activities between indigenous communities and ladino colonists. Between 1995 and 1999 the cultural zone lost 0.2% of forest cover while the buffer zone lost 10% of forest cover due to deforestation [38]. More recent studies found similar differences but with continuing deforestation in the buffer zone and increasing deforestation within the cultural zone [34,39].

2.2. Data Collection and Analysis

This study used a mixed-method case study approach. Using a household survey instrument, we gathered quantitative information about demographics, land use, agriculture activities, forest product collection and communal land use rules and norms [40]. Two local indigenous assistants administered the surveys to a random sample of 84% of households. The head of household with the nearest approaching birthday was selected to answer survey questions [41]. The survey consisted of 72 questions, which were read to participants in the language of their choice, either Spanish or Miskito. Key survey questions related to land use practices, agricultural production and sales, and forest-product use.

Qualitative data about Miskito swidden agriculture practices and Ladino cattle ranching practices were collected through purposively selected farm visits to gain an in-depth understanding of Miskito swidden agriculture system and ladino ranching practices. Four farms were run by Miskitos and two farms were cattle ranches owned by Ladino residents. Information about the crop selection and production, planting techniques, the size of planting areas, the extent of fallow areas, and the presence or absence of pastureland and head of cattle was collected during each visit. These data were linked back to our survey data to help verify and enrich our findings.

Participatory community workshop and group interviews were conducted after household surveys had been completed [42]. Seventy-two people attended the first workshop and 84 people attended the second session. We used the workshop forum to facilitate open dialogue about community values. Participants were asked to identify, define, discuss, and rank community values that were most important to maintaining autonomy, culture and traditional ways of life. They later used these values to analyze the potential impacts of REDD+ scenarios and payment schemes on those values. We broke the participants into smaller homogenous groups (young males, elder males, young women, elder women) and asked them to brainstorm the values of the community that were important to the Miskito identity.

OCA was calculated at the farm level with $/ha rents were derived by dividing the sum of gross annual returns of production and forest products by the total area used [23,26]. Annual return (AR) is the market value of a crop's gross production. We used a 0% discount rate because the value of agriculture and forest products for end users will not decrease over time, as subsistence values do not vary. We used gross value because capital investments for agriculture practices are minimal. Most agriculture labor is performed by members of the household, without the assistance of wage labor. We used market prices because many of the agricultural products are only sold once, thus the selling price is also the purchase price.

A sample of 143 of 170 households in the Miskito community of Nueva Jerusalen provided data on agricultural production, farm size, crops planted, and annual income from the sale agricultural products as well as forest product collection. We calculated total economic value of all agricultural products by multiplying production in each crop type by its respective market price. We summed the total economic value of all agricultural products and divided it by total number of hectares planted. This provides us an estimate of the Annual Return (AR) per hectare. We averaged agricultural land use, agriculture production, and agricultural income across 141 respondents and applied the averages to the population by multiplying by 170, which is equivalent to the number of households in the community. The same process was used to estimate forest product use and annual value at the household level. Based on interviews, we estimated the total area of land area used by the community when collecting forest products to be approximately 20,000 hectares. We only present results for firewood, dimensional lumber, and canoes because these forest products have a measurable impact on deforestation and forest degradation.

Using Sohngen's [43] data we estimated that one hectare of primary lowland tropical forest contains 300 tCO_2eq. A sensitivity analysis was used to estimate the quantity of avoided emissions because baseline rates of deforestation and rates of tCO2 uptake from secondary forest growth in a swidden agriculture system are unknown. Thus, we provide a range of values, from 100 tCO_2eq to 300 tCO_2eq, for agriculture activities. Assumptions of tCO2eq/ha are much smaller for forest product collection because single trees are being harvested as opposed to entire tracts of land being cleared and burned. With the exception of firewood, a substantial amount of carbon remains in a solid state as building material or as a canoe for 10 or more years. Our estimates for forest product collection losses range from1 tCO2eq/ha to 10 tCO2eq/ha.

2.3. Limitations

We made assumptions about quantities of carbon per hectare and provide high, medium, and low estimates based on literature from other regions of Central America [43]. We were also unable to calculate opportunity costs for cattle ranching operations due to a lack of data. In the Miskito community, the households that pursue these activities are outliers. There were only two ladino households within Nueva Jerusalem at the time of the study.

3. Results

Responses were obtained from a random sample of 143 households, with a response rate of 99%. We only provide responses from Miskito households (n = 141). Two-thirds of respondents were female heads of households. The average household size was seven people, with an average of four children under the age of 18. The median annual household income was $1,560 (in U.S. dollars), and ranged from $135 to $16,130 (n = 64).

3.1. Traditional Agricultural Practices and Deforestation

Nueva Jerusalen's economic activities are similar to other Miskito communities, in that they depend heavily on subsistence agriculture, but they also seek wage-labor opportunities to obtain cash income. Dependence on subsistence agriculture for food staples was substantial, with three-quarters of the households reporting that they have land holdings for agriculture. The median number of hectares managed was 17.5, and a median 1.7 hectares were planted per household. The discrepancy between land managed and land planted may be in part explained by the swidden agriculture system used by Miskito farms.

Surveys and farm visits indicate that the Miskito swidden agriculture system includes six primary crops (Table 1). Swidden agriculture operates on a rotational cycle where primary forest is cleared for planting crops like rice or yuca. After several years of production, the fields fallow for an average of five to seven years, but in some cases as many as twenty years. After fallow, the secondary forest, known as guamile, is slashed and burned for other crops such as beans, bananas, or plantains. These fallow rotations necessitate large land holdings, which can exceed several hundred hectares [36].

Most agricultural products are consumed at the household level and never enter the market. However, some excess production generates cash income, with rice being the most important terms of gross economic income (Table 1). Rice accounts for more than one-third of gross agricultural production and about 20% of the total land area planted. While rice has the greatest income earning potential only 16% of producers sold rice in 2009. A substantial investment of labor is required to clear enough forest to have excess rice to sell, thus limiting the number of farms capable of producing excess rice.

Table 1. Production, area planted, annual returns and cash income from swidden agriculture in Nueva Jerusalen 2009.

Crops	n	# of sellers	Total area planted (Ha) [1]	Production (quintales) [2]	Gross AR [3,4]	Gross income [4]	AR/Ha [4]	Price/ quintale [2,4]
Rice	58	14	46	1,072	$86,457	$9,799	$1,897	$80.7
Beans	74	24	24	248	$33,394	$2,641	$1,393	$134.4
Corn	37	13	22	174	$7,505	$1,011	$351	$43.0
Plantains	25	20	28	451	$7,274	$3,715	$256	$5.4
Bananas	38	32	70	594	$6,697	$3,741	$96	$4.8
Yuca	31	26	33	549	$14,757	$8,817	$442	$27.88
Total/*Average*~	90	53	222	3,088	$156,084	$29,724	*$702*~	–

[1] Ha = Hectares; [2] Quintales = 100 lbs; [3] AR = Annual Return; [4] In US Dollars (Currency converted using August 2010 exchange rate for U.S. Dollars to Honduran Lempiras: USD 1.00 = LMP 18.60).

Approximately 80% of annual crop production contributes to subsistence. The remaining 20% of agricultural production is sold almost exclusively to other members within the community. This may be partly due to the lack of market access, but also demonstrates the community's reliance upon local subsistence agriculture, even by families who do not manage farms.

The prices at which crops could be sold and total return/ha did not appear to determine the amount of land planted in each crop type (Figure 2). The clearest example is that bananas are planted across the largest area of land even though they have the lowest market value (Table 1). Beans, which have the highest market value, were planted across the second fewest number of hectares. Farm visits also indicated that land-use decisions at the household level about which crops to plant were influenced more by cultural food preferences, crop success, biophysical conditions, labor intensity, and crop rotation systems and food safety than local market prices and annual returns of crop types.

Agricultural practices revealed a preference for planting rice, plantains, and yuca on land that was converted from primary forest while beans were primarily planted in guamile (Figure 3). Land recently cleared of primary forest was considered to be more productive and required less weeding, a condition necessary for rice production, but incurs greater loss of carbon when cleared. Guamile encompasses land in any stage of secondary forest; it therefore has less carbon stored in above ground carbon stocks, and presumably less nutrients. Guamile is commonly used to plant banana and bean crops [36]. Approximately 60% of the land planted in 2009 was cut from primary forest cover. These considerations are important for accurately accounting for carbon losses from swidden agriculture practices.

Figure 2. Relationship between price per unit of agricultural product and area planted (n = 90).

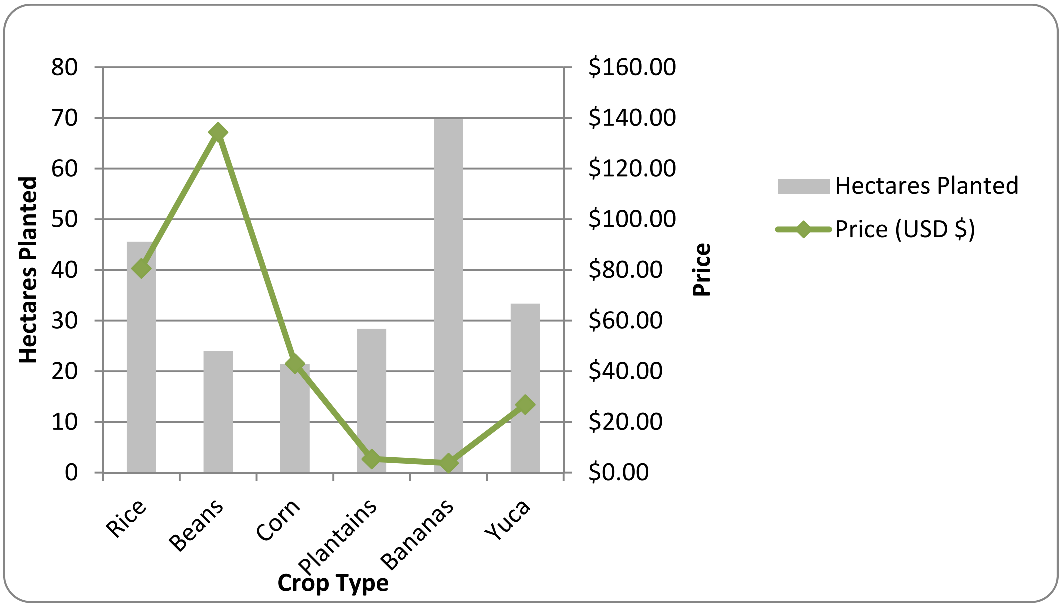
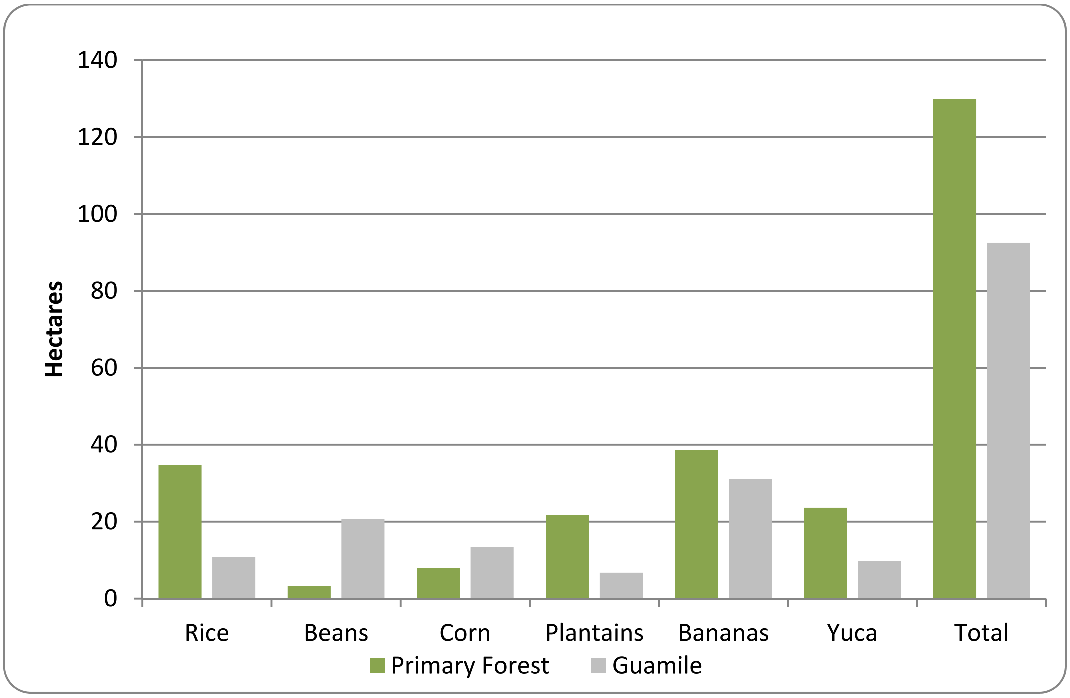


Figure 3. Area of subsistence crops planted by type of land cover cleared (n = 90).



In addition to agricultural products, forest products represent an important part of Miskito subsistence living and cultural practices. Economic values were calculated for three of the most important forest products used in the community (Table 2). Firewood is a daily necessity for cooking and is used by more than 90% of households. The AR value of $157/household is likely a low estimate in terms of opportunity cost because substituting firewood with fossil fuel replacements, such as kerosene or propane, would cost significantly more than the current market value of firewood.

Table 2. Estimates of annual returns from forest product collection in Nueva Jerusalen.

Forest products	n	Units	Value/unit (USD)	Quantity/time	Gross AR [1]	AR [1]/ user household
Firewood	131	Bundles	$0.43	1 bundle /day	$20,566	$157
Lumber	104	Board feet (bf)	$0.48	2500 bf /20 yrs	$12,339	$132
Canoes	43	Canoes	$520	1 canoe/20 yrs	$2,073	$49

[1] AR = Annual Return.

Durable products like canoes and lumber have a lower AR value than firewood, but they have significantly larger upfront costs. They would have even more substantial replacement costs. Canoes and lumber are usually not paid for in full through a cash exchange. Bartering and trades in services (*Pana Pana*) are a common means for soliciting assistance for felling, transporting, and processing trees. Although these costs are not negligible, they represent a fraction of the cost of substituting imported products for locally sourced products.

3.2. Opportunity Cost Assessment

Opportunity cost analysis based on the land area used for agriculture and forest product collection demonstrates that REDD+ payments that meet OC would nearly double current median income levels (Table 3). At the community level, the payment required to offset all agricultural activities was $187,149/year. At the household level, the OC payment necessary to prevent deforestation from all agricultural activities was $1,485/year/household.

Table 3. OCA for subsistence activities in Nueva Jerusalen.

Activity	Ha [1]	AR [2]	OC/Ha [3]	Estimated community Ha	Estimated annual household OC	Estimated annual community OC	Estimated OC over 20 yrs.
Agricultural production	222	$156,084	$702	267	$1,485	$187,149	$3,742,976
Wood-based forest products	20,000	$34,977	$2	20,000	$278	$43,376	$867,524

[1]Ha = Hectares; [2]AR = Annual Return; [3]OC based on average annual return per hectare.

OCA based on a price per tCO2eq is presented in Table 4. Estimates for emissions avoided by stopping deforestation associated with agriculture and forest product collection range from 26,670 to 80,010 tCO2eq. Estimates for avoided emissions from agriculture ranged from 100 to 300 tCO2eq. This range of values was used to take into account the removal of forests and the quantity of carbon sequestration over the next 20 years. The rate of carbon sequestration was unknown, and it will vary depending on subsequent land uses and rates of forest regeneration [38]. Emissions avoided translates into an OC ranging from $2.34 to $7.02 per tCO2eq for agricultural activities.

Forest product use was associated with lower values of tCO2 emissions, between 1 and 10 tCO2/ha, because removal of woody materials involves selective tree harvesting rather than clearing and burning large forest patches. However, the area over which those losses would occur was nearly two orders of magnitude larger. Under these assumptions, avoided emissions are estimated to range from 20,000 to 200,000 tCO2eq and OC values from $0.22/tCO2eq to $2.17/tCO2eq. The large area over which these assumptions are applied amplifies the variability of these estimates to more than 180,000 tCO2eq over the first 20 years of a REDD+ project.

Table 4. OCA of avoided tCO2eq. from subsistence activities.

	Assumed emissions tCO2eq/ha [1]		
Agriculture	100 tCO2eq/Ha	200 tCO2eq/Ha	300 tCO2eq/Ha
Avoided tCO2	26,670	53,340	80,010
$/tCO2 eq [2]	$7.02	$3.51	$2.34
Forest-Product Use	1 tCO2eq/Ha	5 tCO2eq/Ha	10 tCO2eq/Ha
Total Avoided TCO2	20,000	100,000	200,000
$/TCO2 eq [2]	$2.17	$0.43	$0.22

[1] Three values of tCO2eq/ha are assigned to provide a range of values to account for uncertainties (e.g., forest regrowth) associated with agriculture and forest-product contribution to offsetting carbon emissions; [2] Avoided tCO2eq = Avoided emissions multiplied by the estimated number of hectares used by the community for each type of subsistence activity.

3.3. Social and Cultural Values

During community workshops, participants generated and ranked a list of community values. The community’s values reflect their reliance upon traditional land-use practices, the social and cultural importance of these practices, and the institutions necessary for their sustained management (Table 5). Of the seven top ranked values, six related to social and cultural land uses norms, rules, and practices. For example, sustainable use of forests represents a suite of subsistence activities including agriculture, traditional medicines, hunting, and the cultural knowledge and practices that support and perpetuate strong relationships between forest use, cultural survival and cultural identity. Highly related to these activities was the cultural norm of *Pana Pana* or social reciprocity, necessary to use and manage forests. The prohibition on selling land represents a cultural norm supportive of forest uses and governs who can use land and for what purposes. Agricultural practices represent the cultural knowledge and agricultural production embedded in the practice of swidden agriculture. These links between community values, active forest uses and governance issues highlight the importance of cultural practices tied to food production, customs and rituals.

The presence of lobster diving as the most important community value for young men is a clear signal that there is a need for cash income. However, market-based values were not central to the set of community values that participants identified and wished to perpetuate.

Community members also recognize the centrality of their land use practices to cultural autonomy, livelihoods and overall welfare. The survey question, “What are the long-term consequences of selling your land?” serves as a proxy for understanding respondent’s outlook on a future where they might be displaced by colonists or REDD+ incentive payments and thus unable to practice traditional agriculture. Ranked responses included: (1) losing their livelihood; (2) levels of poverty would increase; and (3) forced integration into cash economy and the need to purchase everything. These responses demonstrate the value of cultural autonomy gained from practicing traditional land uses.

Table 5. Ranking of community values by community groups.

Community Groups	Rank of community values		
	1st	**2nd**	**3rd**
Male Elders	Sustainable use of forests	Agriculture practices (*Milpa*)	Community labor trade (*Pana Pana*)
Female Elders	Sustainable use of forests	Traditional medicines	Miskito foods, customs, rituals
Young Males	Lobster diving	Community labor trade (*Pana Pana*)	Miskito foods, customs, rituals
Young Females	Not selling land	Miskito foods, customs, rituals	Agriculture practices (*Milpa*)

4. Discussion

4.1. Beyond OCA

OCA used in this study indicates that the OC required for slowing deforestation from subsistence agriculture ranges from \$2 to \$7/tCO2 eq. and even less for other forest uses. These prices appear to be in line with OC in other Latin American countries [10,22]. They are also within the range of voluntary carbon market prices, before verification and transaction costs, and could provide an economic justification for the development of a REDD+ project. However OCA does not capture the complex relationships between indigenous land uses, perpetuation of cultural practices and protection of community values linked to these land uses. In fact compensation based on OC and the foregone engagement in these land use practices may undermine the very institutions and livelihoods that have maintained these forests over time.

OC may also be an inadequate measure of the value of swidden agricultural products because the majority of production from Miskito farms never enters markets. Research by Dodds [36] showed that Miskito people depend upon bananas as a staple food because it is a highly productive and reliable crop. Our results show that even though bananas have the lowest selling price and generate the smallest amount of revenue, they occupy the greatest proportion of land cultivated by Miskito farmers. Dodds also demonstrated that decisions about what crops to plant had more to do with cultural food preferences and food security [36]. These findings contradict the assumption that all people are motivated by maximizing short-term profits and the assumption implicit in OCA that the seller will always choose to pursue the opportunity with the greatest economic benefit.

While economics may contribute to farmers' decisions about agricultural land use, no evidence suggests that it is the most important factor. OCA may be appropriate for setting prices in places like the Amazon, where most deforestation leads to the production of high value industrial agricultural products such as soy and beef that are easily distributed into regional markets [44]. However, in indigenous subsistence systems the full value of agricultural products and land use is not captured in their market prices.

Our results related to social and cultural values suggest that displacing indigenous subsistence forest activities with REDD+ payments may have significant cultural consequences and potential implications for local forest governance. Most community values center around cultural land-use practices that support cultural integrity. From a cultural perspective, if participating in REDD+ means giving up livelihoods, land-use norms and cultural traditions, it may not be very different than selling their land to colonists. Under either circumstance, Miskito people could be compensated with what equates to the net present value of the opportunity cost of the land. Accepting payments will likely force sellers to seek new livelihoods that are likely located outside of the community.

Displacing subsistence activities with cash payments poses a high, if not certain, risk that “leakage” of these activities will occur. These culturally rooted subsistence practices fulfill basic needs that must be met. REDD+ projects could encourage the community to integrate further into a cash economies and regional markets and move away from the land use practices that promote and reinforce cultural autonomy, local governance institutions, cultural practices, identity and ultimately maintain large regions of primary forest. Such a rapid transition is not likely to produce positive social and ecological outcomes [9]. Due to their remote location, this community is a price taker in the regional market. Consequently the community is already subject to high prices for basic goods due to transportation costs. They also face significant risks associated with commodity price instability and long-term priceincreases and seasonal availability of basic goods such as food, cooking fuel, and construction materials. There is no guarantee that fixed cash payments for avoided deforestation would be sufficient to smooth these price and availability risks [9]. Discrepancies between current OC and future prices for basic goods could produce severe negative impacts on the poor and could undermine the autonomy and livelihood strategies that have historically sustained this community.

Additionally the economic replacement values used in OCA fail to capture the cultural and social importance of cultural autonomy, land-use norms and traditional livelihoods. The ranked list of norms generated by the community illustrates the linkage between forest based subsistence, the cultural knowledge required to be successful at subsistence living, the agricultural and forest harvesting practices which support the norms that foster cooperation, and the institutions that govern forest management in order to ensure continued communal access. Performance based payments to reduce emissions would likely lead to the community abandoning subsistence agriculture, thus eroding the foundational cultural practices which uphold their systems of norms, governance, and identity. No replacement cost exists for these cultural intangibles.

The practices of subsistence swidden agriculture and forest product collection support historic land use norms that have resulted in low levels of deforestation within this study area. Changing these subsistence practices has the potential to create a negative ecological response. The extensive forest cover is partly attributable to the indigenous institutions and governance which have served to limit and manage users. This has not only decreased pressure on forests, but also ensured that users generally follow that same sets of rules that encourage the use of swidden agriculture cycles, discourage extensive clearing, and maintain primary forests [34,36]. As can be seen in the comparison of deforestation rates between the cultural zone and the buffer zone, land managed by indigenous groups may be more likely to maintain forest cover and thus protect carbon stocks.

Opportunities may exist to mitigate the negative consequences of providing payments to reduce deforestation surrounding this community. Approximately 60% of agricultural land was cleared from primary forest and a small percentage of this land produces crops that are sold for cash income. Payments based on OC and targeted at users to forgo the relatively small amount of cash crop production might represent one approach to slow indigenous deforestation without provoking social and cultural changes.

4.2. Slowing Deforestation by Improving Institutions

Previous studies in this region demonstrate subsistence agriculture is not the primary driver of deforestation in La Mosquitia [34,45]. Cattle ranching practices of ladino colonists have been the proximate drivers of the majority of forest clearing in the buffer zone and increasingly within the Cultural Zone of the RPBR [34,38,39]. Insecure land tenure, changing governance regimes, and weakening local institutions are the underlying drivers which have encouraged or failed to prevent land expropriation and illegal deforestation [34].

This case study highlights that in the context of weak governance and insecure land tenure, broader investments are necessary beyond targeted payments based on OC. It supports the assertions of numerous authors who conclude that in this context REDD+ projects aimed at reducing deforestation through performance payments will require substantial upfront investments to align national policy to compliment rather than undermine REDD+, and to strengthen local institutions capable of managing local REDD+ projects, improving local governance and titling lands. [6,10–12,46]. These circumstances extend well beyond the RPBR region. Well over two-thirds of the world's deforestation occurs in regions that need this type of support before they are ready to participate in performance-based REDD+ projects [13,47].

Such concerns call into question whether REDD+ projects should rely on OC to estimate project costs and appropriate payment levels for indigenous territories where indigenous rates of deforestation are relatively low. Project costs should include building the capacity to prevent outside users from expropriating and converting indigenous lands to cattle ranching. This requires settling outstanding uncertainties regarding land tenure, improving institutional capacity, the creation of new rules, the establishment of boundaries, the removal of colonists on indigenous lands, equitable benefit distribution, and monitoring and enforcement. Providing support for local institutions and land-use practices, while requiring accountability of these institutions, can build legitimate institutions capable of conservation efforts that also provide positive social outcomes [16–20,47,48].

Based on this research, we offer several suggestions for more holistic approach to establishing REDD+ projects and appropriate uses of OCA in subsistence contexts. Although these recommendations are specific to the situation in the RPBR, they may be considered for other regions that share similar conditions. We make the following four recommendations:

(1) Focus the use of OCA on both the market and non-market values of indigenous forest uses with an explicit recognition that that social and cultural values derived from subsistence land use practices are integrally linked to local forest governance. A participatory approach to OC would help to identify potential long-term costs of foregoing traditional forms of subsistence agriculture and land-use practices in exchange for compensation and would serve as a valuable component of a Free Prior Informed Consent process [19,47].

(2) When developing REDD+ projects in indigenous territories, examine what land uses produce for-profit carbon emissions and those land uses that produce cultural carbon emissions. For-profit carbon emissions transacted in a market economy might be appropriately targeted by performance payment schemes and adequately accounted for using OCA. Cultural carbon emissions likely have high levels of non-market local benefits not included in economic incentives. Communities characterized as cultural carbon emitters may be candidates for

funding activities that strengthen local institutions and broader governance arrangements necessary to maintain these forests. These activities might include securing community land rights and investing in enforcement actions [47,48].

(3) Focus direct compensation mechanisms on foregone for-profit carbon emissions and in a participatory manner explore alternative indirect incentives with indigenous community members that could improve land management practices and reduce emissions. Participatory planning could help determine potential indirect benefits such as provision of agricultural technical assistance, health care, education, or micro-finance [19].

(4) Consistent with agreements and strategies articulated in the Cancun Agreements [49], our findings related to OC, social and cultural values, and linkages to governance warrant a similar approach in indigenous territories with initial efforts focused on building or strengthening institutional capacity and providing non-conditional REDD finance as a cautious progression towards the development of REDD+ performance payments [16–18,20].

5. Conclusions

The use of OCA in REDD+ project planning and design establishes the OC necessary to compensate land-users for foregoing deforestation, but it assumes that land users focus on maximizing short-term profit. As we demonstrate here, not all land use change behavior is economically driven and not all land use values can easily be calculated in monetary terms. Marginalizing the social, cultural and governance values of subsistence practices through compensation payments has the potential to undermine the culturally rooted forms of communal forest management that have historically maintained primary forests. In the context of this case study and the local institutional challenges for REDD+, a purely economic approach to REDD+ is likely to be ineffective as it will not address the primary drivers of deforestation.

OCA can assist in clarifying different economic and non-economic values associated with land use practices. However an alternative approach would include OC in conjunction with social and cultural information gathered through participatory community assessments. Moving beyond considerations of economic efficiency and equity, we suggest that REDD+ project developers engage communities in examining the following questions: (1) what are the short and long-term cultural impacts of interventions to avoid deforestation and related emissions on long-term sustainability of forest governance? And (2) how are short- and long-term governance impacted by changing cultural practice/norms to avoid deforestation? REDD+ approaches that seek to incorporate and support these diverse economic, social and cultural values and their linkages to local governance have the potential to effectively address REDD+ objectives while generating positive social, cultural, and ecological outcomes.

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Conflict of Interest

The authors declare no conflicts of interest.

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