Hindawi Publishing Corporation
International Journal of Forestry Research
Volume 2014, Article ID 920964, 12 pages
http://dx.doi.org/10.1155/2014/920964

Research Article

The Cost of Managing Forest Carbon under REDD+ Initiatives: A Case of Kolo Hills Forests in Kondoa District, Dodoma, Tanzania

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Received 7 February 2014; Revised 15 July 2014; Accepted 15 July 2014; Published 20 August 2014

Academic Editor: Sunil Nautiyal

Countries considering participating in a REDD+ mechanism need information on what it would cost them to reduce emissions from deforestation and forest degradation. This study was conducted to estimate the cost of managing forest carbon under REDD+ initiatives in Kolo Hills Forest, Kondoa, Tanzania. Socioeconomic and biophysical information was collected through structured questionnaires, focus group discussions, and forest inventory, respectively. Results show that the community participated in managing the forest by undertaking a range of activities such as tree planting, patrolling, and fire protection. The estimated total cost was USD 418,349.38 while the average cost was USD 79.06/ha. The average carbon stored was 19.75 tC ha^{-1}, which is equivalent to 72.48 tCO_2 ha^{-1}. Costs incurred by managing the forest in relation to tCO_2 stored were USD 1.0485 tCO_2 $e^{-1}ha^{-1}$. The project was found to be economically feasible at 5%, 10%, 15%, and 20% discount rates with NPVs of USD 107,102,331.83, USD 33,986,255.86, USD 10,312,945, and USD 1,245,905.11, respectively. The internal rate of return was 21.21% which is much higher than the World Bank rate of 15.8% and the Tanzania rate of 14.8%. We therefore conclude that the decision to undertake this REDD+ project was worthwhile and should be favoured against the "do nothing" alternative.

1. Introduction

Forests are the largest terrestrial reservoir for atmospheric carbon dioxide [1]. Tropical forests, for example, were estimated to store more than 320 billion tons of carbon [2]. Tanzania has about 33.4 million hectares of forests and woodlands [3]. Out of this total area, almost two thirds consist of woodlands on unreserved land, which lack proper management [4]. A forest resource on the unreserved land is under enormous pressure, from expansion of agricultural activities, livestock grazing, fires, and other human activities. About 13 million hectares of the total forest areas in Tanzania have been gazetted as forest reserves of which 1.6 million ha is under natural forests for water catchment and 80,000 ha are under industrial forest plantation [4]. In the tropical region where also Tanzania lies, deforestation and forest degradation have been occurring on a large scale, playing a critical role in the carbon cycle, with implications for climate and biological diversity [5]. Deforestation is the conversion of forested areas to nonforest land use such as arable land, urban use, logged area, or wasteland [6]. Deforestation can result from deliberate removal of forest cover for agriculture or urban development, or it can be an unintentional consequence of uncontrolled grazing (which can prevent the natural regeneration of young trees). The combined effect of grazing and fires can be a major cause of deforestation in dry areas. Degradation on the other hand involves reduced forest quality, density and structure of the trees, the ecological services supplying the biomass of plants and animals, the species diversity, and the genetic diversity.

Globally, CO_2 emissions from deforestation and other land use changes were 0.9 ± 0.5 GtC on average during 2003–2012, accounting for about 8% of all emissions from human activity (fossil fuel, cement, and land use change) [7]. Reducing forest loss is therefore of utmost importance for climate change mitigation, and this is reflected in the commitment to include reduced emissions from deforestation and forest degradation plus sustainable forest management, enhancement of carbon stock, and conservation (REDD+) in the post-2012 agreements of the United Nation Framework Convention on Climate Change [8].

In Tanzania, forest deforestation and degradation rates are higher around 403,000 ha annually equivalent to 1.16% of the forest estate; hence the country is an important source of greenhouse gases (GHGs) emissions [3, 9]. REDD+ is a concept that has been gaining momentum in climate change policy negotiations at both the international and national levels. Hence a number of government funds have been established to support REDD+ activities, such as the Australian Forest and Climate Initiative, the German Climate Protection Program, and the Norwegian government's fund. Also a number of developing countries announced initiatives to address emissions from deforestation and degradation. At the same time, conservation organizations, project developers, and governments were beginning to implement voluntary market-based REDD+ pilot activities on the ground in developing countries. Currently, sixteen (16) countries including Tanzania were receiving funding for piloting the REDD+ under the UN-REDD program. The program's policy board approved a total of US$59.3 million for national programmes in these 16 partner countries. These funds help to support the development and implementation of national REDD+ strategies in the respective countries [10]. Also there were 28 UN-REDD program countries not receiving direct support to national programmes but engage with the program in a number of ways, including observers to the program's policy board, and through participation in regional workshops and knowledge sharing, facilitated by the program's interactive online workspace [10].

In Tanzania there are eight (8) REDD+ pilot projects being implemented in different ecosystems by nongovernmental organizations (NGOs) in collaboration with central, local government, academic institutions, and private sectors in implementing the projects [11]. Among those projects was advancing REDD+ in Kolo Hills Forest (ARKFor) under African Wildlife Foundation (AWF) [11]. The potential of REDD+ pilot projects as part of a post-2012 climate change regime remains uncertain, in part, due to lack of detailed information on the likely costs associated with forest carbon projects and REDD+ programmes in particular [12].

Angelsen et al. [13] argue that there is no doubt that REDD+ payments can do many activities that lead to deforestation and degradation less attractive. However, countries considering participating in a REDD+ mechanism need information on what it would cost them to reduce emissions from deforestation and forest degradation [14]. Therefore, as Tanzania prepares to embark on REDD+, it needs information on the future costs and benefits of these programmes. This is because it will remain difficult to develop REDD+ policy for initiating future REDD+ activities without empirical evidences of the costs and benefits of deforestation and degradation and the avoidance of such activities. Meanwhile, several studies, for example, Wertz-Kanounnikoff [15] and Lubowski [16], have developed some economic models and estimated several costs associated to REDD+ at global level. The costs include the opportunity costs, the transaction costs, and the management costs, among others. But according to Pagiola and Bosquets [14] these estimates provide very little guidance in this regard; as in addition to the inevitable crude approximations that must be made in any such large-scale exercise, conditions within any given country (such as Tanzania) will differ substantially from any international and indeed any non-Annex 1 country conditions. Also, Wertz-Kanounnikoff [15] argued that information on the transaction costs of REDD+ schemes remains limited.

This study was delimited in identifying and estimating transaction costs associated with establishment and implementing of advancing REDD+ in Kolo Hill pilot project. Understanding and minimizing the transaction costs are critical for reducing tropical forest losses [17]. The results will help in identifying costs per specific areas in the course of implementing REDD+ project and will help in assessing the economic viability of the project. This due to the fact that more attention to transaction costs would benefit the institutional design of a new global program intended to combat tropical deforestation in developing countries and provide information on how emission reductions might potentially be able to "sell" to a REDD+ mechanism at a given price. It will also serve as a source of information to policy makers and planners for initiating cost-effective future REDD+ activities. Therefore, the aim of this study was to identify and estimate the transaction cost associated in managing forest carbon under REDD+ initiatives at Kolo hills forests. Specifically, it was based on identifying routine and nonroutine activities in establishing and running the project. Thereafter, we estimated their associated transaction costs incurred in setting up and running the project. Finally, we estimated carbon stock in Kolo Hill forest under REDD+ project.

2. Material and Methods

2.1. Location of the Study Area. This study was conducted in Mnenia forest a part of the ARKFor pilot project commonly known as Isabe and Salanga forest reserve and the surrounding village of Mnenia in Kondoa district (Figure 1). The Mnenia forest, in which the study conducted, composed of five (5) hills, namely, Singe, Chemchemi, Kwachondo, Resthouse, and Malawi. The forest is located 30 km east-south of Kondoa district. The Kolo hills forest is estimated to be 18,000 ha. The village and the forest are located in Kondoa district, Dodoma, at S $4^{\circ}54'983''$ and E $35^{\circ}47'937''$. Therefore, the average altitude of an area ranges from 1650 to 2000 M above sea level.

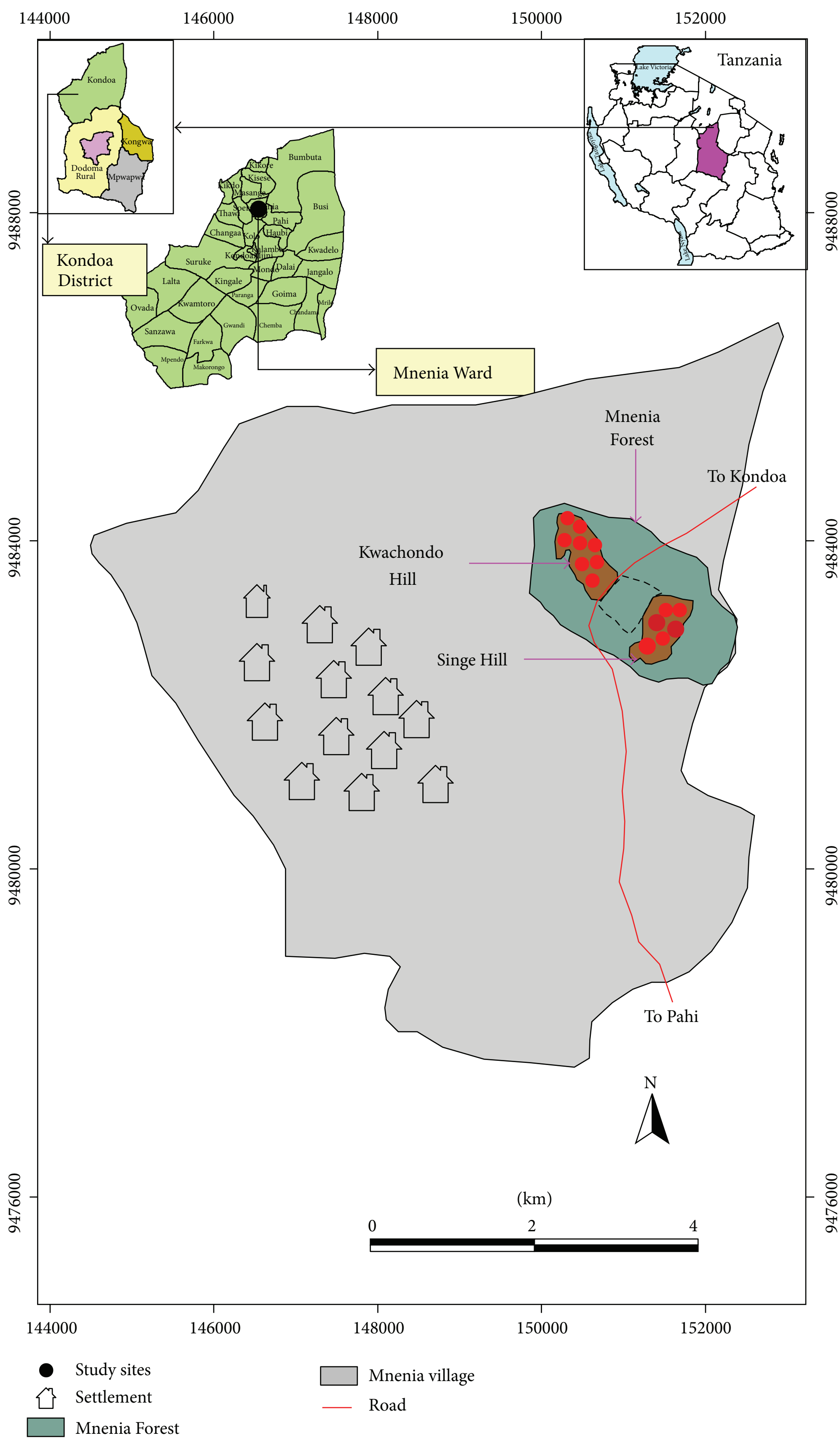

Figure 1: Map of Kondoa district showing the study area.

2.2. Sampling Procedures

2.2.1. Sampling for Socioeconomic Survey. The sampling unit of the study was households. However in this study a household is defined as a group of people who eat in a common pot and usually share a dwelling house and may cultivate the same land (Poate and Daplyn, 1988 as cited by [18]). The Mnenia village was selected purposefully based on the accessibility, potentiality, and proximity to the forest reserve. Further, it was under the REDD+ pilot project and sampled by the CCIAM-SUA project. The households were obtained from the village registers. Moreover the respondents were selected by matching their numbers in the register with the first three numbers in the table of random numbers. Therefore, five percent (5%) of households in the village was sampled randomly resulting into 35 households. According to Boyd et al. [19], a recommended and reasonable representative sample size of particular populations under the study should be at least 5%. Further, other people were selected purposefully: village chairman, members of village natural resource committees, and project coordinator of advancing REDD+ in Kolo Hills forest (ARKHFor) at Kondoa; this is because we are better informed about the specific costs of managing the forest under REDD+ initiative.

2.2.2. Sampling for Biophysical Survey. Forest inventory was conducted in Mnenia forest which is part of the Kolo Hill forest reserve. This part of the forest falls under five hills that are Singe, Chemchemi, Kwachondo, Rest-house, and Malawi which covers an area of 5,500 ha. However, the aim of selecting this portion of the project was based on limited time and resources to cover the whole project area of 18000 ha during forest inventory. The information obtained from the forest was extrapolated to cover the whole area due to the fact that the ARKFor project covers the same ecosystem. The Mnenia forest was under joint forest management strategy introduced by the project in the area; hence information on forest carbon stock in relation to the cost accrued by stakeholders assumed to be similar in other forest blocks of the project. Consequently in order to cover the whole area of the forest, systematic sampling design was adopted. The number of sample plots was determined using the following formula: $N = (\mathrm{TA} * \mathrm{Si}/\mathrm{Ps} * 100)$, where N is the number of sample plots, TA is the total area of the forest, Si is the sampling intensity, and Ps is the plot size. In addition to that the sampling intensity of 0.05% was adopted, a total of 39 circular plots (0.07 ha) was laid out on 8 transects. Further, the distance and distribution of plots between transects were 250 m and 200 m between plots. Furthermore, GPS was used to locate and mark each plot during the inventory. Therefore, this is because the data obtained can be used in ground-truthing (remote sensing) and develop location mapping of the forest.

2.3. Data Collection. A cross-sectional design was employed in this study. However, the design allows collection of information at one point in time [20]. In addition to that, it involves two sets of data that are socioeconomic (identification of activities and transaction cost estimation) and carbon stock estimation. Consequently, in order to obtain all information required for the study both primary and secondary data were collected. Hence, the study was conducted in three phases. In phase one reconnaissance survey was conducted to provide a general picture of the research area through a rapid assessment. Nonetheless, during this survey the study village was selected, the questionnaires were pretested, the forest for inventory activities was identified, and training to field team was done. Further, for phase two the collection of socioeconomic information in the selected village was done. Lastly in phase three the collection of the vegetation information on the identified forest was done.

2.3.1. Primary Data

(1) Socioeconomic Data. A Socioeconomic survey using a structured questionnaire was conducted to collect information with regard to socioeconomic aspects of the communities surrounding the Mnenia forest. This involved solicit routine, nonroutine activities conducted by stakeholders, and cost accrued in managing the forest. However, among all of the data collected were time and resources used by local people in the REDD+ project set-up and costs involved in institutional basis for making REDD+ (cost for defining land rights and establishing new village committees and costs of start-up information program, e.g., number of meeting and people involved). Subsequently, conservation institutions such as AWF and district forest office were also contacted for additional information. Therefore, the socioeconomic information was collected through structured questionnaires (open and close ended). Further, focus group discussion and participant observation were used in collecting data. According to Kajembe [18] as cited by Haule [21] focus on group discussion and participant observation were used in order to triangulate information given through questionnaires, to cross check respondent's answers, and to obtain information that may not be covered by the questionnaire.

(2) Forest Carbon Stock Data. Forest inventory was conducted as to collect information on biophysical data of the Mnenia forest. However circular sample plots with 2 m, 5 m, 10 m, and 15 m radius were adopted during the study because they are easy to lay out and counting errors during inventory of border trees are minimised. URT [22] reported that the edge effect is reduced in circular plots as compared to other plot shapes. A circular plot when subdivided ensures that small trees are measured in small plots and large trees (which constitute most of the biomass per unit area) are measured in large plots and therefore normality of forests can be measured. The tropical natural forests are characterized by having negative exponential diameter distribution such that there are several small size trees and the number of trees decreases with increasing tree sizes [22]. During the inventory the plots were located systematically running from the forest border with the first starting point selected randomly. In addition to that the plots were measured using a measuring tape and all plot coordinates of each transect were Geo-referenced using a

GPS and the direction of the transect line determined using compass to allow transect to be relocated in the future. In each plot along the transect line the data recorded were diameter at breast height (DBH) of all trees with DBH greater than 5 cm. A tree was defined as any standing woody plant with a straight stem of at least 3 m and with a diameter greater than 5 cm and below 4 cm was counted as regenerates. In addition to that species names (vernacular and botanical) of all measured trees were recorded in each plot. Further local people assisted in identifying the tree species in local names and translated into botanical names using a checklist and literatures.

2.3.2. Secondary Data Collection. There was one category of data collected during the research as the secondary information. This information was on cost categories in socioeconomic data. However secondary data included other research findings and experience from different case studies related to the transaction cost analysis and carbon stock estimation. Hence data on transaction cost category were collected from pilot project coordinating office in Kondoa and AWF headquarter in Arusha by using existing annual reports and relevant records for two years (January, 2010 to December, 2011). Further, data were obtained from different publications, journals, and visiting websites to form an overview and identify information gaps.

2.4. Data Processing and Analysis

2.4.1. Socioeconomic Data. Data from the questionnaires was analysed using the SPSS computer program. The data that were analysed were household characteristics such as age, sex, and occupation of the respondents. The collected data was first coded into meaningful computer language to assist in the analysis. Hence, the analysis which included the determination of descriptive statistics (such as central tendency and dispersion of responses) was summarised and presented as percentage, means, and frequency tables. Data on routine and nonroutine activities of the local community were listed, coded, and analysed through multiple response domain and presented in frequency tables. In addition to that, data on cost (resources) from the local level and reports for ARKFor project were listed, coded, and analysed using Microsoft Excel spreadsheet to generate information on the total cost accrued by the local community and an NGO (AWF). It was assumed that paying per day for local community was equivalent to \$3.3 when an exchange rate of \$1 was equal to 1500Tsh that depends on the prevailing average farm labours in the study site.

2.4.2. Above Ground Forest Carbon Stock of ARKFor Project. Data collected from the forest was analysed using the Microsoft Excel spreadsheet so as to obtain above ground carbon stock in terms of tons of biomass and carbon per hectare. A locally available allometric equation developed by Chamsahama et al. [23] used to estimate forest biomass because the equation used to estimate carbon in Miombo woodland. The allometric equation that was used was Biomass $= 0.0625D^{2.553}$, where biomass is tree biomass (kg/ha) and D is tree diameter at breast height (cm). Therefore, the use of local allometric equations for areas with similar vegetation type is recommended in the literature [24]. In addition to that the allometric equation has R^2 of 0.97 making it reliable for the estimation of biomass. Further this equation includes trees from 1 cm diameter at breast height (dbh) and it has the advantage of requiring only Dbh as a variable. Furthermore, forest average biomasses were obtained by dividing the obtained biomass per plot by area (ha) of each cycle: biomass (kg/ha) is biomass (kg)/area (ha). Then, the average above ground biomass (AGB) values across all measured plots was calculated using the following formulae: AGB $= \sum_{\mathrm{pl}=1}^{p}(\mathrm{Bpl})/\mathrm{Npl}$, where Bpl is the total biomass of all plots and Npl is the total number of plots in the study forest. In addition to that the average biomass per hectare (Kg/ha) obtained was converted to carbon using a biomass-carbon ratio of 0.49 [25, 26]. It involves multiplying average biomass estimated to be obtained from hectare by 0.49 to obtain carbon stock per ha (Kg/ha). Therefore the average carbon stock estimated to be obtained per hectare was converted into tonne per ha by the following formulae: $\mathrm{tC} = \mathrm{C(kg/ha)}/1000\,\mathrm{Kg}$, where tC is the tonne of carbon and C (Kg/ha) is the carbon (Kg) per hectare. Lastly, the cost per tonne of carbon dioxide stored per ha in the forest was obtained by using the following formula: Cost per tonne of $CO_2 = \mathrm{ATC}/\mathrm{t}CO_2$, where ATC is the average total cost and $\mathrm{At}CO_2$ is the average total carbon stored in the forest. It was assumed that the average conversion factor of 3.66 is equal to $1\mathrm{t}CO_2$ stored in the forest.

2.4.3. Cost Benefit Analysis (CBA). CBA is the most widely used approach in project appraising and it was the one used in Mnenia forest project a part of the ARKFor pilot project. The aim of doing CBA in this study was to determine whether managing Mnenia forest was economically profitable by using Net Present Value (NPV) as a decision criterion. The formula we used for NPV was:

$$\mathrm{NPV} = \sum_{t=1}^{n} \frac{Bt - Ct}{(1+r)^t}, \qquad (1)$$

where NPV is Net Present Value, Bt is project benefit in year t, Ct is project costs in year t, r is Discount rate, and n is number of years in the planning horizon. According to this criterion, an investment is profitable only if the NPV is greater than zero. In this evaluation two alternatives were considered: with project alternative and without project alternative, the latter being the do nothing alternative. According to Kessy et al. [27] with such mutually exclusive alternatives NPV is the best criterion compared to internal rate of return and benefit/cost ratio because the last two criteria may be misleading as they do not show the monetary magnitude of the return.

(1) Costs, Benefit, and Emission Baseline Components. The costs considered in this analysis were based on the amount incurred by stakeholders and projection in setting up and running the project for 40 years. Further other costs were based on estimated amount of carbon credit emitted by considering the baseline deformation rate of 0.46% for the forest (Table 4). According to the feasibility study done by

CAMCO [28], the historical annual deforestation for Kolo hills forest is estimated to be 0.46%. They assumed that future rates of deforestation will remain constant after implementing the project. Therefore, it was assumed that under a baseline (business as usual) scenario, annual deforestation would be 0.46% based on forest area of 5500 ha; that is, 25 hectares of closed forest was deforested (to bush) per year. For the purposes of the baseline emissions assessment we have assumed a decrease in carbon stocks of 30% from opened to closed forest. The benefit component considered included the estimated value that was assumed will be obtained through trading projected carbon credit stored in the forest. The projections were based on reducing deforestation and forest degradation to 50% of baseline levels during years 1–5 and achieving 100% reduction between years 6–40, that is, completely preventing deforestation and forest degradation. Further we assumed that the community incentive should be 50% of the benefit obtained in trading the carbon. The analysis considered the estimated project life span of 40 years and the average sequestration rate of 5.3 $tCO_2\ ha^{-1}\ yr^{-1}$ as reported by Zahabu [29]. The market price considered in this study was based on the verified carbon standards (VCS) for "Voluntary" of \$8.5 tCO_2e (Diaz et al., 2011).

(2) Discounting Rate. The discount rates of 5%, 10%, 15%, 20%, 21.21231441%, and 25% were used in the analysis. Through this method internal rate of return (IRR) was estimated. The World Bank recommends a 15.8% [30] discount rate in project evaluation for development projects with external funding whereas the Bank of Tanzania charges an interest of about 14.8% [31] for long term lending including investment in forestry and carbon projects. A switching value approach was used to perform sensitivity analysis. Sensitivity analysis is a procedure that analyses how changes of particular input values (such as income or value of investment), resulting from inappropriate prediction or any other reason, influence certain criteria values and the total investment project evaluation [32]. According to Kessy et al. [27] it is also designed to find out how much should project elements change in a negative way before the project meets the minimum level of acceptability as indicated by at least one of the identified measures of project worth. Decision makers have the responsibility to find out how likely they felt that such a change was possible in the project.

The objective of this analysis was to find out by what proportion the benefits would have to be reduced before the NPV could fall to zero and eventually becomes negative. Uncertainties associated with the project that could contribute to the reduction of the benefits included

(i) change in wage rate and administrative costs;

(ii) change in the market price of carbon;

(iii) shortage of labour;

(iv) unwilling of the community to participate in the project;

(v) increase in factors influencing deforestation in the project area,

where the sequestration rate of the forest does not conform with the stipulated assumptions identified for this project.

3. Results

3.1. Activities and Costs Incurred by Community in Managing Kolo Hills Forest. The findings showed that various activities were identified to be conducted in the area. It showed that the community attended various activities in managing the forest (Table 1). Further, we found the total amount of costs incurred by community adjacent of the forest in managing the forest by considering the identified routine and nonroutine activities were US\$35,667.63 (Table 1). It was estimated by considering prevailing average of farm labours in the study site that the pay per day was equivalent to US\$3.3 when an exchange rate of US\$1 was equal to 1500Tsh. The estimated amount accrued in forest patrolling was US\$ 17,382.62. The activity of forest patrolling observed to be the main activities in the area performed by community adjacent of the forest such as charcoal making and livestock keeping prevention.

3.2. Cost Incurred by the ARKFor Pilot Project in Managing the Forest. Results showed that the costs were incurred by ARKFor in managing the forest divided into two categories that were set up and running costs. Setting cost was divided into two categories that were costs according to function and actors in the project that was estimated to be US\$407,391 (Table 2). The second category was setting up the project according to paying personnel and purchasing assets of the project that estimated to be US\$149,954 (Table 1). Meanwhile, the total costs incurred in running the project were divided into two categories. A first category was according to function and actors in the project that estimated to be US\$524,405. The second category was running of the project according to paying personnel and purchasing assets estimated to be US\$ 143,663 (Table 2).

In addition to that the actual total cost accrued by the project in setting up and running the ARKFor project in Kondoa from January, 2010 to December, 2011, was US\$1,252,413 spent by AWF in managing the forest covers of the whole area of the ARKFor pilot project estimated to be 18,000 ha. Meanwhile as the Mnenia forest (part of the ARKFor project) covers estimated areas of 5500 ha then the cost estimated to manage the forest was \$382,681.75. However, the findings (Table 2) showed that the estimated total cost accrued by the community surrounding the Mnenia forest in managing the forest was US\$35,667.63. Therefore, the total cost assumed to be accrued by stakeholders (AWF and Mnenia community) was estimated to be \$41,349.38 in managing the Mnenia forest. For that reason, the average estimated cost incurred in managing the Mnenia forest on a hectare basis by stakeholders (AWF and local community) was US\$76.06/ha. As a result this amount of US\$76.06/ha shows what it will cost AWF as an organization administering REDD+ and community adjacent of the forest to achieve the desired reduction in deforestation and emissions at the Mnenia forest on per hectare basis.

Table 1: Activities and their associated cost incurred by community in managing the ARKFor pilot project.

Routine and nonroutine activities	Frequency	Estimated days and costs			
		Per day ($US)	Number of days per month	Number of days per year	Costs ($US)
Routine activities					
Tree planting	29	3.33*	—	1	96.57
Forest patrolling	29	3.33*	15	180	17,382.60
Forest boundary making	25	3.33*	—	1	83.25
Land use planning	21	3.33*	—	5	349.65
Attending seminar	25	3.33*	—	5	416.25
Selected as a focal farmer	12	3.33*	5	60	2397.60
Making server stoves	12	3.33*	5	60	2397.60
Conducting beekeeping activities	14	3.33*	15	210	9790.20
Nonroutine activities					
Attending the village meeting	31	3.33*	—	2	206.46
Forest fire protection	26	3.33*	—	15	1298.70
Demarcating forest boundary	22	3.33*	—	1	73.26
Preventing keeping and livestock in the forest	25	3.33*	—	15	1248.75
Total					**35,667.63**

Source: field data.
*Pay per day was equivalent to $3.3 when an exchange rate of $1 was equal to 1500Tsh that depends on the prevailing average farm labours in the study site.

3.3. Above Ground Forest Carbon Stock, Costs per Tonne of CO_2, and Profitability of the Pilot Project. The results showed that the estimated forest carbon stock of the forest was 19.75 tC ha^{-1}. Findings showed that distribution of forest parameters (biomass and carbon) by DBH class portrays a normal "*J*"-shaped trend as expected for natural forest (Figure 2). The trees with small DBH have low biomass and carbon stock content while trees with higher BDH have high amount of biomass and carbon stock.

Further we found that the average tone of carbon dioxide (tCO_2) stored in the forest was 72.48 $tCO_2e\ ha^{-1}$.

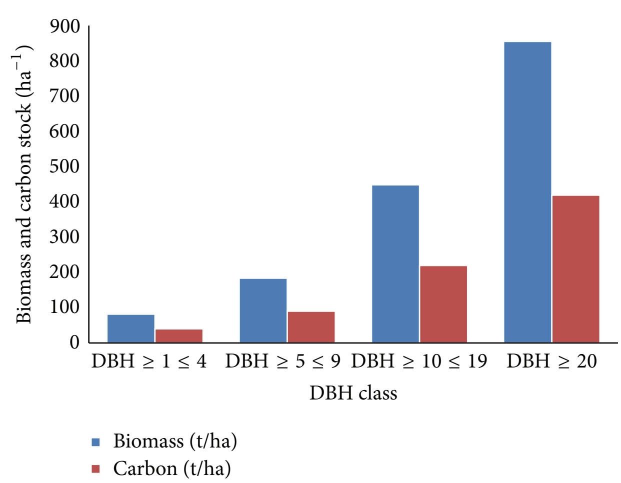

Figure 2: Above ground biomass and carbon stock distribution in Mnenia forests, Kolo Hills, Kondoa.

3.4. Discounting and Internal Rate of Return. The results (Table 3) indicate that even when the discount rate is as high as 21.21% the project is still economically efficient. However the magnitude of NPV decreases by 68.27%, with the increase in discount rate from 5% to 10% and again the magnitude of benefits decreases by about 96.33% with the increase in discount rate from 10% to 20%. For a lower discount rate the present value of future benefits is high compared to the situation when higher discount rates are used. The project internal rate of return (IRR) was about 21.21% which means that if the project is to recover its investment and operating expenses in forty years time and still breakeven, then the maximum interest that the project can pay for the resources used is about 21.21%. The IRR is higher than the World bank rate of 15.8% [30] and the Bank of Tanzania rate of 14.8% [31] implying that the project is profitable. However, in the analysis we did not consider some intangible benefits from the catchment forest particularly the economic value of matured trees for timber production, ecological benefits such as regulation of the flow of water by slowing down run-off, absorb and hold water that recharges streams and groundwater, reduce the amount of sediment washing in streams by reducing soil erosion, influence on climate-moisture in the air coming from trees via transpiration and evaporation, providing habitats for wildlife species, and buffer against noise and aesthetically pleasing to the people around the project area.

4. Discussion

4.1. Routine and Nonroutine Activities and Their Associated Costs of Managing the Forest. The forest patrolling was

Table 2: Setting up and running costs of the ARKFor pilot project from 2010 to 2011.

Cost centers	NGO main office (AWF-Arusha)	NGO local office (AWF-Kondoa)	Partner	Consultancy	Monitoring body	Verifications	Villages and villagers	Total (US$)
				Setting up costs				
Negotiating contracts, planning, decision making, administration, and finances	150,107	—	192,132	—	—	—	—	342,239
Developing institutions	1,625	2383	125	—	—			4,133
Information programs and payment programs/communication	4908	—	4146					9,054
MRV systems	48,514	—	3451	—	—			51,965
Personnel cost	12,290	42,255	—	—	66	—	—	54,611
Office costs	—	20,832	—	—	—	—	—	20,832
Capital assets	—	74,511	—	—	—	—	—	74,511
				Running costs				
Negotiating contracts, planning, decision making, administration, and finances	110,225	—	—	64,638	—	—	—	174,863
Developing institutions	223,313	—	$2314	53,885	—	—	46,274	325,786
Information programs and payment programs/communication	788	—	—	38,582	—	—	—	39,370
MRV systems	185	—	—	11,201	—	—	—	11,386
Personnel cost	26,388	58,183	—	—	5310	—	—	89,881
Office costs, include consumables, travelling costs and miscellaneous	27,986	2500	3600	3500	—	—	14,770	52,356
Capital assets	—	1426	—	—	—	—	—	1,426
Total								**1,252,413**

Source: ARKFor pilot project annual report from 2010 to 2011.

observed to be the main activities in the area performed by community adjacent of the forest such as charcoal making and livestock keeping prevention. This could be a result of the amount paid to local communities in attending those activities or they have realised the importance of the surrounding forest in their livelihood. Kugonza et al. [33] stated that a wide range of socioeconomic factors influence local community participation in managing the forest as they realise the importance of forestry on their livelihood strategies. Therefore costs incurred by local community were calculated based on the days or time spent monthly in undertaking those activities for the purpose of managing the forest.

In addition to that, the community adjacent of the forest was observed to devote much of its time in forest patrolling. This could be possibly due to the presence of various human activities like crop cultivation in the forest as shifting cultivation and cut down of the trees for charcoal making, buildings, and fire woods; hence patrolling activities accrue much time or costs than other activities in the area. In addition to that it was learned that in the village there were forest guards trained by AWF and VNRC members who were involved in the forest patrolling activity. However, it was noted that the established institution in community faces a range of challenges like lack of forest patrolling equipments but devoted much of their time in the managing the forests. This is because Mnenia forest was the source of water for irrigation and domestic purposes, and other forest products such as honey and fuel wood obtained from that forest. Meshack et al., [34] reported that in a situation in which forestry is just one of many livelihood activities, costs as a proportion of total costs can be significantly higher marking up to 20% of the costs. In addition to the estimated cost incurred by communities adjacent of the forest, other costs incurred by an NGO (AWF) and other partners were estimated in order to estimate the total costs accrued in managing the forest. It involved the actual cost incurred in setup and running the ARKFor project based on function, actors, and budget of the project.

4.2. The Cost Incurred by ARKfor Pilot Project

4.2.1. The Starting Costs. The cost of negotiating, planning, decision making, and administration arises due to time

Table 3: NPV at various discount rates of 5%, 10%, 15%, 20%, 21.21231441%, and 25%.

Year	Costs	Benefits	Net benefit	NPV					
				r = 5%	r = 10%	r = 15%	r = 20%	r = 21.21231441%	r = 25%
1	3543152.72	0	−3543152.72	−3374431.16	−3221047.92	−3081002.36	−2952627.26	−2923096.33	−2834522.17
2	3593028.46	0	−3593028.46	−3258982.73	−2969445.01	−2716845.71	−2495158.65	−2445497.20	−2299538.21
3	3420371.10	0	−3420371.10	−2954645.16	−2569775.43	−2248949.52	−1979381.42	−1920582.63	−1751230.00
4	3422613.50	0	−3422613.50	−2815792.59	−2337691.07	−1956890.38	−1650565.92	−1585516.93	−1401902.49
5	3420373.74	0	−3420373.74	−2679952.32	−2123782.99	−1700530.25	−1374571.49	−1307193.39	−1120788.07
6	3402751.78	0	−3402751.78	−2539185.77	−1920764.67	−1471103.50	−1139574.69	−1072876.68	−892010.96
7	44800.00	5825985.00	5781185.00	4108580.25	2966662.02	2173361.58	1613422.63	1503798.55	1212402.37
8	42300.00	6274785.00	6232485.00	4218391.17	2907500.25	2037410.40	1449476.82	1337479.99	1045637.47
9	36800.00	6646447.50	6609647.50	4260637.71	2803135.76	1878874.34	1280993.97	1170193.30	887131.87
10	36800.00	7018110.00	6981310.00	4285918.74	2691597.22	1725673.06	1127520.54	1019693.11	749612.45
11	36800.00	7389772.50	7352972.50	4299130.73	2577172.00	1580471.61	989621.76	886030.68	631615.53
12	36800.00	7761435.00	7724635.00	4301365.81	2461306.77	1443789.51	866369.22	767921.88	530832.88
13	36800.00	8133097.50	8096297.50	4293639.43	2345208.99	1315874.69	756711.37	664016.38	445098.66
14	36800.00	8469697.50	8432897.50	4259186.28	2220645.48	1191810.09	656809.43	570587.71	370882.75
15	36800.00	8876422.50	8839622.50	4252009.56	2116135.35	1086340.86	573739.87	493437.97	311016.57
16	36800.00	9248085.00	9211285.00	4219795.79	2004643.99	984361.85	498219.00	424201.62	259274.62
17	36800.00	9619747.50	9582947.50	4181008.25	1895935.08	890503.89	431934.53	364086.41	215788.79
18	36800.00	9991410.00	9954610.00	4136346.07	1790424.11	804383.44	373905.47	312020.31	179326.31
19	36800.00	10363072.50	10326272.50	4086456.68	1688428.07	725578.85	323221.25	267027.17	148817.27
20	36800.00	10734735.00	10697935.00	4031939.19	1590179.87	653646.81	279045.51	228225.98	123338.79
21	36800.00	11106397.50	11069597.50	3973347.50	1495841.03	588135.21	240616.64	194827.48	102099.02
22	36800.00	11478060.00	11441260.00	3911193.26	1405512.72	528592.95	207246.14	166129.02	84421.60
23	36800.00	11849722.50	11812922.50	3845948.60	1319245.42	474577.37	178315.34	141508.41	69731.19
24	36800.00	12221385.00	12184585.00	3778048.81	1237047.28	425659.74	153271.30	120417.30	57540.08
25	36800.00	12593047.50	12556247.50	3707894.69	1158891.40	381429.13	131622.07	102374.38	47436.16
26	36800.00	12957697.50	12920897.50	3633882.71	1084133.76	341309.86	112870.46	86911.52	39051.02
27	36800.00	13336372.50	13299572.50	3562268.14	1014460.59	305489.29	96815.31	73803.27	32156.39
28	35000.00	13708035.00	13673035.00	3487904.23	948134.04	273102.32	82944.97	62597.37	26447.50
29	35000.00	14079697.50	14044697.50	3412107.59	885369.42	243935.51	70999.66	53046.51	21733.12
30	35000.00	14451360.00	14416360.00	3335620.60	826180.74	217731.07	60732.09	44921.40	17846.59
31	35000.00	14823022.50	14788022.50	3258680.87	770436.52	194212.44	51914.83	38015.53	14645.35
32	35000.00	15194685.00	15159685.00	3181504.98	717999.68	173124.80	44349.66	32150.99	12010.74
33	35000.00	15566347.50	15531347.50	3104289.87	668729.57	154234.10	37864.13	27174.81	9844.16
34	35000.00	15938010.00	15903010.00	3027214.28	622483.78	137326.00	32308.51	22955.67	8063.78
35	35000.00	16309672.50	16274672.50	2950440.02	579119.62	122204.68	27552.98	19381.00	6601.79
36	35000.00	16681335.00	16646335.00	2874113.16	538495.36	108691.70	23485.17	16354.45	5402.04
37	35000.00	17052997.50	17017997.50	2798365.19	500471.22	96624.75	20007.94	13793.64	4418.12
38	35000.00	17424660.00	17389660.00	2723314.05	464910.18	85856.50	17037.42	11628.26	3611.69
39	35000.00	17796322.50	17761322.50	2649065.13	431678.66	76253.46	14501.29	9798.34	2951.11
40	35000.00	18167985.00	18132985.00	2575712.23	400647.00	67694.86	12337.28	8252.77	2410.29
				107102331.83	**33986255.86**	**10312945.00**	**1245905.11**	**0.00**	**−2620793.84**

and resources spent to wrap up the negotiations, planning, communication, and travel costs. In addition to that, as the project was in the initial stage this tends to incur much cost possibly because as the foundation of the project lay properly then the project could be thriving. Dudek and Wiener [35] stated that negotiation costs would arise in the form of time spent to conclude the negotiations, communication, and travel costs and possibly a fee for specialised consultants in legal or financial matters. Further, it was found that purchasing of capital assets accrued more during stating the project. This could be due to the fact that the project was in the establishment stage then things like vehicles and other important assets must be purchased for proper management of the project. Milne [36] stated that

Table 4: Estimated amount of GHG abated (CER/ERU).

Year	Estimation of baseline net GHG removals by sinks (tonnes of CO_2e)	Estimation of actual net GHG removals by sinks (tonnes of CO_2e)	Estimation of leakage (tCO_2e)	Estimation of net anthropogenic GHG removals by sinks (tonnes of CO_2e)	Estimation of net benefit accrued by trading carbon (USD)
0	396,806.26	0	0	−396,806.26	−3,372,853.18
1	397,723.13	0	0	−397,723.13	−3,380,646.59
2	396,808.36	0	0	−396,808.36	−3,372,871.10
3	395,895.71	0	0	−395,895.71	−3,365,113.50
4	394,985.15	0	0	−394,985.15	−3,357,373.74
5	394,076.68	0	0	−394,076.68	−3,349,651.78
6	0	427,790.00	0	427,790.00	3,636,215.00
7	0	456,940.00	0	456,940.00	3,883,990.00
8	0	492,140.00	0	492,140.00	4,183,190.00
9	0	521,290.00	0	521,290.00	4,430,965.00
10	0	550,440.00	0	550,440.00	4,678,740.00
11	0	579,590.00	0	579,590.00	4,926,515.00
12	0	608,740.00	0	608,740.00	5,174,290.00
13	0	637,890.00	0	637,890.00	5,422,065.00
14	0	664,290.00	0	664,290.00	5,646,465.00
15	0	696,190.00	0	696,190.00	5,917,615.00
16	0	725,340.00	0	725,340.00	6,165,390.00
17	0	754,490.00	0	754,490.00	6,413,165.00
18	0	783,640.00	0	783,640.00	6,660,940.00
19	0	812,790.00	0	812,790.00	6,908,715.00
20	0	841,940.00	0	841,940.00	7,156,490.00
21	0	871,090.00	0	871,090.00	7,404,265.00
22	0	900,240.00	0	900,240.00	7,652,040.00
23	0	929,390.00	0	929,390.00	7,899,815.00
24	0	958,540.00	0	958,540.00	8,147,590.00
25	0	987,690.00	0	987,690.00	8,395,365.00
26	0	1,016,290.00	0	1,016,290.00	8,638,465.00
27	0	1,045,990.00	0	1,045,990.00	8,890,915.00
28	0	1,075,140.00	0	1,075,140.00	9,138,690.00
29	0	1,104,290.00	0	1,104,290.00	9,386,465.00
30	0	1,133,440.00	0	1,133,440.00	9,634,240.00
31	0	1,162,590.00	0	1,162,590.00	9,882,015.00
32	0	1,191,740.00	0	1,191,740.00	10,129,790.00
33	0	1,220,890.00	0	1,220,890.00	10,377,565.00
34	0	1,250,040.00	0	1,250,040.00	10,625,340.00
35	0	1,279,190.00	0	1,279,190.00	10,873,115.00
36	0	1,308,340.00	0	1,308,340.00	11,120,890.00
37	0	1,337,490.00	0	1,337,490.00	11,368,665.00
38	0	1,366,640.00	0	1,366,640.00	11,616,440.00
39	0	1,395,790.00	0	1,395,790.00	11,864,215.00
40	0	1,424,940.00	0	1,424,940.00	12,111,990.00
Average over Crediting period (2010–2040) (tCO_2e)	**57,958.42**	**793,006.10**	**0**	**735,047.68**	**6,247,905.25**
Total for Crediting period (2010–2040) (tCO_2e)	**2,376,295.28**	**32,513,250.00**	**0**	**30,136,954.72**	**256,164,115.12**

NB: baseline deforestation rate was 0.46%, sequestration rate was 5.3 tCO_2/ha/year, and price per carbon was 8.5 USD/tCO_2e.

procurement, scheme design, and negotiation are important categories of transaction costs during establishment of REDD projects.

4.2.2. Running Cost. The developed institution (such as the established JFM in the village, plan, training communities, and register JFM and conducting training to communities) accrued high cost in managing the forest. This was possibly due to the fact that more attention was given to each village adjacent of the forest involved in managing the ARKFor pilot project which has a credible management institution that will oversee all the activity in the community. It was learned that in running the developed institution in the village, training of local communities was undertaken to ensure its sustainability. The high cost incurred in developing an institution, for example, in Tanzania, is involved in establishing a joint management plan and development agreement between local communities surrounding the forest. Further, it requires much time and resources in completing. Bond et al. [37] argued that realising REDD projects or schemes in weak governance settings is likely to imply higher transaction costs than in settings or running where institutions and rights are well defined and well functioning. Further, it was found that personnel cost such as salaries and fringe benefit of the staff project accrued more cost than other cost centers. This was possibly due to the initial stage of the project that requires more personnel who will make sure that the established activities in the area are properly managed like project coordinator and other supporting staff. Further, it was learned that the project provides a contract for conducting baseline on establishing an MRV system in the area that leads in employing various people; hence more resources were spent for paying personnel and execute administrative activities.

4.2.3. Above Ground Forest Biomass, Carbon Stock, Costs per Tonne of CO_2, and Profitability of the Pilot Project. Despite differences in methodologies and environmental conditions other Miombo woodlands studies have reported similar carbon (C) stock and cost per tonne of CO_2 to those obtained in this study. Shirima et al. [38] reported that eastern Miombo woodlands in Tanzania have been shown to have C storage potential of between 25 and 80 tCha^{-1}. Zahabu [29] found that in Kitulangalo Forest Resource the C stock was 17.6–22.9 $\mathrm{tC\,ha}^{-1}$ equivalent to 64.59 $\mathrm{tCO_2\,ha}^{-1}$ and 84.04 $\mathrm{tCO_2\,ha}^{-1}$, respectively. Nhantumbo and Izidine [39] reported that Nambita forest project in Mozambique with 19 $\mathrm{tC\,ha}^{-1}$equivalent to 69.73 $\mathrm{tCO_2\,ha}^{-1}$ at a price of \$4 $\mathrm{tCo_2}^{-1}$ and a net benefit of \$476 was feasible and profitable at discount rate of 10%.

5. Conclusion and Recommendations

According to the stated assumptions, the project was found to be economically feasible at 5%, 10%, 15%, and 20% discount rates with NPVs of about USD. 107,102,331.83, US\$ 33,986,255.86, US\$ 10,312,945.00, and USD. 1,245,905.11, respectively. The internal rate of return (IRR) was found to be about 21.21% which is much higher than the World Bank rate of 15.8% [30] and the Tanzanian rate of 14.8% [31]. We therefore conclude that the decision to undertaking this project was worthwhile and should be favoured against the "do nothing" alternative. Although the estimates suggest that abatement costs observed in the ARKFor pilot project was between the ranges of the estimates in non-Annex I countries more investigation should be done to other forest ecosystems in Tanzania. Further, knowledge gained by the communities surrounding the forest could be disseminated to other parts of the country to improve conservation and reduce forest degradation through deforestation.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

Acknowledgments

This paper has been produced under a research project "REDD+ Architecture in Tanzania" funded by the Norwegian Government through a Programme on Climate Change Mitigation and Adaptation for Tanzania based at Sokoine University of Agriculture. The findings and views expressed in this document are the sole responsibility of the authors and do not necessarily represent the views of the institutions involved in this project or the funder. The authors would like to express their sincere acknowledgement to the Royal Norwegian Government for supporting this work. REDD+ Pilot Project under the African Wildlife Foundation, Leaders of the Local Government in Kondoa district, and Mnenia village council are highly acknowledged. Lastly the communities in Mnenia village are acknowledged for agreeing to participate in this research.

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