Evaluation of non-market environmental services in small holder forest plantations with choice experiments in Dormaa forest district, Ghana

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Abstract

Forest management in Ghana is focused mainly on timber which has direct market benefits. Largely, environmental services (non-market values) of forests are not taken into account in forest management planning. This may be as a result of the lack of knowledge, understanding and estimation of the value of environmental services provided by forests. This study sought to fill this information gap by estimating the values of environmental services of smallholder forest plantations using choice modelling. From literature and reconnaissance surveys, environmental attributes of forest plantation were identified. Conjoint analysis was employed to estimate the value of these services. Orthogonal design was used to generate different combinations of attribute levels into profiles. Respondents ranked these profiles from most to least preferred. The results show that water regulation was the most influential attribute in the ranking of choice profiles from the study forest plantation. The results of the ordered logistic models show that respondents who are not married, respondents from Abonsrakrom community, respondents with no formal, primary and middle school education placed higher value on choice profiles made up of higher attribute levels. In all, farmers were willing to accept GH¢400/hectare/year as compensation for improving environmental services. The findings on non-market environmental services and the socio economic characters of farmers engaged in small holder forest plantation establishment can help forest managers to better evaluate actions, plans and policies to enhance sustainable forest management.

Keywords: Environmental services, small holder plantation, Choice experiment, Ordered logit, Ranking

Introduction

Forests in Ghana produce multiple environmental services alongside consumable goods like timber and non-timber forest products (NTFPs). Notwithstanding, forests in Ghana have progressively disappeared over the years. The country has one of the highest rates of deforestation in West Africa (Marfo et al., 2012), and while the rates have been reported to be alarming it is becoming increasingly difficult to get precise figures for the state of the nation's forest cover (Hansen et al., 2009). Deforestation in Ghana has several damaging consequences on the environment, economy and results in extreme poverty. According to the Forest Commission of Ghana (2012), the contribution of the forestry sector to the GDP is offset by an annual economic cost of forest degradation of about ten per cent per year. Moreover, deforestation indirectly accounts for 20% of annual carbon emission into the atmosphere (WRI, 2000) and this has an impact on climate change which is expected to hit developing countries the hardest.

To address this problem of rapid decline in forest cover and avert accompanying consequences, Ghana has made efforts to introduce remedial measures over the years. These measures include policy reforms, strengthening of forest law enforcements (Beeko and Arts, 2010), and replanting of degraded forest areas among others. The government of Ghana in the 1930s, initiated a plantation development programme using the taungya system in which farmers were given plots of degraded forest reserves to cultivate food crops and also to assist in the establishment and maintenance of timber trees (Agyeman et al., 2003). This system was reviewed and relaunched in the year 2002 as the Modified Taungya System (MTS). The core objective of forest plantations in Ghana is timber production (direct use value). But forest plantation ecosystems also provide a wide range of indirect benefits (indirect use and non-use values).

Again in Ghana, the focus of forest management is on timber which has direct market benefits. Largely, environmental services (e.g. non-market values) of forests are not taken into account in forest management planning and in the national income accounting (Damnyag et al., 2011). Even the provisioning services (i.e. food, fiber, genetic resources) from natural and plantation forest ecosystems which are included in forest management planning and national income accounts are undervalued. This may be attributed to the lack of knowledge, understanding and estimation of the value of environmental services provided by forest plantations. Not including these non-market benefits of forests in management planning could substantially affect the provision of these benefits, and also may increase the pressure for conversion of forests to other land uses.

The causal factors of deforestation and forest degradation in Ghana are complex and varied (Damnyag et al., 2011). As such, designing effective policies and management practices to address deforestation requires a thorough understanding of the causes. Population change, agricultural expansion, bush burning, illegal and inefficient logging practices are mostly cited as the main forces underlying forest loss. However, environmental economists have drawn attention to a major but mostly ignored factor, i.e. non-market ecological functions of forest (Pearce, 2001; Richmond et al., 2007). The zero price of non-market forest services to a large extent fuels the conversion of forests to other land uses (Pearce, 2001). The issue is such that when conversion competes with conservation, conversion wins because conservation values appear to be low or zero whereas conversion values have markets (Pearce, 2001). This calls for the estimation of non-market values of forests and the internalization of values in land use decision-making as part of the efforts to halt further degradation.

Most forest related studies in Ghana focus on timber and NTFPs which have direct market values. Little attention is given to the non-market aspects of forest ecosystems hence, the need for this study. Society cannot recognize the economic impact of deforestation and forest degradation if the ecosystem services they provide are not valued. Richmond et al., (2007) argues that, if empirical values for forest ecosystem services were available, degradation could be reduced. Translating forest ecological functions into empirical values would also encourage the restoration of degraded forest areas and also make a strong case for conservation when land use changes are contemplated. This paper estimates the value of environmental services of MTS plantation forests using choice experiments. The specific objectives were to: (i) identify attributes of environmental services of MTS forest plantations most relevant to forest managers and farmers; and (ii) estimate willingness to accept (WTA) compensation for improving environmental services through MTS forest plantations.

Theoretical framework

Benefits or cost of losing or preserving ecosystem services (ES) have been broadly classified into use and non-use values (Bateman et al., 2002). Non-use values are recognized to be an important component of the total economic value (TEV) of ecosystems and as such, certain decisions are required to conserve them (de Groot et al., 2002). Within the neoclassical economics framework, upon which environmental economics and valuation methods are based, non-use values are defined and measured in monetary units of willingness-to-pay (WTP) or willingness-to-accept (WTA). Contingent valuation method (CVM) and discrete choice experiments (DCE) are stated preference techniques used to estimate non-use values in the form of WTP/WTA (Adamowicz, 2004).

Stated preference (SP) methodologies consist of asking individuals to provide responses to questions about how much they are willing to pay (or willing to accept) for some hypothetical scenario involving changes in the ES of interest. The measures of WTP/WTA are achieved by modelling the data based on utility theory, where choice is explained with regards to the maximization of utility (Adamowicz et al., 1998). This requires a precise definition and understanding of the utility function (Hensher et al., 2005). The Random Utility Theory (RUT) was suggested by Thurstone (1927), then developed and improved by McFadden (1974) to explain the choice behaviour of humans. The individual's utility function is described as the sum of two different components: a rational/systematic one (i.e. corresponding to explainable factors of choice), and a random one (i.e. unexplainable factors of choice) (Marre, 2014). Some assumptions are made with regards to the rational component. One such assumption commonly made is the additivity and linearity of the attributes or characteristics relative to the alternative (Lancaster, 1966; Hensher et al., 2005). This multi-attribute utility theory also forms the basis of the choice experiments method (Bateman et al., 2002).

SP methods (CVM and DCE) differ in how they value ecosystem services. DCE focuses on valuing different attributes of goods and services rather than treat them as a whole (Bateman et al., 2002). The questionnaire which is the main data collection tool is designed in a similar way as CVM but here, the respondent is typically presented with a series of alternatives representing various proposed changes to the attributes of the good or service with an added payment/compensation component from which they are to make a choice. The changes are depicted as levels of the attributes listed. Ranking the alternatives is also another option for the individual. The respondent is showed successively several choice cards involving two or more alternatives usually with a status quo. The respondent's duty is to arrange these alternatives from the most to the least preferred (Louviere et al., 2000). Then, in accordance with RUT, the choice data collected are modelled to estimate preferences.

Various studies over the years have employed the DCE valuation technique. For example, Naidoo and Adamowicz (2005) employed this technique to estimate nature-based tourism value of forest reserves in Uganda, Gelo and Koch (2012) used it to estimate the values of community forestry in Ethiopia. Vecchiato and Tempesta (2013) applied it in valuing the benefits of an afforestation project in the peri-urban area of Veneto region in Italy and Palma et al., (2009) applied it in measuring environmental and social values from plantation forests in New Zealand. In Ghana, Vondolia, (2009) and Damnyag et al., (2011) have estimated the benefits of the forest ecosystem services and their impacts on the welfare of local farm households using this approach. The MTS plantation forests in the present study has many attributes (Kalame et al., 2011). As such, the appropriate technique to use in estimating the non-market benefits is the choice experiment.

Study site

The study was conducted in selected communities fringing the Pamu-Berekum forest reserve in the Dormaa forest district (Figure 1). Pamu-Berekum forest reserve (7°25N and 2°56W) covers a land area of 189.1 km^2 and its forest type is dry semi-deciduous to moist semi-deciduous (DS–MS) with a mean annual rainfall of over 1000mm (Dormaa Municipal Assembly, 2013). The reasons for selecting this site are the large and increasing degraded forest reserve lands and the restoration of portions these degraded forest reserves (Blay et al., 2008). Three communities namely, Abonsrakrom, Twumkrom and Ntabene were selected for the study. The criteria for selecting these communities were nearness to the degraded forest reserve and their involvement in reforestation of portions the degraded forest reserve under the Modified Taungya System (MTS).

Sampling technique

Simple random sampling was used to select participating farmers in target communities for the interview whilst convenient sampling was used to sample Forest Services Division (FSD) officials for the study. A list of farmers participating in the International Tropical Timber

Organization (ITTO) project PD 530/08 Rev.3 (F) in the selected communities was obtained from the Dormaa FSD office. The list was updated with the help of heads of farmer groups (taungya heads) as some of the participating farmers had either passed on and had been replaced by a relative or they had left the community entirely. A total of 100 participating farmers (35 out of 40 from Abonsrakrom, 35 out of 40 from Twumkrom, and 30 out of 40 from Ntabene) and 11 Dormaa FSD officials were selected and interviewed for the study. This sample size is large enough to ensure reliability and again, it satisfies the requirement for the conjoint analysis.

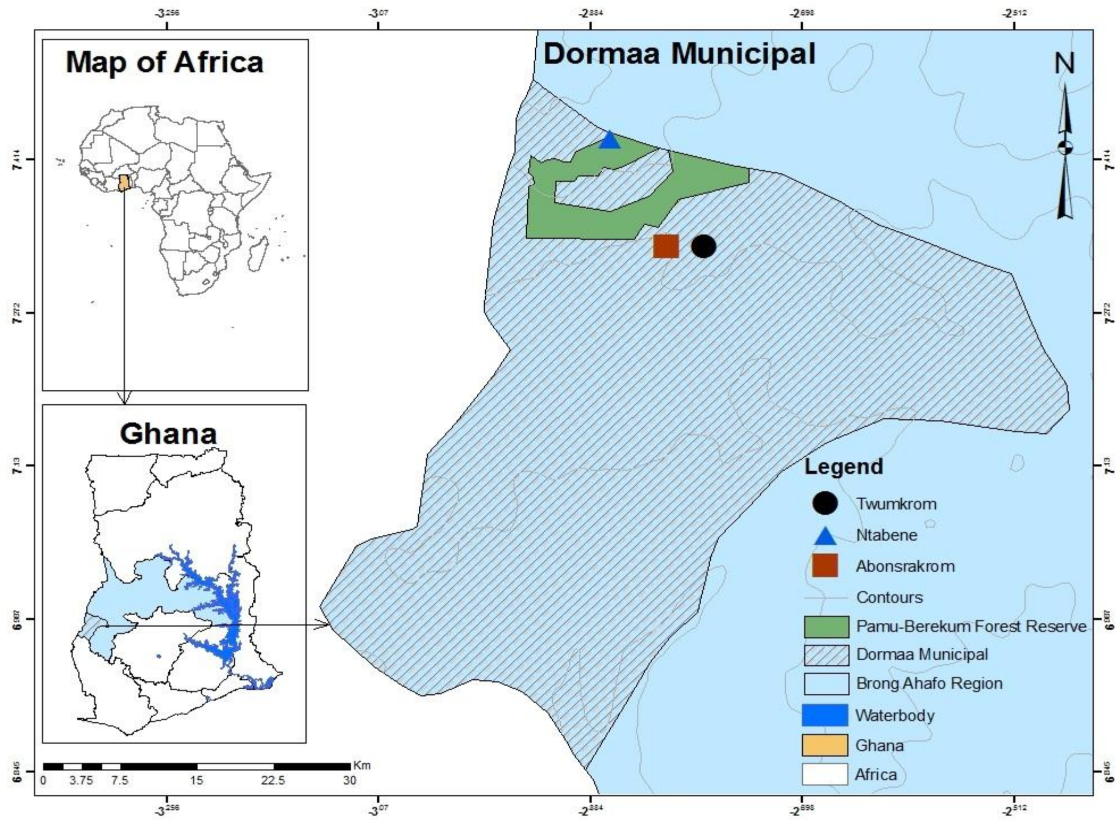

Figure 1: Map of Ghana showing the study sites

Survey design

The questionnaire used to collect the CE data was constructed to include environmental attributes of MTS forest plantation and other socio-economic information about the respondents. The CE scenario was presented to highlight the negative impact of deforestation and degradation of the of Pamu-Berekum forest reserve and the environmental services that are lost accordingly. An already implemented course of action (rehabilitation of degraded forests by local communities under ITTO project PD 530/08 Rev.3 (F) to restore/enhance the benefits lost to deforestation) was also presented to solicit respondents' willingness to accept compensation for their contribution towards the restoration of environmental services. Two payment vehicles were considered for the purpose of this study; direct payment to participating farmers and donation to a community development fund. Upon a focus group discussion, the former was selected as the preferred vehicle. The designed questionnaire was pretested on the field to fine tune the methodology before conducting the final survey. The mode of delivery of the questionnaire was through personal interview (paper and pencil method) (Adamowicz, 2004). The questionnaire was administered in the local dialect of farmers to enhance their understanding of the study.

Attributes and levels selected

From different studies on MTS (Kalame et al. 2011; Ros-Tonen et al. 2013), attributes of MTS were identified. These were validated with forestry experts, managers and in focus group discussions with participating farmers engaged in the restoration of portions of the degraded forest reserves at the study sites. Through the focus group discussions, respondents identified the most important environmental services that MTS plantations provide. Four of the environmental attributes (Table 1) which participants were familiar with and which appeared more pronounced amongst them were selected for the valuation survey (Palma et al., 2009).

Table 1: Attributes and levels used in the choice experiment

Attributes	Status quo level	Alternative levels
Increasing output of crops (Nutrient cycling)	Low output	Moderate output, High output
Improving water yield in water courses and storages (Water regulation)	No retention	Moderate retention, High retention
Prevention against windstorms	No Protection	Low Protection, High Protection
Biodiversity promotion	10% NTFP habitat	40% NTFP habitat, 70% NTFP habitat
Money	Gh₵0 per year	Gh₵400 per year, Gh₵450 per year, Gh₵500 per year

The levels for the first three attributes were agreed upon in the focus group discussion. The levels for biodiversity promotion were obtained from the work of Siikamäki (2001) and were validated by the focus group as well. The biodiversity promotion attribute was not a count of the flora and fauna present but rather the milieu that the MTS plantation forest had created for other non-timber species to thrive. Ahiale (2012) and Shaikh et al., (2007) gave the rationale for selecting the levels of the monetary attribute. In the study conducted by Shaikh et al. (2007), WTA for tree planting was quoted in dollars and as such, the cedi equivalent was calculated to enhance the selection of levels. Again, these were validated in the focus group discussion. To enhance understanding among less literate respondents, pictures were used to reflect both the meaning and the variation in the different levels of the attributes (Table 2).

Table 2: Photographs used to interpret attribute levels

Attribute	Levels		
Increasing output of crops (Nutrient cycling)	 Low output	 Moderate output	 High output
Water yield and storage (Water regulation)	 No retention	 Moderate retention	 High retention
Protection against windstorm	 No protection	 Low protection	 High protection
Biodiversity promotion	 10% NTFP habitat	 40% NTFP habitat	 70% NTFP habitat

The orthogonal design

The experimental design for this study was the orthogonal array/design. The orthogonal design was employed to deal with instances where there would be too many cases for a subject to judge in a meaningful way (Pearmain et al., 1991; Louviere et al., 2000). In a bid to reduce the number of cases, the status quo levels were not included in the generation of the orthogonal plan (Palma et al., 2009). For this study, only main effects (subset of all possible profiles) were considered. No holdouts or simulations were specified. Eight profiles were generated. Respondents were tasked to rank these profiles from most to least preferred.

Data analysis and model estimation

Collected data was cleaned, coded and fed into IBM SPSS statistical software (version 23). Quantitative methods involving means and rankings were used to ascertain the most relevant environmental attribute. Chi-square (Kruskal Wallis H and Mann-Whitney U) tests were used to validate the significance of the responses from various groupings of respondents. SPSS conjoint which uses the full-concept approach was used in the estimation of WTA. A command syntax file was created to link the orthogonal plan to the ranked choice profile data file for analysis. In writing the syntax, discrete model was specified for nutrient cycling, water regulation, protection against windstorm and biodiversity promotion (MORE) factors whilst linear (MORE) model was specified for the monetary factor since it was expected that higher amounts would increase preference for a profile. Part-worth for each factor level was estimated for each factor level and their scores were added together to give the total utility of a combination. To get an idea of how the factors compare, importance scores for each factor was computed. The Pearson's R and Kendall's tau statistics were used as an indication of how well the model fitted the data.

Ordinal regression model

This method was employed to model the relationship between response variables (ranking of choice profiles from most to least preferred) and a set of explanatory variables (attribute levels and characteristics of respondents). A normality test (Shapiro-Wilk; $p<0.05$) was performed to enable the determination of the appropriate link function and subsequently the statistical model to use in the analysis. For this study, the complementary log-log (clog-log) link function was considered suitable for the dataset. Clog-log link function is often used to analyze ordered categorical data when higher categories are more probable. The parallel line assumption test was done to ascertain the use of the ordered logistic regression analysis in this study. SPSS PLUM procedure (an extension of the general linear model to ordinal categorical data) was utilized for the analysis. Model fitting information, goodness of fit, pseudo R-square and test of parallel lines were used as indicators of how well the model fitted the data.

The ordered logistic model is specified as equation 1, where the indirect utility that is derived from a choice profile is a function of the attributes of the profile and the respondent's characteristics.

$$V_i(P_f)^* = b_1Z_{1f} + \dots b_5Z_{5f} + c_1X_1 + \dots c_{Rf}X_R + \varepsilon_{if} \quad (1)$$

where $V_i(P_f)^*$ is an unobserved measure of the utility that respondent i derives from the attributes of the profile, $Z_{1f} \dots Z_{5f}$ is a vector of levels of the observed attributes of the profiles, $X_1 \dots X_R$ is a vector of the respondent's characteristics, $b_1 \dots b_5$ and $c_{1f} \dots c_{Rf}$ are unknown parameters. ε_{if} is a random error term. While the indirect utility derived from a particular alternative cannot be observed, the rankings of each choice profile/alternative of 1 to 8, could be observed where:

Ranking = 1 if $P_f^* \leq \mu_1$
Ranking = 2 if $\mu_1 < P_f^* < \mu_2$
Ranking = 3 if $\mu_2 < P_f^* < \mu_3$
Ranking = 4 if $\mu_3 < P_f^* < \mu_4$
Ranking = 5 if $\mu_4 < P_f^* < \mu_5$
Ranking = 6 if $\mu_5 < P_f^* < \mu_6$
Ranking = 7 if $\mu_6 < P_f^* < \mu_7$
Ranking = 8 if $P_f^* < \mu_7$
Where $\mu_1 \dots \mu_7$ are the intercepts or 'cut points'. The probability that the farmer will give a ranking of j to an alternative is given as:

$$P_{fj} = \Pr[\text{Ranking}=j] = \Pr\,[\mu_{j-1} < (\beta_1 Z_{1f} + \ldots + \beta_5 Z_{5f} + c_{1f}X_1 + \ldots + c_{Rf}X_R) < \mu_j] \quad (2)$$

ZX is the vector of attributes of the profiles and respondent characteristics while β and c are vectors of parameters to be estimated. Because higher categories (utility from most preferred choice profile made up of higher levels of observed attributes) were more probable, the clog-log link function was used. In the clog-log function, the form of the link is defined as:

$$\log[-\log(1- P_{fj})] = \Pr\,[\mu_{j-1} < (\beta_1 Z_{1f} + \ldots + \beta_5 Z_{5f} + c_{1f}X_1 + \ldots + c_{Rf}X_R) < \mu_j] \quad (3)$$

or

$$P_{fj} = 1- \exp(- \exp(\Pr\,(\mu_{j-1} < (\beta_1 Z_{1f} + \ldots + \beta_5 Z_{5f} + c_{1f}X_1 + \ldots + c_{Rf}X_R) < \mu_j)) \quad (4)$$

Results

Socio-demographic characteristics of respondents

The modal age class of the survey was 55-64 representing 33% of respondents. Females were dominant (54%) and a significant portion (34%) of the respondents had attended middle school (10 years of schooling). Aside farming, 51.6% of respondents were engaged in trading. Twenty-five percent of the respondents earn between GH¢1001-1500 annually. Majority (56%) of the respondents had knowledge about environmental services of plantation forests (Table 3).

Table 3: Demographic characteristics of respondents

Variable	Class (Frequency)	%	Variable	Class (Frequency)	%
Gender	Male (46)	46	Knowledge about plantation forest services	Yes (56)	56
	Female (54)	54		No (44)	44
Age (years)	18-24 (1)	1	Number of years resident in community	1-15 (12)	12
	25-34 (7)	7		16-30 (20)	20
	35-44 (19)	19		31-45 (27)	27
	45-54 (31)	31		46-60 (32)	32
	55-64 (33)	33		>60 (9)	9
	+65 (9)	9			
Highest formal education attained	No formal education (25)	25	Household size	1-3 (7)	7
	Primary (20)	20		4-6 (36)	36
	Junior high (17)	17		7-10 (51)	51
	Middle school (34)	34		+10 (6)	6
	Senior high (1)	1			
	University (3)	3			
Other occupation(s)	Trading (16)	51.6	Annual household income (GH¢)	<100 (3)	3
	Artisan (11)	35.5		101-500 (20)	20
	Civil servant (4)	12.9		501-1000 (21)	21
				1001-1500 (25)	25
				1501-2000 (18)	18
				>2000 (13)	13

Ranking of environmental services of MTS plantation forests

Table 4 shows how respondents ranked environmental services from MTS plantation forests. Ranking was done on a scale of 1 to 7 with 1 indicating most important and 7 the least important. The mean indicates the average ranking score obtained by each environmental service. From the survey, the most important environmental service was water regulation, with the lowest mean ranking score of 2.53. The second and third most important environmental services were nutrient cycling ($\bar{x}$ = 2.85) and biodiversity promotion ($\bar{x}$ = 3.09) respectively. A Kruskal-Wallis H test revealed statistically significant differences among communities who ranked water regulation ($p<0.001$), nutrient cycling ($p=0.009$), protection against windstorm ($p<0.001$), carbon sequestration ($p=0.001$) and soil erosion control ($p<0.001$) (Table 4). Gender, age, level of formal education attained and annual household income did not have any significant influence on how respondents ranked environmental services of MTS plantation forests.

Table 4: Ranking of environmental services of MTS plantation forests

Forest environmental services	Number of respondents	Minimum	Maximum	Mean	H test statistics, mean rank, p-value in TANF
Water regulation	111	1	7	2.53	**TANF:52,49,55,94 H(3)=19, p<0.001
Nutrient cycling	111	1	7	2.85	**TANF:41,59,66,65 H(3)=12, p=0.009
Biodiversity promotion	111	1	7	3.09	**TANF:67,50,52,53 H(3)=6, p=0.114
Protection against windstorm	111	1	7	3.18	**TANF:59,44,52,95 H(3)=23, p<0.001
Air quality	111	1	7	4.86	**TANF:49,55,67,48 H(3)=6, p=0.101
Carbon sequestration	111	1	7	5.68	**TANF:60,55,64,22 H(3)=17, p=0.001
Soil erosion control	111	1	7	5.82	**TANF:67,74,39,11 H(3)=51, p<0.001

*The significance level is .05
**TANF: Twumkrom (T), Abonsrakrom (A), Ntabene (N), Dormaa FSD (F)

Estimate of WTA compensation for planting trees

Pearson's R and Kendall's tau statistics were computed as two measurements of correlation between the observed and estimated preferences. In this study, the Pearson's R statistic value for the overall model was 0.723 indicating a good fit of the data. The Pearson's R statistic was found to be significant for all cases (p=0.021) (Table 5). Kendall's tau statistic also showed a significant positive association (τ = 0.500, p=0.042) between the observed and predicted rank orders (Table 5). Contrary to expectation, there was an inverse relationship between money and utility (highest monetary level corresponded to the lowest utility). However, higher crop output (nutrient cycling) corresponded to a higher utility as anticipated.

Table 5: Utility scores of aggregate preference

Attribute	Attribute levels	Utility estimate	Std. error
Nutrient cycling:	Moderate output	-0.077	0.300
	High output	0.077	0.300
Water regulation:	Moderate retention	0.390	0.300
	High retention	-0.390	0.300
Protection against windstorm:	Low protection	0.188	0.300
	High protection	-0.188	0.300
Biodiversity promotion:	40% NTFP habitat	-0.060	0.300
	70% NTFP habitat	0.060	0.300
Money:	GH¢400	0.000	0.000
	GH¢450	-0.025	0.362
	GH¢500	-0.051	0.723
B Coefficient		-0.025	
(Constant)		4.519	0.404

Pearson's *R* statistic = 0.723, p=0.021; Kendall's tau statistic = 0.500, p=0.042

The ideal amount as compensation for the overall conjoint study was calculated to be GH¢400 based on utility values. This amount was calculated by dividing the sum of the three money levels (GH¢400, GH¢450 and GH¢500) by the sum of the utility values for the money levels (0.000, -0.025 and -0.051). This resulted in each unit of utility being worth -GH¢18000. The ideal amount is found at a utility value of zero (which does not add or subtract from the perceived value). The utility value at zero for the three price points was 0.000. This number was multiplied by -GH¢18000 to get 0 and subtracted from the amount with zero utility to get, GH¢400. This resulted in the amount of GH¢400/hectare/year as ideal compensation.

Relative factor importance scores

Relative factor importance scores were computed from average part-worth scores of attributes to ascertain the difference each attribute made in the total utility of a profile. The computation indicated that water regulation (24.62%) was almost equally important as money (22.62%), followed by biodiversity promotion (18.93%) (Figure 2).

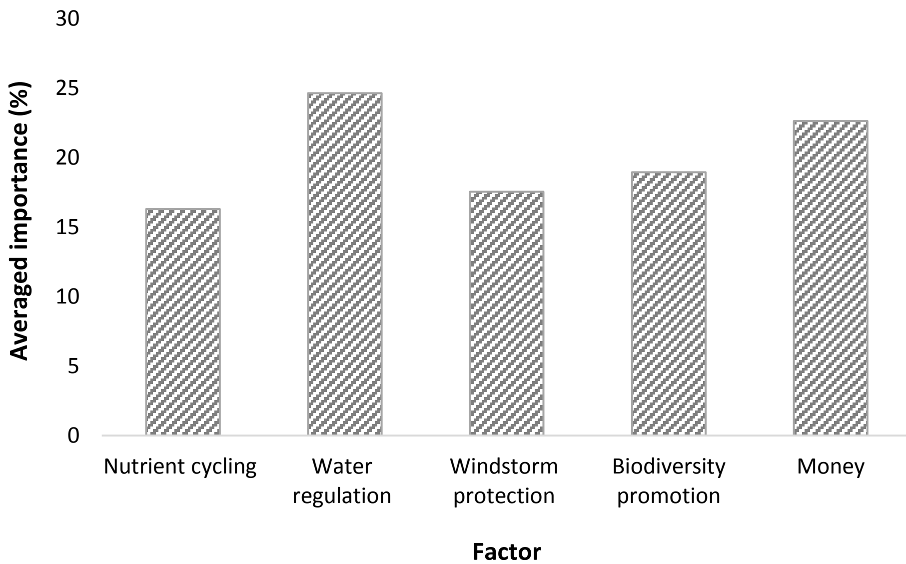

Figure 2: Relative importance scores of attributes of environmental services

Ordered logistic regression results

Table 6 contains the estimated coefficients for the two models (1 with only attributes levels and 2 with only respondent's characteristics). From the results, educational level of a respondent, community a respondent belongs to and marital status are the significant variables explaining the ranking of profiles. Respondents who were not married (p=0.015) are more likely to be in higher categories (utility from most preferred choice profile made up of higher levels of observed attributes) compared to widows. Again, respondents from Abonsrakrom community (p=0.032) are more likely to be in higher categories compared to their counterparts in Ntabene community. Those with no formal education (p=0.013), primary (p=0.007) and middle school education (p=0. 014) are also more likely to be in the higher categories compared to those with university education. The results also revealed that attribute levels had little effect on the ranking of the profiles. Respondent's gender and age had insignificant effects on how profiles were ranked (Table 6).

Table 6: Ordered logistic results on ranking of profiles

Variable	Estimate	Std. Error	Wald	df	Sig.
Model 1					

Attributes and levels						
Nutrient cycle	Moderate crop output	-4.057	2.233	3.301	1	.069
	High crop output	0[a]	.	.	0	.
Water regulation	Moderate water retention	-1.164	1.981	.345	1	.557
	High water retention	0[a]	.	.	0	.
Windstorm protection	Low windstorm protection	1.053	1.812	.337	1	.561
	High windstorm protection	0[a]	.	.	0	.
Biodiversity promotion	40% NTFP habitat	-1.840	1.822	1.020	1	.312
	70% NTFP habitat	0[a]	.	.	0	.
Money	Gh₵400	-2.939	3.353	.769	1	.381
	Gh₵450	-2.893	3.388	.729	1	.393
	Gh₵500	0[a]	.	.	0	.
Model 2						
Characteristics of respondent						
Gender	Male	.028	.332	.007	1	.933
	Female	0[a]	.	.	0	.
Marital status	Single	3.136	1.285	5.953	1	.015
	Married	.663	.576	1.322	1	.250
	Separated	.955	.831	1.321	1	.250
	Widowed	0[a]	.	.	0	.
Age	25-34	-.617	.840	.540	1	.462
	35-44	-.553	.641	.743	1	.389
	45-54	-.065	.620	.011	1	.917
	55-64	-.831	.586	2.012	1	.156
	>65	0[a]	.	.	0	.
Education	No formal education	2.560	1.034	6.130	1	.013
	Primary	2.824	1.043	7.330	1	.007
	Junior high	1.705	.971	3.086	1	.079
	Middle school	2.483	1.010	6.040	1	.014
	University	0[a]	.	.	0	.
Communities	Twumkrom	.369	.309	1.424	1	.233
	Abonsrakrom	.709	.330	4.607	1	.032
	Ntabene	0[a]	.	.	0	.

*Link function: Complementary Log-log.
**a. This parameter is set to zero because it is redundant.

Various measures of model fitting were used as indicators of how well the models fitted the data. Both model 1 (χ^2=17.105, p=0.025) and model 2 (χ^2=75.445, p<0.001) outperformed their null models. Hence, the null hypothesis that the model without predictors is as good as the models with the predictors was rejected (Table 7).

Table 7: Model Fitting Information

Model 1	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	36.585			
Final	19.480	17.105	6	.025
Model 2				
Intercept Only	296.713			
Final	221.268	75.445	16	.000

The Pearson and Deviance Chi-square values were statistically insignificant at a p-value of 0.05 which is an indication that the models adequately fit the data (Table 8). Again, the Cox and Snell and Nagelkerke R^2 values for model 1 explains over 40% of the variation in the dependent variable while that of model 2 explains over 80% variation (Table 9).

Table 8: Goodness-of-Fit

Model 1	Chi-Square	df	Sig.
Pearson	14.710	15	.473
Deviance	13.844	15	.537
Model 2			
Pearson	11.211	15	.738
Deviance	11.607	15	.709

Table 9: Model Summary (Pseudo R-Square)

Model 1		Model 2	
Cox and Snell	.427	Cox and Snell	.885
Nagelkerke	.456	Nagelkerke	.939
McFadden	.201	McFadden	.759

According to the test of parallel lines results (Table 10), there was no significant difference for the corresponding regression coefficients across the response categories, suggesting that model 1 (χ^2=8.634 and p=0.567) and model 2 (χ^2=95.591 and p=0.493) do not violate the assumption of parallel lines (Table 10). Thus, both models with the complementary log-log link provide evidence that satisfies the parallel lines assumption.

Table 10: Test of Parallel Lines

Model 1	-2 Log Likelihood	Chi-Square	df	Sig.

Null Hypothesis	19.480			
General	10.847	8.634	12	.567
Model 2				
Null Hypothesis	298.434			
General	202.843	95.591	16	.493

Discussion

Socio-demographic characteristics of respondents

A greater number of respondents in this study were females reinforcing the findings of Abugre et al., (2010) that, the MTS is gender friendly. It is important to note that majority of respondents were aged between 55-64, with most of them being resident in their communities for over 45 years. This was of great significance as they would have been around long enough to have observed the changes the forest had undergone to make meaningful contribution to the study. Most of the respondents had completed middle school (10 years of schooling) and as such, had some form of knowledge about plantation forest environmental services. Owubah et al., (2001) argue that the level of education of farmers influences their ability to engage in sustainable forest management. On the contrary, Ardayfio-Schandorf et al., (2007) argue that although secular education may be important, it is not the only determinant for people to engage in forestry but factors such as indigenous knowledge of trees by people also play a critical role. This was what farmers who had no formal education depended on in answering the survey questions. In general, respondents had large family sizes to provide labour on farms.

Ranking of environmental services of MTS plantation forests

The ranking of water regulation as the most essential environmental service was unanimous amongst the study communities. The sources of water for domestic and agricultural use in these communities are rainwater, boreholes and dug-out wells owned by individuals. This has been the case since the degradation of the Pamu-Berekum forest reserve led to the loss of the watershed protection function of the forest ecosystem which in turn affected their streams and catchment areas (Blay et al., 2008). In reaction to this development, new sources of water had to be provided. The main challenge with these new sources of water is that they are very far from the farms and as such, high cost has to be incurred in carrying out irrigation activities. Since respondents to the study were mostly peasant farmers, they lacked the capacity to improve productivity through irrigation on a large scale. However, with the rehabilitation of the degraded areas, farmers lauded the change in their ecosystem. They cited instances where the plantation forest had improved water yield and storage in artificial dams, helping them irrigate their farms and also, raise nurseries to reforest other degraded areas. Farmers in Ntabene and Abonsrakrom communities reiterated the fact that streams which used to dry up during the dry season can be accessed all year round owing to the protection that the established plantation offers (Willis, 2002; Dyck, 2003).

Respondents applauded the stability the plantation forest had brought to their soils through the control of run-off erosion corroborating the findings of Krieger (2001) and Dyck (2003). This was more pronounced in Twumkrom because, the open and undulating nature of their land made it easy for loose topsoil to be carried off anytime it rained. This phenomenon had also resulted in the siltation and drying up of most of their streams and artificial dams. Aside erosion control, respondents also testified of improvement in soil moisture retention (Kumar, 2005). Again, respondents commended the contribution the plantation forest had made towards improving soil nutrient. The farmers revealed that the plantation forest had reduced their cost of improving nutrient of agricultural lands with chemical fertilizers.

Both farmers and FSD staff agreed on how the plantation forest had improved the diversity of flora and fauna in the study communities. They were of the view that the plantation forest had provided habitat for resident and transient species, pollinators and other non-timber forest products to thrive, curbing biodiversity decline in the area (Adamowicz et al., 1998; Dyck, 2003). According to Oduro (2002), NTFPs contribute immensely to the livelihoods and welfare of populations living in and adjacent to forests. Farmers were pleased they could once again collect snails, harvest mushrooms and hunt bush meat to supplement their dietary needs. They could also harvest creeping vines or forest climbers to bind firewood or foodstuffs gathered for transportation (Falconer, 1992). In addition, some were pleased with the aesthetic view the plantation forest provides and also, knowing that the flora and fauna would continue to exist for future generations because of the habitat that the plantation forest has provided.

The results indicated that the FSD staff had a significantly stronger preference for carbon sequestration than the communities. In another breadth, the awareness of communities about the carbon sequestration function of forest might have influenced how they ranked this service. Though some of them mentioned that forests are able to remove harmful substances from the atmosphere, they could not explain the mechanisms behind it. Those who made these remarks were taungya heads (leaders of participating farmer groups) or individuals who by virtue of their positions have attended workshops or seminars where the roles of forest in climate issues were discussed. The remaining farmers had very little to say on the carbon sequestration service of the forest plantation. Moreover, the significant difference between the responses of FSD staff and farmers is an indication of the communication gap that exists between these stakeholders (Marfo, 2010). In general, it was observed that farmers were more interested in environmental services which had direct impact on their agricultural activities whilst the FSD officials were more concerned about those which ensured ecological stability.

Willingness to accept compensation for planting trees

Each step of the research leading to the estimation of WTA was built on the perspectives of respondents who were also participants in the selection of plantation forest environmental services. Participants in this study reported that water regulation was the most influential attribute in ranking of the profiles. This finding reinforces results obtained for the most relevant environmental attribute. The high relative importance that respondents placed on water regulation revealed how they appreciate the watershed protection role of plantation forests, in the absence of which farmers incur huge cost in carrying out irrigation activities. Contrary to the result in this study, most conjoint studies (Hardy et al., 2000; Behe et al., 2005; Mason, 2007), found price (money) to be the most important factor. However, in this study, increasing monetary values had no effect on the ranking of choice profiles. The increasing money variables rather produced negative utilities.

Respondents perceived nutrient cycling as the least important factor. This could be attributed to the difficulty encountered by respondents in judging between the factors presented in the study (Hardy et al., 2000). It could also be that respondents placed themselves in a realistic situation where they have to leave established plots when tree canopy closes (Agyeman et al., 2003) and thus, gain no direct benefit from soil enrichment in situ. The improvement in soil nutrient translated into bumper crop harvest corroborating the findings of Kalame (2009), Kalame et al., (2011) and Ros-Tonen et al., (2013) that MTS plantation forests contribute significantly to food security. In this study, higher crop output corresponded to a higher utility as anticipated. Again, higher levels of habitat provision for NTFPs produced high utilities. Respondents however, expected species diversity to increase over time as forest composition becomes more developed (Oliver and Larson, 1996). The indigenous species (*Terminalia superba, Entandrophragma* spp, *Khaya* spp) used in the plantation would also enhance biodiversity (Blay et al., 2008).

The amount of money respondents were willing to accept as compensation for improving environmental services of plantation forest was calculated by converting utility values into monetary values. Orme (2001) suggests that converting utility values into monetary values enhances the interpretation of conjoint data. The utility to monetary value calculations in this study were done strictly for the purpose of interpretation. The results revealed that respondents were willing to accept GH¢400/hectare/year as compensation in addition to future proceeds from sale of timber per the benefit sharing agreement of MTS (Agyeman et al., 2003). A study by Shaikh et al., (2007) corroborates this finding. In their study, farmers were also willing to accept compensation for planting trees on their agricultural lands to sequester carbon aside future benefits from the trees. In a similar study by van Beukering et al., (2008), farmers were willing to accept compensation in the form of agricultural inputs (seedlings, fertilizers and pesticides) aside the most preferred type of compensation (money, grants or subsidies).

The ordinal logistic result revealed that characteristics of respondents had more influence on ranking of choice profiles compared to attribute levels. The finding that respondents from Abonsrakrom community are more likely to be in higher categories of choice profiles with higher utilities was not surprising. This community has the highest reforested total area of 76.208ha compared to Twumkrom (26.558ha) and Ntabene (24.774ha) (Damnyag et al., 2015). As a result, their expectation is to derive the maximum benefit accruing from the plantation. Again, the likelihood of respondents with no formal, primary and middle school education to be in the higher categories of choice profile with the highest utility is understandable. Respondents with university education had employment in the civil or public sector and as such, have diversified sources of income compared to those with no formal, primary and middle school education whose occupation is only farming. Odds ratios were not computed for the ordered logistic regression models because of the complicated nature of the clog-log link function (Chan, 2005) which places limitations on the direct interpretation of parameter estimates. As such, only the direction of the coefficients were explained. The choice experiment technique allowed respondents to indicate the relative value that they place on various environmental services of small holder MTS plantations.

Conclusions

This study investigated environmental values from MTS forest plantations in the Dormaa forest district. From literature and focus group discussions, environmental services of plantation forests were identified. Respondents were asked to determine the significance of these services. Results of the study revealed that water regulation was the most essential environmental service for stakeholders. In general, it was observed that farmers were more interested in environmental services which had direct impact on their agricultural activities whilst FSD officials were more concerned about those which ensured ecological stability. The environmental values of plantation forests were estimated through choice modelling. This non-market valuation method was selected because it allows multiple-choice options and attributes. It also allows the integration of respondent's characteristics to elicit their environmental preferences. It was discovered that water regulation was the most influential attribute in the ranking of choice profiles. Farmers were willing to accept GH¢400/hectare/year as compensation for improving environmental services in addition to future benefits from sale of trees. The study provides useful information to forest managers for the evaluation of actions, plans and policies to enhance sustainable forest management in Ghana and in other tropical countries.

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