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Sustaining Protected Forests and Forest Resources in Ghana: An Empirical Evidence

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ABSTRACT

The increasing concern for sustainable forest and protected forest resources motivates this study. In the wake of rising protected forest depletion, climate change and public health problems, this study through a bidding game format develops a sustainability index to show households' sustainability behavior toward the protected forests in the Greater Accra Region of Ghana. Relying on a cross-section of household survey data and regression analysis, this study finds that overall, approximately 79% of respondents exhibited sustainable behavior toward protected forests in GAR. Also, this sustainable behavior is associated with expected revenue of GH¢ 80,837,594 (USD$ 15,368,398) per annum. We also find that socioeconomic, psychological, and environmental factors are the main drivers of protected forest sustainability in the Greater Accra Region, Ghana. This study has important implications for institutions working toward sustaining protected forest and forest resources in Ghana.

KEYWORDS

Forest; forest resources; sustainability; revenue; survey; Ghana

Introduction

Globally, the value of forest resources for sustainable life and wellbeing cannot be overemphasized (Food and Agriculture Organization [FAO], 2020; Haase et al., 2014; Roy et al., 2012). Baumgartner (2019) demonstrates how forest ecosystems is essential to life, and directly or indirectly linked to the Sustainable Development Goals (SDGs). Forests provide food and fiber, wood, minerals, and serve as a habitat for several wildlife, especially endangered species, among other use values (Atmiş, 2016; Miller & Hajjar, 2020). They also provide nonuse values such as recreation, mitigation of global warming and serve as a symbol of cultural identity (Dreyer et al., 2019; Duinker et al., 2015; Endreny, 2018; Van der Jagt & Lawrence, 2019).

Depletion of forest and forest resources over the years have brought damages to several fauna and flora, reducing potential levels of wellbeing (Akanwa et al., 2020; Jusoff & Taha, 2008; Okoji, 2001; Rahman, 2015; Renó & Novo, 2019). For example, rapid rates of forest depletion since the year 2000 is closely associated with severe changes in the climate, which have become a pertinent issue in this dispensation (Cantarello et al., 2014; Mutoko et al., 2015). Several climate change control policies including REDD+ (Reducing

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Emissions from Deforestation and forest Degradation) and the SDGs (Goal 12, 13, 15) are being implemented to help address the harmful effects of global warming (Hajjar, 2015). These are necessary and meant to improve sustainable life on the planet. While significant gains in forest resource regeneration have been made over the years in developed countries, the reverse is the case in many developing countries (Denga et al., 2017; Food and Agriculture Organization [FAO], 2020; Nath & Magendran, 2021; Van der Jagt & Lawrence, 2019). The situation in most developing countries appear to follow the forest transition channel which predicts a direct relationship between the state of economic development and forest regeneration (Lambin & Meyfroidt, 2010; Rudel et al., 2020).

Forest transition paths seek to explain how forest resource undergoes a gradual process of shrink and regeneration over time (Lambin & Meyfroidt, 2010; Rudel et al., 2020). Currently, the shrinking forest cover in developing countries, especially those in Africa, are generally influenced by human activity (e.g., population growth, urbanization, increased demand of forest products), global economic forces and government policies (Amoah & Korle, 2020; Cantarello et al., 2014; Lambin & Meyfroidt, 2010; Mutoko et al., 2015). The extent of forest cover on the continent has significantly decreased (on average by about 3.5 million hectares annually from 1999 to 2020), limiting the benefits of carbon storage and climate regulation, among others, that this resource provides (Food and Agriculture Organization [FAO], 2020; Moon & Solomon, 2018). However, of all the notable forest transition pathways, there is no consensus on which specific or mix of pathways to inform efficient regeneration of forests resources in Africa (Oduro et al., 2015; Van der Jagt & Lawrence, 2019).

Furthermore, the huge diversity among individuals and communities in Africa presupposes that forest transition paths relating to socio-economic, environmental, political and psychological factors are unique among countries (Lambin & Meyfroidt, 2010; Oduro et al., 2015). Although key global and national intervention programmes have already begun in several regions of Africa, Van der Jagt and Lawrence (2019) point to the fact that outcomes of such policies could be improved with a holistic evaluation of preferences and backgrounds of various stakeholders. This has been echoed by Acharya et al. (2019), highlighting a peculiar gap in forest resource evaluations in Africa because of market failure and information asymmetry. Granted that all these aspects are addressed, the amount of forest cover lost can be restored with well-informed policy intervention and awareness creation.

Oduro et al. (2015) assert that the forest transition path observed in Ghana is the result of reaction to scarcity of forest resources emanating from severe depletion, seen in reforestation policies such as tree planting and enactment of rules for their protection. However, the authors argue that low rate of forest plantation activities as well as rapid population growth and urbanization, create excess demand for wood and encroachments on forest reserves. Based on this phenomenon, they maintain that there is no strong force to a forest transition in Ghana. As it is the general case in Africa, Amoah & Korle (2020) have drawn attention to the fast and growing levels of forest cover loss in Ghana between the years 1990 and 2020. The share of the forestry and logging subsector has been on a decline as indicated by the Ghana Statistical Service (2019). Overall, the contribution of the forestry and logging subsector declined from 6% to about 1.6% of total non-oil GDP in 2018. The argument for sustainability of forest resources in the country is strong because the subsector provides employment opportunities for large proportion of the youthful population (Osei-Tutu et al.,

2010). Lumbering activities is the fourth largest foreign exchange earner, accounting for 1.3% of merchandise exports in 2019 (Bank of Ghana, 2020).

A few studies have examined the scope of forest resources in Ghana and the threats brought by their depletion. While some focus on valuations (Ansong & Røskaft, 2014; Navrud & Vondolia, 2005), others explore the drivers of forest cover losses (Amoah & Korle, 2020; Hawthorne & Musah, 1993; Oduro et al., 2015; Tuffour, 2013). For instance, Amoah and Korle (2020) have provided a robust evidence of forest depletion in Ghana. This, they argue are driven largely by varying intensities of human activity, institutional failure and climate change. Conspicuously missing in these studies is an insight on the sustainability of protected forests undergoing rapid depletion. As a result, the current study intends to focus on sustainability of such protected forest resources to prevent extinction of several endangered species of plants and animals.

The key research objective in this study, therefore, is to identify the proximate and underlying elements of sustainable forest actions of households. Sustainability in this context is the commitment revealed through a bidding game process involving households, which is intended to provide pecuniary and real means for restoration and maintenance of protected forest resources. We operationalize this idea in terms of a simple binary index. This index is generated through a simultaneous interaction between expressed willingness to pay for restoration (present) and maintenance (future) of forest ecosystem in three municipal areas within the Greater Accra Region (GAR), respectively. In order to predict values of this index, we follow Nath and Magendran (2021) and hypothesize that a household's decision to conserve forest resources or household's sustainable forest behavior is influenced by socio-economic, environmental and psychological factors.

The contribution of the study is evident in extending the discourse on sustainable forestry through conceptualization, operationalization, and evaluation of sustainable forestry behavior. That is, it goes beyond presenting evidence of forest depletion to presenting a new means of revealing sustainable household forestry behavior. Also, the paper provides unique policy insights with relevance to developing countries, especially where forest depletion is still endemic.

The rest of the paper is organized as follows: Section two elaborates on the materials and methods used for the study. Section three presents the results which is followed by the discussions in Section four. Section five dwells on the conclusion and policy implications.

Materials and methods

Study site

This study focuses on three protected forests as the study sites. These sites are located in different municipal areas of the GAR, Ghana. Specifically, the Gua Kuo Sacred Forest is located in the Ga North Municipal and currently covers an area of 0.70 square kilometers. Also, the Achimota Protected Forest which now covers an area of 4.02 square kilometers is located in the Okaikwei North Municipal. The Shai Hills Protected Forest is located in the Shai Osudoku Municipal covering an area of 52.67 square kilometers. That is, currently, the Gua Kuo Scared Forest is the smallest protected forest in the region whiles the Shai Hills Forest is the largest in land area.(see Figure 1)

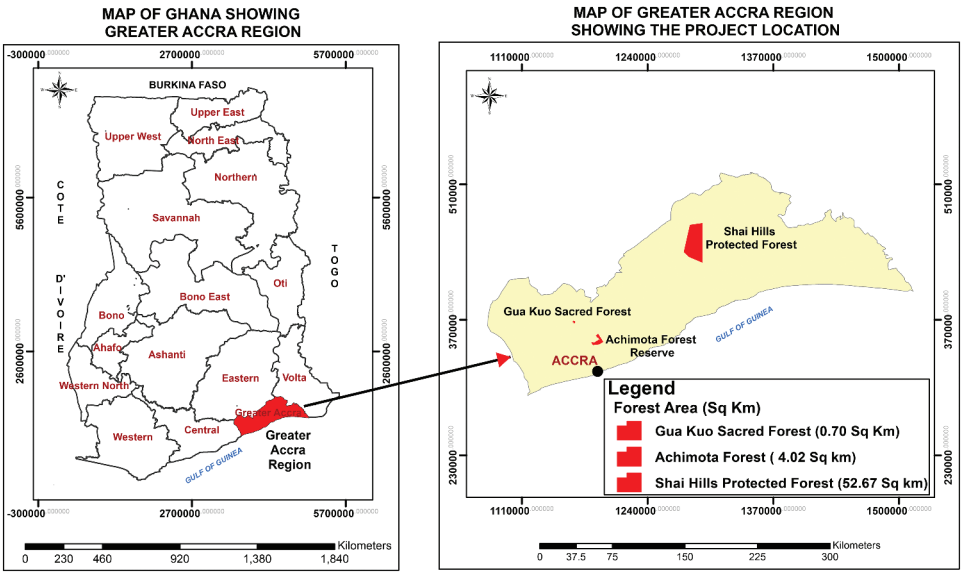

Figure 1. Map of the Study Area.

The primary animal species commonly found in these urban protected forests may include green monkeys, baboons, birds (examples: violet Turaco, Paradise Flycatcher, Green Turaco, Red-billed Hornbill, Yellow-fronted Tinkerbird, and Red-necked Buzzard), antelopes, bats, cats, duiker, Guinea fowls, kobs, monitor lizards, African python, royal python etc. If urgent sustainable measures are not taken, the region is likely to lose its forests and forest resources in a short while.

The closed and open canopies, built-up areas, shrub and grass cover of the three urban protected forests are presented in Figures 2, 3, 4. Amoah and Korle (2020), have used these indicators to argue that from 1990 to 2015 there is overwhelming evidence of depleting trend in all the three protected urban forest and forest resources. Admittedly, government

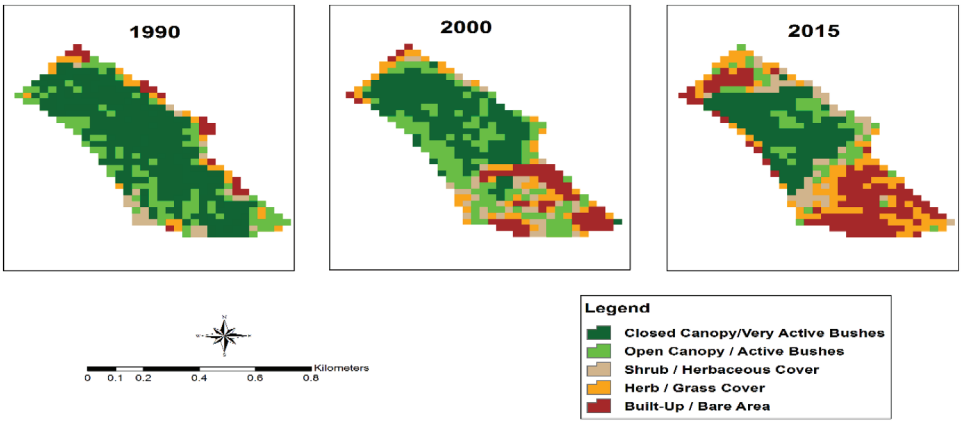

Figure 2. Trend of Depletion at the Gua Kuo Sacred Forest (Adapted from Amoah and Korle, 2020).

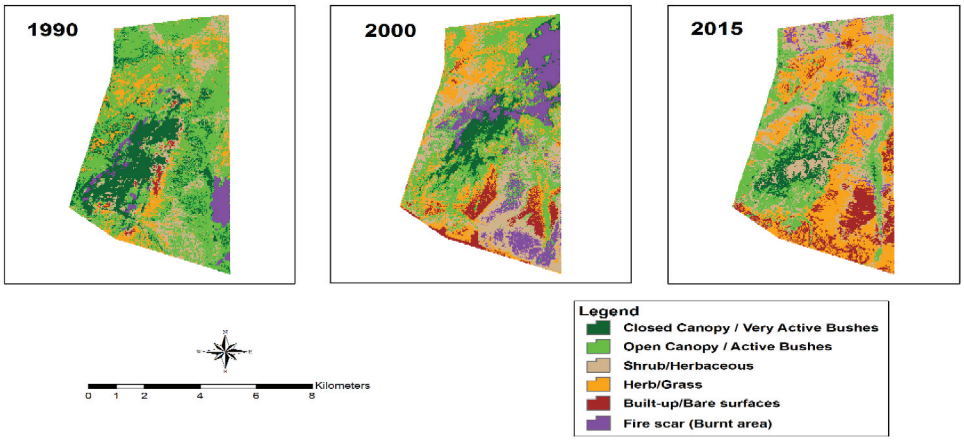

Figure 3. Trend of Depletion at the Shai Hills Forest (Adapted from Amoah and Korle, 2020).

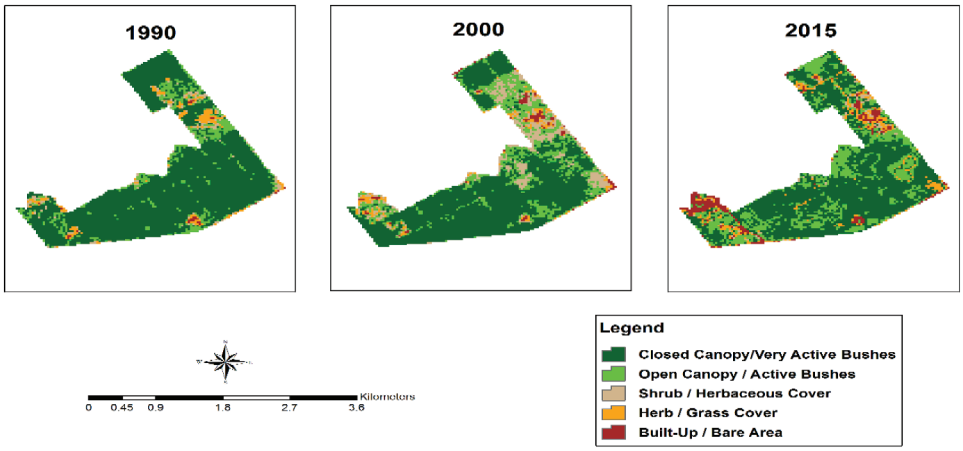

Figure 4. Trend of Depletion at the Achimota Forest (Adapted from Amoah and Korle, 2020).

through the Municipal Assemblies and the Forestry Commission have made efforts toward restoring these forests. Nonetheless, not much has been achieved as the trend of depletion persists. Indeed, to preserve the once beautiful biodiversity for the current as well as the future generation, a sustainable effort is critical.

Data processes

This study relies on a quantitative approach. Data was collected during the months April to June, 2019, by which time the region had a population of 4,010,054 inhabitants and 766,955 households (Ghana Statistical Service, 2012). Primary data collected from households in the three municipal areas in the GAR is used. To obtain the data, the stratified random sampling method was applied. This was achieved by constructing community-level strata from the three defined municipal areas. Each stratum had housing units listed, out of which

respondents were randomly selected. In all, this probability sampling method yielded a sample size of seven hundred and thirty-three (733) household respondents. Given that not all respondents responded to all questions, we acknowledge about 18% missing responses. Nonetheless, the total observation of six hundred and twenty-three (623) is representative of the population. This approach allows for generalization of the research findings to the study region (GAR). There was a nearly equal share of respondents from each of the municipal areas. That is Shai Osudoku Municipal, Okaikwei North Municipal, and Ga West Municipal represented 33.02%, 33.83% and 33.15%, respectively.

The fieldworkers included twelve fieldworkers whose activities were coordinated by three field coordinators. In each municipal area, five data collectors were assigned. This comprised of four fieldworkers whose activities were supervised by a field coordinator. The project investigators together had oversight responsibility over the fieldwork from commencement to the end of the data collection. All field workers were trained for the purpose of the data collection. This was to ensure that administrators of the questionnaire exhibited mastery over the content and worked within a reasonable time with less fatigue to both the interviewer and the interviewee. The first task of the trained fieldworkers was to administer the pilot survey which took place in a day.

For simplicity of presentation, the questionnaire is structured into sections which include demographic information on the respondent, forest and environment data, and sustainability measure (or valuation) questions. The approved and tested questionnaire was administered to households using the face-to-face interview method. That is, this study relies on a cross-sectional household survey data to determine the factors that drives forest sustainable behavior in Ghana.

To generate the sustainability index as illustrated in Table 1 (i.e., a measure of sustainable forest behavior), two main questions were asked the respondent after a hypothetical market scenario of a restored and well-maintained forest was described. These are:

Q1: *Are you willing to pay X-amount per annum for the* **restoration (present/today/now)** *of the forest and forest resources in your district?*

Q2: *"Are you willing to pay X-amount per annum for the* **maintenance (future/tomorrow)** *of the forest and forest resources in your district?"*

Empirical strategy

The sustainability index is an ordinal variable which takes the value of 1 if the respondent subscribes to forest sustainability and 0 for otherwise. Here, forest sustainability is strictly defined as the willingness to pay for forest and forest resources restoration (*present*) as well as its maintenance (*future*). This description has its basis in the United Nations Brundtland Commission (1987) definition of sustainability: "meeting the needs of the present generation without compromising the ability of future generations to meet their needs" (p. 1). Given that our construct of sustainability yielded a binary dependent variable, Gujarati et al. (2012) has presented three approaches to modeling such data framework. These include ordinary least squares (OLS), which yields the linear probability model (LPM), the logit model, which follows the logistic probability distribution, and the probit model which is based on the normal distribution. In this study, the LPM model is used as the preferred model whiles the logit model is also estimated for robustness checks. Similar to Hajdu et al. (2020), and Angrist and Pischke (2008), the LPM is preferred because it is able to estimate

an effect without the need to impose a certain functional form, which is not the case in logit and probit models (Angrist & Pischke, 2008). Secondly, the LPM coefficients are interpreted directly as marginal effects unlike the probit and logit whose parameters have to be transformed into marginal effects. Admittedly, the LPM predicted probabilities can fall outside the 0 to 1, interval. However, given that our aim is to estimate the average partial effect, this drawback is made redundant (see Wooldridge, 2015). Now, we present the LPM as equation 1:

$$Y_i = \alpha_0 + \alpha_1 X_{1i} + \alpha_2 X_{2i} + \ldots + \alpha_k X_{ki} + u_i \tag{1}$$

The dependent variable, Y_i is a binary variable which is described as a linear probability model. The X_s are the independent variables explaining the probability that the dependent variable will take a one (1) or a zero (0). The α_s are the unknown parameters to be estimated in the model and u is the error term which captures all other determinants of the dependent variable not included in the model.

The expected probability of the dependent variable given the independent variables are presented as

$$E(Y|X_1, X_2, \ldots.., X_k) = P(Y = 1|X_1, X_2, \ldots., X_3) \tag{2}$$

where the right-hand side of equation 2 is re-written and equated to the linear model presented in equation 1.

$$P(Y = 1|X_1, X_2, \ldots., X_3) = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \ldots + \alpha_k X_k \tag{3}$$

From equation 3, α_j is defined as the change in the probability that the dependent variable equals one ($Y_i = 1$), assuming the other $k - 1$ regressors equal zero. We re-write equation 3 in its estimable form as:

$$SI = \alpha_0 + \alpha_1 SE_1 + \alpha_2 Psy_2 + \alpha_3 Env_1 + u \tag{4}$$

where the dependent variable, *SI* is protected forest sustainable index, *SE* is a vector of the socio-economic variables, *Psy* is a vector of psychological variables that can influence respondents' sustainability behavior, *Env* is a vector of environmentally related variables used in the model, and u is as already defined. However, because of possible heteroscedasticity, the final model is estimated as LPM with fixed effects. As expounded by Hajdu et al. (2020) and Timoneda (2021), the LPM with fixed effects can exhibit superiority over the logit and probit maximum likelihood estimators. Based on the LPM model (as well as the Logit model), we hypothesis that sustainable forest behavior is determined by socio-economic, psychological, and environmental factors. It is important to reiterate that in the final regression results as shown in Table 5, both LPM with fixed effects and the logit maximum likelihood are shown.

Results

Table 2 presents the descriptive statistics of the variables used in the model. For each variable presented in the table, the results are analyzed at the 25th, 50th and 75th percentile. These descriptive results provide some background information that helps us understand the profile of respondents in the sample.

Table 1. Generation of sustainability index.

WTP Restoration (Today/Now)	WTP Maintenance (Future/Tomorrow)	Categorized Index (Today & Future)	Coding Index (Today & Future)	Sustainability Index (Today & Future)
Yes	Yes	Yes	Yes = 1	1
No	Yes	No	No = 0	0
Yes	No	No		
No	No	No		

WTP implies Willingness-to-pay

Table 2. Descriptive analysis of results.

Variable	N	p25	p50	p75
Sustainability Index (SI)	623	1	1	1
Age	623	27	32	42
Gender	623	0	1	1
Income (GH¢)	623	445	800	1600
Admire	623	0	1	1
Eco-Friendly	623	1	1	1
Global Environmental Knowledge	623	0	0	1
Noise Pollution	623	0	0	1
Communal Env. Services (Park)	623	1	1	1
Educational Status	623	0	1	1
Trust in Forest Institutions	623	0	0	1
Forest Depletion	623	2	3	4

*Note: P means Percentile, GH¢ is Ghana Cedis

First, the results from Table 2 show that most respondents reflected sustainable behavior toward forest resources at the 25th, 50th and 75th percentile in the data. Indeed, across all percentiles, the results show that respondents also indicated that they were engaged in eco-friendly practices in their communities. This finding is similar to results from studies on Ghana such as Amoah and Addoah (2021), who argue that respondents demonstrate pro-environmental behavior based on their knowledge of the environment. This finding also aligns with the results of Nath and Magendran (2021), whose also find evidence of sustainability behavior toward forests in Malaysia.

Furthermore, males aged 32 years, educated and earning GH¢800 averagely dominated at the 50th percentile. Although this adult cohort averagely demonstrated much global knowledge on environmental issues and avoided noise pollution, the results show that the majority of respondents at this percentile engaged in communal environmental services (cleaning parks and surroundings, etc.) and agreed to forest depletion, albeit moderately. Nevertheless, this cohort of respondents also reported a lack of trust in forest institutions.

We find that the profile of respondents at the 50th percentile differs from those at the 75th percentile in the data. Males also dominated at the 75th percentile, being 42 years averagely, educated and earning GH¢1600 averagely. By implication, this cohort of respondents earn relatively more, contributes more to revenue of the government, and would expect more from government. Further, the results also show that respondents at the 75th percentile of the data are knowledgeable in global environmental issues, engage in eco-friendly environmental practices and communal environmental services, have trust in forest institutions and agreed to the fact that the extent of forest depletion is high. In addition, these respondents admitted being indifferent to noise pollution.

Finally, females aged 26 years on average, uneducated and earning GH¢445 were dominant at the 25th percentile. Despite engaging in eco-friendly and communal

environmental services, these respondents did not have much admiration for forest resources, had no knowledge on global environmental issues and did not trust forest institutions. Furthermore, respondents in this percentile shunned noise pollution and agreed that there was evidence of forest depletion, albeit low in magnitude.

The results suggest that most respondents exhibited sustainable behavior toward forest resources despite the difference in characteristics of respondents in the sample. In the empirical literature, this finding aligns with Nath and Magendran (2021), whose study shows that most respondents show positive signs toward sustaining forest reserves. Also, Amoah and Addoah (2021) present recent evidence on how citizens in Ghana show evidence of pro-environmental behavior based on their knowledge of the environment.

We further examine the extent of sustainable behavior reported of respondents by focusing on different forest reserves in the Greater Accra region. The results, presented in Table 3, show that respondents do exhibit sustainable behavior toward particular types of forest reserves. That is, the results show that majority of sustainability behavior is toward the Shai Hills Forest (84%), followed by the Achimota forest (78%) and the Gua Kuo forest (74%). Previous studies have also come to a similar conclusion. These include studies such as Steenberg et al. (2013), Young and McPherson (2013), Baur et al. (2016), and Nath and Magendran (2021), which all show that residents respond positively to efforts aimed at sustaining forest reserves in their study areas.

This paper goes further to make projections regarding potential revenue that can be made based on sustainability behavior of respondents toward forest resources. The projects are financial estimates obtained by capitalizing on the dominance of sustainable behavior of respondents in the sample. Therefore, looking at the results presented in Table 3, out of the 79% of respondents who showed sustainable behavior, average proposed payments per household by residential structure yield approximately GH¢105.4 annually. This estimate converts to GH¢30,338,537.5 as the expected revenue per annum for each residential structure in the region as shown in Table 4.

At the heart of the paper is the hypothesis that a household's decision to conserve forest resources is influenced by socio-economic, environmental, and psychological factors. With the linear probability model (LPM) specified and discussed under the empirical strategy, we are able to carefully test this hypothesis. The results from the estimation of the econometric model are presented in Table 5. In line with the paper's empirical strategy, LPMs are applied to obtain the regression coefficients of Equation 4. Although the results from the LPM, shown in columns three and six in Table 5, are relied on for interpretation, we also apply the Logit estimation technique to estimate Equation 4 to check for robustness of results. Both estimation techniques yield consistent results – the signs and the statistical significance of the estimated coefficients of Equation 4 are consistent with prior expectations. This assures us that the results presented are robust.

Table 3. Percentage sustainability index (SI) by protected forest.

Achimota Forest		Shai Hills Forest		Gua Kuo Forest	
SI	*Percent*	*SI*	*Percent*	*SI*	*Percent*
0	22	0	16	0	26
1	78	1	84	1	74

Table 4. Expected revenue from households with sustainable behavior.

	Greater Accra Region		
	Expected Revenue/Household/Annum	*Number of Residential Structures*	*Expected Revenue/ Annum*
GH¢	105.4007	287,840	30,338,537.5
USD ($)*	20.0382	287,840	5,767,795.49
USD ($)**	17.6551	287,840	5,081,843.98

Average Exchange Rate as at the time data (April-June, 2019) was collected (GH¢ 5.26 = USD 1),September, 2021(GH¢ 5.97 = USD 1)*

The LPM estimation results are of interest because the paper's focus is on relationships and not the magnitude of the coefficients. Following the motivations for using the LPM discussed earlier, we also compliment the LPM results with marginal effects results from the logit estimator – see columns 1, 2, 4 and 5 of the table.

Table 5. Regression analysis of results.

VARIABLES	(1) Logit	Marginal Effects Delta-Method	(2) LPM	(3) Logit (Fixed Effect)	Marginal Effects Delta-Method	(4) LPM (Fixed Effect)
Socio-economic Factors						
Age of Respondent (Years)	−0.016*	−0.002*	−0.00250*	−0.0175*	−0.002*	−0.003**
	(0.009)	(0.001)	(0.00141)	(0.00938)	(0.001)	(0.001)
Gender (Male)	0.429*	0.054*	0.0654**	0.413*	0.057*	0.064**
	(0.221)	(0.032)	(0.0329)	(0.228)	(0.031)	(0.033)
Income of Respondent (log)	−0.361***	−0.041***	−0.0528***	−0.312**	−0.043*	−0.041**
	(0.128)	(0.018)	(0.0186)	(0.132)	(0.018)	(0.019)
Education Level (Higher)	−0.155	−0.026	−0.0239	−0.208	−0.029	−0.0336
	(0.248)	(0.036)	(0.0370)	(0.255)	(0.035)	(0.0365)
Environmental & Psychological Factors						
Admire Other Forest Resources	0.301	0.046	0.0416	0.447*	0.062**	0.0626*
	(0.230)	(0.033)	(0.0336)	(0.242)	(0.034)	(0.0339)
Eco-friendly Practices	1.060***	0.179***	0.191***	1.157***	0.190***	0.198***
	(0.245)	(0.047)	(0.0409)	(0.264)	(0.048)	(0.0419)
Global Environmental Knowledge	0.570**	0.082**	0.0819**	0.663***	0.091***	0.0918***
	(0.235)	(0.033)	(0.0343)	(0.244)	(0.033)	(0.0339)
Less Noise Pollution Concern	−0.550**	−0.078**	−0.0805**	−0.623***	−0.087**	−0.0853***
	(0.223)	(0.033)	(0.0325)	(0.232)	(0.032)	(0.0321)
Communal Env. Services (Park)	0.502*	0.071*	0.0824*	0.554*	0.076*	0.0837*
	(0.290)	(0.041)	(0.0466)	(0.301)	(0.041)	(0.0459)
Trust in Forest Institutions	−0.528**	−0.074**	−0.0858**	−0.462*	−0.067*	−0.0674*
	(0.231)	(0.037)	(0.0353)	(0.242)	(0.036)	(0.0353)
Depletion of Protected Forest – (*Baseline:No depletion*)						
Low	1.239	0.232	0.248	1.488	0.272	0.269*
	(0.903)	(0.192)	(0.162)	(0.936)	(0.191)	(0.161)
Moderate	1.491*	0.268*	0.281*	1.851**	0.321**	0.318**
	(0.897)	(0.190)	(0.161)	(0.928)	(0.188)	(0.160)
High	1.260*	0.235*	0.251*	1.544*	0.280*	0.276*
	(0.894)	(0.191)	(0.160)	(0.922)	(0.189)	(0.159)
Constant	1.684		0.722***	1.120		0.632***
	(1.271)		(0.207)	(1.413)		(0.221)
Fixed Effects Dummies	*No*	*No*	*No*	*Yes*	*Yes*	*Yes*
F(13, 609), LR chi (13, 18), F(18, 604),	*64.95****		*5.62****	*89.78****		*5.63****
Observations	623	623	623	623	623	623
R-squared/Pseudo R2	0.103		0.107	0.143		0.144

*Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1*

In addition, the regressions control for fixed effects such as the respondents' residing district – see columns four to six in Table 5. Accounting for these fixed effects improves overall model fit while preserving expected coefficient signs and statistical significance.

Starting with socio-economic factors, the results first show that older respondents and those with higher incomes are less interested in sustaining forest resources. This is because, across all the columns in Table 5, the coefficients of age and income of the respondent are negative and statistically significant.

In addition, the results in Table 5 shows that males, relative to females, exhibit more sustainable behavior toward forest and forest resources in the GAR. This is deduced from the positive and statistically significant coefficient of gender, which is seen in both LPM and logit results.

Unfortunately, the results do not show any influence of education of the respondents on sustainable behavior toward forest and forest resources in the GAR. This stems from the negative and statistically insignificant coefficient of education, which is seen in both LPM and logit results.

Aside the biographic characteristics of respondents, previous studies argue that forest resources are impacted by human behavior, some institutional factors, and policies (Amoah & Korle, 2020; Mutoko et al., 2015). Therefore, we also consider the extent to which other human and institutional factors influence sustainable behavior toward forest resources in Ghana.

First, consider environmental and psychological factors such as respondents' admiration of other forest reserves relative to their admiration for forest reserves in their locality. The results in Table 5 show that respondents who admired other forest reserves reflect more sustainable behavior toward forest reserves in their locality, irrespective of their district or location. This can be seen in columns four to six of Table 5, where the coefficient of admiration of other forest resources is positive and statistically significant at the 5% level.

[1]Similarly, the results show that holding all other influences constant, the respondents' eco-friendly practices is a statistically significant determinant of respondents' sustainable forest behavior. That is, respondents had engaged in eco-friendly practices show sustainable forest behavior. The is deduced from the coefficient of respondents' eco-friendly practices is positive and statistically significant at the 1% level across all the models.

We again find similar results regarding respondents' knowledge of global environmental issues. The results presented in Table 5 show that respondents' knowledge of global environmental issues is a significant determinant of sustainable forest behavior. This means that respondents with knowledge on global environmental issues are more likely demonstrate sustainable forest behavior. This stems from the positive and statistically significant coefficient at the 1% and 5% levels across all the columns in Table 5.

Likened to these results are the findings on respondents' participation in communal environmental services such as joint cleaning exercises and, desilting of gutters and cleaning parks. The results presented in Table 5 show that respondents' participation in communal environmental services is a significant determinant of sustainable forest behavior. The coefficients of respondents' participation in communal environmental services are positive

[1]Bank of Ghana (2007). Housing Market in Ghana. https://www.bog.gov.gh/wp-content/uploads/2019/07/bog-housing.pdf

and statistically significant at the 10% level, across all the models, which affirms our conviction regarding this determinant.

These results suggest that positive attitudes or psychological behaviors toward the environment significantly influence respondents' sustainable forest behavior. Contrary to this, we find that respondents' sustainable behavior toward forest resources is affected negatively by attitudes such as noise pollution activities. That is, the results presented in Table 5 show that respondents who are not concerned or actively engaged in noise pollution are less likely to exhibit sustainable forest behavior. This conclusion is affirmed based on the negative sign and statistical significance of the coefficients of respondents' noise pollution activities across all the models.

Also, the results in Table 5 show that the lack of trust in forest institutions is another negative attitude that affects respondents' sustainable behavior toward forest resources. That is, the results show that respondents who do not have trust in forest institutions are less likely to engage in sustainable forest behavior. This conclusion is affirmed because of the negative sign and statistical significance of the coefficients of respondents' trust in forest institutions across all the models.

Finally, relative to the "*no forest depletion*" respondents, those who believed that the extent of forest depletion is low, moderate, and high significantly influences respondents' sustainable forest behavior. That is, the more respondents know of the depletion, the more they are likely to engage in sustainable forest behavior.

The statistical significance of coefficients of socio-economic, environmental, and psychological factors presented in the regression results in Table 5 give us the confidence that, indeed, such factors influence a household's decision to conserve forest resources. The findings presented in Table 5, therefore, provide enough evidence to support the main hypothesis in this paper.

Again, the results align with findings from earlier studies who show that community involvement and sustainable behaviors exhibited by residents help to improve protection of forest resources. Thus, the quality and effectiveness of resource management decisions of the community or households are influenced by public participation, which ensures social consensus, local empowerment, and environmental justice (Baur et al., 2016; Steenberg et al., 2013; Young & McPherson, 2013). In addition, involving the public in forest management decisions encourages participation, provides opportunities for learning, and builds social capital, respect, and accountability among participants (McKinney & Field, 2008; Parkins & Mitchell, 2005; Wagner & Fernandez-Gimenez, 2008).

Discussion

Globally, emerging issues such as Voluntary Partnership Agreement (VPA), Forest Certification, Climate Change and Reducing Emissions from Deforestation and forest Degradation (REDD+) have implications for sustaining protected forests and livelihoods. With similar relevance, the Ghana Forest and Wildlife Policy (2012) was introduced to ensure equitable and sustainable forest and forest resources management. Among other interests, the policy also seeks to enhance active participation of communities through "The Collaborative Forest Management (CFM)" approach as well as promote sustainable management of forest and forest resources. Admittedly, the conscious effort by successive governments brought some structural changes in Ghana's forest management, however, it

is important to also acknowledge that these efforts have been unsuccessful in halting protected forest and forest resources degradation.

Revisiting the objectives of the global and local forest policies in line with the SDG 12, 13 & 15, this study develops a measure of sustainable protected forest and forest resources using the bidding game format and find evidence of sustainable behavior through community participation. In line with the CFM approach and what households can contribute through property rates, this sustainable behavior is associated with an expected revenue of GH¢30,338,537.5 (USD$5,767,795.49). Similarly, our results identify socioeconomic, psychological, and environmental factors as key determinants of the sustainable behavior.

With regard to socioeconomic factors, age was included to gauge the experience of respondents with regard to their observation of the forest overtime. The results of the study show that the coefficient of age is negative and statistically significant, following Alvarez and Larkin (2010). This implies that as age rises by a year, sustainable behavior toward forest protection declines. This is plausible in that as people get older, there is pressure on their meager incomes due to health-related expenditure and family responsibilities thereby affecting household behavior toward forest sustainability. Also, as people age and observe the depletion of the forest overtime due to human activity and failure of institutions to enforce environmental regulations their confidence in its sustainability dwindles. Regardless of the reasons, it is imperative to pay attention to the age differentials in advocating support for forest conservation.

In addition to age, differences exist in the environmental literature regarding the attitude and behavior of males and females to participate in activities that enhance the sustainability of the environment (Amoah & Addoah, 2021; Briscoe et al., 2019; Kamri, 2013; Mainieri et al., 1997). In view of this, gender was incorporated to examine the disparities in males and females' behavior toward forest sustainability. The estimated results reveal that the coefficient of gender is negative and statistically significant. The implication is that all things being equal, males are less likely to engage in activities that promote forest sustainability compared to their female counterparts which is consistent with a priori expectations.

Another key socioeconomic variable which affects attitude and behavior is education (see, Ajzen, 1991; Kollmuss & Agyeman, 2002; Meyer, 2015;). To ascertain whether respondents' knowledge could influence their ability toward forest conservation education was included. Since the overall literacy rate of a country is a measure of empowerment of its citizens, it is expected that higher level of literacy and for that matter income, should translate into a positive attitude and behavior toward forest sustainability. Surprisingly, the study finds that household behavior toward forest sustainability is not influenced by the level of education of respondents. Again, higher income reduces the behavior that promote forest sustainability. This finding could be a true reflection of reality in that if the educated and the affluent in the sample do not recognize apparent personal benefits of the forest, they would not demonstrate behavior that sustains the forest. Additionally, if the educated and higher income earners in the sample expect the government to use the revenue generated from their income taxes to fix the forest, then their behavior toward forest sustainability would be reduced.

Quite apart from socioeconomic factors, environmental factors are also critical in influencing attitude and behavior. In this study, global environmental knowledge was added to determine its effect on respondents' behavior toward forest conservation. Global

objective environmental knowledge examines specific knowledge relating to the environment compared to education which is broad (Amoah & Korle 2020; Amoah et al., 2021; Blankenberg & Alhusen, 2018). The coefficient of global environmental knowledge is positive and significant validating a priori expectations. The result indicates that global environmental knowledge exerts a positive and significant effect on attitude and behavior that sustains the forest. All things being equal, respondents with knowledge of the adverse effects of forest depletion and climate change on human wellbeing are likely to exhibit behavior that encourages forest sustainability. Thus, global environmental knowledge is important in making sustainable forest and forest resources decisions.

Critical amongst environmental factors is the extent to which households admire forest resources. The coefficient of those who admire forest resources is positive and significant. The result indicates that those who admire forest resources are likely to engage in behaviors that sustains the forest. The reason for this observation is not far-fetched, as echoed by Krieger (2001), that people who admire forest resources for its functions such as its ability to control flood, soil erosion, provision of food and water as well as the provision of site for recreation and spiritual wellness are likely to engage in a behavior that sustains the forest. However, the value placed on forest and the use of same is contingent on the abundance and scarcity of these resources in relation to human needs.

Similarly, the coefficients of eco-friendly practices and communal environmental services are positive and significant. It stands to reason that, pro-environmental behavior such as planting of trees, cleaning of environment, the use of energy efficient electrical gadgets and engagement in communal environmental services demonstrate positive attitude toward forest sustainability. Undoubtedly, as human activities become more pro-environmental, it may have a consequential effect on other environmental resources such as forest sustainability (Amoah et al., 2021).

In contrast with eco-friendly practices and communal environmental services, the coefficient of noise pollution is negative and significant as established by Duan and Sheng (2018). This implies that respondents who appreciates less noise pollution are more inclined to exhibit sustainable forest behavior. This negative relationship validates theoretical proposition in that when human activities become less pro-environmental, it has adverse implications for forest sustainability.

Furthermore, the coefficient of trust in institutions is negative and significant validating a priori expectations. This could be attributed to the fact that those who trust in institutions such as the Forestry Commission of Ghana and local governmental agencies such as the metropolitan, municipal and district assemblies to maintain the forest would not demonstrate behavior which sustains the forest. This finding corroborates with Amoah et al. (2017) who find negative evidence between trust and sustainable behavior.

Finally, knowledge regarding the depletion of protected forest was sought to ascertain household behavior toward forest sustainability. It is expected that respondents who believe that their protected forests have been depleted would demonstrate a positive behavior toward forest sustainability (see, Amoah et al., 2021). The results show that respondents have demonstrated different levels of the extent to which the protected forests have been depletion. This ranges from no depletion, low, moderate and high which is consistent with theoretical expectation. By implication, relative to respondents who indicated – no depletion in their ranking, respondents who ranked forest depletion as low, moderate, and high are more likely to exhibit sustainable forest behavior.

The broader implication of this study is that an attempt has been made to construct an index to measure the sustainability of protected forest in a developing country. This simple but useful approach provides the opportunity for sustainable environmental resources to be measured especially in countries without a comprehensive or exhaustive measure of sustainable environmental resources.

Admittedly, just like most indices, this newly developed index is not without its weaknesses as it may not be exhaustive in capturing both qualitative and quantitative aspects of what it sought to measure. However, in the absence of an exhaustive measure, this is considered an attempt to measure a complicated concept.

Conclusion

The study empirically tests the hypothesis that a household's decision to conserve forest resources is influenced by socio-economic, environmental and psychological factors. First, the study develops a sustainability index which takes the value of one (1) if the respondents demonstrate sustainable behavior and zero (0) if otherwise. This sustainability index is important because it contributes to sustainability measurements in empirical studies. The index revealed a positive sustainable behavior among respondents in the GAR.

The paper then estimates a linear probability model, which identifies socioeconomic, psychological and environmental factors as proximate and underlying determinants of household sustainable forest behavior.

Regarding forest policy, our evidence that majority of respondents demonstrated sustainable forest behavior presents an assuring situation toward enforcing existing policies in an effort toward sustaining protected forest and forest resources in Ghana. Again, the estimated expected revenue could be of help to policy makers and tourist operators who are interested in tourism development in protected forest areas. To achieve this, government institutions such as the Forestry Commission in collaboration with the local administrative authorities should ignite efforts toward promoting tree planting exercises, clean-ups and increasing surveillance and security in these protected forest areas. Again, through property rates, the local administrative authorities can capitalize on the estimates to raise revenue for the purposes of sustaining the protected forests.

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