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Willingness to Contribute Time versus Willingness to Pay for the Management of Harmful Algal Blooms

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Abstract: The harmful impacts of the ongoing Sargassum invasions in the Atlantic Ocean include fish kills, skin and eye irritation, beach fouling, and declines in fisheries and tourism in West Africa and the Americas. This study was conducted to address important gaps in the non-market valuation literature and support the design of effective adaptation policies to reduce the harmful impacts of algal blooms. Contingent valuation survey data and linear mixed-effects regression models were utilized to estimate the drivers of willingness to pay (WTP) and willingness to contribute time (WTCT) for the management of invasive Sargassum seaweeds in Ghana. The study revealed that income, education, family size, years of residence, sex, attitudes, and political affiliation are significant drivers of WTP, while distance to the beach, occupation, house ownership, attitudes, and political affiliation are also significant predictors of WTCT. Hence, only attitudes about invasive seaweeds and political affiliation influence both WTP and WTCT. The findings suggest that for developing countries to generate enough funding and adequate economic support for coastal resource conservation, they should design local resource protection programs that give residents the option to contribute both time and money.

Keywords: harmful algal blooms; invasive species; Sargassum invasion; willingness to contribute time; willingness to pay

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1. Introduction

Harmful algal blooms continue to plague marine and freshwater ecosystems around the globe. For instance, Ulva invasions have been occurring in North America, Europe, and China for decades [1–3]. Although such blooms have been recorded as far back as the 1970s, recent occurrences warrant a cause for alarm. The ongoing proliferation of Sargassum in the Atlantic Ocean has resulted in the invasion of coastal waters and shorelines in the countries bordering the Atlantic Ocean [4,5]. Prior to 2011, modest amounts of free-floating Sargassum seaweeds migrated from the Sargasso Sea and washed up along the shorelines in the Caribbean Sea and the Gulf of Mexico every summer [4,5]. However, there has been a dramatic increase in the amount of beaching Sargassum since 2011, invading coastal waters and shorelines in North, Central, and South America, the Caribbean Islands, and West Africa [4,5]. Similar to Ulva blooms, the proliferation of Sargassum in the Atlantic Ocean and the Gulf of Mexico has been attributed to nutrient pollution, particularly from the Amazon and the Mississippi and Congo rivers [5,6]. Additionally, scientists have also suspected changing ocean temperatures and iron-rich dust pollution from the Sahara Desert as driving factors behind the ongoing Sargassum blooms [5,6]. In 2018, Wang et al. [7] discovered that the "Great Atlantic Sargassum Belt" contained more than 20 million metric tons of Sargassum. The Belt, stretching from the Americas to West Africa, continues to pose severe threats to marine resources, human health, and coastal economies.

Sargassum provides numerous ecosystem benefits that support healthy marine wildlife. Floating mats of Sargassum serve as shelter and safe breeding grounds for marine animals including pelagic fish species and sea turtles [8,9]. However, the high volumes of Sargassum inundating marine ecosystems have created more harm than benefits because they cause fish kills and impede fish growth. High volumes of Sargassum usually end up causing anoxia and eventually kill fish and other sea animals, including endangered sea turtles, as massive amounts of invasive Sargassum compete with marine animals for oxygen and nutrients [8,9]. Floating mats of Sargassum also disrupt the movement and feeding of fish and slow down the maturity of fish by blocking sunlight (see Boeuf and Le Bail [10]). As the seaweeds decay, the piles of rotten Sargassum along the shorelines emit hydrogen sulfide, a poisonous, foul-smelling gas that causes skin and eye irritation [11–13]. In addition to fouling the beaches, the presence of decaying Sargassum drives away tourists, harming tourism-related businesses and local residents who depend on beach visitors for their livelihoods. In coastal regions such as West Africa, marine fisheries are already struggling with collapsing fish stocks and declining fish catch for decades because the fisheries are poorly managed and have practically become open-access resources for citizens. Drifting mats of Sargassum clog and destroy fishing nets and engines on fishing vessels and hinder vessel navigation, thereby making fishing activities more costly and time-consuming as fishers spend more money to replace damaged fishing gear and waste productive hours attending to the invasive seaweeds, respectively. Consequently, the ongoing influx of Sargassum continues to further reduce fish catches and fishing incomes in the already declining fisheries in the region [11,14,15].

According to experts, as long as climate change and nonpoint source nutrient pollution continue, harmful algal blooms such as the proliferation of Sargassum in the Atlantic Ocean are expected to become a common occurrence [7]. Hence, to protect their marine resources, public health, and coastal economies, countries affected by Sargassum invasions are working to adopt adaptation policies to monitor the migration of the floating seaweeds and implement periodic seaweed removal programs [16]. To help design and implement effective adaptation policies, scientists and marine resource managers would benefit from a deep understanding of how important or valuable invasive seaweed management is to stakeholders and citizens struggling with harmful algal blooms. In the environmental economics and environmental policy literature, non-market valuation techniques have been utilized to quantify the monetary and non-monetary benefits that natural resource protection provides to citizens. In non-market valuation research, scholars attempt to estimate total economic value, which is the sum of use and non-use values. Use values include the present or future benefits that individuals may derive from a resource, whether directly or indirectly. Individuals also may assign non-use values to a resource on ethical grounds. For instance, an individual may value a resource for the sake of existence or because the resource will benefit others or future generations. Research shows that non-market valuation is a very instrumental tool that can be utilized to provide economic, political, and cultural justification for implementing resource protection programs [16]. Countries affected by harmful algal blooms can use non-market values both as an indicator of the economic importance of resource protection as well as inputs for conducting cost-benefit analyses for resource protection projects. Likewise, they can also use non-market values as a basis for designing new taxes to fund the implementation of resource protection projects. Similarly, the size of non-market values that affected citizens assign to resource protection can also signal their level of political support for such projects (see Aldy et al. [17] and Wan et al. [18]). Last but not least, given the positive correlation between non-market values and the cultural attachment to a resource, non-market values can also signal cultural support for resource conservation (see Ison et al. [19]).

In contingent valuation (CV), one of the leading non-market valuation techniques, two major estimates for non-market values exist, namely, willingness to pay (WTP) and willingness to contribute time (WTCT). WTP is the estimate of the maximum amount (i.e., money) individuals are willing to pay to support resource protection, whereas WTCT is the maximum time (i.e., hours) individuals are willing to contribute to support resource protection. In the literature, WTCT is synonymous with willingness to contribute labor, willingness to work, and willingness to volunteer. Scholars generally prefer WTP over

WTCT for good reasons. In advanced countries with robust labor markets and low unemployment rates, WTP estimates provide a straightforward economic measure of value. For direct comparison, scholars typically attempt to convert WTCT (i.e., hours) to WTP (i.e., money). One major challenge is that there is no consensus on the best approach for converting WTCT to WTP because the monetary value of time may vary based on whether an individual chooses to use work time or leisure time to support resource protection efforts. However, in a developing country context, several reasons justify the importance of WTCT studies. In developing countries with a huge informal sector, less robust labor markets, and high unemployment rates, households may be "income-poor but labor-abundant" [20], suggesting that households in these countries may have more time than money to contribute toward resource conservation. Also, poor households with very limited cash income may be mischaracterized as "free riders" in a WTP survey if they elect to pay zero but may be willing to contribute more than zero hours in a WTCT survey [21]. Hence, as opposed to WTP surveys that favor affluent households, WTCT surveys provide better, more equitable estimates of non-market values in developing countries [19]. Research also shows that in developing countries, residents, especially in rural areas, are familiar with supporting common-pool resource management efforts through voluntary contributions of both time and money [19,22].

The non-market valuation literature in developing countries reveals that the majority of households elect to contribute time instead of money. In rural Ethiopia, Asrat et al. [23] discovered that 60% of respondents opted to contribute time rather than money to support soil conservation. In the same country, Girma et al. [24] found that two-thirds of respondents are willing to contribute time toward lake restoration. In Rwanda, Kalisa [25] revealed that 56% of respondents preferred to contribute time instead of money for rural electrification. In Fiji, Ison et al. [19] found that about 93% and 17% of respondents were willing to contribute time and money, respectively, to support marine protected areas. In the Philippines, Ballad et al. [26] conducted a similar study regarding support for marine protected areas. In comparing WTCT and WTP, they found that WTCT is about four to five times higher than WTP [26]. In central Chile, Schiappacasse et al. [27] revealed that more than 96% of rural residents were willing to pay time to support the restoration of ecosystem services.

Despite the importance of studying both WTP and WTCT for resource conservation, several important gaps exist in the non-market valuation literature on harmful algal blooms. First, a thorough review of the relevant literature reveals that only a handful of studies have examined both WTP and WTCT in support of resource conservation efforts (see Table A1 under Appendix A). Second, although the increasing occurrence of algal blooms and the serious threats they pose to marine ecosystems, public health, and coastal economies is alarming, to say the least, no research has been conducted to understand WTCT for the management of harmful algal blooms. As Table A1 reveals, none of the 12 relevant studies (excluding this study) have focused on harmful algal blooms. This study aims to address these important gaps and help design effective adaptation policies to reduce the harmful impacts of algal blooms by studying both WTP and WTCT for the management of harmful algal blooms in a developing country context. Specifically, this study was conducted to estimate the drivers of WTP and WTCT for the periodic removal of invasive Sargassum seaweeds and the protection of coastal resources in Ghana. In the present study, household CV survey data and mixed-effects linear regression models were utilized to identify the significant drivers of both WTP and WTCT for the management of invasive Sargassum seaweeds in Ghana.

It was revealed that the household income, education of the household head, family size, years of residence, sex of the household head, attitudes about invasive seaweeds, and political affiliation are significant drivers of WTP. The findings also reveal that distance to the beach, occupation of household members, house ownership, attitudes about invasive seaweeds, and political affiliation significantly influence WTCT. Hence, attitudes about invasive seaweeds and political affiliation proved to be significant drivers for both WTP and WTCT. Apart from making contributions regarding the differences in the drivers of

WTP and WTCT, this study also provides several policy insights to inform the management of harmful algal blooms and invasive species and marine and coastal resource conservation in developing countries.

2. Materials and Methods

2.1. Contingent Valuation Survey

Since 2011, the invasion of harmful Sargassum seaweeds has become a common phenomenon in West Africa. The influx of huge amounts of floating biomass of seaweeds has caused fish kills in the already collapsing marine fisheries in the region [11,15]. The influx of Sargassum seaweeds in West Africa continues to cause havoc in coastal communities that are almost entirely reliant on marine resources for their livelihoods. For instance, the ongoing beach fouling caused by piles of decaying Sargassum along the coast drives away tourists and local residents from the beach [11,14,16]. Additionally, the floating seaweeds interfere with the operations of marine fishers as the seaweeds destroy fishing gear and clog vessel engines, forcing fishers to waste productive hours attending to the seaweeds and spending more money to replace destroyed fishing gear. According to affected marine fishers, the floating mats of seaweeds have caused a decline in fish landings and a loss of fishing jobs [11,15]. Although residents and local governments in the affected coastal towns are eager to protect their marine resources and livelihoods, a major drawback discouraging the periodic removal of these harmful seaweeds is the lack of adequate funding. Hence, Ofori and Rouleau [16] conducted a contingent valuation survey in Elmina, one of the foremost coastal fishing towns struggling with invasive Sargassum seaweeds in Ghana.

In July 2018, Ofori and Rouleau [16] administered their CV survey to 550 households in Elmina, with 91% of heads of households completing the survey. Ofori and Rouleau [16] followed best practices in designing and administering their survey to elicit valid non-market valuation data, including the recommendations by the "Blue Ribbon Panel" constituted by the National Oceanic and Atmospheric Administration (NOAA) in 1992. In their CV survey, Ofori and Rouleau [16] utilized the most suitable WTP elicitation format in developing countries, i.e., the closed-ended iterative bidding format, to elicit valid WTP and WTCT data. They used the following question to elicit WTP data: "What is the maximum amount your household would be willing to pay each month, for a year, to support Sargassum seaweed cleanup in Elmina? (in GHS, circle one) 0 1 5 10 20 50 75 100 150 200 500 750 1000 1500 2000 > 2000 don't know". In their survey, some households opted to support the seaweed cleanup program by contributing time (or labor). For these households, they used the following question to elicit WTCT data: "How many hours would your household be willing to contribute each month, for a year, to support Sargassum seaweed cleanup in Elmina? (circle one) 0 1 5 10 20 30 40 50 60 70 80 90 100 120 140 160 > 160 don't know". In addition to the non-market valuation data, their survey collected several demographic data, including data income of household monthly income, educational attainment of the household head, sex of the household head, distance from a respondent's house to the beach, family size (number of household members), occupation of household members (whether at least one member has a sea-dependent occupation or not), years of residence in Elmina, house ownership (whether a household owns its current residence or not), attitudes about invasive Sargassum seaweeds (whether a respondent feels the influx of Sargassum is a good or bad phenomenon, or is indifferent), and political affiliation of respondent (whether a respondent supports the party in power, supports an opposition party, or is indifferent).

2.2. Econometric Models

Mixed-effects models, also known as multilevel or hierarchical models, have been receiving increasing attention because of their ability to model outcome variables with a correlated, nested, or hierarchical structure. In Ofori and Rouleau [16], the drivers of WTP for invasive seaweed management were found to be different for high-income and low-income households in Ghana. However, estimating separate coefficients for each income group would yield several different sets of estimates for WTP and WTCT. Thus, a mixed-effects regression technique was used to model WTP and WTCT separately, while at the same time accounting for differences in households' income status. Specifically, a linear mixed-effects regression model was developed to estimate the drivers of WTP and WTCT as follows:

$$Y_i = X_i\beta + Z_i b_i + \varepsilon_i$$

where Y_i is the vector of the response variable (i.e., WTP or WTCT), X_i is the fixed-effects design matrix of predictor variables, β is the vector of fixed-effects coefficients, Z_i is the random-effects design matrix, b_i is the vector of random-effects, and ε_i is the vector of residuals.

Due to their experimental nature and potential to overestimate non-market values, state preference approaches such as the CV technique have received some criticism. In the presence of survey interviewers, critics point to the likelihood that respondents may select a WTP amount higher than their true WTP in order to appear more supportive of environmental protection than they really are. However, such concerns need to be re-examined in the context of developing countries. In such countries, it is customary for households to contribute money or labor toward communal projects at the request of local traditional authorities, and Ghana is no exception. Rather than overestimate, there is every reason to assume that rational households would underreport their WTP. Hence, the true WTP value (WTP_i^*) could be assumed as lying between the WTP amount selected by respondents (i.e., lower bound, WTP_{iL}) and the next higher WTP amount of the survey (i.e., upper bound, WTP_{iU}), which suggests that $WTP_{iL} < WTP_i^* < WTP_{iU}$. As a result, a second model, i.e., an interval mixed-effects regression model, was also utilized to estimate the drivers of WTP and WTCT.

For each of the models, i.e., linear and interval mixed-effects regression models, a random-coefficient component based on households' high-income (more than GHS 500 per month) and low-income (GHS 0–500 per month) status was included. Using Stata 17 software, the WTP and WTCT models were estimated as a function of the independent variables in Table 1.

Table 1. Summary of CV survey data.

Continuous Variables	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs.**
WTP (GHC, monthly)	30.51	106.03	0	1000	328
WTCT (hours, monthly)	9.14	16.61	0	110	167
Family size	6.71	5.93	1	54	497
Years of residence	25.56	15.81	0.17	85	483
Categorical Variables	**Pct.**	**Obs.**	**Categorical Variables**	**Pct.**	**Obs.**
Household income (GHS, monthly)		492	Occupation: at least one household member has a sea-dependent occupation		502
Less than 100	21.95		Yes	63.75	
Between 100 and 500	49.59		No	36.25	
Between 500 and 1000	19.51		Sex of the household head		501
Between 1000 and 5000	8.33		Male	51.90	
Between 5000 and 10,000	0.00		Female	48.10	
More than 10,000	0.61		Other	0.00	
Education of the household head		497	House ownership		499
No formal education	14.69		Own my house	52.91	
Primary: grades 1–6	16.50		Do not own my house	47.09	
Junior high: grades 7–9	40.44		Attitudes about invasive seaweeds		476
Senior high: grades 10–12	16.10		Seaweeds invasion is bad	76.26	
Tertiary	12.27		Seaweeds invasion is good	15.34	
Distance from house to beach		502	Indifferent	8.40	
Southern communities (nearest)	27.29		Political affiliation		488
Central communities	46.22		Affiliated to party in office	21.72	
Northern communities	26.49		Affiliated to opposition party	41.60	
			Neutral	36.68	

3. Results

3.1. CV Survey Data

Table 1 contains the summary statistics for the WTP and WTCT data from the CV survey conducted by Ofori and Rouleau [16]. On average, respondents elected to pay about GHC 31 (USD 6.4 in 2018) and 9 h in monetary and time contributions, respectively, per month. The WTP data ranged from GHC 0 to 1000, while the WTCT data also ranged from 0 to 110 h per month. Given the skewed distribution of the WTP and WTCT datasets (Figure 1), the dependent variables (WTP and WTCT) were transformed into natural logarithms for the regression analysis. Table 1 also displays data for the predictor variables included in the regression models.

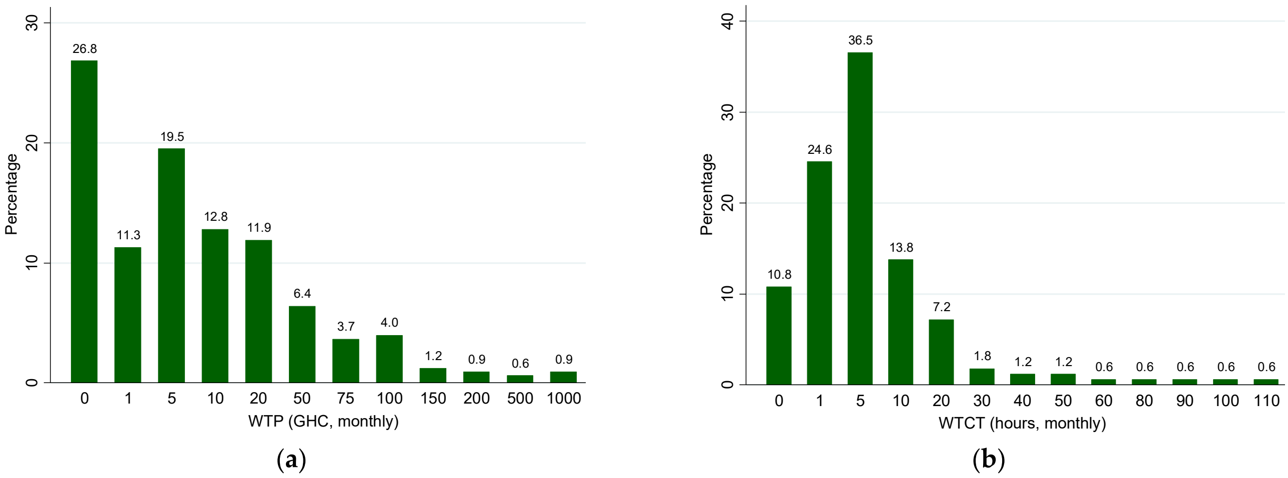

Figure 1. (**a**) Distribution of WTP data; (**b**) distribution of WTCT data.

3.2. Drivers of WTP and WTCT

For both WTP and WTCT, the linear and interval mixed-effects regression models were estimated to identify and understand the differences between their determinants. Table 2 contains the coefficient estimates for a total of four models, two each for WTP and WTCT, with all coefficients having the expected signs. For the WTP models, the linear model produced more significant coefficients than the interval model. The income of the household, education of the household head, years of residence, and attitudes about invasive seaweeds are significant in both WTP models. However, family size, sex of the household head, and political affiliation of respondents are only significant in the linear model for WTP. Nonetheless, occupation type and house ownership are not significant coefficients in both WTP models. It is important to note that the WTP estimates for the simple interval regression model in Ofori and Rouleau [16] are similar to the WTP estimates for the interval mixed-effects regression model in this study.

For the WTCT models, the linear model yielded more significant coefficients than the interval model. In both WTCT models, the significant coefficients are attitudes about invasive seaweeds and the political affiliation of the respondent. However, distance to the beach, occupation type, and house ownership are significant coefficients in the linear model only, while family size is also a significant coefficient only in the interval model. Between the linear and interval models, the linear model makes fewer assumptions, i.e., it does not assume that the true WTP is unknown and lies between an interval. Hence, the linear model is preferred, and the discussions that follow from here will make a reference to the linear models for both WTP and WTCT.

Table 2. Drivers of WTP and WTCT for invasive seaweed management in Ghana.

Variables	WTP Models				WTCT Models			
	Linear [1]	**s.e.**	**Interval [2]**	**s.e.**	**Linear [1]**	**s.e.**	**Interval [2]**	**s.e.**
Household income	0.01 ***	(0.00)	0.43 ***	(0.13)	0.05	(0.08)	−0.06	(0.12)
Education of the household head	0.23 ***	(0.04)	0.58 ***	(0.10)	0.13	(0.14)	0.01	(0.11)
Family size	0.03 *	(0.02)	0.02	(0.02)	0.06	(0.07)	0.05 *	(0.03)
Years of residence	−0.01 **	(0.00)	−0.01 *	(0.01)	0.00	(0.00)	0.01	(0.01)
Distance from house to the beach	−0.38	(0.45)	−0.41 **	(0.17)	−0.08 ***	(0.02)	−0.04	(0.17)
Occupation of household: sea-dependent vs. others	0.05	(0.10)	0.26	(0.27)	0.28*	(0.15)	0.22	(0.25)
Sex of the household head: male vs. female	−0.08 **	(0.04)	0.24	(0.23)	−0.34	(0.45)	−0.11	(0.22)
House ownership: own vs. do not own	0.06	(0.13)	0.02	(0.24)	−0.24 ***	(0.01)	−0.09	(0.23)
Attitudes: invasive seaweeds are good vs. bad	−0.51 *	(0.29)	−1.16 ***	(0.38)	−0.92 ***	(0.08)	−0.55 *	(0.32)
Attitudes: indifferent vs. invasive seaweeds are bad	−1.28 ***	(0.32)	−0.78 *	(0.40)	0.12	(0.09)	0.15	(0.40)
Political affiliation: opposition vs. party in office	−0.46	(0.44)	−0.42	(0.30)	−0.48 **	(0.19)	−0.45	(0.30)
Political affiliation: neutral vs. party in office	−0.75 **	(0.36)	−0.46	(0.31)	−0.74 *	(0.38)	−0.58 *	(0.33)
Constant	2.94 ***	(1.09)	0.36	(0.69)	1.52 ***	(0.26)	1.75 ***	(0.64)
Observations	240		328		122		138	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. [1] Linear mixed-effects regression model (preferred). [2] Interval mixed-effects regression model.

4. Discussion

The goal of this study was to investigate the differences in the significant drivers of WTP versus WTCT to address important gaps in the non-market valuation literature on the management of harmful algal blooms in developing countries. In this study, household CV survey data from Ghana and mixed-effects linear regression models were utilized to identify the determinants of WTP and WTCT for the management of invasive Sargassum seaweeds in Ghana (Table 2). For WTP, income of the household, education of the household head, family size, years of residence, sex of the household head, attitudes about invasive seaweeds, and political affiliation of the respondent were found to be significant drivers. For WTCT, the significant drivers were distance to the beach, occupation of household members, house ownership, attitudes about invasive seaweeds, and the political affiliation of the respondent. As a result, only attitudes about invasive seaweeds and the political affiliation of respondents proved to be significant drivers of both WTP and WTCT for the management of harmful algal blooms and coastal resource conservation in developing countries.

It was revealed that households who feel the influx of invasive seaweeds is a bad phenomenon are willing to pay 51% more in monetary contributions and 92% more in time contributions to support the management of harmful algal blooms compared to households who feel the influx of invasive seaweeds is a good phenomenon. With respect to households who are indifferent about seaweed invasion, households who feel seaweed invasion is bad are willing to pay 128% more money. It was also revealed that households who support the political party in power are willing to pay 75% more and 74% more in monetary and time contributions, respectively, to support the management of harmful algal blooms compared to households who do not support any political party. In comparison with households who support an opposition political party, households who support the political party in office are willing to contribute 48% more time.

A review was conducted to identify relevant studies in the non-market valuation literature that have examined the drivers of both WTP and WTCT for aquatic and terrestrial resource conservation in developing countries. The review produced a total of 12 relevant articles (excluding this study) focusing on several resource conservation topics, from marine protected areas and river conservation to forest protection and invasive species management in developing countries (Table A1). Regarding the conservation of resources in developing countries, several of these studies (Table A1) support our finding that income, education, years of residence, sex, and attitudes significantly influence WTP [20,22,24,25,27–32]. In contrast, although family size and political affiliation were found to be significant drivers of WTP in this study, none of the studies on aquatic resource conservation provide similar findings (Table A1). Several studies in Table A1 also confirm that distance, type of occupation, and attitudes influence WTCT for resource conservation in developing countries [22,24,29,31,33,34]. Unfortunately, none of these studies revealed that house ownership and political affiliation are significant drivers of WTCT. A review of existing studies also reveals that income, education, sex, and occupation are significant predictors of both WTP and WTCT for resource conservation in developing countries (Table A1). While this study did not find similar evidence, the present study reveals that attitudes about the resource in question and the political affiliation of stakeholders significantly predict both WTP and WTCT for resource conservation in developing countries. In addition to these contributions, this study makes a unique contribution as the first study to investigate the influence of political affiliation on both WTP and WTCT for resource conservation.

This study also provides several policy insights to help public agencies better address harmful algal blooms, invasive species, and coastal resource management challenges. Although it was not a surprise that income influences WTP positively, it is interesting to know that income does not influence WTCT. First, this finding suggests that both poorer and richer households in developing countries would equally support resource conservation programs with labor or time contributions. Also, given that households in developing countries are usually "income-poor but labor-abundant" [20], significant public support for resource conservation may come in the form of time contributions instead of monetary contributions. It was revealed that education positively influences only WTP. Unlike WTP, it is refreshing to note that WTCT not being influenced by education means that resource managers could expect similar time contributions from both highly educated and poorly educated households. Given that the majority of resource-dependent households in coastal regions are not highly educated, resource managers should not expect any sizeable monetary contributions but should count on relatively more substantial time contributions from households. Similar to income and education, WTP is influenced by family size, years of residence, and sex of the household head. These findings also indicate that resource managers should expect similar time contributions from households irrespective of family size, years of residence, and the sex of the household head. Conversely, distance to the beach, occupation type, and house ownership all influence only WTCT. These findings mean that to support resource protection programs, households nearer to a resource would contribute more time than households farther away, households having at least one member in a sea-dependent occupation such as fishing or fish processing would contribute more time than households that do not, and households who own their house would contribute less time than households that do not. The current study also reveals that attitudes toward resource protection and political affiliation are significant determinants of both WTP and WTCT. These findings imply that resource managers should know that all households, irrespective of whether they elect to contribute money or time, do care about their views regarding the importance of resource protection and support for the political party in office when making decisions about monetary or time contributions.

A limitation of this study has to do with the small sample size of the WTCT data, i.e., 122 observations as opposed to 240 observations for WTP. Despite this limitation, the findings in the present study support the findings from relevant studies in the non-market valuation literature. This study has made important contributions regarding the differences in the drivers of WTP and WTCT for harmful algal blooms, invasive species management, and coastal resource conservation in developing countries. Additionally, this study recommends that for developing countries struggling with funding, the policies they design to generate revenue or increase economic support for resource conservation should be flexible enough to allow stakeholders to choose between contributing money or time, or both. In particular, such countries should focus on designing policies that would specifically encourage time contributions, given that households in developing countries would potentially offer substantial time contributions as opposed to monetary contributions. By adopting policies that combine both payment vehicles (i.e., WTP and WTCT), resource managers stand a better chance of generating adequate economic support for resource conservation programs and garnering a level of political support high enough to pave the way for a smooth implementation of resource protection policies.

5. Conclusions

This study was conducted to address important gaps in the non-market valuation literature and support the design of effective adaptation policies to reduce the harmful impacts of algal blooms by studying the non-market values for the management of harmful algal blooms in developing countries. To achieve this objective, household CV survey data and mixed-effects linear regression models were utilized to identify the significant drivers of both WTP and WTCT for the management of invasive Sargassum seaweeds in Ghana. It revealed that household income, education, family size, years of residence, sex of the household head, attitudes about invasive seaweeds, and political affiliation are significant drivers of WTP, while distance to the beach, occupation of household members, house ownership, attitudes about invasive seaweeds, and political affiliation are also significant predictors of WTCT. Therefore, attitudes about invasive seaweeds and the political affiliation of respondents are the only drivers that proved to be significant for both WTP and WTCT for the management of harmful algal blooms in developing countries. In addition to these contributions, this study also provides several policy insights to inform the management of harmful algal blooms and invasive species, marine protection, and coastal resource conservation in developing countries. The findings in this study suggest that for developing countries to generate enough funding and adequate economic support for resource conservation, they should design local resource protection programs that give affected residents the option to contribute money, time, or both. Specifically, it is recommended that developing countries design policies and programs that would induce time contributions, given that households would potentially offer substantial time contributions as opposed to monetary contributions. By adopting policies that combine both monetary and time contributions, developing countries stand a better chance of generating adequate economic support for resource conservation programs.

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Appendix A

Table A1. Drivers of WTP vs. WTCT for natural resource conservation in developing countries.

No.	Author (Year)	Resource and Location	Significant Variables in		
			Only WTP Model	**Only WTCT Model**	**Both WTP and WTCT Models**
1	Hung et al., (2007) [33]	Forest fire prevention, Vietnam	none	education	farming occupation
2	O'Garra (2009) [22]	Marine resource conservation, Fiji	income, education, fishing occupation, anthropocentric view of resource	hours of work, number of children, supports resource protection for future generations	gender, involved in management decisions, works outside resource area
3	Casiwan-Launio et al., (2011) [28]	Marine protected areas (MPAs), Philippines	education	age, gender, knowledge about number of mpas	income
4	Alam (2013) [29]	River ecosystem restoration, Bangladesh	income, head of household	education, sex, age, dependency on resource	occupation type, concern for river
5	Schiappacasse et al., (2013) [27]	Forest restoration, Chile	income, size of farmland, believes that forests can be exploited sustainably	age, non-work hours, believes that forests are important symbols	none
6	Tilahun et al., (2013) [20]	Forest conservation, Ethiopia	income, education, interaction of education, and length of residence	gender, family size (15- to 64-year-olds), interaction of age and length of residence	none
7	Kalisa (2014) [25]	Rural electrification using dangerous gas from lake, Rwanda	income, age, years at current residence, location of residence, owns residence, knowledge about electricity project	knowledge about gas extraction for electricity generation	has electricity at home, has home-based business
8	Tilahun et al., (2017) [34]	Invasive tree species mitigation, Ethiopia	none	extent of invasion by species on pasturelands and government lands	occupation, non-farm income, physical injury by invasive species
9	Girma et al., (2021) [24]	Lake restoration, Ethiopia	farm income	education, distance from lake to farm	size of farmland
10	Ting et al., (2021) [30]	Ecotourism and conservation in National Park, China	income	none	supports tourism, payment vehicle type, location of residence
11	Petcharat et al., (2022) [31]	Endangered wetland plant habitat conservation, Thailand	age	income	values improved biodiversity, values improved water quality, values improved upstream conditions
12	Xu et al., (2022) [32]	Ecosystem conservation in nature reserves, China	community attachment, degree of acceptance to pay	degree of acceptance to work	income, education
13	Ofori (this study)	Invasive seaweed management and coastal protection, Ghana	income, education, sex, family size, years of residence	distance to the beach, occupation type, house ownership	attitudes about invasive seaweeds, political affiliation

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