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Willingness to pay for and economic feasibility of solid waste management in Cape Maclear, Malawi

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ABSTRACT

Improving solid waste management (SWM) can better public health locally and mitigate climate change globally. However, it requires thorough financing and business models. This study assessed the willingness to pay (WTP) of four stakeholder groups in the village Cape Maclear, Malawi, using the double-bounded dichotomous choice contingent valuation method as well as direct questions. Households (N = 259) would be willing to pay an average of MWK 1507 (USD 0.90) per month if they did not have to separate their waste themselves, as opposed to MWK 899 (USD 0.54) per month if they had to separate their waste at the collection point. Lodges were willing to pay USD 13.00 per month for their own waste management and an additional USD 4.22 for public waste removal. The WTP of businesses was assumed to be zero due to an unrepresentative sample. Tourists were found to have an average WTP of USD 1.75 per day. We recommend a sustainable business model based on all cost and revenue streams of the system. Thereby, tourists show the greatest potential. Nevertheless, it is recommended to make the monthly operation of the system independent from external sources, but to use these sources for long-term investments and infrastructure improvements.

1. Introduction

Climate change is one of the greatest challenges faced by humankind and represents an irreversible threat to societies and the planet as a whole. Due to the release of greenhouse gases (GHG) during waste treatment and disposal, municipal solid waste management (SWM) is recognized as a significant contributor to climate change (Onyanta, 2016). In 2016, treatment and disposal of solid waste generated 1.6 billion metric tons of carbon dioxide equivalent (CO_2e), which accounted for 5% of global emissions (Kaza et al., 2018). Thirty-three percent of the generated municipal solid waste is not managed in an environmentally safe manner, and especially in the Global South, there is a lack of regular waste collection and disposal services (Onyanta, 2016; Kaza et al., 2018). Without improvements, emissions from solid waste treatment and disposal are projected to increase to 2.6 billion metric tons CO_2e by 2050, with open dumping and uncontrolled burning being the main drivers (Kaza et al., 2018). Due to the high rate of urbanization and population growth in the coming decades, the total waste production in sub-Saharan Africa is expected to triple (Freire and Hoornweg, 2013; Kaza et al., 2018). Therefore, efforts to formalize waste management have significant potential to reduce GHG emissions. Furthermore, improved waste management reduces the contamination of soil, water, and air, therefore reduces the stress on ecosystems and decreases the chances of disease transmission, which improves public health (Chinasho, 2015). Moreover, it makes a location more attractive for tourism and therefore also supports local businesses.

Located in south-east Africa, Malawi is a sub-Saharan country with around 24 million residents (International Monetary Fund, 2023). It is one of the poorest countries in the world in terms of GDP per capita, and the country relies heavily on rain-fed agriculture, making it vulnerable to climate change and fluctuating commodity prices (International Monetary Fund, 2023). Cape Maclear is a rural village on the southern shore of Lake Malawi in Malawi. The village stretches 3.5 kilometers along the shore. It has no paved roads and is densely populated with randomly arranged houses and narrow streets. Cape Maclear is surrounded by Lake Malawi National Park, which was declared a UNESCO World Heritage Site in 1984 for its natural beauty, outstanding biodiversity values, and exceptional diversity of freshwater fish (UNESCO World Heritage Centre, 2025). In the early 1990s, Cape Maclear was a small fishing village of 2000 inhabitants, but in the last decades, it has become one of the largest tourist destinations in the country (Mahdjoub et al., 2021). The population has grown to 15,000 people (Y. Kusakari, personal communication, November 4, 2023) and tourism has increased the wealth of the village, resulting in a significant increase in waste production.

According to Kaza et al. (2018), the average waste collection coverage in sub-Saharan countries is about 44%, while in rural areas 9%

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of waste is collected. The waste collection rate for Malawi's largest cities, Lilongwe and Blantyre, is 30% (Kaza et al., 2018). There is no official waste collection service in Cape Maclear, and the isolated location of the village limits the ability to transport waste out of the area for disposal (Kalina et al., 2022). One of the lodge owners privately initiated waste collection for the lodges, but participation was not mandatory and has declined since the COVID-19 pandemic. There is no household waste collection. In Cape Maclear, waste is often dumped or burned, which causes several problems. Burning releases toxic chemicals into the air, and dumping contaminates water sources through liquid runoff. In addition, dumped waste can serve as a source of food or shelter for disease-carrying animals such as rats, mosquitoes, and scavenging animals (Kaza et al., 2018). The prevalence of acute respiratory infections is six times higher and diarrheal diseases are twice as common in communities with poor service coverage than in areas with frequent waste collection (UN-Habitat, 2010).

In low-income countries, waste management accounts for an average of 19% of municipal budgets, compared to 4% in high-income countries (Kaza et al., 2018). Therefore, waste management is the single largest budget item for many local governments, and financing SWM systems is a major challenge. In low-income countries, businesses and households are typically charged a flat fee that is collected on a door-to-door basis, while volume-based waste fees are still uncommon because they require coordinated planning and strong enforcement. In addition, Kaza et al. (2018) found that the most effective user fees are those that match users' ability and willingness to pay (WTP). Furthermore, costs can be recovered through the sale of recycled materials and compost, energy from waste, financial deposit schemes, or taxes on consumer goods (Kaza et al., 2018).

The double-bounded dichotomous choice contingent valuation method has been used in research to estimate households' WTP for SWM services in various African countries including Ghana (Owusu et al., 2011), Uganda (Banga et al., 2011), Nigeria (Rahji and Oloruntoba, 2009), and Ethiopia (Girma et al., 2022). In Malawi, dichotomous contingent valuation was used to determine the WTP for solid waste collection in Lilongwe (Assa, 2013), in Blantyre (Ndau and Tilley, 2018), and in Mzuzu (Kapanda, 2020). All studies found positive values for WTP, indicating that households in all three cities are willing to pay for solid waste collection.

The natural beauty and the unique biodiversity of Cape Maclear as well as the health and safety of residents are threatened by the lack of SWM services, habits, and practices. The locally registered NGO Sustainable Cape Maclear approached the Global Health Engineering Group at ETH Zurich for help in developing a waste management system that is inclusive of the entire community. This paper is one of five studies that was conducted for the overall project to develop a coherent waste management strategy for Sustainable Cape Maclear (related studies: Colbach, 2024; Meier, 2024; Peduzzi, 2024; Stricker, 2024).

The paper evaluates the WTP of four distinct stakeholder groups for waste collection and treatment in Cape Maclear: households, lodges, businesses, and tourists. Given the traditionally high costs of SWM and its usual top-down implementation, this work underlines the potential of a community-based SWM system, which is novel and unique in the field of SWM. The stakeholder-specific surveys fostered an understanding of current waste management practices, and identified the best payment mode for the different stakeholder groups. To design a sustainable business model, the summarized WTP of the different stakeholders was compared with the costs of waste management in Cape Maclear estimated in other studies, considering different scenarios regarding the number of collection points and waste transport modes. This case study represents a first example for policy makers of how decentralized SWM in underserved Malawian communities could function.

2. Methods

A survey was conducted to determine the WTP for solid waste collection and treatment in Cape Maclear among four different stakeholder groups: households, lodges, businesses, and tourists. Tailored questionnaires were designed for each group. Except for the tourist survey, the questionnaires were administered through Qualtrics XM by five enumerators in face-to-face interviews to prevent the exclusion of illiterate respondents. These enumerators were local villagers who had completed high school and were about to start university. Data were gathered in Cape Maclear in November and December 2023. Permission to conduct the study was granted by the National Committee on Research in the Social Sciences and Humanities of Malawi, National Commission for Science and Technology, Protocol No P. 08/23/788. Informed consent was obtained by either signing or fingerprinting a consent form that was explained to the participants.

2.1. Experimental design: Households

The household questionnaire was designed to gather information regarding the households' WTP, alongside an examination of their current waste management practices and disposal pathways. Furthermore, inquiries about the perception of SWM in the village and related concerns about the environment, the willingness of the households for waste separation, fertilizer usage patterns, and socioeconomic characteristics were integrated into the questionnaire. The questionnaire was formulated based on a similar WTP study conducted in Blantyre by Ndau and Tilley (2018) and modified to align with the specific conditions of Cape Maclear.

2.1.1. Sampling design

Fig. 1 shows a map of Cape Maclear with the sampling paths taken by enumerators. The sampling paths are numbered 0–47 and clustered into three phases. The zero point was set at the northern end of the village, delimited by the foot of the hill north of Cape Maclear. The southern end of the village was defined by the gate to the National Park. According to the initial map, the village had a length of 3500 m. Each starting point belongs to a straight line running through Cape Maclear from west to east. The enumerators traversed the village as closely as possible along these designated lines. During phase 1, enumerators walked along stripes 0–11 and surveyed every third house (stripes are marked in red on the map). During phase 2, the enumerators followed stripes 12–23 and surveyed every second house (stripes marked in green on the map). Finally, during phase 3, enumerators walked along stripes 24–47 surveying every second house (stripes are marked in blue on the map). Ultimately, the sampling paths were 75 m apart. In instances where no one was present in a household, the enumerators proceeded to the next house to continue the survey until a suitable household was found. The final sample size for the household survey (N = 259) was determined by time and resource limitations.

2.1.2. Households' WTP

To estimate the households' WTP for the waste management system, a double-bounded dichotomous choice contingent valuation method was used (Assa, 2013; Ndau and Tilley, 2018; Girma et al., 2022). The contingent valuation method is a survey-based approach used to estimate the economic value of goods and services that are not typically traded in markets (Arrow et al., 1993). Conventional dichotomous choice contingent valuation questions (single-bounded approach) have been criticized for their inefficiency in accurately capturing individuals' WTP (Cameron and Quiggin, 1994; Hanemann et al., 1991). Introducing follow-up dichotomous choice questions, also known as the double-bounded approach, results in more accurate estimates of individuals' WTP for waste management services (Hanemann et al., 1991). This double-bounded dichotomous choice contingent valuation method is often used to estimate households' WTP for SWM services (see

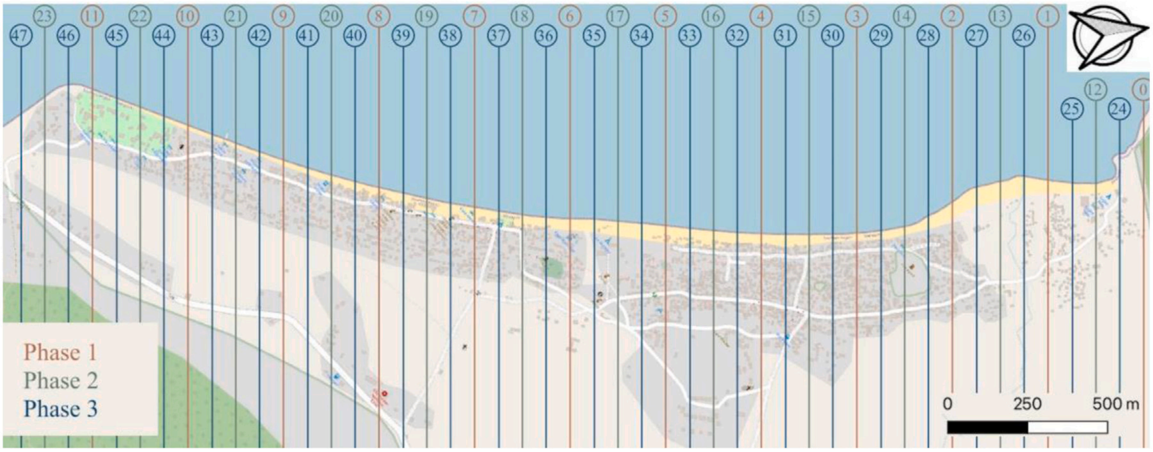

Fig. 1. Sampling stripes of the household survey, adjusted map from OpenStreetMap contributors (2023).

Table 1
Initial and follow-up bid amounts in MWK (bid 1 & bid 2).

Bid 1 *initial bid*	Bid 2 *if answer to initial bid = "no"*	Bid 2 *if answer to initial bid = "yes"*
1000	500	2000
1500	750	3000
2000	1000	4000
2500	1250	5000
3000	1500	6000

Constance, 2021; Ezebilo, 2013; Girma et al., 2022; Wegedie et al., 2020; Ghimire et al., 2024; Chung and Yeung, 2019).

In the double-bounded approach, respondents are presented with a series of two questions containing a binary (dichotomous) choice, typically a yes-or-no question, regarding their WTP for the good or service being evaluated (Hanemann et al., 1991). To estimate the WTP, the participants were first presented with an initial starting bid which would hypothetically have to be paid as a fee for the service. If the response to this initial bid was "no", then the follow-up question contained a second bid with half the amount of the initial bid. Conversely, if the respondent said "yes" to the initial bid, the second bid was double the amount of the initial one. There were six different starting bids in the household questionnaire, ranging from MWK 500 to MWK 3000 in increments of MWK 500. Table 1 illustrates the starting and follow-up bids.

Starting point bias and anchoring bias occur in surveys because respondents tend to be influenced by the initial information presented to them, shaping their subsequent responses. This bias persists as individuals anchor their judgments or decisions around the initial reference point (Veronesi et al., 2011). To reduce these biases in the WTP estimation, the starting bids were randomized among participants. Likewise, the double-bounded approach helps to reduce these biases.

2.1.3. Waste separation

Two different hypothetical SWM scenarios were included in the WTP study. In both scenarios, a service would be provided for the regular collection of waste from a nearby collection point. Households would have to carry their waste and walk no more than 15 minutes to these collection points. The collection points would always be available and when the container is full, it would be emptied. The service would be paid for by a monthly fee. In the first scenario, participation in the waste management system would not require households to separate their waste. In contrast, participation in the second SWM scenario would require households to separate their waste at the collection point into different waste streams, such as plastics, food and yard waste, glass, paper and cardboard, metals, and used hygiene products. Each participant completed the WTP estimation twice (once with, once without separation). The initial starting bid varied randomly between participants but was kept constant for both scenarios completed by each participant.

2.1.4. Environmental concern

Delavande (2023) has shown that in research involving participants with lower literacy levels, physical objects can be useful as visual aids to facilitate the expression of probabilities and preferences. In this method, participants are asked to allocate items such as stones, peanuts, or beans, allowing them to articulate their probabilistic beliefs in a more tangible and less abstract way (Delavande, 2023; Vargas Hill, 2009; Anderson et al., 2017). In the present study, the Beans Game was utilized to assess the relative importance of the natural environment compared to other public policy sectors, as well as to compare SWM to other environmental issues (see Appendix A.1 for more details).

2.2. Experimental design: Lodges

The lodge questionnaire contained questions about the current waste management practices of the lodges and the disposal pathways. It covered the same waste categories as the household survey. Furthermore, the questionnaire served to estimate the WTP for the SWM system of the lodges. In Cape Maclear, there are a total of 16 lodges. Only lodge owners or managers were considered as eligible participants.

2.3. Experimental design: Businesses

The business questionnaire was designed to gather information regarding the businesses' WTP, their current waste management practices as well as the disposal pathways. Additionally, it included questions regarding the perception of SWM in the village, expectations for the future SWM system, and socioeconomic characteristics. Stricker (2024) estimated the total number of businesses in Cape Maclear to be over 400. People selling fruits on the side of the road without a fixed stand were not considered as a business. Based on this estimate and the time required to conduct the household survey, it was decided that every second business should be interviewed as part of the business survey. For safety reasons, bars and all businesses associated with sex work were systematically excluded. In contrast to the household survey, Cape Maclear was divided into five areas rather than stripes: Madothi side; area around the bar "Stopover"; Chembe lakeside; main street Chembe; market. Appendix Figure 2 shows the fragmentation into the five areas.

2.4. Experimental design tourists

The questionnaire designed for tourists diverged significantly from the other questionnaires. Tourists were surveyed regarding their perception of waste management in Cape Maclear. The tourist survey was exclusively self-administered through online channels. Participants were directed to the survey via a link or by scanning a QR code. QR codes were distributed to lodges at the beginning of the fieldwork phase, with instructions to inform their staff about the ongoing study and to make guests aware of the survey. Therefore, the QR codes were displayed at lodge receptions. All lodges agreed to participate in the study. The survey was intentionally designed to be short, requiring approximately five minutes to complete, to minimize the churn rate.

2.5. Analysis

The dichotomous choice contingent valuation method was used to estimate households' WTP for the waste management system, using the ‘‘doubleb’’-command in Stata, developed by Lopez-Feldman (2012). This command uses the maximum likelihood under the assumption of normality, to estimate the double-bounded dichotomous choice model for contingent valuation proposed by Hanemann et al. (1991). The analysis excluded invalid surveys for all stakeholder groups.

3. Results and discussion

This section is organized according to the different stakeholders in Cape Maclear and begins with an overview of the survey results. It then discusses the necessary conditions for a sustainable business model and provides recommendations for its implementation. All calculations are based on the exchange rate as of November 2023: USD 1 = MWK 1680.

3.1. Households

The final sample comprised 259 valid responses. With an average of 5.3 members per household, the surveyed households represent about 10% of the population of approximately 15,000 people in Cape Maclear. Additional information on the sample characteristics of the households can be found in Appendix A.4. Over 40% of the surveyed households reported a monthly income below MWK 50,000 (USD 30). This income level appears notably low, given an average household size of 5.3 members and a minimum wage in Malawi's rural areas of 50,000 MWK per person per month (WageIndicator, 2024).

The acceptance of the different bid amounts is presented in Table 2. The first column shows all possible bid amounts of the double-bounded contingent valuation method, while the six starting bids, ranging from MWK 500 to MWK 3000 in increments of MWK 500, are highlighted in bold. The other bids are either double or half the starting bids. For a more detailed overview of the bid amounts and their acceptance, see Appendix A.2. Each starting bid was presented to 42, 43, or 44 participants. Since the follow-up bids depended on the response to the first bid, the distribution of respondents to the second bid was not uniform. Therefore, the figures are not intended to compare the different bids within a scenario, but to compare the two scenarios with each other. The willingness to accept higher bids to pay for waste management is higher in the no-separation scenario than in the separation scenario. Conversely, the lower bids were more popular in the separation scenario, indicating that households that must separate their waste are willing to pay less.

Table 3 shows the influence of various covariates on the WTP estimates. Covariates were categorized into demographics, education, village, and SWM. Models (1) and (2) represent the baseline scenarios without considering any covariates, in which the WTP was estimated to be MWK 1507 and MWK 899 per month for the no separation and separation scenario, respectively. This difference was expected because households have to invest more time and effort to separate their waste, which explains their lower WTP. In terms of participants' demographics (models (3) and (4)), older respondents were less willing to pay for waste management. Furthermore, household heads had a significantly higher WTP than non-household heads. The higher a respondent's education (models (5) and (6)) and the higher a household's income (models (7) and (8)), the higher their WTP. Participants who were willing to engage in the SWM system, either by paying a fee or by contributing their time, showed significantly higher WTP than those who were not willing to engage in the system (models (11) and (12)). Furthermore, respondents who assigned a higher importance to the natural environment compared to other public policy sectors (measured by the average number of beans a participant assigned to the natural environment) showed a higher WTP.

Table 2
Participants' acceptance of different bid amounts.

Bid [MWK]	No separation Yes	Separation Yes
250	3	7
500	11	16
750	4	7
1,000	45	34
1250	8	6
1,500	24	17
2,000	18	11
2,500	6	4
3,000	17	12
4,000	9	10
5,000	6	5
6,000	4	4
	155	133

Note: Starting bids are presented in **bold**.

To sum up, the model confirms that differences in respondent characteristics, environmental concerns, and expectations of the SWM system led to differences in household WTP. Respondents showed a higher WTP when they did not have to separate their waste, implying that the design of the SWM system affects the WTP. Source separation aims to separate waste by material type at the point of generation to facilitate subsequent reuse, recycling, or disposal. It is an effective approach to reducing environmental impact and conserving resources by increasing purity through reduced contamination (Zhang et al., 2022). Proper waste separation at the source can result in cost savings by reducing the effort needed to sort waste at a later stage.

The questionnaire also assessed respondents' willingness to participate in the SWM system. 75% of the participants would prefer to contribute their time compared to 12% who would be willing to pay the fee, while 8% do not want to participate in the SWM system at all. While 86% of the households are hence willing to participate in one way or another in SWM, it is noticeable that the majority of households would prefer to contribute their time rather than pay a fee. This is not surprising given that 60% of the respondents were unemployed and that most households in Cape Maclear were living at subsistence level. These findings are also reflected in the analysis of the Beans Game, where food security was chosen by far as the public sector most worthy of attention, followed by unemployment and poverty (see Appendix Table 7).

While it may be more accurate than the single-bounded approach, it is important to note that there are limitations to the double-bounded approach. The double-bounded dichotomous choice contingent valuation method is based on hypothetical scenarios in which respondents are not obligated to make the payment they indicate. According to Diamond and Hausman (1994), stated WTP is a poor indicator of actual WTP, therefore limiting the validity of the contingent valuation method. Most studies comparing stated and actual WTP have found divergences between the two, with stated WTP being overestimated (Christie, 2007; Harrison, 2006; Loomis, 2011; Murphy et al., 2005; Onwujekwe et al., 2005).

Table 3
Household WTP models, values expressed in MWK (NS: no separation, S: separation).

	Unit	(1) NS	(2) S	(3) NS	(4) S	(5) NS	(6) S	(7) NS	(8) S	(9) NS	(10) S	(11) NS	(12) S	(13) NS	(14) S
Observations	*n*	251	251	239	239	245	245	225	225	249	249	234	234	213	213
Constant		1506.6***	898.9***	2122.7***	1612.4**	−98.0	−321.9	613.4**	150.0	2950.1***	2083.6***	−2376.7**	−3288.3**	−697.1	−906.3
		(182.4)	(215.9)	(571.1)	(652.0)	(738.2)	(840.9)	(287.4)	(343.0)	(509.4)	(555.4)	(1051.3)	(1334.5)	(1654.9)	(2008.1)
Sigma		2534.8***	2818.2***	2390.6***	2674.3***	2433.3***	2745.9***	2411.6***	2726.3***	2412.8***	2693.5***	2366.5***	2785.2***	2050.5***	2432.8***
		(212.8)	(265.1)	(202.4)	(253.3)	(205.8)	(260.9)	(215.2)	(268.8)	(202.4)	(253.2)	(203.7)	(269.3)	(184.2)	(240.9)
Demographics															
Male	1/0			431.7	90.2									209.9	220.7
				(542.1)	(602.9)									(596.2)	(686.5)
Age	yr			−30.8**	−28.4**									−10.2	−18.5
				(12.5)	(14.3)									(13.4)	(16.2)
Unemployed	1/0			−179.3	−398.4									−12.5	−122.7
				(379.3)	(433.0)									(385.9)	(462.3)
Head of HH	1/0			1059.0	2228.9**									1279.7*	2074.0**
				(774.0)	(947.4)									(757.4)	(947.2)
Head of HH & lead in SWM	1/0			−167.9	−1321.6									−1256.4	−2030.2**
				(772.8)	(932.1)									(773.1)	(963.2)
Education															
Basic education	1/0					1296.8*	868.1							−0.5	−240.2
						(765.0)	(865.7)							(732.7)	(885.6)
Higher education	1/0					2510.4***	2071.3**							642.8	539.8
						(804.3)	(908.6)							(835.8)	(1007.5)
Monthly HH income															
50,000–100,000	1/0							1199.8**	1307.9**					815.0*	935.0*
								(466.7)	(540.8)					(444.6)	(536.2)
100,000–150,000	1/0							1094.1**	593.2					1004.0*	545.5
								(533.4)	(611.3)					(529.6)	(630.6)
150,000–200,000	1/0							2236.0**	1738.6*					1594.6*	1056.3
								(879.5)	(967.4)					(844.9)	(952.4)
200,000–250,000	1/0							2598.5***	1846.7*					1804.7**	1279.7
								(958.4)	(984.6)					(869.7)	(943.0)
250,000–300,000	1/0							136.6	13 615.2					−351.2	11 770.5
								(2432.9)	(478832.1)					(2246.7)	(459880.5)
more than 300,000	1/0							2565.6***	2721.6**					3814.5***	4125.2***
								(980.6)	(1129.5)					(1073.5)	(1293.1)
Village															
Muonda	1/0									−1895.9***	−1756.9**			−1321.3*	−1329.8
										(651.5)	(739.2)			(685.6)	(808.0)
Nkhono	1/0									−1833.5***	−1622.5**			−864.2	−766.2
										(624.5)	(691.1)			(649.9)	(748.1)
Katukumala	1/0									−1025.0	−474.8			−417.4	−230.6
										(635.2)	(703.4)			(655.9)	(763.3)
Kafukuta	1/0									−2555.6***	−2055.7**			−2634.1**	−2005.8*
										(857.9)	(955.7)			(1060.2)	(1214.3)
Chembe	1/0									−1249.5*	−1052.2			−174.8	−382.6
										(653.9)	(724.4)			(705.7)	(818.4)
SWM															
Willing to pay a fee	1/0											2538.6***	2806.4**	1332.2	1001.1
												(881.0)	(1111.7)	(862.3)	(1062.0)
Willing to contribute time	1/0											2206.6***	2896.6***	1740.5**	1963.0**
												(765.4)	(993.0)	(769.6)	(961.3)
Importance of SWM	[0–40]											27.3	15.8	42.0	23.7
												(41.1)	(49.5)	(42.3)	(50.5)
Importance of natural environment	[0–40]											173.2***	126.6**	172.4***	134.6**
												(53.2)	(62.8)	(58.1)	(68.2)
Satisfaction with current SWM	[1–5]											236.1*	231.9	−0.5	72.6
												(142.4)	(172.1)	(160.3)	(192.8)

Note: The WTP was always calculated for both scenarios (NS: no separation, S: separation). The difference is that in the separation scenario, the households would have to separate their waste themselves. HH stands for households.

* Robust standard error in parenthesis, $p < 0.1$.

** Robust standard error in parenthesis, $p < 0.05$.

*** Robust standard error in parenthesis, $p < 0.01$.

Due to the different external conditions in different countries and regions, a direct comparison of these WTP results to other contexts is not possible. However, comparable studies showed positive results for WTP, and the proportion of respondents willing to pay for waste management was very high in all studies (Assa, 2013; Constance, 2021; Ezebilo, 2013; Girma et al., 2022; Kapanda, 2020; Ndau and Tilley, 2018; Wegedie et al., 2020). While in Rwanda 77% of respondents were willing to pay for waste collection, in Nigeria it was 80%, and in Ethiopia it ranged from 87% to 89% in different cities (Constance, 2021; Ezebilo, 2013; Girma et al., 2022; Wegedie et al., 2020). In Malawi, the 2018 WTP in Blantyre was MWK 945 to MWK 2138 (USD 1.26 to USD 2.85 in 2018), depending on different scenarios, while 56% of respondents were willing to pay for improved SWM management (Ndau and Tilley, 2018). A 2020 study in Mzuzu City found an average WTP of MWK 1507 (USD 2.09 in 2020) per month, while 86% of respondents were willing to pay for solid waste collection (Kapanda, 2020). In Cape Maclear, the willingness to participate in the SWM system was 86%, while the average WTP ranged from MWK 899 to MWK 1507 (USD 0.54 to USD 0.90), depending on the waste separation scenario. Differences in time and space, as well as the constant depreciation of the Kwacha, make direct comparisons even within Malawi impossible. However, the high willingness to participate in SWM in Cape Maclear is noticeable.

3.2. Lodges

In this study, 13 of the 16 lodges in Cape Maclear (81%) were successfully surveyed. Respondents were 62% male, on average 50 years old, and 77% lodge owners, with the remaining 23% being managers (see Appendix A.5 for more detailed sample characteristics). There is a simple waste collection system in place for some of the lodges. This system was originally initiated and is now organized by one of the lodge owners. Currently, 46% of the lodges pay for SWM, while 38% of the surveyed lodges participate in this waste collection initiative (Appendix Table 8). Lodges participating in the system are currently charged a monthly fee of MWK 8000 (< USD 5) for waste collection services. Waste collection is usually done once a week and is facilitated by a local resident who uses a pick-up truck to collect the waste from the lodges. According to this resident, the collection process takes around half a day. The waste is transported to a small hole in the ground behind the village, where soil has been excavated for brick-making. The waste is burned at this site and the resulting ash is left behind, with permission of the landowner. Sixty-nine percent of the lodges were dissatisfied or extremely dissatisfied with their current waste management options in Cape Maclear.

All lodges were willing to participate in the proposed SWM system, and 92% of them were willing to pay a fee. Seventy-seven percent of lodges prefer a monthly payment system. None of the lodges wanted to pay an annual fee, a fixed fee per guest, a fee based on a percentage of

Table 4
Financial overview and WTP of lodges. Mean values were calculated including values of 0.

Variable	Unit	Min	Max	Mean
Capacity of guests	guests	8	85	32.08
Nights on average	nights/guest	2	7	2.75
Avg. turnover				
– Busiest month	USD/month	1,200	15,000	6,457
– Slowest month	USD/month	0	4,500	1,478
WTP				
– Waste lodges	USD/month	0	23	13.00
– Public waste	USD/month	0	12	4.22

their income, or a fee per volume/kilogram of waste produced. Therefore, none of the lodges favored the polluter pays principle which aims to create economic incentives to prevent and reduce pollution by making polluters financially responsible for the pollution they cause (Ambec and Ehlers, 2016). The lodges were willing to pay for the waste management system, but only under the condition that all other lodges pay the same fee, independent of the waste production. A periodic fee is also the easiest to implement because there are no standardized buckets, scales, or other materials to measure waste in Cape Maclear. Sixty-nine percent of the lodges were willing to pay an additional fee for public waste collection on top of the waste disposal fee. Public waste was defined as all waste in the village, such as litter on the streets, beaches, and lake areas for which no one takes responsibility. The majority of lodges would prefer to have their waste collected twice a week.

Table 4 provides an overview of the financial situation of the lodges and their WTP. Guest capacity and average turnover vary considerably between lodges. Collectively, the 13 lodges surveyed can accommodate a total of 417 guests (extrapolated to all 16 lodges of Cape Maclear: 513 guests). Most lodges reported an average stay per guest of two to three nights. Disparities between lodges persist throughout the year, with the average monthly revenue varying from USD 1500 to USD 6500. All lodges were willing to engage with the waste management system, either by paying a fee or contributing time. The average monthly WTP for the SWM system was USD 13 per lodge. In addition, the lodges are willing to pay an average of USD 4.22 for the removal of public waste. Assuming that all 16 lodges in Cape Maclear would have to pay these fees, the total monthly revenue for the SWM system from the lodges would be USD 208, plus an additional USD 67.5 per month for public waste removal. Note that most lodges would only be willing to pay for the SWM system if the households were also involved.

3.3. Businesses

In total, 240 businesses were surveyed, out of which 117 (49%) were small shops and markets for everyday goods (see Appendix Table 3 for an overview of the different business types and their daily turnovers). The average daily turnover per business varied widely, ranging from MWK 2000 to MWK 300,000, with an average turnover of MWK 38,260. Furthermore, most of the shops (46%) were based in Muonda, the sub-village where the market is located (Appendix Table 4). Eighty-three percent of the business survey participants were business owners, while 14% were employees. On average, a business employed 2.7 workers, and 81% of the businesses had fewer than four employees. Moreover, nearly 50% of the surveyed businesses reported that most of their waste was plastic waste, followed by 22% who reported that it was food waste. See Appendix A.6 for further information on the sample characteristics of the business survey.

Overall, 91% of businesses were willing to engage in the SWM system. Seventy-eight percent preferred to contribute their time to the SWM system compared to paying a fee, while an additional 3% preferred to contribute an employee's time. Eleven percent preferred to pay a fee. Among these businesses, payment preferences varied, with 46% opting for a weekly fee and 54% preferring a monthly payment structure. The average weekly WTP was MWK 496, while the average monthly WTP was MWK 1571. Hence, the aggregated monthly WTP of the businesses paying on a weekly basis is higher than that of the businesses paying on a monthly basis. Consolidating these observations, the average WTP per business per month is MWK 1838 (USD 1.09).

Note that the calculated WTP value is based on responses only from those businesses that preferred a cash, rather than a time contribution. Therefore, the WTP of businesses for SWM in Cape Maclear was assumed to be zero for further calculations (as only 11% were willing to pay a fee).

3.4. Tourists

The tourist survey generated 85 valid responses, of which 13% were Malawians and 26% were living in Malawi. Fifty-two percent of the respondents were male, with an average age of 37 years and an average daily expenditure of USD 85 in Cape Maclear. Sixty-six percent of the tourists were not satisfied with the waste management situation in Cape Maclear, while 76% encountered waste-related problems such as littered areas and limited waste disposal possibilities. See Appendix A.7 for detailed sample characteristics.

The estimated average WTP per tourist was USD 1.75 per day. Given that all lodges in Cape Maclear have a combined capacity of 513 tourists, the revenue for the SWM system from tourists per month is calculated in Table 5, taking into account the different seasons. Based on lodge owners' indications, it is assumed that the different seasons in Cape Maclear range from 5% occupancy during the low season to 100% occupancy during the holiday season. Calculating the average WTP of tourists per year based on these assumptions results in a total of USD 165,707, which would be on average USD 13,809 per month. These results indicate that charging tourists for waste management could have a significant impact on the overall revenue of the SWM system.

In Europe, specific taxes primarily focused on the tourist sector are common. According to the European Commission (2017), short-term stays in paid accommodations are subject to occupancy taxes. They are usually charged per person, per night, or occasionally as a percentage of the total cost of the accommodation and vary depending on the standard of the accommodation. While tourists have to pay these taxes, the accommodation facility is responsible for collecting the tax. Compared to the cost of the accommodation itself, they represent a small proportion of the total cost. Tourism taxes are commonly used to improve infrastructure, tourism services, or the design of public services such as waste management (European Commission, 2017). Tourist taxes in Europe vary from destination to destination, ranging on average from approximately USD 0.4 to USD 2.5 per person per night, depending on the type of accommodation (European Commission, 2017). The average WTP for Cape Maclear of USD 1.75 per person per day is within this range and confirms that tourists are willing and used to pay for waste management systems.

Three biases could lead to an overestimation of the actual WTP of tourists: First, due to sampling limitations, tourists staying in the more expensive lodges of Cape Maclear were over-represented among the survey respondents. Second, due to self-selection into the survey, mostly tourists who are interested in waste management and aware of the problem filled out the survey, who might have a higher WTP than the average tourist. Additionally, the results may be skewed due to potentially higher stated values from foreign tourists who have larger travel budgets than local Malawians or foreigners living in Malawi.

Table 5
Potential income based on tourists' WTP for SWM in Cape Maclear.

Occupancy		Low-season 5%	Season 50%	High-season 75%	Holidays 100%
Potential income[a]	[USD/month]	1,347	13,472	20,208	26,945
Duration	[months/yr]	3	4	4	1

[a] Note: The average WTP was estimated to be USD 1.75 per tourist per day.

Table 6
Total costs of the SWM system by scenario and transportation mode (Stricker, 2024).

Scenario	Pickup truck [USD/month]	Hand trolley [USD/month]	Motorcycle [USD/month]	Small truck [USD/month]
Only lodges	83.77	78.75	74.86	93.99
Lodges + 4 CP	235.89	348.99	281.72	216.35
Lodges + 24 CP	271.32	383.66	312.21	262.20

Note: CP = collection points.

3.5. Business model

Based on further studies of the overall project, the following empirical values have been used to estimate the total operating costs of the waste collection and treatment system for Cape Maclear. Waste treatment includes an incinerator and a glass crusher constructed during the fieldwork phase in Cape Maclear. We assume that (a) an average worker is paid MWK 100,000/month (Stricker, 2024); (b) the glass crusher is operated 2 hours/day (Colbach, 2024); and (c) the cost of operating and maintaining the incinerator is MWK 60,000/month and MWK 50,000/year, respectively (M. Peduzzi, personal communication, April 06, 2024).

Based on these estimates, the operating costs of the glass crusher are USD 17.41/month and the operating costs of the incinerator are USD 38.19/month. Stricker (2024) calculated the cost of waste collection in Cape Maclear for different collection scenarios and different modes of transport. Table 6 shows the total costs of the waste management system, consisting of waste collection and the operation of the incinerator and glass crusher, broken down by scenario and transportation mode. The three different scenarios are either collecting waste only from the lodges, collecting waste from the lodges plus an additional four collection points in the village, or collecting waste from the lodges plus an additional 24 collection points. Furthermore, waste can be collected by trucks, hand trolleys, or motorcycles. The costs of the SWM system range from USD 75/month to USD 384/month.

Table 7 provides an overview of the different WTPs for the defined stakeholder groups as well as the expected overall revenue per stakeholder group. The calculations in the total revenue column are based on the assumption that all stakeholders within a stakeholder group would pay the estimated average WTP, e.g. 2830 households in Cape Maclear would pay MWK 1507/month without waste separation. When the total revenues from the different stakeholder groups are compared with the costs of the different waste management scenarios, it can be seen that the costs are easily covered. However, the stated WTP is likely to overestimate the actual WTP. Since the revenues can cover the costs, it is recommended to set the actual fee for waste management lower than the average WTP per stakeholder group.

In the following, a recommendation for a sustainable business model is outlined. Since the WTP for the businesses was estimated to be zero and the costs can be covered without their contribution, these stakeholders are not expected to pay for the SWM system. Since lodges are only willing to pay if households also participate in the waste management system, households must be included in the system. Nevertheless, the households' fee for waste management has been minimized as they are already living at subsistence level and the fee for waste management should not put an additional burden on them. In the questionnaire, only 12% of households indicated that they would prefer to pay a fee rather than contribute their time. Therefore, households should be given the choice of contributing either time or money to the system. If they choose time, they have to bring a certain amount of public waste to the disposal site. In this way, the villagers act as waste collectors. Assuming that only 12% of the households would pay the fee and the remaining households would collect public waste, the fee for waste management per household would be MWK 750/month. This fee is lower than the average WTP of households for both scenarios, with and without waste separation. In addition, it is recommended that lodges pay USD 15/month for waste management services, consisting of USD 12 for their waste and USD 3 for public waste. Through cross-subsidization, where lodges pay a higher fee than necessary to cover their own costs, they contribute more to the waste management system. This approach redistributes the financial burden of households, thereby promoting a more equitable distribution of waste management costs. If all 16 lodges pay USD 15/month and 12% of the households pay MWK 750/month, a total of USD 392/month is collected. This revenue could cover the cost of all the scenarios presented and all the different modes of transportation.

Table 7
WTP and total revenue for SWM across different stakeholder groups in Cape Maclear.

Stakeholder	*n*	WTP/stakeholder [USD/month]	Total revenue [USD/month]
Households	2,830		
– No separation		0.90	2,539
– Separation		0.54	1,514
Lodges	16		
– Lodge waste		13.00	208
– Public waste		4.22	68
Businesses	~500	0	0
Tourists	513	26.92	13,809

Note: USD 1 = MWK 1,680.

By making the monthly operations independent of external sources of funding (e.g. tourists), the SWM system can be protected from external shocks such as the COVID-19 pandemic. Nevertheless, it is recommended to introduce a tourist tax per night in Cape Maclear, collected by the lodges. The revenue from this tax can be used for major long-term investments, such as purchasing a new truck or improving the waste management infrastructure. It can also be used as a buffer to cover unexpected hurdles, as well as to fund future projects and facilitate recycling efforts. Furthermore, implementing waste separation for organic waste would be recommended to encourage community composting efforts (Meier, 2024). The finances need to be managed by an independent accountant to keep the system trustworthy. It is important to note that this is only one possible recommendation; with the given parameters, other scenarios can be designed.

4. Conclusions

With the goal of contributing to a sustainable waste management system in Cape Maclear, this study determined the average WTP of four defined stakeholder groups: households, lodges, businesses, and tourists. All stakeholders in Cape Maclear are willing to contribute to the waste management system by paying a fee or contributing their time. The costs of the system as well as the different revenue streams, estimated based on the average WTP per stakeholder group, were determined. Lodges and households should pay a fee to cover operating costs, with the lodges cross-subsidizing the households who choose to contribute time instead. The revenue collected from tourists through the introduction of a tourist tax should be used as a buffer, for long-term investments, or improvements in the waste management infrastructure. Lodges and households would pay the fee on a monthly basis, while tourists would pay the tax per night.

WTP studies can provide valuable information about the financial feasibility of waste management initiatives and community preferences, but it is important to recognize that WTP studies have limitations. Stated WTP is based on hypothetical scenarios in which respondents are not obligated to make the payment they indicate, and often overestimates actual WTP. Furthermore, socio-economic parameters such as income levels and perceptions of the importance of SWM influence the results. In addition, there may be other potential sources of funding for the SWM system, such as government subsidies, other taxes, and external funding mechanisms (e.g., carbon finance). Carbon finance provides payments to projects that reduce GHG emissions, such as composting organic waste (Galgani et al., 2014). These projects achieve certified emissions reductions that can be sold in an emissions trading system. Furthermore, this study did not involve the UNESCO World Heritage body that designated Lake Malawi as a World Heritage Site to explore potential co-funding of an SWM system from UNESCO funds. This study did not include such alternative funding mechanisms as possible revenue sources for the waste management system which could minimize waste management fees for the stakeholders in Cape Maclear.

A subsequent phase requires the implementation of the system. Decisions regarding a waste collection scenario and the mode of transport are necessary; at the time of writing it was not clear if Sustainable Cape Maclear, a coalition of chiefs, or a private entity would be responsible for operationalizing the system. Such decisions have the potential to reduce the fees to be paid by stakeholders. In addition, determining the actual WTP of stakeholders and comparing it to the stated WTP would be a valuable contribution to research efforts. Despite the identification of the parameters for a sustainable business model, uncertainties remain regarding the scope of implementation. Questions arise about the structure of the payment system and the enforcement of the waste management fees, the appointment of an independent accountant, the level of actual fees, and the involvement of the village chiefs. In addition, the amount of public waste that a household would need to deliver to the waste disposal site in order to offset the monthly fees needs to be defined. These decisions are essential to optimize the waste management strategy and achieve financial sustainability within the system. As such, future research should first focus on understanding the payment and default rates, the impact of waste services on community health, the perception of tourists and residents, and on validating the results in other geographical contexts. Given the long-standing engagement of the research team in Cape Maclear, we intend to explore these aspects in upcoming research work.

Overall, a sustainable business model for the waste management system in Cape Maclear has been identified, and its implementation will bring several benefits. It should help prevent pollution of Lake Malawi and the surrounding landscape. Further, it should improve public health, promote tourism and mitigate climate change. The waste management system will provide employment and stimulate economic activities such as recycling and composting. Through community participation, the system can lead to the development of sustainable practices and promote environmental stewardship.

There is growing awareness of the impacts of tourism on the environment and on community wellbeing. From a policy perspective, this work shows how tourism could potentially contribute positively to a more sustainable Cape Maclear through small tourism levies, serving as an example for similar communities worldwide. Furthermore, this work highlights the importance of coordinating financial contributions between multiple stakeholders, including residents who despite their poverty can make small contributions and, in doing so, increase the long-term sustainability of the SWM system. As Malawi increasingly becomes a tourist destination (for instance, it has been featured in the New York Times' 52 most recommended travel destinations), this works serves as a template for similar communities who struggle with SWM and the effects of unregulated tourism.

CRediT authorship contribution statement

Elena Abgottspon: Writing – original draft, Methodology, Investigation, Conceptualization. **Jan Freihardt:** Writing – review & editing. **Jakub Tkaczuk:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Elizabeth Tilley:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.rcradv.2025.200281.

Data availability

The data underlying the results is available at Abgottspon et al. (2025).

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