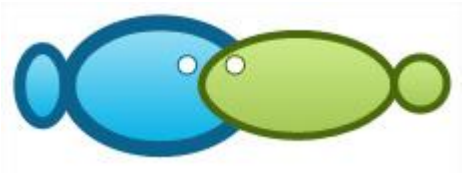

# Application of discrete choice experiments in solving marine plastic litters on beaches in Belitung District, Indonesia

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**Abstract**. Marine plastic litter comes from non-point sources, and solving this problem requires strategies that involve various actors and stakeholders. Enhancing collective action is one of the strategies in addition to top-down policies. This research aimed to apply Discrete Choice Experiments to analyze people preferences in solving marine plastic litter on several beaches in Belitung District, Indonesia. The results show that local communities prefer time contribution, while visitors prefer money contributions. The individual Marginal Willingness to Pay (MWTP) for both groups is 6.6 USD per month and 0.2 USD per visit, respectively. Thus, an annual 4.89 million USD Total Willingness to Pay (WTP) is obtained since the level of beach cleanliness significantly impacts human welfare. Meanwhile, a higher welfare change can be created by implementing a high improvement scenario. Raising collective action to solve marine plastic problems should consider time and money contributions for local community and visitors. The research provides inputs for policymakers, environmental managers, and activists in designing programs or issue calls to action in solving marine plastic litter.
**Key Words**: economic valuation, money and time donation, willingness to pay.

**Introduction**. Marine plastic litter is a global challenge, including transboundary and localized issues. In addition, it is related to the Sustainable Development Goals (SDGs), particularly SDG 6 concerning clean water and sanitation, SDG 11 focusing on sustainable cities, SDG 12 addressing sustainable production and consumption, and SDG 14 emphasizing life below water. Marine plastic litter originates from a variety of sea and land-based activities, including households, tourism, aquaculture, shipping, and fishing (Lusher et al 2017). The problem arises from inadequate disposal practices and behaviors, mismanagement of solid waste on land, as well as the discharge of sewage and pollutants from streams (Vince & Hardesty 2017; Kaza et al 2018). China, Indonesia, Vietnam, the Philippines, and Thailand are responsible for more than 50% of global plastic waste in the oceans (Jambeck et al 2015). Less than 20% of the total plastics produced enter the value chain in mechanical, chemical, and thermal recycling, while vast amounts end up in terrestrial and marine environments every year (UN 2020). 8 million tons of land plastic waste is flushed into the ocean annually, and the flow potentially decreases by 45% if 75% of the leakage can be prevented (WEF et al 2016).

The persistence of externalities such as plastic litter is facilitated through non-excludability and non-rivalry characteristics of the marine ecosystem, which negatively affect the public. The non-excludability characteristic creates difficulties in excluding individuals from the loss of welfare, such as damage and dis-amenity. Meanwhile, non-rivalry implies that the disutility experienced by any individual exposed to externalities does not affect others (Oosterhuis et al 2014). The negative impacts of marine plastic litter do not always affect only the polluters, but the broader population.

Solving marine litter problems requires local and global governance, engagement, and collective actions of various stakeholders with divergent perspectives and interests, including government, private sectors, NGOs, and community (Vince & Hardesty 2017; Löhr et al 2017). Different forms of governance and instruments participate in programs

to alleviate marine litter problems. These include incentive-based instruments (such as deposit-refund schemes, subsidies, and fiscal incentives), direct payment/awards, price differentiation, preferential treatment, public procurement, and disincentive-based instruments (penalty, charges on products, taxes, and liability) (Oosterhuis et al 2014). The community-based approach has become a powerful method of reducing plastic litter, by changing behavior in littering and increasing participation in cleaning the environment (Vince & Hardesty 2017). This approach needs to be enhanced by education, provision of adequate waste facilities, and enforcement of legislation (Storrier & McGlashan 2006). For households, an instrument such as taxes or charges may shape consumption or littering behavior, contributing to plastic litter reduction. In the case of tourism visitors, this has not been proven, but can support cleaning equipment or facilities (Oosterhuis et al 2014).

Understanding public preference to solve marine plastic litter is critical to formulating effective approaches. This can be achieved through Ecosystem Service Valuation (ESV) to estimate the total willingness to pay (WTP) of individuals to enjoy environmental services (Marre et al 2016). In practice, ESV should be connected with the decision-making process, implementation and science-policy interface to enhance development planning (Kieslich & Salles 2021).

There are extensive researches on measuring WTP to reduce beach litter (Enriquez-Acevedo et al 2018; Adam 2021; Mutuku et al 2022; Grilli et al 2022; Khedr et al 2023; Mutuku et al 2024). Different factors affect individual WTP, namely educational attainment, perception of beach litter (Adam 2021), personal traits and beliefs (Tyllianakis & Ferrini 2021). However, research on the forms of contribution preferred by community groups is limited. Nelson et al (2018a) reported that individuals prefer to donate more money than time for marine conservation. Furthermore, donation behavior is significantly influenced by distributional preference types, categorized as benevolent, egalitarian, own-money-maximizing, and malevolent (Nelson et al 2018b). Therefore, this research aimed to understand individual's preferences and measure the willingness to contribute money or time to solving the marine litter problem. Discrete Choice Experiment (DCE) is applied to answer the research objective. Understanding individual preferences in contributing and assessing WTP to address the issue is important for informing policy-making at micro and mid-range levels. The understanding is important, particularly in Indonesia, where massive marine tourism is growing very fast with increased small-scale fisheries.

## Material and Method

***Description of the research sites***. This research was conducted in Belitung District, where tourism and fishery sectors were affected by marine litter problems (Figure 1). Belitung District is a rising tourism destination, with assorted beautiful beaches, coral reefs, seagrass beds, and other marine living organisms. Four sites were selected as centers for tourism and fishery activities, namely Keciput and Tanjung Binga Villages in Sidjuk sub-district, and Padang Kandis and Teluk Gembira Villages in Mambalong sub-district. These sites are facing plastic litter problems because of limited awareness, cleaning facilities, and rule enforcement. Furthermore, there is no waste disposal in the area, which drives illegal garbage dumps (Figure 2).

***Data collection***. An online pre-survey was conducted with key persons to finalize factors included in DCE design. This was followed by an in-person survey of 166 households in the coastal area and 102 local tourism visitors. Households and tourism visitors are important actors that need to be called for action, because they contribute significantly to marine plastic litter in coastal areas. In addition, interviews with a few respondents were also performed, including officials and managers of a tourism ship association.

***Design of discrete choice experiment***. Based on the online pre-survey, three attributes are included in the DCE design, namely cleaning equipment and labor (equip), regulation enforcement (rule), and donations in the form of money (mon) or time (time). 'Equip' pertains to technical aspect and 'rule' pertains to institutional aspect, which matter for solving the marine plastic litter problem. 'Mon' represents cost implication to provide cleaning equipment and labor, which is an important element in DCE to measure WTP.

'Time' pertains to beach cleaning activities, an alternative to money contribution. Beach cleanness (clean) comprises environmental outcomes resulting from intervention based on alternatives set up in the design. The workability of each attribute is considered in determining the value of levels based on information from the pre-survey and expert judgment (Table 1).


Figure 1. Map of Indonesia and Belitung District (source: google.com/maps).

Figure 2. From left to right, plastic litter in beach area, open waste disposal and plastic waste in resident area.

Four alternatives are set as interventions to improve the status quo (SQ) condition, considering changes in levels of attributes. The four alternatives include moderate improvement with 'time' (Option 1), moderate improvement with 'mon' (Option 2), high improvement with 'time' (Option 3), and high improvement with 'mon' (Option 4). Moderate or high improvement is related to the outcome level determined by the provision

of attributes in the scenarios. These options are available for local community (com) and visitors (vis) (Table 2).

Table 1

Attribute levels

| *Attribute* | *Attribute levels* |
|---|---|
| Clean | Unclean (0)<br>Quite clean (1)<br>Clean (2) |
| Equip | Existing condition (0)<br>A 50% increase (1) |
| Rule | Unenforced (0)<br>Well-enforced (1) |
| ComMon | No donation (0)<br>A monthly donation (2 USD) |
| VisMon | No donation (0)<br>A single-entry donation (0.13 USD) |
| ComTime | No beach clean-up activity (0)<br>A weekly beach clean-up activity (120 minutes) |
| VisTime | No beach clean-up activity (0)<br>A beach clean-up activity (15 minutes) |

Note: 1 USD is equivalent to 15000 IDR.

Table 2

Options for clean beach program by local community and local visitors

| *Alternatives* | *Clean* | *Equip* | *Rule* | *Mon* | *Time* |
|---|---|---|---|---|---|
| Status quo | 0 | 0 | 0 | 0 | 0 |
| Option 1 (mod_time) | 1 | 1 | 0 | 0 | 120 min *<br>15 min ** |
| Option 2 (mod_money) | 1 | 1 | 0 | 2 USD *<br>0.13 USD ** | 0 |
| Option 3 (high_time) | 2 | 1 | 1 | 0 | 120 min *<br>15 min ** |
| Option 4 (high_money) | 2 | 1 | 1 | 2 USD *<br>0.13 USD ** | 0 |

Note: clean - beach cleanness; equip - cleaning equipment and labor; rule - regulation enforcement; mon - money contribution; time - time contribution; * - community; ** - visitors.

There are six choice sets or tasks offered to the respondents comprising two alternatives. The SQ is included in each choice set to provide an option for respondents who do not contribute to environmental change.

***Choice analysis***. The random utility model (RUM) shows the DCE data analysis. RUM specifies that the individual utility function ($U_{ij}$) comprises two factors, namely deterministic ($V_{ij}$) and unobservable factors ($e_{ij}$) (Schuhmann et al 2016; Rai et al 2019). Meanwhile, WTP can be measured by estimating individuals' utility level (i) on alternatives (j) offered and the function is expressed as follows:

$U_{ij} = V_{ij} + e_{ij}$

Deterministic factors consist of the beach cleanness (Clean), cleaning equipment and labor (Equip), regulation enforcement (Rule), and money donation (Mon) and time donation (Time) made by households or visitors. Individual income (Income) constitutes socio-economic factor included in the model that is statistically significant. The deterministic factors are expressed as follows:

$V_{ij}=f(Clean_{ij}, Equip_{ij}, Rule_{ij}, Income_{ij}, Mon_{ij}$ or $Time_{ij})$

Deterministic factors of money and time utility models were analyzed independently to understand the preferences of local community and tourism visitors. Accordingly, 'mon' cannot be assumed as an equivalence of 'time'.

RUM shows that an individual is expected to decide on a choice (j) providing higher utility than other alternatives (k) (Fauzi 2015). For example, Choice Task 1 provides three options for the respondents, namely Option 1, Option 2 and SQ. Option 1 (j) is selected when perceived to provide higher utility than Option 2 and SQ. The probability is expressed as follows:

$P=Pr(V_{ij}+e_{ij}) > V_{ik}+e_{ik}, \forall k$ in the set, $j \neq k$

The utility functions of each type of contribution for the two groups are written as follows:

$V_{Mon}=\beta_{i1}Clean+\beta_{i2}Equip+\beta_{i3}Rule+\beta_{i4}Income+\beta_{i5}Mon$

$V_{Time}=\beta_{i1}Clean+\beta_{i2}Equip+\beta_{i3}Rule+\beta_{i4}Income+\beta_{i6}Time$

Where: $\beta_{i1}$, …., $\beta_{i6}$ constitute parameters for each attribute.

Mean WTP (MWTP), also known as the implicit price, shows the amount an individual is willing to sacrifice for a marginal change in attribute. WTP is obtained from the attribute's coefficient divided by the price or cost (Scarpa et al 2008). MWTP of each group is estimated from $V_{Mon}$ function (Equation 4) by dividing the coefficient of 'clean' by 'mon' (Fauzi 2015), as follows:

$MWTP = \beta_{i1}/\beta_{i5}$

The economic value is estimated by multiplying MWTP by the related population, expressed as follows:

EV=MWTP x population

Time duration of individuals willing to clean the beach is assessed using the $V_{Time}$ function, by dividing the coefficient of 'clean' by 'time'. By knowing the mean of MWTCt, the doable time length for clean-up activity can be considered in real practice using the following formula:

$MWTCt = \beta_{i1}/\beta_{i6}$

Compensating surplus (CS) reflects the change in welfare due to the improvement in 'clean'. It is defined as the change in disposable income or expenditure that holds utility constant, given a change in environmental quality (Morrison & MacDonald 2011). CS is estimated using the following formula:

$CS=-1/\beta_{i5}(V_1-V_0)$

Stata 16.0 was used to conduct a conditional logit model selected due to the relevance for analyzing data comprising choice-specific attributes (Greene 2003).

## Results

***Preferred forms of contribution***. Marine plastic litter consitutes a form of social dillemma in public goods. Opportunism is the cause of the social dilemma, where everyone wants a clean environment, but many of them do not want to contibute in protecting the

environment. Such a paradox shows that individual goals in utilizing the environment are not always in line with social goals. The local community and visitors expressed the desire to have or enjoy a clean beach (Figure 3), but in reality, we saw that such a desire does not exist, because many people do not care about beach cleanness. So, the challenge is how to raise public awareness and invite them to contribute collectively to solving environmental problems.

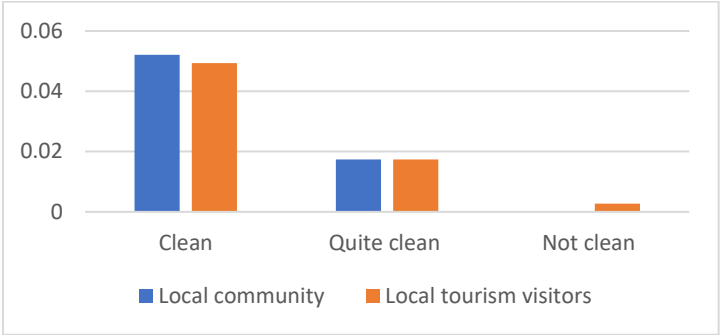


Figure 3. Preference of local community and visitors on beach condition.

The majority of local community and visitors expect to have a higher improvement program of beach cleanness, but the preferences in forms of contribution are relatively different. The most choices made by local community are on Option 3, showing their high preference to have beaches clean and a strong willingness to contribute time to the activities. Meanwhile, the visitors selected Option 4, which is a high improvement program through money contributions to support the provision of cleaning services. The village head has an important role in inviting the community to work together (gotong-royong) in residential areas. In beach tourism areas, managers can set rules regarding waste levies to support cleanliness in those areas.

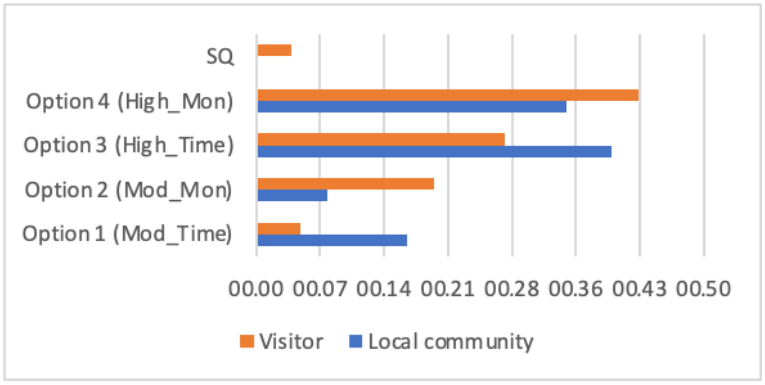


Figure 4. Choices made by local community and visitors.

Table 3 shows the results of the conditional logit model for 'mon' and 'time' of both groups. For model ComMon, 'mon' has a negative effect (-0.0000247) on the decision of local community. This shows that no alternative is preferred when 'mon' is increased. Therefore, 2 USD (30000 IDR) constitutes the highest amount charged to local community. Model VisMon shows that local visitors have a positive response to 'mon' (.0006828). There is no objection to donating 0.13 USD (2000 IDR) per visit, but the participation level is reduced when the beach management increases the donation rate. The VisCom model also suggests 0.13 USD as the ideal amount of single-entry donation.

Table 3

Response of local community and visitors for money and time contribution

| *Coef.* | *ComMon* | *VisMon* | *ComTime* | *VisTime* |
|---|---|---|---|---|
| Clean | 2.457889 | 1.905317 | 2.318309 | 2.185141 |
| Mon | (.0000247) | .0006828 | | |
| Time | | | .0077635 | (.1030757) |
| Odds ratio (mon) | .9999753 | 1.000683 | | |
| Odds ratio (time) | | | 1.007794 | .9020587 |

ComTime shows positive responses from local community on time contribution. This informs that local initiators may invite the community to clean the beach for up to 120 minutes per week. However, an increase in the length of work may result in lower participation. VisTime suggests negative responses from local visitors on time contribution due to low willingness to contribute time to beach cleaning activities.

***Willingness to pay and welfare change***. WTP represents the amount of money an individual is willing to sacrifice to obtain a certain level of beach cleanness. MWTP of local community to improve beach cleanness was 6.63 USD (99510 IDR) per month or equal to 79.81 USD per year. By multiplying MWTP with the 60460 households in Belitung in 2023, the total WTP of local community was estimated to be 4.81 million USD per year. Meanwhile, the MWTP of visitors to improve beach cleanness was 0.19 USD (2790 IDR) per visit. By multiplying MWTP with the 452889 domestic visitors in 2018 (normal condition before Covid-19), the estimated total WTP was 84.24 thousand USD per year. The aggregation of both values, namely 4.89 million USD, shows the economic value of clean beaches in Belitung district in a year. This is related to the value of clean beaches in Belitung District providing comfortability for the society. The values correspond to the tourism economy, which should be measured separately and not included in the research.

The variation in beach cleanness leads to a change in the utility level experienced by individuals. $CS_{2\text{-}0}$ shows the highest welfare change for local community due to the improvement of beach cleanness from an unclean to a clean condition. Similarly, local visitors gain the highest welfare change in $CS_{2\text{-}0}$ and the management must adopt an improvement scenario to gain the highest marginal effect for the public.

Table 4

Compensating surplus due to change in beach cleanness

| | *Local community* | *Visitors* |
|---|---|---|
| Utility at status quo (unclean) ($V_0$) | 0 | 0 |
| Utility at level 1 (quite clean) ($V_1$) | 1.72 | 2.68 |
| Utility at level 2 (clean) ($V_2$) | 4.17 | 4.86 |
| $V_1$-$V_0$ | 1.72 | 2.68 |
| $V_2$-$V_1$ | 2.45 | 2.18 |
| $V_2$-$V_0$ | 4.17 | 4.86 |
| $CS_{1\text{-}0}$ | 4.63 USD | 0.26 USD |
| $CS_{2\text{-}1}$ | 6.63 USD | 0.21 USD |
| $CS_{2\text{-}0}$ | 11.27 USD | 0.47 USD |

**Discussion**. WTP shows the benefits provided by the quality of the beach ecosystem. These benefits are in the form of comfort, quality of life, or well-being. Suffering is also reported due to unsatisfaction in conducting activities or relaxing, and, to some extent, may also cause illness. Therefore, this research aimed to investigate the importance of the economic value of beach cleanness and the reaction towards marine plastic litter problems.

The results on WTP and compensating surplus report that beach cleanness greatly determines the utility of local community and visitors. WTP is a dynamic value determined

by the availability and quality of environmental goods or services. Furthermore, the quality of the environment is directly proportional to WTP.

Local community prefers 'time' rather than 'mon' due to social relationships. 'Gotong-royong' constitutes voluntary action that has become a custom for Indonesians, particularly in rural areas. A wide range of activities and purposes of 'gotong-royong' has been practiced to solve public problems such as cleaning the environment and constructing public facilities. In the case of Belitung, local community has been practicing 'gotong-royong' to clean the environment.

Marine plastic litter is a non-point-source public bad, and various strategies are required to solve this problem. Strengthening public awareness on the environment and mobilizing collective action such as beach clean-ups and fundraising are among the strategies that need to be implemented. In addition, it needs a sufficient budget to facilitate good waste management, well-enforced rules to regulate human action, as well as support and commitment from the private sector. A hybrid governance model, which comprises stakeholders, such as government, private, and community is also needed in solving this problem.

Applying a high improvement scenario results in the highest marginal effect or welfare change, and this should be considered in designing and implementing programs for beach clean. The implementation requires a budget, commitment to enforce rules, and raise collective action from the public. Additionally, innovative instruments must be promoted to raise the volunteering level of the public.

**Conclusions**. Beaches were reported to provide environmental services and serve as an important area for fishing activities, tourism activities, and biodiversity. The ecosystem services enjoyed by local community and visitors are intangible, and no market price shows the value. Improving the quality of beach cleanliness will improve the value of the ecosystem as well as the welfare of the people, thus contributions from the public are needed. Local community prefer contributions of time over money, unlike visitors. This result provides suggestions for the village head to initiate 'gotong royong' with the local community, and beach tourism managers to set up waste levy for visitors. The duration of beach clean-up activity and the amount of single-entry fees should not be increased to maintain the level of participation. Local community and visitors have higher WTP than the money contribution set up in DCE. This shows an increased level of awareness regarding the importance of beach cleanness for well-being. The total WTP of both groups is related to the value of a clean beach, excluding other intrinsic values of the ecosystem. Improving the quality and values of the ecosystem provides more benefits for humans. In contrast, polluting the area reduces the economic value due to the decrease in comfort and hygiene. Failure to properly care for the ecosystems might result in the loss of numerous benefits. Therefore, different policies and programs must be initiated to prevent damage. The choices of coping with marine plastic litter provides the information for formulating better strategies. In this context, the government is suggested to implement a high improvement program to create maximum marginal effects or changes in societal welfare. The program should include an increase in the provision of cleaning facilities and services, the establishment of regulations, and the promotion of collective action in the form of money or time contributions. Strong collaboration between stakeholders, including local community and visitors, is a key to solving the problem of marine plastic waste.

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**Conflict of Interest**. The author declares that there is no conflict of interest.

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