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NON-USE VALUES FOR PROTECTING CORAL REEFS: A REVIEW

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ABSTRACT: This study reviews 23 studies on the non-use values of coral reefs, focusing on the benefits people derive from knowing these ecosystems exist and are preserved, even without direct use. Coral reefs provide essential services like coastal protection, tourism, and fishing. Non-use values include existence, bequest, and option values, with individual willingness to pay (WTP) ranging from \$0.99 to \$487 per year, and household WTP reaching up to \$695.87 per year. Studies using choice experiments (CE) generally showed higher and broader WTP values than contingent valuation (CV). The review also incorporates studies that do not report annual per individual or per household WTP estimates but provide qualitative insights into non-use values. Significant factors affecting WTP include income and education, with distance decay effects observed. The study also highlights biases in WTP estimates and the uneven global distribution of research. The results suggest caution when comparing CV and CE results and emphasise the need for improved understanding of coral reef value in policy-making, environmental conservation approaches and sustainability initiatives.

KEYWORDS: Choice experiment, Contingent valuation method, Coral reefs, Existence value, Non-use values

Introduction

Coral reefs are among the most productive and biologically diverse ecosystems on Earth, providing a wide range of products and services to human communities (Brander et al., 2007; Tseng et al., 2015; Yasir Haya & Fujii, 2019). Despite covering less than 0.1% of the ocean floor, coral reefs support over 25% of marine life, demonstrating their crucial role in global biodiversity. The Indo-Pacific region, including the Red Sea, Indian Ocean, and Southeast Asia, harbours the majority of the world's coral reefs (Spalding & Grenfell, 1997). Beyond their ecological significance, coral reefs serve as natural barriers against storms and waves, contribute to fisheries and tourism, and play a vital role in nutrient cycling, including carbon and nitrogen fixation. They also provide essential habitats for marine species, underscoring their value to both ecological and human systems (Bellwood et al., 2024; Burdett et al., 2024; Good & Bahr, 2021).

When valuing coastal ecosystem services, Stated Preference (SP) approaches have become indispensable for assessing non-market benefits such as biodiversity, recreation, and coastal protection. These techniques, including choice experiment (CE) and contingent valuation (CV), capture the monetary value individuals assign to ecosystem services that are not traded in traditional markets. By integrating SP data into cost-benefit analyses (CBA), policymakers can make informed decisions that balance the benefits of coral reef preservation with developmental goals (Abrina & Bennett, 2021). The inclusion of non-market values ensures a comprehensive understanding of the societal importance of coral reefs.

Academic research increasingly highlights the non-use values of coral reefs, which extend beyond direct utilisation (Cesar, 2002; Cesar & van Beukering, 2004). These include existence value (the benefit derived from knowing reefs exist), option value (the value of preserving reefs for potential future use), and bequest value (the importance of conserving reefs for future generations) (Arin & Kramer, 2002; Grafeld et al., 2016; Krutilla, 1967). By incorporating these values into environmental assessments, researchers can provide a more integrated approach to conservation and economic development planning.

Several studies have contributed to the understanding of the non-market valuation of coral reefs, though gaps persist in specific areas. De Valck & Rolfe (2022) categorised research based on the Total Economic Value (TEV) framework and ecosystem services, noting that habitat- and process-focused proxies often provide more comprehensive evaluations than species-centred approaches. Similarly, Rolfe & De Valck (2021) examined the economic benefits of improved Great Barrier Reef protection, revealing consistency within specific benefit categories but less clarity in temporal trends.

Other studies, such as De Valck & Rolfe (2019), identified gaps in understanding the linkages between biodiversity and ecosystem services within the TEV framework. Stoeckl et al. (2011) highlighted an overemphasis on tangible services like tourism and fishing, with less attention to intangible benefits. In the U.S., Brander & Van Beukering (2013) found that non-use values, such as cultural and existence benefits, are often underrepresented due to limited geographic and service coverage.

Despite these contributions, a comprehensive assessment of the non-use values of coral reef preservation is still lacking. This study aims to address this gap by critically evaluating existing research, integrating diverse methodologies, and providing a more holistic understanding of coral reefs' non-market values. Specifically, this study focuses on non-use values of coral reefs, such as existence, option, and bequest values, by examining the determinants of WTP for their conservation. The review examines how WTP is elicited, particularly through CV and CE methods, while also including studies that, although not reporting individual or household monetary estimates, provide insights into non-monetary expressions of value. The study analyses geographic distribution to identify potential biases or distance decay effects and evaluates methodological factors such as sample composition and payment vehicles.

This paper is organised as follows. In the next section, we will elaborate on two key conceptual foundations, total economic value and non-use value, which explain the broader economic valuation framework and the role of non-use values within it; and stated preference methods, which review the primary valuation techniques used to estimate non-use values, with a focus on their relevance to coral reef ecosystems. The Methods and Data section describes the systematic review process, conducted in accordance with PRISMA 2020 guidelines. The Results section synthesises findings from the reviewed studies, including estimates of WTP for non-use values and their determinants. Finally,

the Discussion and Conclusions address methodological challenges, geographic gaps, and research biases based on the findings, whilst suggesting concrete recommendations.

Total economic value and non-use value

The TEV framework for coral reef ecosystems encompasses both use and non-use values (Figure 1), providing a comprehensive understanding of their multifaceted contributions to human and ecological well-being (Cesar & van Beukering, 2004; O'Garra, 2012; Spurgeon, 1992). TEV is further divided into direct use values, indirect use values, and various components of non-use values, making it a robust tool for evaluating the overall worth of coral reefs. In essence, the TEV of coral reefs is the sum of direct extractive and non-extractive uses, indirect uses, and non-use values.

Direct use values arise from both extractive activities, such as capture fisheries and mariculture and non-extractive activities, including tourism and recreation (Cesar, 2002; Cesar & van Beukering, 2004). Indirect use values, on the other hand, encompass ecological functions that provide essential services, such as nutrient cycling, fish habitat maintenance, and shoreline protection. Non-use values capture the satisfaction from preserving ecosystems regardless of direct use, including *bequest value* (value of preserving ecosystems for future generations), *altruistic value* (concern for the well-being of others), and *existence value* (knowing that ecosystems and biodiversity persist) (Krutilla, 1967). Option value represents the importance of conserving ecosystems, such as coral reefs, for potential future direct or indirect uses, while *quasi-option value* reflects the benefit of avoiding irreversible damage and keeping future possibilities open [Spurgeon, 1999]. In the literature, option value has been classified as a use value, sometimes a non-use value, or an intermediate category (Cesar, 2000; Pascual et al., 2012; Spurgeon, 1999).

While the TEV framework has been widely applied to coral reefs (Cruz-Trinidad et al., 2011; Madani et al., 2012), much of the existing research has focused on specific components, particularly use values associated with fishing, tourism, and recreation (Cazabon-Mannette et al., 2017; Grafeld et al., 2016). Nonetheless, growing attention has been given to non-use values, such as those highlighted by O'Garra (2009) and Rolfe & Windle (2012).

Estimating the non-use values of coral reefs is critical for recognising their ecological significance as well as their economic importance. SP methods, such as CE and CV, are commonly employed for this purpose. These approaches gauge individuals' WTP or willingness to accept (WTA) compensation for preserving non-market ecosystem benefits (Subade & Francisco, 2014). Despite their utility, the estimation of non-use values is fraught with challenges.

One major issue is distance decay, which reflects how perceived value diminishes with increasing distance from the ecosystem. People living closer to coral reefs often assign higher values than those further away, making the generalisation of findings problematic. Additionally, the abstract nature of non-use values can lead to biases in survey responses. Participants may struggle to relate to hypothetical scenarios, leading to hypothetical, strategic, or other scenario biases, which undermine the reliability of WTP/WTA estimates. However, some studies have successfully mitigated these biases through methodological improvements (Abrina & Bennett, 2020; Rogers, 2013b).

Another challenge is information gaps. Insufficient knowledge about coral reef ecosystems may lead participants to undervalue their non-use benefits. Furthermore, preference heterogeneity, or the variability in individuals' motivations and values, complicates analysis and requires careful treatment to avoid oversimplification. Scope effects, which address how the magnitude of conservation efforts influences perceived value, must also be accounted for within the TEV framework to ensure accurate representation of both use and non-use values (Abrina & Bennett, 2020; Armstrong et al., 2017).

Despite these limitations, the inclusion of non-use values in CBA is essential for informing conservation policies. By presenting the full spectrum of benefits, CBA enables policymakers to make informed decisions that balance ecological preservation with economic development (Abrina & Bennett, 2021). Studies like those by Brander & Van Beukering (2013), Marre et al. (2015) and Abrina & Bennett (2020) emphasise the importance of prudence and rigour in non-use value estimation, highlighting both its benefits and its challenges.

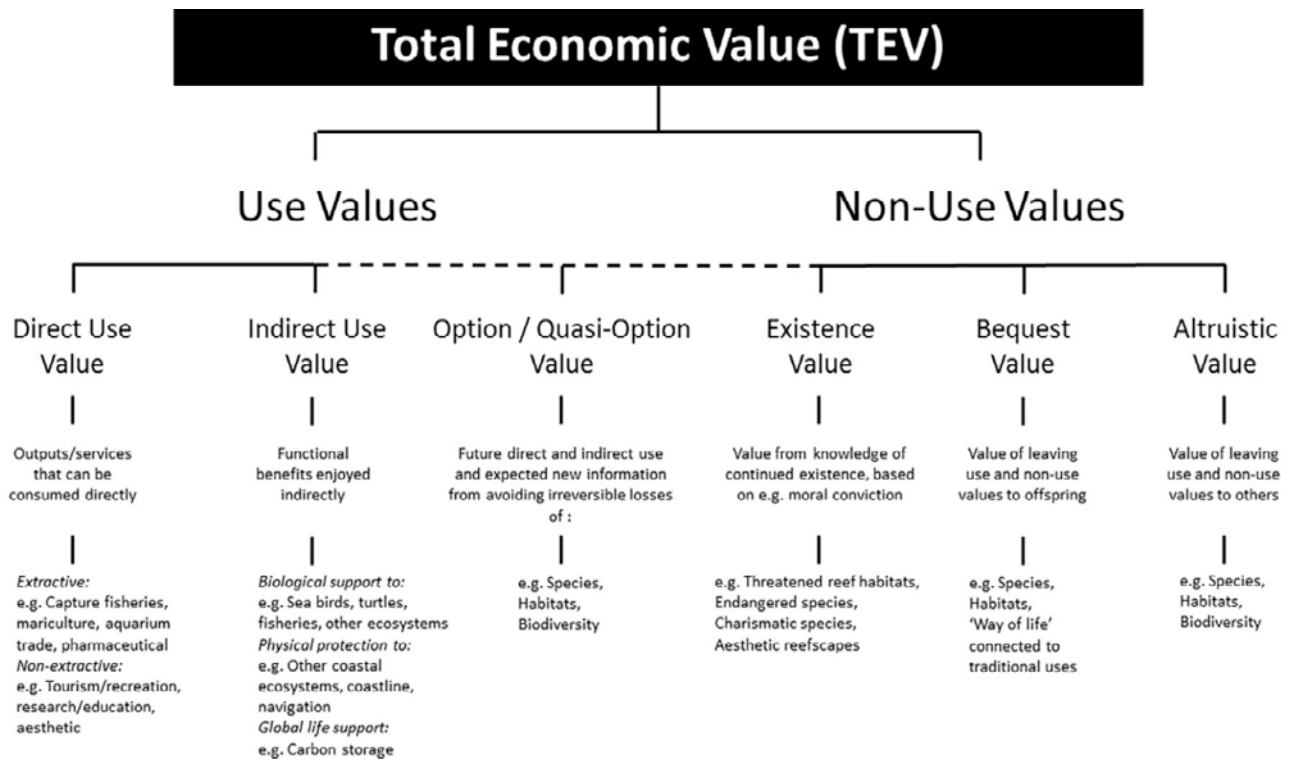


Figure 1. Total economic value framework for coral reefs. Adapted from De Valck & Rolfe (2019)

Stated preferences methods

SP approaches are widely used survey-based methods for estimating WTP for changes in the supply of non-market goods, such as the ecosystem services provided by coral reefs (Pearce et al., 2006). These approaches construct hypothetical market scenarios in which respondents are asked to indicate their preferences for the use or preservation of a resource (Hanley & Barbier, 2009; Johnston et al., 2017). The two most common SP techniques are CV and CE. CV typically asks respondents directly about their WTP for a specific environmental change or program, whereas CE presents respondents with a set of alternatives described by different attributes and levels, from which they choose their preferred alternative (Aizaki et al., 2014). Thus, each of these methods allows researchers to infer the TEV of a good, such as coral reefs (Pearce & Özdemiroğlu, 2002).

CV and CE are particularly relevant for assessing option and non-use values (O'Garra, 2009; Subade & Francisco, 2014), but they can also be applied to estimate direct and indirect use values of coral reefs (Peng & Oleson, 2017; Xuan et al., 2017). A common approach has been to ask respondents to divide their total WTP for a resource, such as coral reef ecosystems, across multiple motivations (Sattout et al., 2007; Vesely, 2007). However, this approach is problematic because it assumes that individuals can accurately separate their WTP into distinct motivations. The primary difficulty lies in disentangling use and non-use values, which are often intertwined (Carson et al., 1992; Cummings & Harrison, 1995).

An alternative strategy is to evaluate non-use values by framing scenarios in which individuals express their WTP for improvements in environmental quality without requiring them to allocate their motivations (Carson et al., 1992). Defining non-use values as WTP for changes that do not involve direct use helps address the complexity of disentangling motivations (Carson et al., 1992; O'Garra, 2009). While SP methods are generally used to elicit WTP for marginal changes in the quality and/or quantity of a resource, surveys can also include follow-up questions asking respondents to explain their reasons for the stated WTP (Lienhoop & Fischer, 2009). Combining these approaches can improve the understanding of how respondents form their values in SP studies.

Methods and data

This study adhered to the PRISMA 2020 statement, an updated guideline for reporting systematic reviews (Page et al., 2021). The review was conducted to identify relevant studies on the non-use values of coral reefs, focusing on economic valuation methods and WTP estimates. The review utilised the key search terms “non-use value,” “ecosystem services,” “economic valuation,” and “coral reefs,” applied to the title, abstract, and keywords of journal articles published between 1997 and 2024. Boolean operators (“AND”) were used to connect the terms, and the search strings were structured as follows: “non-use AND value AND ecosystem AND economic AND valuation AND coral AND reefs” and “use AND non-use AND value AND coral AND reefs.” Articles were sourced from Scopus, Web of Science, and Google Scholar, and the review process was finalised by the end of 2024.

The initial search identified 5,289 articles. After removing duplicates and screening for relevance, the pool of studies was reduced to 69 articles for further analysis. To be included, articles had to meet the following criteria: published in English, specifically address coral reefs and ecosystem services, include empirical data or findings, and focus on the non-use values of coral reefs. Of these, 39 studies were excluded for focusing on topics outside the review’s scope, such as marine protected areas, artificial reefs, or the total economic value of marine ecosystems.

Additionally, 7 reports categorised as grey literature were excluded due to their lack of peer review, which is a critical criterion for ensuring scientific rigour and data reliability. The excluded grey literature was classified into four specific types: Reason 1: working papers, which are often preliminary and lack formal peer review; Reason 2: reports, typically organizational or institutional publications without rigorous evaluation processes; Reason 3: congress papers, which may not include detailed methodologies or robust findings; and Reason 4: dissertations, which, while valuable, do not always undergo the standardized peer-review process required for this systematic review. By excluding grey literature, the review ensured consistency and methodological quality, aligning with best practices for systematic reviews to enhance credibility and replicability of results (Page et al., 2021).

Figure 2 illustrates the PRISMA flow diagram for the screening process, with a clear distinction between records and reports. Records refer to all items retrieved during the initial search across databases, including duplicates. Reports are the unique documents remaining after duplicate removal and are subject to further screening for eligibility.

After applying these exclusion criteria, a total of 23 articles published between 2001 and 2020 were included in the final analysis. These studies explicitly examined the non-use values of coral reefs within the TEV framework, employing CV or CE techniques for economic valuation. While most studies reported annual individual or household monetary WTP estimates, five studies did not; however, they still provided valuable qualitative insights into non-use motivations, including existence, option, and bequest values. Key factors influencing WTP, such as respondents’ determinants, sample composition, payment vehicles, geographic effects, and distance decay, were analysed in these studies.

Studies were conducted in 14 countries in 5 continents, with a concentration in Asia (8 studies), Oceania (7 studies) and Europe (6 studies). The Philippines (4 studies), Australia (3 studies), Fiji, Norway, Ireland, Thailand, having 2 studies each and Hawai’i, France, Tobago, Belize, Solomon Islands, Iran, Scotland, Madagascar, Taiwan, New Caledonia, having 1 study each, were some notable countries where the reef sites were located (Table 1).

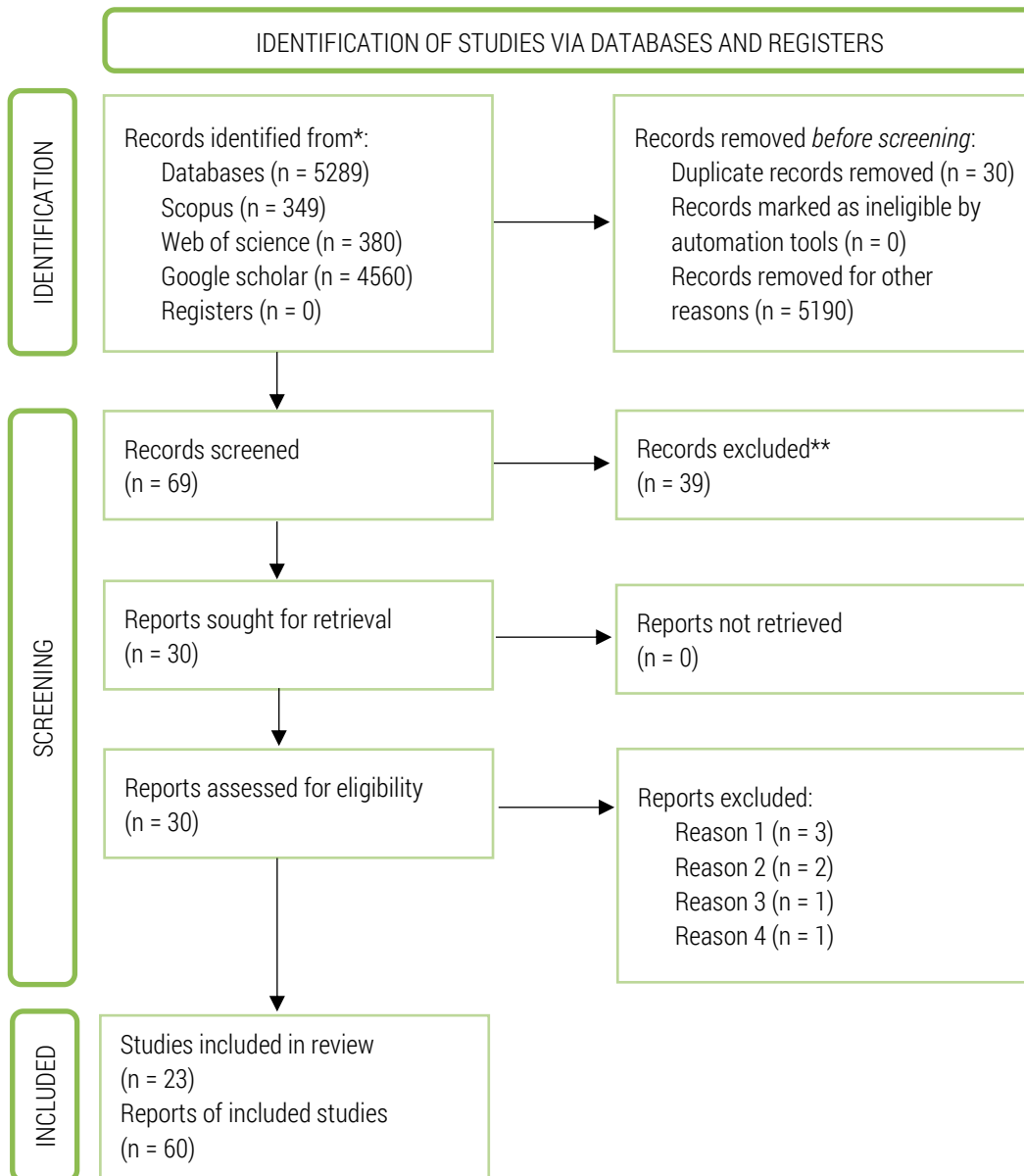


Figure 2. PRISMA 2020 flow diagram depicting the process of choosing studies for inclusion in the systematic review

Source: Page et al., 2021.

Table 1. Description of studies valuing non-use values of coral reefs

Lp	Year	Authors	Method	Survey mode	Value	Country/Region	Valuation Goal
1	2001	Brown et al.	CV	Face-to-face	E	Tobago/North America	Trade-off analysis for marine protected area management
2	2004	H. S. J. Cesar & van Beukering	CV	Face-to-face/ Online	E	Hawai'i/Oceania	Economic Valuation of the Coral Reefs of Hawai'i
3	2007	Ahmed et al.	CV	Face-to-face	E	Philippines/Asia	Economic valuation of coral reef ecosystem services
4	2009	O'Garra	CV	Face-to-face	B	Fiji/Oceania	Bequest Values for Marine Resources
5	2010	Glenn et al.	CE	Mail	E, O and B	Ireland/Europe	Marine protected areas-substantiating their worth

Lp	Year	Authors	Method	Survey mode	Value	Country/Region	Valuation Goal
6	2011	Cruz-Trinidad et al.	CV	Face-to-face	E, O and B	Philippines/Asia	Valuing recreational and conservation benefits of coral reefs
7	2011	Wattage et al.	CE	Mail	E	Ireland/Europe	Economic value of conserving deep-sea corals in Irish waters
8	2012	Madani et al.	CV	Face-to-face	E, O and B	Iran/Asia	Economic valuation of the coral reef within Kish Island
9	2012	O'Garra	CV	Face-to-face	B	Fiji/Oceania	Estimates of the economic value of coastal ecosystem services
10	2012	Rolfe & Windle	CE	Paper and web-based	O	Australia/Oceania	Assessing National Values to Protect the Health of the Great Barrier Reef
11	2013a	Rogers	CE	Web-based	E	Australia/Oceania	Evidence from a Choice Experiment of Marine Reserves in Australia
12	2013b	Rogers	CE	Online	O	Australia/Oceania	A Discrete Choice Experiment of the Ningaloo Marine Park in Australia
13	2014	Jobstvogt et al.	CE	Mail	E and O	Scotland/Europe	Estimating the value of protecting deep-sea biodiversity
14	2014	Subade & Francisco	CV	Face-to face	E and B	Philippines/Asia	Economic valuation of conserving Tubbataha Reefs, Philippines
15	2015	Aanesen et al.	CE	Workshop	E and B	Norway/Europe	Willingness to pay for preserving cold-water corals in Norway
16	2015	Failler et al.	CE	Face-to-face	O, E and B	France/Europe	Valuation of marine and coastal ecosystem services as a tool for conservation
17	2015	Marre et al.	CE	Face-to-face	E and B	New Caledonia/Oceania	Non-market use and non-use values for preserving ecosystem services over time
18	2015	Oleson et al.	CE	Face-to-face	B	Madagascar/Africa	Cultural bequest values for ecosystem service flows among indigenous fishers
19	2016a	Seenprachawong	CV	Face-to-face	E, O and B	Thailand/Asia	An Economic Analysis of Coral Reefs in the Andaman Sea of Thailand
20	2016b	Seenprachawong	CE	Face-to-face	E and O	Thailand/Asia	An Economic Valuation of Coastal Ecosystems in Phang Nga Bay, Thailand
21	2017	Armstrong et al.	CE	Workshop	E	Norway/Europe	Use and Non-Use Values in an Applied Bioeconomic Model of Fisheries and Habitat
22	2019	Maynard et al.	CV	Online	E and B	Taiwan/Asia	Estimate Willingness to Pay for Coral Reef Conservation
23	2020	Abrina & Bennett	CE	Face-to-face	E	Philippines/Asia	Estimates of coral reef restoration non-market values in the context of Mass Larval Enhancement

Note: E: Existence, O: Option, B: Bequest; "Lp" column to refer to these studies in subsequent analysis.

Face-to-face surveys were the most commonly used method, applied in 14 studies. Online or web-based surveys were used in 5 studies, while mail surveys were employed in 3 studies. Additionally, 2 studies used workshop-based methods, and one study combined face-to-face with online data collection. The studies used either CV (10 studies) or CE (13 studies) methods to elicit the non-use values of coral reefs in different countries or regions (Table 1).

Results

Study characteristics

The non-use values measured by the studies include existence, option, and bequest values. The most common value type was existence, followed by bequest and option. Most studies (18) estimated the existence value, which reflects the value individuals place on knowing the coral reef exists, even if they never use it directly. Also, 12 studies included bequest value, reflecting the value individuals place on preserving the coral reef for future generations.

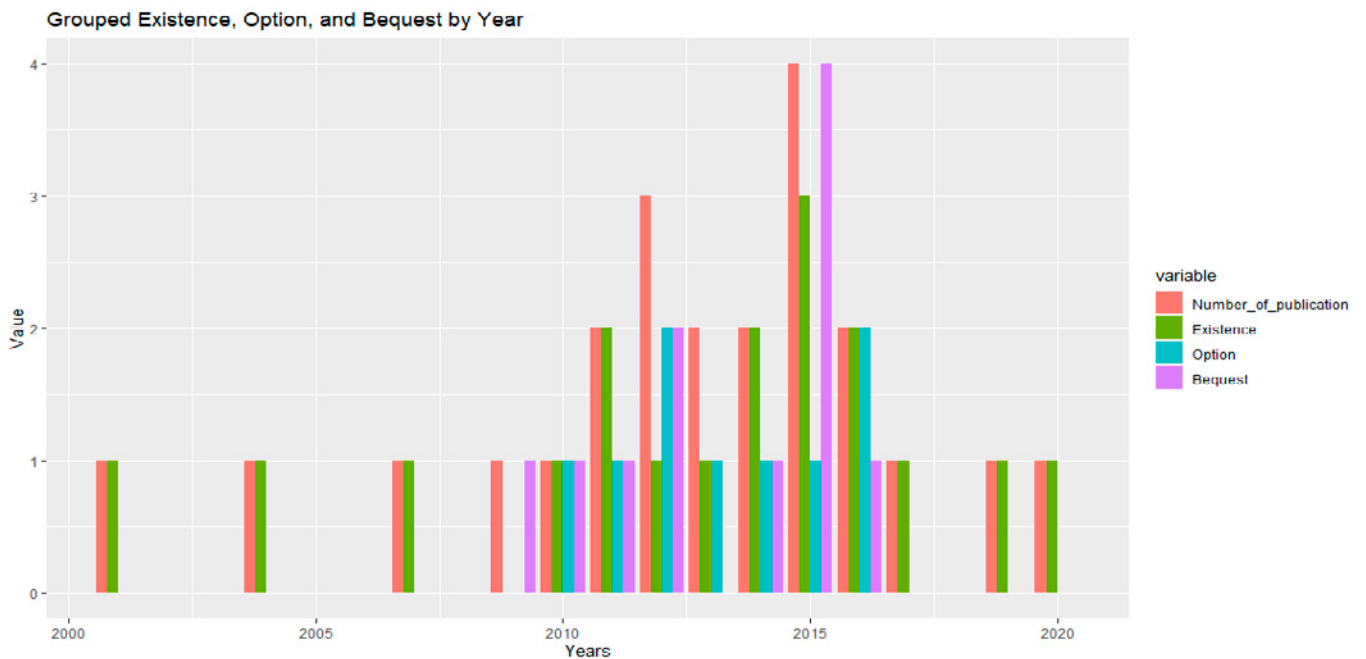


Figure 3. Total number of publications and the non-use values found in these publications

Eight studies estimated the option value, reflecting the value individuals place on having the option to use the coral reef in the future, even if they do not currently use it. Four studies indicated all these non-use value types in their analyses, seven studies revealed two non-use value types, seven studies indicated only the existence of non-use value types, two studies showed only the option non-use value type, and three studies showed only the bequest non-use value type of coral reefs (Table 1 and Figure 3).

A thorough summary of sample compositions and payment vehicle types utilised in various studies evaluating the non-use values of coral reefs is provided by the data in Table 2. Residents, members of the general public, and tourists are the main targets of the studies, which comprise a wide variety of sample compositions. Lp 1, for example, concentrated on sizable resident populations in an effort to record regional or national valuation viewpoints. Smaller, targeted groups like tourists, fishers, or aquaculture operators were included in studies Lp 6 and 16, reflecting an understanding that specialised groups may have unique valuation perspectives or stronger incentives for coral reef preservation.

Table 2. Sample composition and payment vehicle for coral reefs

Lp	Sample composition	Payment vehicle
1	1,000 visitors and residents	Annual monetary contribution
2	459 individuals	Annual monetary contribution
3	92 Visitors	User fees
4	204 household heads and individual adults (residents)	Annual monetary contributions
5	5000 residents	Additional annual tax
6	1624 of fishers, aquaculture operators, tourists, and general public	Annual monetary contributions
7	5000 residents	Additional annual tax
8	1661 households of general public	Annual monetary contributions
9	118 households in villages	Annual monetary contributions
10	1919 individuals of general public	Annual monetary contributions
11	1,025 individuals of the general public	Annual environmental tax
12	407 individuals of the general public	Environmental levy
13	1984 households of general public	Additional annual income tax
14	800 individuals of the general public	Annual contribution to trust fund
15	402 individuals of the general public	Annual increase federal tax
16	1200 individuals of tourists and residents	Annual cost of payment for restoration
17	550 residents	Monthly payment in trust fund
18	195 individuals of the general public	Short-term loss in income
19	200 domestic vicarious users of general public	Monetary contribution in trust fund
20	300 individuals of the general public	Increased income tax
21	400 individuals of the general public	Additional annual costs of payment
22	231 individuals of the general public	Annual payment in conservation fund
23	989 individuals in two locations	Additional cost to electricity bills every month

The geographical scope varied throughout the studies as well. In order to produce a more broadly applicable depiction of societal values, some research made use of much larger samples, such as nationwide surveys (Lp 2), while others employed smaller samples of household or village residents (Lp 3, 9, 19). The wide range of payment methods chosen reflected institutional or cultural preferences as well as the study's dimension. Recurring contributions to coral reef conservation were often reflected through trust funds (Lp 17 and 19), environmental taxes (Lp 11 and 15), and annual WTP payments without specifying the exact means through which the monetary contribution will be channelled (Lp 1, 2, and 14). In particular, trust funds highlight a strategy that appeals to long-term preservation goals and attracts people who are prepared to make a consistent financial commitment to conservation initiatives. Again, some studies (Lp 13 and 23) included payments within regular bills, such as an annual income tax (Lp 13) or a monthly electricity charge (Lp 23). By embedding costs in familiar payment channels, these studies aimed to make the charges feel more routine and acceptable to respondents.

Distinct valuation patterns appear across various non-use categories in a comprehensive synthesis of the data in Table 3, which give WTP estimates for the non-use values of coral reefs (existence, option, and bequest). In the end, each category provides insights into the economic benefit of protecting these ecosystems beyond direct usage by reflecting various motivating factors for individuals' or households' contributions to coral reef conservation.

Monetary valuations ranged from as low as \$0.99 per individual annually (Lp 23) to as high as \$695.87 per household annually (Lp 21), illustrating a broad spectrum of perceived values. The high-

est individual WTP was reported in Lp 17 (\$487) and the lowest in Lp 23 (\$0.99). For household-level values, the highest was also Lp 21 (\$695.87) and the lowest was Lp 2 (\$10.74). In total, 7 studies reported household-level values, and 11 studies reported individual-level values, complicating direct comparison.

In terms of non-use value types, existence values were the most frequently reported, followed by bequest and option values. Most studies (Lp 6, 8, 13, 14, 15, 17, 19, 20, 22) captured more than one type of non-use value, reflecting variation in how different studies framed and combined existence, option, and bequest values. Notably, Lp 6 and Lp 19 captured all three non-use values (E, O, B), suggesting more comprehensive value framing, possibly influencing higher respondent valuations.

Table 3. Studies depicting WTP estimates for non-use values of coral reefs (2022 International dollars)

Lp	Elicitation formats/Attributes	WTP/Household/year	WTP/Individual/year
1	Open ended and dichotomous choice		\$26.85 "E"
2	Payment card	\$10.74 "E"	
3	Double-Bounded Dichotomous choice		\$ 4.52 "E"
4	Payment card	\$295 "B"	
5	"Activity of Fishing restrictions, Area of Coral protection extent"		
6	Payment ladder		\$ 5.19 "E, O, B"
7	"Activity of fishing restrictions, Area: Coral protection extent"		
8	1.5-Bounded Dichotomous Choice	\$ 12.28 "E, O, B"	
9	Payment ladder		\$102.60 "B"
10	"Improve water quality, Increase conservation zones, Reduce greenhouse gases"	\$20.95 "O"	
11	"Coral, Target Fish Stocks; Marine Turtles; Whale Sharks"		
12	"Coral, Fish, Marine turtle, Whale shark populations;"		\$19.89 "O"
13	"New medicinal potential, Protected deep-Sea species"	\$ 138.69 "E, O"	
14	Dichotomous choice and closed-ended		\$37.19 "E, B"
15	" Protected area size, Protected area attractiveness for oil/gas & fisheries, Protected area importance as fish habitat"	\$70.92 "E, B"	
16	"Biodiversity: habitat and critical species; Marine habitats, Marine species, Marine biodiversity, Social values, Cultural values (including religious and spiritual), Way of living associated to coastal ecosystems"		
17	" Quantity of fished animals; Health and richness of marine life, Coastal and lagoon natural landscapes, Areas of practice"		\$487 "E, B"
18	"Bequest, Social cohesion, Shoreline protection; Commercial fisheries"		
19	Single-bounded dichotomous choice (referendum)		\$ 58.8 "E, O, B"
20	"Increased living coral cover, Increased income from fishery, Flood occurrence, Increased protected area"		\$ 157.48 "E, O"
21	"Size of protected area, Protected area attractive for oil/gas and fisheries, Protected area important as fish habitat"	\$695.87 "E"	
22	Payment card		\$ 50.52 "E, B"
23	"Coral cover, Fish population, Fish species"		\$ 0.99 "E"

Note: Table 3 estimates for coral reef non-use values were standardised by adjusting for inflation to a 2022 base year, consumer price index (CPI = 2022) and converted to United States dollars (USD) using purchasing power parity (PPP). Inflation adjustments were made in the source currency before converting to USD. See Appendix 1 for the original WTP values without standardisation. E (existence), O (option), and B (bequest) in parentheses represent the types of non-use values. Elicitation formats and attributes represent CV and CE, respectively.

Elicitation formats varied across studies, with dichotomous choice-based methods (single-, double-, or 1.5-bounded formats) and payment cards/ladders being most common. Dichotomous choice formats were generally associated with lower average WTP values (Lp 3: \$4.52), possibly reflecting more conservative responses under referendum-style valuation designs. In contrast, studies using payment cards (Lp 4: \$295) tended to yield higher WTP values.

Finally, the attributes used to characterise the good to be valued range from specific ecological features (coral cover, fish populations) to more abstract concepts such as social cohesion and bequest potential. Studies incorporating broader ecosystem services or multiple species (Lp, 17, 20, 21) tended to report higher WTP values, possibly reflecting the greater perceived utility and intergenerational significance of comprehensive reef conservation scenarios.

Studies without reported monetary WTP estimates for coral reefs

As shown in Table 3, five studies in this review (Lp 5, 7, 11, 16, and 18) did not report individual or household monetised WTP estimates, yet they provide valuable insights into how people value coral reef ecosystems. In some cases (Lp 5, 7, and 11), the cost attribute in choice experiments was statistically insignificant, largely due to lexicographic preferences; respondents prioritised reef protection over financial trade-offs. Supplementary responses confirmed principled non-payment motivations, such as a belief that government or industry should bear conservation costs, or a preference for alternative funding mechanisms. These findings illustrate that the absence of monetary WTP did not reflect indifference, but rather a refusal to express value in monetary terms.

Other studies adopted alternative valuation approaches. Lp 16 applied an ecosystem service framework and reported that coral reefs contributed approximately €1.78 million per km² per year, even though no Individual or household-level WTP estimate was provided. Lp 18 measured WTP as foregone income per spring tide, capturing bequest and option values in a low-income context, though not in standardised annual individual or household terms.

Overall, these studies demonstrate that non-use values can be expressed through qualitative motivations, ecosystem service valuations, or context-specific trade-offs, rather than conventional WTP metrics. Their inclusion broadens the evidence base by showing that reliance solely on monetary estimates risks underrepresenting the full spectrum of values attached to coral reef conservation.

Determinants of WTP for non-use values of coral reefs

Table 4 presents a consolidated overview of determinants employed in studies estimating WTP for the non-use values of coral reefs. Among the determinants examined, education and income emerged as the most consistently significant positive predictors. Education was positively associated with WTP in eight studies, indicating that higher educational attainment likely enhances environmental literacy and valuation of passive-use ecosystem services. Similarly, income exhibited a positive relationship in six studies, consistent with economic theory linking WTP to the ability to pay. However, in isolated cases (Lp 10 and 11), education and income showed negative associations, suggesting that context-specific perceptions of payment responsibility or trust in governance mechanisms can mediate this relationship.

ENGO was another robust positive predictor in five studies, underscoring the influence of pro-environmental identity and prior engagement in shaping conservation preferences. Notably, Lp 13 reported a negative association, potentially due to protest responses or alternative conceptions of responsibility for reef conservation.

Age produced mixed results: four studies found a positive correlation with WTP, whereas two found it to be negative. These differences may reflect generational variations in conservation priorities, intergenerational equity concerns, or disposable income levels.

The influence of gender on WTP varied across studies. Male respondents were significantly more willing to pay in three studies, while one study showed the opposite. In contrast, female respondents were significant positive predictors in Lp 15 and negative in Lp 14. These inconsistencies suggest that gender effects on WTP are not uniform and may depend on how coral reef conservation is framed in the valuation scenario.

Table 4. Summary of determinants used in WTP studies for non-use valuation of coral reefs

Determinant	Positive significant (Lp)	Negative significant (Lp)	Insignificant (Lp)	Not analyzed (Lp)
Age	8* (E, O, B), 9* (B), 15*** (E, B), 23* (E)	17*** (E, B), 19* (E, O, B)	3, 10, 13	1, 2, 5, 7, 11, 14, 16, 20, 21
Environmental non-governmental organization (ENGO)	2**(E), 11*(E), 12***(O), 15*** (E, B), 23*** (E)	13*(E, O)		1, 3, 6, 7, 16, 5, 8, 14, 17, 19, 20, 21
Gender (men)	4**(E), 9*(B), 11**(E)	13**(E, O)	10, 23	1, 2, 3, 6, 7, 5, 8, 16, 17, 19, 20, 21
Gender (women)	15*(E, B)	14**(E, B)		3, 21, 1, 2, 6, 16, 5, 8, 17, 20, 19, 7
Education	3**(E), 8*(E, O, B), 9*(B), 14*(E, B), 15*** (E, B), 17*** (E, B), 19*(E, O, B), 23*(E)	10*** (O), 11**(E)		1, 2, 6, 5, 7, 13, 16, 20, 21
Income	3*** (E), 4*(B), 8*(E, O, B), 14*** (E, B), 17*** (E, B), 23*(E)	10*** (O)	15	1, 2, 5, 6, 7, 11, 13, 16, 20, 21, 22
Household size	15**(E, B)		23	1, 2, 5, 7, 8, 13, 14, 16, 17, 19, 20, 21, 22,
Knowledge, familiarity and awareness	12*** (O), 14*(E, B)		23	1, 2, 3, 6, 5, 7, 8, 11, 16, 17, 19, 20, 21, 22

Note: ***, **, and * indicates significant probabilities level at 1%, 5% and 10% respectively. Existence value(E), Option value(O) and Bequest value (B)

Other less frequently analysed variables, such as household size and environmental awareness or familiarity, also showed positive effects with WTP for coral reefs. For example, awareness positively influenced WTP in Lp 12 and 14, while household size was significant in Lp 15. Despite their relevance, these determinants were omitted in a majority of the studies, representing a gap in capturing the full range of cognitive and social drivers of WTP.

In contrast, some determinants (Lp 3, 10, 13, 23 for various factors) were found to be statistically insignificant, while several studies did not analyse common predictors such as income, education, or age at all. This heterogeneity in variable inclusion and significance underscores the methodological variability in WTP studies and highlights the importance of incorporating both socio-demographic and attitudinal variables in future research to enhance explanatory power and policy relevance.

While demographic and socioeconomic variables such as gender, education, age, and income are often correlated, none of the reviewed studies explicitly reported controlling for such correlations in their models. Consequently, the potential influence of multicollinearity on WTP estimates remains unclear.

Hypothetical bias in contingent valuation and choice experiments for coral reefs

CV and CE are widely used SP methods for estimating individuals' WTP for non-market environmental goods such as coral reef conservation. While CV is appreciated for its simplicity and directness, and CE for capturing multi-dimensional attributes, both are prone to hypothetical bias, which occurs when stated WTP differs from observed WTP in a market situation, not limited to overestimation (Blumenschein et al., 2008; Broadbent, 2014). Techniques such as cheap talk, certainty scales, and dissonance minimisation have been employed to address this issue, although their effectiveness varies (Mahieu et al., 2012; Morrison & Brown, 2009).

Maynard et al. (2019) highlighted that bias in WTP surveys is inevitable to some degree, especially when reduced sample sizes or non-random sampling are used. To improve data reliability, ex-post data screening, larger sample sizes, and follow-up surveys were recommended. These measures help refine WTP estimates and better reflect societal values.

Both dichotomous choice and open-ended formats have potential biases that can affect WTP estimates. Dichotomous choice questions can overestimate WTP due to yeah-saying or strategic misrepresentation, while open-ended formats can produce either underestimates due to free rider effects or overestimates due to strategic over-bidding, although empirical evidence suggests that understatement is more likely when these formats do not capture true WTP (Brown et al., 2001). To address these issues, Brown et al. (2001) used a dual-format approach: dichotomous choice results were reported as upper-bound values, and open-ended responses were used as a comparative lower-bound measure. This strategy provides a broader, more balanced range of WTP estimates and helps mitigate format-specific biases.

No elicitation format is entirely free from limitations. Payment card formats may suffer from anchoring, and open-ended questions from non-response or protest behaviour. Despite these drawbacks, dichotomous choice remains widely used, particularly when framed as an incentive-compatible referendum (Johnston et al., 2017). Combining formats, as Brown et al. (2001) did, offers a practical way to strengthen robustness.

In CE studies, bias-reduction techniques were embedded in questionnaire design. These included rigorous pre-testing, pilot studies, neutral wording, and specialised enumerator training (Abrina & Bennett, 2020; Rogers, 2013). To establish consequentiality, respondents were informed that survey results would directly inform government planning. Respondents were also reminded to consider personal financial constraints to promote realistic valuations.

Nevertheless, CE studies still face challenges. Armstrong et al. (2017) and Jobstvogt et al. (2014) noted that scope and embedding effects can skew results when respondents overvalue broad ecosystems instead of specific components. Yet, Armstrong et al. (2017) found that such bias was relatively limited in their study. To further refine WTP, segmentation based on attribute non-attendance (ignoring payment components) was used to better understand variations in financial sensitivity (Marre et al., 2015).

The choice of elicitation format significantly influences WTP outcomes and susceptibility to bias (Champ & Bishop, 2006; Vossler & Holladay, 2018). While follow-up certainty questions help align stated and actual WTP (Blumenschein et al., 2008), methods like cheap talk and dissonance minimisation show mixed effectiveness. In CE, applying these techniques can be more complex due to multi-attribute designs, and WTP values can vary significantly by method (Shi et al., 2018). Thus, careful selection of elicitation format and bias-mitigation strategies remains essential.

Distance decay on non-use values of coral reefs

People frequently exhibit higher WTP and higher values for items, services, or environmental benefits that are located close to them as opposed to those that are farther away. However, since non-use values do not necessitate physical interaction, distance decay might not have a large impact on them. WTP calculations might be less affected by distance in these circumstances. According to Abrina & Bennett (2020), a respondent's proximity to the restoration site might not significantly affect value estimates. Similarly, the Great Barrier Reef in Australia is a significant iconic asset, and Rolfe & Windle (2012) found that apparent distance decay effects appear to be explained by variations in future usage and state responsibility, rather than proximity. In other words, larger values were linked to the likelihood of future visits, indicating that option values played a significant role in influencing answers.

For some non-use values, distance decay may have some bearing on WTP, but it may not be the only deciding factor. Additionally, socioeconomic characteristics, education level, cultural background, personal values, and environmental awareness affect how much people value things and are ready to pay for them. These variables interact intricately with distance decay, leading to a complex understanding of how non-use values are evaluated across various demographics and geographical regions.

Geographic bias in the non-use valuation of coral reefs

Research on the non-use values of coral reefs has predominantly focused on iconic and well-documented reef systems, such as the Ningaloo reefs, Hawai'i's coral coast, Fiji's coral ecosystems, Norway's cold-water corals, the Great Barrier Reef, Bolinao reefs, and Ireland's deep-sea corals. While

these studies provide valuable insights, they do not fully represent the global diversity of coral reef habitats. This geographic bias is often driven by the popularity of these sites, which attract substantial tourist interest and scientific attention, alongside greater funding and institutional resources.

Studies on coral reef non-use values are unevenly distributed across the globe. Studies have frequently focused on countries such as Australia, Norway, the Philippines, Fiji, and Thailand, while research in Africa and much of America remains sparse, with only a single study identified in each of these regions (Table 1). This uneven geographic distribution may influence the overall understanding of coral reefs' non-use values, highlighting the need for more research in underrepresented regions.

According to Cesar & van Beukering (2004), the majority of the world's coral reefs are located in developing countries, where communities often face high levels of poverty and limited access to education. These socio-economic factors, combined with restricted funding for environmental research, result in a significant underrepresentation of reefs in these regions within the scientific literature.

As noted by Jobstvogt et al. (2014) and Maynard et al. (2019), financial constraints often lead to low sample representation in studies, yielding regionally biased valuation estimates rather than globally representative findings. These limitations undermine the accuracy and generalizability of non-use value estimates for coral reef ecosystems.

Discussion and conclusions

This review offers a comprehensive synthesis of empirical studies assessing the non-use values of coral reefs, contributing to a deeper understanding of how individuals value these ecosystems even without direct interaction. The findings underscore that existence, bequest, and option values are critical components of the total economic value of coral reefs. In particular, the prominence of existence values points to a widespread societal appreciation for preserving these ecosystems, motivated by ethical concerns for biodiversity and future generations.

There is substantial variation in WTP estimates, ranging from under \$1 per individual annually to nearly \$700 per household annually. This disparity reflects the influence of contextual, methodological, and socio-demographic factors. Valuation results varied significantly depending on the elicitation format: payment card methods are efficient but prone to anchoring effects; open-ended formats often suffer from free riding and strategic over-bidding effects; dichotomous choice formats, though commonly preferred, remain vulnerable to strategic bias and yea-saying when not rigorously designed.

Beyond studies that reported monetary WTP estimates, this review also included five studies that did not provide individual/household reef-specific monetary values but nonetheless offered important insights into non-use motivations. These studies often encountered statistically insignificant cost coefficients or reporting limitations, which prevented the derivation of reliable WTP estimates. However, their results still revealed strong qualitative expressions of value, such as existence, bequest, and option motivations, as well as behavioural patterns, where conservation was prioritised irrespective of cost. Incorporating such evidence alongside monetary estimates highlights the limitations of relying solely on WTP as a measure of value and reinforces the argument that coral reef conservation carries significant ecological and cultural importance that may not always be fully captured in individual/household monetary terms.

To improve robustness, researchers are encouraged to adopt multi-format elicitation strategies, as demonstrated by Brown et al. (2001), to capture both lower- and upper-bound WTP ranges. Supplementary practices such as pre-testing, ex-post screening, and non-attendance modelling can enhance response validity (Marre et al., 2015). Triangulating methods help counteract format-specific biases and strengthen the credibility of results for policy applications.

Determinants of WTP consistently include education and income as strong positive predictors, reinforcing the importance of environmental awareness and financial capacity. However, in some cases, negative relationships between determinants and WTP were observed. Respondents with lower public trust, perceptions of unfair cost-sharing, or a stronger belief that the government, not individuals, should bear conservation costs tended to report lower WTP. This highlights the influence of attitudinal and institutional factors on valuation outcomes. Notably, none of the reviewed studies explicitly reported controlling for potential correlations among demographic and socioeconomic variables, which limits the ability to assess whether such interdependencies affect WTP estimates.

A recurring issue is geographic and sampling bias. The concentration of studies on iconic coral reefs such as the Great Barrier Reef, Hawaii and Fiji leads to significant gaps in regions such as Africa, Latin America, and Southeast Asia, where coral reef ecosystems are both ecologically vital and socio-economically vulnerable.

Another debated factor is the distance decay effect. While some studies find that proximity to coral reefs increases WTP, others observe no significant correlation. This suggests that emotional connection, perceived national or global importance, and anticipated future use may influence valuation more than physical distance.

Concerns about value overlap and measurement challenges in non-use valuation are well-established (De Valck & Rolfe, 2019; Glenn et al., 2010). Addressing these challenges requires interdisciplinary collaboration and the inclusion of cultural, relational, and underrepresented non-use values. As Stoeckl et al. (2011) noted, coral reefs are deeply interconnected with surrounding ecosystems, adding to the complexity of isolating values and emphasising the need for broader ecological framing. Rolfe & De Valck (2021) attributed inconsistencies in the Great Barrier Reef valuations to the complexity of reef systems and methodological divergence, a conclusion supported by this review.

In light of these insights, future valuation efforts must broaden their geographic scope by prioritising studies in underrepresented regions, particularly Africa, the Americas, and Small Island Developing States. Methodological standardisation should be a priority, with the adoption of mixed elicitation formats (dichotomous choice, open-ended, and payment cards) and rigorous survey design protocols such as pilot testing, protest-response filtering, and specialised enumerator training. For CE, additional refinements such as careful attribute selection and level balancing, checks for scope and embedding effects, testing for and modelling attribute non-attendance, and using follow-up certainty or consequentiality scripts can further reduce hypothetical bias and improve the reliability of WTP estimates. Incorporating attitudinal and socio-cultural variables, including trust in institutions, fairness perceptions, and environmental values, into WTP models can further explain variation and improve predictive strength. Efforts to reduce scope and distance biases should include qualitative follow-ups and improved framing, helping respondents better interpret ecological scale and relevance. Additionally, valuation findings should be translated into actionable policy mechanisms, such as marine trust funds, eco-taxes, and community-led conservation incentives, by linking survey design directly to real-world outcomes.

The evolving landscape of non-use valuation for coral reefs underscores the urgency of aligning economic valuation with ecological priorities and social equity. As pressures on marine ecosystems intensify, robust, context-sensitive valuation can play a pivotal role in guiding resource allocation and legitimising conservation efforts. Ensuring that diverse cultural, geographic, and institutional contexts are represented in valuation research will be vital to capturing the full spectrum of societal values attached to coral reefs. Strengthening the credibility and applicability of WTP estimates ultimately enhances their utility not only as academic metrics but as tools that can meaningfully influence environmental governance and long-term reef stewardship.

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Appendix 1. Studies depicting WTP estimates for non-use values of coral reefs (Original WTP values without standardization)

Lp	Year	Authors	Method/Non-use value type	WTP/Household/year	WTP/Individual/year
1	2001	Brown et al.	CV (E)		US \$ 3.70-9.30
2	2004	H. S. J. Cesar & van Beukering	CV (E)	US \$3-\$10	
3	2007	Ahmed et al.	CV (E)		PhP25.01 (US\$0.55)- PhP73.17(US\$1.60)
4	2009	O'Garra	CV (B)	FJ\$183.90 (US\$106.91)	
5	2010	Glenn et al.	CE (E, O, B)		
6	2011	Cruz-Trinidad et al.	CV (E, O, B)		US\$0.20(Php8.9) – US\$0.41 (Php18.2)- US\$2 (Php91)- US\$1.65(Php77)- US\$1.89 (Php85)- US\$0.47 (Php21)
7	2011	Wattage et al.	CE (E)		
8	2012	Madani et al.	CV (E, O, B)	53490 RLS (US\$ 5.3)	
9	2012	O'Garra	CV (B)		US\$42.77 (FJ\$73.56)
10	2012	Rolfe & Windle	CE (O)	AUD\$21.68	
11	2013a	Rogers	CE (E)		
12	2013b	Rogers	CE(O)		AUD\$20
13	2014	Jobstvagt et al.	CE (E, O)	£70-£77	
14	2014	Subade & Francisco	CV (E, B)		P233 pesos – P437pesos
15	2015	Aanesen et al.	CE (E, B)	€37 €77	
16	2015	Failler et al.	CE (O, E, B)		
17	2015	Marre et al.	CE (E, B)		1230-2705-4620-6515 (cfp/month)
18	2015	Oleson et al.	CE (B)		
19	2016a	Seenprachawong	CV (E, O, B)		634 THB (US\$15.85)
20	2016b	Seenprachawong	CE (E, O)		THB 1133 (US\$ 28)- THB 2263 (US\$ 57)
21	2017	Armstrong et al.	CE (E)	€360-€699	
22	2019	Maynard et al.	CV (E, B)		8.678 -80.160US\$
23	2020	Abrina & Bennett	CE (E)		PHP16.92

Albert Mensah KUSI

WARTOŚCI POZARYNKOWE OCHRONY RAF KORALOWYCH: PRZEGLĄD

STRESZCZENIE: W niniejszym opracowaniu dokonano przeglądu 23 badań dotyczących nieużytkowych wartości raf koralowych, koncentrując się na korzyściach, jakie ludzie czerpią ze świadomości istnienia i ochrony tych ekosystemów, nawet bez ich bezpośredniego użytkowania. Rify koralowe zapewniają podstawowe usługi, takie jak ochrona wybrzeża, turystyka i rybołówstwo. Wartości nieużytkowe obejmują istnienie, spadek i wartości opcji, przy czym indywidualna gotowość do zapłaty (WTP) waha się od 0,99 USD do 487 USD rocznie, a WTP gospodarstwa domowego sięga nawet 695,87 USD rocznie. Badania wykorzystujące eksperymenty wyboru (CE) generalnie wykazały wyższe i szersze wartości WTP niż wycena warunkowa (CV). W przeglądzie uwzględniono również badania, które nie podają rocznych szacunków WTP na osobę lub gospodarstwo domowe, ale zapewniają jakościowy wgląd w wartości nieużytkowe. Istotne czynniki wpływające na WTP obejmują dochód i wykształcenie, przy czym zaobserwowano efekt zaniku odległości. Wyniki sugerują ostrożność przy porównywaniu wyników CV i CE oraz podkreślają potrzebę lepszego zrozumienia wartości raf koralowej w kształtowaniu polityki, podejściach do ochrony środowiska i inicjatywach na rzecz zrównoważonego rozwoju.

SŁOWA KLUCZOWE: eksperyment wyboru, warunkowa metoda wyceny, rify koralowe, wartość egzystencji, wartości nieużytkowe