Paying for adaptation efforts towards a reef restoration programme

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Abstract

Coral reef ecosystems are under threat from anthropogenic and natural stressors ranging from over-fishing to pollution. This work synthesises global attitudes and values towards restoration programmes for coral reefs in the case of recreational diving. Global survey data from international divers using a contingent valuation method show that the majority are willing to pay to restore a coral reef after a coral bleaching event. Further work shows that the benefits of such restoration programmes are substantial. This information is essential at this time and this is increasingly the case with uncertainties concerning climate change and concurrently the global financial crisis scaling down funds for environment. In sum, the support for restoration programmes implies that coral reefs can be restored. In contrast, a policy of inaction can result in restoration costs rising in the long run, thus making it difficult to restore the habitat.

Key words: climate change, coral restoration, diver attitudes, willingness to pay, contingent valuation

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1. Introduction

The urgency of organized efforts to conserve biodiversity/ecosystems in the oceans is pronounced where a combination of distinct stressors, such as climate change, overfishing and pollution, are overwhelming the ocean's inherent resilience and natural balance, slowing reversibility processes. One driver of such change is climate change caused by carbon emissions that have destroyed or reduced the ocean's benefit to human welfare. The degradation of marine and/or coastal ecosystems results in the loss of goods and/or services not only to coastal but also inland communities (UNEP, 2006).

This true in the case of coral reefs, as highlighted by the Intergovernmental Panel on Climate Change report (IPCC, 2007); this type of marine ecosystem is under stress due to global warming, given its low adaptive capacity and resulting vulnerability to thermal changes. Coral reefs provide a range of benefits to ocean biodiversity and human activities; however, their sensitivity to the impacts of global warming results in ocean acidification and bleaching events. Most areas endowed with coral reefs are located in developing countries where people are poor and highly dependent on these ecosystems for food, employment in fishing, shoreline protection, recreational services through tourism, and cultural and spiritual benefits. Furthermore, the adverse impact of coral bleaching, particularly on recreational activities such as scuba diving, means that the scenic beauty associated with an abundance of fish in multi-coloured corals is replaced with white coloured coral with minimal fish stock.

The environmental benefit of recovering these biomes and saving them from further damage implies that any management and/or administrative effort should prioritize the bleached sites to accelerate the recovery and resilience process. One way in improving the resilience of the coral reef ecosystem is the reef restoration, which refers to the act of bringing a degraded ecosystem as close to its original condition as possible. The expected recovery time is long term, i.e. at least 5–10 years, and varies as to whether the restoration is physical or biological (Edwards et al., 2007).[1] Specifically, taking action in restoration programmes on reef ecosystems after a natural threat such as a coral bleaching event(s) requires that any anthropogenic stressors are ameliorated prior to undertaking restorative actions in the area.

[1]Physical restoration of a reef environment refers to an engineering focus whereas biological restoration focuses on restoring the biota and ecological processes. Physical restoration also relates to artificial reefs and biological restoration includes coral transplanting. Physical restoration is expensive and may vary from US$100,000 to US$1,000,000 per hectare (Edwards et al., 2007).

Reef restoration programmes have received the attention of management, planners and local communities such as those in Fiji, the Philippines and Tanzania. These communities have restored corals biologically at a cost ranging fromUS$2,000 to US$13,000 per hectare; the lower cost involved transplanting two corals per m^2 on existing reef that had around 20% coral cover (Edwards et al., 2007). Restoration costs vary with site specifics and the success of coral restoration is not guaranteed. Indeed, as pointed out by Marshall and Schuttenberg (2006), coral loss can be expected despite a restoration programme. Nevertheless, what is essential is to weigh the costs against the total benefits of such programmes. This valuation study fills this gap by examining the benefits associated with coral reef restoration using a contingent valuation method (CVM) to estimate the willingness to pay (WTP) for such programmes.

We further examine the policy implications of such programmes for improving reef ecosystems after coral bleaching events. Our contribution to the literature is threefold. First, we examine the values attached to coral reef restoration as little is known about these values for adaptation purposes. Second, we further examine divers' attitudes and their climate change perceptions to offer insights into global concern about climate change specifically in relation to coral reefs. Indeed, most valuation studies on recreational diving have focused on general attitudes, making it difficult to link behaviour, perception and attitudes to specific adaptation efforts. Third, we carry out a sensitivity analysis to re-examine the restoration benefits against coral coverage (low, medium and high rates) considering that coral reef quality is an important element in recovery and resilience.

This paper is structured as follows: section 2 describes the current literature related to willingness to pay for coral reefs before and/after climate change effects (coral bleaching), section 3 presents the data description and survey procedure used in the analysis. In section 4, the WTP results are presented together with a discussion of climate change effects related to current policy. Finally, section 5 offers the conclusions.

2. Literature review of valuation related to coral bleaching

There is a dearth of literature on valuation estimates for coral reef restoration programmes under climate change and the existing literature has focused on coral bleaching. However,

these studies vary from one country to another, or within a country, making it difficult to compare valuation estimates across countries or areas. We focus on specific literature with reference to coral bleaching such as: Ngazy et al. (2004), Andersson (2007) and Doshi et al. (2012). This review is relevant as coral bleaching loss implicitly involves the monetary and non-monetary losses experienced by divers. Restoration benefits imply that the associated values support coral reef resilience thus reduces the coral bleaching cost. Consequently, such benefits may assist decision makers and/or managers to plan and cost programmes for affected sites.

Ngazy et al. (2004) used a recreational demand and WTP model for coral reef recreation in Zanzibar. The study involved a face-to-face questionnaire administered at the airport, hotels and seaport to approximately 157 tourists in 2001.The questionnaire format used was open-ended and employed a CVM. Three coloured pictures were shown to respondents to represent three different coral reef scenarios: dead coral with high fish stock, pristine coral but no fish, and both abundant fish life and healthy coral. Using an ordinary least squares (OLS) regression, they found that some covariates were significant in both recreational demand and WTP models. For instance, in the demand model, the duration of stay, tourist's annual income and tourist diving experience were positive and significant, whereas for WTP, the sex of the respondent and tourist diving experience were positive and significant. Based on these results they concluded that individual WTP ranged from US$5 to US$500 a year to visit a pristine reef with fish life and healthy coral. In addition, they estimated the economic losses of bleaching by multiplying the percentage of divers at 25%, 50% and 75% with the estimated average WTP of US$85. The authors concluded that the stated WTP was higher than divers were actually paying and that the respondents were in favour of returning to Zanzibar to dive irrespective of the bleaching.

Andersson's (2007) study compared WTP and willingness to accept (WTA) before and after coral bleaching events using both stated and revealed preferences in Tanzania. For stated preference, a CVM with open-ended questions was administered to 551 and 71 tourists at hotels in Zanzibar and Mafia Island, respectively. A face-to-face administration elicited both WTP and WTA in relation to the loss of the coral reef before (1996/1997) and after (1999) a bleaching event. Most of those interviewed were international tourists approximately 98% of whom were from developed countries. For revealed preference, data were collected based on the tourists' travel cost. Estimation of probit and truncated models was used with no

covariates except for a bleaching dummy. The findings reported a significant negative effect for access to Zanzibar where WTP was approximatelyUS$300 less, whereas for Mafia Island all values for bleaching were negative and significant with WTP for Mafia Island access reduced by US$110 after the bleaching event. With regard to WTA, for Zanzibar this was not significant, but for Mafia Island it was US$555 or US$255 for the constrained estimate. In sum, the study pointed out that information released on coral bleaching events may have a negative impact on the tourist industry for developing countries. Importantly, the sensitivity of releasing such bleaching information as "worst case" scenarios affect the efforts of local communities in reef restoration programmes such as in Mafia Island. Moreover, such information affects the divers' visitation rates to specific sites, resulting in falling diving markets to such sites where local communities depend on tourism related to diving for income generation.

Recently, a comparative and comprehensive study examining bleaching costs was undertaken by Doshi et al. (2012) for three countries in South East Asia namely: Thailand, Malaysia and Indonesia. In their work, a choice experiment approach was used to estimate the change in consumer surplus due to coral bleaching events in the area. Data from approximately 578 divers (of which 434 samples were usable) in the three countries were collected by face-to-face interviews in popular diving sites. Divers were presented with choice cards representing different scenarios with distinct levels of amount and variety of coral, marine life and proportion of coral bleaching loss. Their logistic regression showed that the loss from bleaching ranged from US$44 to US$58 for each dive. In their study, the divers' profiles or attributes, such as whether they were local and/or international visitors, did not influence the WTP values.

In all these valuations, the range of WTP for coral bleaching losses was as high as US$100–US$300 (Andersson, 2007) and as low as US$85 (Ngazy et al., 2004) and US$44–US$58 in Doshi et al. (2012). Overall, the distinctiveness of these sites in terms of coral bleaching loss and the different questionnaire formats may explain this wide range of WTP values. Nevertheless, there is an opportunity to examine the benefits of reef restoration programmes in relation to these bleaching costs.

3. Survey structure, data and methodology

3.1 Survey description and implementation

The questionnaire comprised seven main sections: introduction, coral bleaching information, valuation exercise, total travel expenses, and socio-economic, demographic and de-briefing questions. The valuation exercise was located in the third section of the survey; two pictures representing healthy and bleached corals were presented prior to the hypothetical scenario. Also, a cheap talk script reminding them of their budget constraints was added to the scenario. [2] The survey was translated into French and Spanish for the non-English respondents. The administration of the survey was done online and was only for recreational divers. It was disseminated using social networking tools such as: divers' blogs, Twitter, Facebook and Linkedin. The total number of responses was 1,005; however, only about 50% of the total was valid for analysis.

Furthermore, we gathered data on general attitudes towards developing countries' economies and the environment using a set of citizenship questions (see Morrison et al., 2000). Finally, we also used value orientation type questions, i.e. egoistic, altruistic and biospheric, as used by Spash (2006); however, these results are not included or discussed in this paper.

3.2 Data description

Table 1 shows the respondents' views concerning climate change and coral reefs. We had *a priori* expectations that some attitudes towards climate change might influence WTP estimations; hence we collected data on respondents' attitudes and perceptions concerning

[2]The hypothetical scenario with the cheap talk script reads: "Now we would like you to imagine your next trip to a developing country and that you are requested to pay some funds to maintain the health and condition of the natural reefs at the diving site after a coral bleaching incident. Note the following is only a hypothetical situation (that means suppose it happens), and that there are no right or wrong answers. Please keep in mind your personal income constraints when answering the following questions. Remember this is only one of many environmental issues that may cost you money. Also, remember that there are other developing countries providing similar types of service that may not be affected by coral bleaching. In this scenario, the local authority wants to combat the climate change threat to corals. There is a trust fund to be set up and jointly managed by a non-profit organization and agreed management board. Note the trust fund will be used solely to help restore the coral reefs and related biodiversity which have been damaged by coral bleaching events. Consider for a moment that you will be asked to pay a one-time fee when entering this site to enable an increase in coral reef quality due to a coral bleaching incident that had occurred previously. Would you be willing to pay ...?"

climate change in general and also specifically in relation to coral reef ecosystems. A sizeable share of the respondents believed that pollution constituted a major threat to the ocean, followed by climate change and un-sustainable fishing. Furthermore, most believed that human activities had an impact on the global climate. With regard to mitigation efforts, nearly half of the respondents were interested in taking action against climate change.

Table 1 Attitudes and perceptions towards climate change and coral reef ecosystems

Variables	Description/ level of concern	Share of respondents (%)
Threats to ocean health		
pollution	High	41
loss of habitat	High	8
unsustainable fishing	High	20
climate Change (CC)	High	21
loss of biodiversity	High	11
Concern about CC		
coral reef	Very concerned	65
coral reef in developing countries	Very concerned	60
Responsibility		
effect of human activity on earth's climate	Large effect	79
CC impact		
the next 12 months	Major	25
the next 5 years	Major	57
the 25 years	Major	83
Taking action		
interest in mitigating CC	Very concerned	53

N=465 usable sample size

In addition, the share of respondents who agreed that climate change had an effect on coral reefs (in general) compared to those who agreed that climate change had an impact on coral reefs in developing countries (specifically) was 65% and 60% respectively. This slight variation between the two responses was further examined by correlating to the "citizenship questions", as in Morrison et al.'s (2000) study in which responses favouring either the environment or the economy for developing countries were elicited. However, the correlation coefficients of these statements were low, suggesting that support for reef management under

climate change is negligibly linked to the geo-politics of developing countries. Significantly, there was a positive relationship for charging higher fees in developing countries under climate change, suggesting that the respondents endorse increased fees for these countries.

With regard to the socio-economic and demographic (SED) details in relation to the sample size and the general population, the proportion of responses varied by global region, as shown in Table 2. In some cases, the sample sizes in Latin America and the Caribbean (LAC), East Asia and the Pacific, and the Middle East and North Africa (MENA) corresponded to the relative population of the regions for those who are above 65 years old. However, in all cases the proportions of female respondents in the sample were significantly higher than the population except in North America and LAC.

Table 2 Socio-economic and demographic characteristics of the sample against the general population by region

	Population aged65 years and above (% of total)	% of sample (n)	Population, female (% of total)	% of sample (n)	Self-employed, female (% of females employed)	% of sample (n)
North America	13.50	23.20	50.50	48.00	7.00	26.67
Australia	13.50	15.63	50.50	38.00	10.50	75.00
Sub-Saharan Africa	3.00	9.09	50.00	18.00	NA	20.00
Latin America & Caribbean	7.00	9.38	50.60	50.00	31.80	0.00
South Asia	5.00	0.00	48.60	29.00	84.60	50.00
Europe and Central Asia	11.00	7.75	52.30	44.00	18.70	48.15
East Asia and the Pacific	8.00	7.23	48.80	39.00	NA	33.00
The Middle East & North Africa	5.00	6.25	49.70	18.00	NA	0.00

Table 3 shows the descriptive statistics of covariates used in the final estimations where nearly all were dummy variables (taking the value of 1 for “yes”) except for the bid amount, which was a continuous amount in US$. Importantly, some of these variables, such as strong views on the effects of climate change on humans, high certainty about bid amounts, and

receiving coral reef education prior to diving, were important in the analysis. Indeed, our *a priori* expectation was that there would be positive and negative influences of these covariates on WTP and in other instances, such as educational level, the direction could be ambiguous – either positive or negative in other words those who are highly (poorly) educated will be willing to pay more (less) depending on the type of good /service .

Table 3 Descriptive statistics of covariates used in the estimation

Variable name	Description	No. of observations	Mean	Std. dev.	Min.	Max.	*A priori* expectation
bid1	bid amount	742	29.41	14.02	10	50	-
q0054_0001~f	refused to give income information, yes, dummy	517	0.10	0.30	0	1	-
q0053cat5	PhD education level, yes, dummy	517	0.08	0.27	0	1	-/+
q0055cat2	age between 20-29, categorical	517	0.30	0.46	0	1	+
q0015genco~1	climate change coral in general, very concerned, yes, dummy	742	0.60	0.49	0	1	+
q0030cat2	climate change potential effects on coral reef in developing countries, moderate effect, yes, dummy	685	0.40	0.49	0	1	-/+
q0014cat3	effect of human activities on earth's climate, large effect, yes, dummy	740	0.76	0.43	0	1	+
q0016_ccmj12	climate change impact on coral reef, major change in12 months, yes, dummy	742	0.24	0.43	0	1	+
q0031miti1	not concerned in taking action against on climate change in developing countries, yes, dummy	685	0.06	0.23	0	1	-
q0025belie~2	not believe management fund will help recover, yes, dummy	685	0.21	0.41	0	1	-
q0027contr1	mandatory contribution to conserve coral, yes, dummy	685	0.55	0.50	0	1	+
q0012divedu1	spend time to receive coral reef education, yes, dummy	742	0.77	0.42	0	1	+
q0008disti2	cannot distinguish healthy vis-a-vis deteriorating coral, yes, dummy	742	0.17	0.38	0	1	-
q0058cat1	donated money to environment group, yes, dummy	517	0.62	0.49	0	1	+
q0029certn	certain about the bid value selected, yes, dummy	685	0.74	0.44	0	1	+

Note: Total sample size varied with final estimations

3.3 Valuation methodology

As in previous valuation studies, a CVM was selected to estimate the benefits of reef restoration programmes where a single bounded question, also referred to as a referendum question, elicited a one-time fee payment from divers. A hypothetical scenario was described in which a coral restoration programme after a coral bleaching event was proposed, whereby the payment proposed by the single bounded question would be perceived by divers as a public good. There was no specific mention of the proportion of coral restoration coverage or restoration activity type. Five levels of WTP amount were used: 10, 20, 30, 40 and 50.[3] The respondents did not see all these amounts but only one was randomly generated online. The selected amounts were arbitrarily determined in a pre-test study session at an international scuba diving exhibition held at the *Borsa Internazionale del Turismo* (BIT**)** held on 16–19 February 2012 in Milan, Italy.

Table 4, shows the variation of "yes" and "no" responses to the bid amounts. The validity of responses to the bids was cross-checked using follow-up questions to determine whether there were valid "no" responses and protest responses; the protests comprised 19% of the total responses.

Table 4 Total number of responses to single bounded bids

	Bid amount					
	10	**20**	**30**	**40**	**50**	**Total**
No	15	21	26	41	35	138
Yes	141	128	129	106	100	604
Total	156	149	155	147	135	742

Note: number varies with final estimations

With regard to the follow up to the "yes" responses, the majority of those who agreed to pay said that the benefit was for society as a whole (47%), followed by those who were motivated by the next generation (36%). Conversely, of those who were not willing to pay for the restoration programme (see Table 5), nearly 50% refused to pay because there was insufficient information to make a monetary choice. In addition, approximately 23% thought that the government should take responsibility for protecting corals.

[3]The global survey had the option for respondents to select their own currency and all the selections were converted from Euros, British Pounds Sterling and Australian Dollars to US dollars.

Table 5 Reasons for not paying for the coral restoration (not WTP)

Reason for refusing to pay	% of responses
I do not care about the coral reefs and related biodiversity	0.74
Coral reefs do not need protection/conservation	0.74
It already costs too much to visit the coral reef area	17.04
The money would be wasted on the coral reef	2.22
The government should pay for coral reef protection	22.96
Businesses should pay for coral reef protection	2.96
Not enough information	53.33

n=138

4. Results and policy discussion

We estimated a probit model where a logistic regression of a "yes" or "no" response was the determinant and the bids together with SED characteristics and attitudes were used as predictors. Table 6 shows the probit model with a relatively reasonable pseudo-R^2 (0.35). Indeed, the distinct covariates related to SED variables affected the WTP estimations and, as we had expected, some were positive and significant namely: donation to environmental groups, certainty about bid values, as well as agreement with a mandatory contribution to reef conservation.

In the same vein, those variables that were negative and significant as expected were: those who were not concerned with climate change mitigation efforts (*q0031miti1*), as well as those who did not believe the management fund would help recover the coral reef (*q0025belie~2*). Moreover, we had expected the education variable to have both positive and/or negative effects and in our result those with a PhD were less likely to pay more towards coral reef recovery (*q0053cat5*).

What is more, *q0015genco~1* was contrary to our *a priori* expectations; in other words, for those who were very concerned about the effects of climate change on reef ecosystems, there was a negative influence on WTP which was significant at the 5% level. At first, this may seem puzzling although one plausible explanation could be related to the general form of the

query in that there were no specific linkages between climate change and corals. This is evident from other positive and significant questions that included specific terms such as "human activities" or "developing countries" in linking climate change and corals. This was the case for *q0030cat2*, where the potential moderate effect of climate change on reefs in "developing countries" was emphasized, as well as *q0014cat3*, which describes the effect of "human activities" on the earth's climate.

Table 6 Probit model for coral reef restoration programme

Variable	**Coef.**	**Std. Err.**	**z**	**P>|z|**
bid1	-0.03***	0.006	-5.14	0.000
q0054_0001~f	-0.04	0.262	-0.16	0.876
q0053cat5	-0.51*	0.275	-1.86	0.063
q0055cat2	-0.10	0.189	-0.53	0.593
q0015genco~1	-1.27**	0.545	-2.32	0.020
q0030cat2	0.37*	0.197	1.87	0.062
q0014cat3	0.48**	0.220	2.17	0.030
q0016_ccmj12	0.23	0.198	1.14	0.253
q0031miti1	-0.69*	0.402	-1.72	0.086
q0025belie~2	-0.49***	0.183	-2.67	0.008
q0027contr1	0.50***	0.167	2.99	0.003
q0012divedu1	0.19	0.197	0.98	0.327
q0008disti2	0.17	0.228	0.76	0.450
q0058cat1	0.33*	0.173	1.88	0.060
q0029certn	1.36***	0.183	7.44	0.000
_cons	0.31	0.415	0.75	0.450
N	516			
pseudo R^2	0.3459			
p >0	0.000			
ll(null)	-225.94			
ll(model)	-147.79			

Note: Levels of significance indicated at *10%; ** 5%; *** 1%

Finally, the variables that were insignificant in the model were as follows: *q0008disti2*, those who could not distinguish healthy coral vis-à-vis bleached (positive); *q0012divedu1*, those who received coral reef education (positive); *q0054_0001~f*, those who declined to provide

income information (negative); *q0055cat2*, those aged between 20–29 years (negative); *q0016_ccmj12*, those who thought there was no major impact of climate change in 12 months (positive).[4]

Table 7 illustrates the estimated designation for restoration programmes with and without covariates. We are unable to compare these results to other studies as no restoration benefits are found in reef valuations. Our results show a wide range of WTP as pointed out by Hanemann et al. (1991) for a single-bounded dichotomous choice, there is a wide confidence interval; nevertheless, our estimates are relatively closer to Ngazy et al. (2004) at US$85 per dive. However, one should be cautious in interpreting the results due to differences in the payment mode and duration used in both cases. In our case, a one-time payment towards a recovery fund was proposed, whereas for Ngazy et al. (2004) WTP per dive was estimated.

Table 7 Willingness to pay for coral reef restoration (in US$)

	WTP	Lower Bound	Upper Bound
mean (covariates)	73.23	61.61	99.08
mean (no covariates)	76.95	62.45	116.07

Note: Krinsky and Robb (95%) confidence interval for WTP measures (No.of responses: 5000)

Information about the total number of visitors or divers across all regions is difficult to construe; however, for the estimation of the total recovery benefits for the population of divers we used a proxy based on the total number of divers affiliated to the Professional Association of Diving Instructors (PADI) globally. In fact, nearly all the respondents (98%) were certified divers. In this regard, we took into account the total number of PADI certified divers from the1970s to 2012. In sum, the total number of PADI certified divers was 21,258,914 resulting in total benefits of US$1,557 million globally. This estimate is under-valued and the benefits maybe substantial as there are other diving agencies apart from PADI which have not been accounted for. Such diving agencies include: Scuba Diving International (SDI), the National Association of Underwater Instructors (NAUI), and Scuba School International (SSI).

[4]For climate change effects, measures for those who were concerned about the potential of climate change effects over five years and 25 years were insignificant at all levels. Moreover, gender, categorical and/or continuous income levels and job occupation (whether indoor or outdoor) were not significant in the overall model and hence were not used in the final estimations.

The sensitivity analysis of the value restoration as stated in the WTP scenario may imply that bleaching costs will be reduced and the coral reef ecosystem will continue to function, albeit at a lower level of quality than prior to the coral bleaching event. Consequently, we examine the long term benefits of restoration by considering the coral coverage in willingness to pay. In this case, we re-estimated the covariate model shown in Table 6 to include coral coverage as a dummy at medium level. Indeed, coral coverage as a measure of coral ecosystem health is a proxy for coral reef quality. Coral coverage rates at three levels –high, medium and low – were elicited from respondents based on their previous visits to coral reef sites across two to three developing countries. In this model, with all covariates we arbitrarily allocated the following "healthy" thresholds: low (l0–40% coral coverage), medium (40–80% coral coverage) and high (80–90% coral coverage) in the analysis. However only the medium level was significant and negative and all other covariates in Table 6 were significant except for *q0015genco~1*. The estimated WTP was US$73.72, relatively similar to the covariate WTP estimations found in Table 6.

Table 8 shows the estimated bounds for low, medium and high quality with respective thresholds of coral coverage in percentages. As can be seen, the results show that at a low coral coverage threshold, the lower and upper bounds of WTP for restoration benefit are the greatest. Again, multiplying these figures with the total number of PADI certified divers globally, the total benefit can be as high as US$3,125 million for low coral coverage sites (10–40%) to as low as US$659 million for high coral coverage (80–90%). As mentioned previously, these estimates may be under-stated as the total numbers of divers from other diving agencies were not taken into account in the overall population. Nevertheless, the cost-effectiveness of this programme can be assessed by comparing these benefits at a conservative estimate for restoration of $13,000/ha (Edwards et al., 2007) to the global potential benefits of reef restoration as found in this study at high coral coverage (upper bound) US$40/ha, medium coral coverage (upper bound) US$64, and at low coral coverage (upper bound) US$95/ha. There is no doubt that the costs are high and the resources (labour, equipment, etc.) required to restore reefs are costly. However, taking into account the fact that the annual growth of PADI divers in 2012 was 1.5%, these benefits may increase with time.

Table 8 Estimated value of total coral reef restoration benefits with respective coral coverage (in US$ million)

	Coral coverage thresholds (healthy)	WTP Lower bound (LB)	WTP upper bound (UB)	Total Benefit (LB)	Total Benefit (UB)
Low	10–40%	98	147	2,083	3,125
Medium	40–80%	62	98	1,318	2,083
High	80–90%	31	62	659	1,318

The policy implication of these results means that for low coral coverage sites that are presently affected by natural stressors, such as coral reef bleaching, some funding mechanism should be considered. Importantly, we should not wait for the coral coverage to be lower to undertake restoration programmes. In fact, waiting or a policy of inaction can be costly and users can perceive any attempts to restore coral reefs to be futile at some point. Consequently, the creation and implementation of a fund towards coral restoration at this time is imperative and should be prioritized by decision makers as well as managers while there is support for such a programme.

Moreover, communication and restoration information to diverse marine stakeholders is fundamental to the sustainability of the programme. In fact, both biological and physical restorations are plausible with sufficient funds, although the cost of the latter can be reduced to a certain extent if local communities participate and use their own general technical expertise, labour and equipment. In sum, both the inclusion of the local community and the timing of funding are crucial; hence the need for vulnerability assessments of both reef ecosystems as well as local communities.

5. Conclusion

This study illustrates that recreational users support restoration programmes benefits reef under threat of climate change. However, recovery costs can be substantially higher when other services such as provisioning and regulating services are also accounted. With increasing population growth and other human pressure on reef ecosystem the acceleration of habitat destruction will increase.

Importantly, we provide a starting point in evaluating one policy option to assess the welfare benefits associated with ecosystem restoration programmes to society. Nevertheless, more work is required to estimate cost-effective strategies in increasing coral reef resilience apart from coral reef restoration. Additionally, further understanding of restoration benefits is needed to link the restoration efforts before and after bleaching events, bleaching frequencies, growth in numbers of divers, as well as coral reef coverage and visitation rates to sites. Furthermore, these results have illustrated that some types of predictors related to divers' attitudes and profiles may influence WTP, such as donations to environmental groups, educational level, and climate change effects on coral, human and general contexts.

Consequently, researchers and survey designers should pay attention to *a priori* expectations as well as the design of hypothetical surveys related to climate change effects. Further work is needed to consolidate other divers' certification profiles from other organizations in estimating the population benefits from reef sites.

These findings have consequential impact on policy as these restoration benefits provide insights into how countries that may have medium or low coral coverage can adapt to climate change. In sum, restoration benefits and/or costs are difficult to capture and thus future work should employ other complementary approaches, such as revealed methods for WTP, to capture the adaptation cost.

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