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Gaining public engagement to restore coral reef ecosystems in the face of acute crisis

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ABSTRACT

The twin crisis of biodiversity loss and climate change make it urgent to find ways of restoring natural ecosystems, including coral reefs. Methods for coral reef restoration are rapidly advancing, bringing with them a range of potential risks and opportunities. Attention to public engagement in the governance of such activities therefore becomes critical. This research examines public attitudinal and behavioral engagement in 'traditional' coral restoration projects in the Great Barrier Reef World Heritage Area (i.e. coral gardening at relatively small scales). Grounded on dual-process decision-making and trust theories, rational factors (i.e., perceived benefits), emotions (i.e., hope and guilt) and trust are conceptually three main determinants of public engagement in ecological restoration. We used a mixed-method approach, including 63 individual interviews and a follow-up survey with 1585 participants, to clarify the roles of these psychological factors in motivating public engagement in current coral restoration projects. Trust was found to be the most important factor influencing public acceptance (i.e., attitudinal engagement) of coral restoration, while the emotion of guilt was the most influential factor affecting public support (i.e., behavioral engagement). Therefore, when advocating for conservation projects, different campaigns could be implemented with: (1) positive messages of hope and trust to gain public acceptance for government-funded restoration projects and (2) messages highlighting individual responsibility to motivate behavioral support to scale up restoration projects.

1. Introduction

As declining biodiversity and global climate change compound and accelerate, scientists increasingly consider the need to actively intervene or manipulate natural systems (Anthony et al., 2020). The Secretariat of the Convention on Biological Diversity (2020) in their recent United Nations Global Biodiversity Outlook urges that "efforts to conserve and restore biodiversity need to be scaled up at all levels using approaches that will depend on local context" (p. 12). Restoring a sustainable balance between ecosystem integrity and human activity may range from interventions that are highly integrated with natural processes, for example, ecosystem-based adaptation (EbA) (Nalau et al., 2018), to those that present completely man-made approaches, such as geo-engineering to reverse anthropogenic impacts on natural systems. Therefore, a considerable volume of research has investigated how to successfully manage environmental restoration projects (Wolff et al., 2018; Budiharta et al., 2018; Urzedo et al., 2020; van Oosterzee et al., 2020).

In the case of the Great Barrier Reef (GBR), Australia, recent research shows that coral populations have declined by half since the 1990s (Dietzel et al., 2020). The rate of the environmental decline is believed to be beyond the innate capacity for natural reef recovery (GBRMPA, 2019; Gouezo et al., 2019). Coral reefs have been at the forefront of suffering significant loss due to human activity. Due to rising sea temperatures, coral reefs have experienced catastrophic coral bleaching events in the last forty years, in addition to multiple other pressures that led to declines in marine biodiversity (Grottoli et al., 2021; Thiault et al., 2021).

To address the decline, at least in some locations, the EbA of coral restoration has become a more popular method in ecosystem-based marine management. Reviewing 329 coral restoration case studies globally, Boström-Einarsson et al. (2020) concluded that the most

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common intervention relates to coral gardening. Coral gardening typically involves the propagation of coral fragments, in situ or in a nursery environment, followed by their transplantation to a degraded coral reef substrate, to promote coral regrowth and ecological recovery of the site. Due to the requirement for manual handling, and associated costs, such endeavors have traditionally been limited to relatively small scales (i.e., up to several hectares). Such coral restoration contributes to enhancing reef resilience by accelerating coral and reef habitat recovery between disturbance events (Montefalcone et al., 2018). Because of a locked-in trend in increasing global temperature from historical CO_2 emissions (Meehl et al., 2005), coral restoration presents an increasingly necessary measure, among other coral reef management and protection efforts, to support the preservation of reef structures and functions (Bayraktarov et al., 2019).

Most coral restoration projects to date have been small-scale, providing localized benefits with minimal associated ecological and social risks (Boström-Einarsson et al., 2020). However, considering the scale of the GBR (approximately 2900 individual reefs spanning an area of 344,400 km^2), and that of other large and internationally significant coral reef ecosystems, traditional coral restoration techniques are incapable of providing the recovery and resilience required to preserve these ecosystems against the changing climate (Hughes et al., 2017). Recent efforts to address this issue of scaled restoration, and of coral reef resilience to climate change, include significant research and development into novel technological interventions (see https://gbrrestoration.org/ for examples). While the risks, benefits, costs and opportunities associated with such interventions remain uncertain, it is clear that public, stakeholder, and rights-holder engagement is critically important, not only because of the financial costs but also because of the impacts on local communities (Westoby et al., 2020; Taylor et al., 2019b). Thus, understanding restoration projects and associated social dimensions will become more and more important.

How people perceive threats to coral reefs, and certain restoration interventions depends on their relationship to nature and this, in turn, varies by context, culture and time in history (Thiault et al., 2021; Corner et al., 2013). While efforts are underway to engage communities in the identification of risks, opportunities and co-benefits, and their meaningful contributions to the governance of novel GBR interventions (RRAP, 2021), there remain gaps in understanding key drivers of public support and acceptance of coral restoration initiatives at their current scale. Our study therefore seeks to address these gaps, by refining and testing a model of non-expert public engagement and support for coral restoration, based on predominant (or traditional) coral gardening techniques. The insightsmay inform future research of larger scale, and potentially higher risk, technological interventions. Further investigation of public engagement in these interventions might be necessary because they are vastly different to coral gardening tested in this research in terms of function and scale.

A growing volume of research investigates how to engage the public in environmental policies in various contexts, including metropolitan regions (Bright et al., 2002), mining (Moffat et al., 2016), forestry (Ford et al., 2014), rivers (Buijs, 2009; Schläpfer and Witzig, 2006) and reef ecosystems (Taylor et al., 2019a; Trialfhianty and Suadi, 2017). These studies emphasize the importance of rational factors, such as values and beliefs, to influence public engagement in restoration efforts. Engagement has been investigated from two different angles: one focuses on attitudinal engagement and argues for the necessity of public acceptance or 'social license' and the other emphasizes the importance of motivating behavioral engagement in environmental restoration (i.e., active support through donations or volunteering) (Scholte et al., 2016; Hein et al., 2019). Even though there is no overt contestation or opposition to coral restoration in the current literature, there could be a gap between passive acceptance and active support intentions (Whitmarsh et al., 2011). Therefore, reticent individuals and groups should be encouraged to actively support coral gardening through effective communication (Ruano-Chamorro et al., 2021).

There is increasing recognition that affective responses to environmental changes and management policies are powerful drivers of behavior (Castillo-Huitrón et al., 2020). Due to humans' bounded rationality, people often rely on their emotions and feelings to make decisions (Evans, 2008; Kahneman, 2011). The experience of loss leads to significant negative emotions and grief (Cunsolo and Ellis, 2018; Curnock et al., 2019; Marshall et al., 2019a). In turn, there is evidence that the recent standstill of human activity due to the COVID-19 crisis has given rise to hope due to prospect of healing (Crossley, 2020). Positive language, rather than negative messages (Johns and Jacquet, 2018), might contribute to mobilizing people, especially when engagement builds on the social-cultural values and meanings associated with the Reef, transferred from generation to generation. The role of emotions in encouraging public engagement remains, however, largely underexplored in the existing body of literature, except some initial work on climate strikers (Martiskainen et al., 2020). Also, trust is a critical factor that influences public engagement in restoration policies that needs to be investigated (Metcalf et al., 2015; Bakaki and Bernauer, 2016; Cologna and Siegrist, 2020).

The current research aims to explore the psychological determinants of public engagement in coral restoration projects, in their predominant form of varied "coral gardening" techniques at localized scales. Grounded on dual-process decision-making theories (Evans, 2008; Kahneman, 2011) and trust theory (Cologna and Siegrist, 2020), it explores the relative contributions of rational factors (i.e., values, beliefs), affective factors (i.e., positive versus negative emotions) and trust in building public attitudinal engagement (i.e., public acceptance) and encouraging public behavioral engagement (i.e., public support). To achieve this overall aim, we conducted two empirical studies examining coral restoration initiatives at the GBR, Australia. First, a qualitative study used individual interviews with Australian citizens (n = 63) to examine psychological factors that lead to public engagement in coral restoration projects. The qualitative results enabled the development of a conceptual framework to explain the relative influence of affect, trust and rational factors on coral restoration engagement. We then conducted a quantitative study, using an online survey of a representative sample of the Australian population (n = 1585) to statistically test hypotheses derived from the conceptual framework, and elucidate the relative contributions of psychological determinants of public engagement.

2. Literature review

This section first discusses two levels of engagement: public acceptance and public support. Next, key determinant factors of public engagement identified in previous studies are reviewed to highlight the lack of research on affective factors. Finally, the dual-process theory is introduced to explore the importance of emotions in encouraging public engagement.

2.1. Public engagement in environmental management and policies

Due to the role of the public in a democratic society, the success and failure of environmental management are often associated with public engagement (Whitmarsh et al., 2011; Metcalf et al., 2015). Public engagement in environmental management may be defined broadly as individuals' evaluation of and responses to environmental restoration, which comprise cognitive, emotional and behavioral components (Lorenzoni et al., 2007). The public can engage in environmental management at different levels, from merely rejecting/accepting them without any actions (i.e. attitudinal engagement) to actively supporting them by providing donations and/or volunteer work (i.e., behavioral engagement).

Previous research has examined attitudinal engagement using several similar concepts such as public acceptance, social acceptability or social license to operate. The concept of public acceptance was first introduced by Firey (1960) to refer to broad opinions of the community

on the benefits and impacts of a government policy in resource management. Based on this conceptualization, getting public acceptance means having a social license to implement the proposed policy/management option (Moffat et al., 2016). Over time, public acceptance or social acceptability has been established as a psychological concept to represent the attitudinal engagement of a wide range of individuals and groups to a particular policy or practice compared to alternatives (Ford et al., 2014).

Public behavioral engagement or public support is more critical than attitudinal engagement in maintaining long-term conservation projects (Cairns, 2000). Whilst public acceptance refers to passive attitudes, public support refers to people's behavioral responses such as intentions to contribute their time, money, efforts, and commitment in restoring ecosystems (Connelly et al., 2002; Proctor, 1998). Therefore, public behavioral engagement or public support has been measured through one's willingness to pay for conservation/restoration projects (Shultz and Soliz, 2007), voter support for restoration funding (Schläpfer and Witzig, 2006), and volunteering and donation intentions (Septianto et al., 2020). In order to distinguish it from passive public acceptance, active public support in the current research is conceptualized and measured as specific actions of making donations or volunteer work.

The public often accepts a conservation/restoration policy, but they may not be willing to take supportive actions for implementing or expending it (Batel et al., 2013; Devine-Wright and Howes, 2010). To ensure the ongoing success of coral restoration projects, both public acceptance and support are vital (Westoby et al., 2020).

2.2. Determinant factors of public engagement in ecological restoration

The existing body of literature on public engagement, including research on both public acceptance and public support, is substantial; however, it is dominated by rational decision-making theories such as the Theory of Planned Behavior (Ajzen and Fishbein, 1977) and trust theory (Cologna and Siegrist, 2020). Based on reviewing empirical studies, Ford and Williams (2016) proposed a conceptual framework, including key identified psychological determinants of public engagement (Fig. 1). The cognitive hierarchy involving values and beliefs about consequences (e.g., perceived benefits) represents the primary pathway to influence engagement. Trust is also important in mediating the influences of values on public engagement. Aesthetic beauty of the conserved area was proposed to enhance beliefs about consequences of environmental management policy, and thus increase public engagement. Further discussion on these psychological factors is provided below.

2.2.1. Place values

Place values are a central factor motivating public acceptance and public support for conservation policies (Ford et al., 2009). Value(s) can be defined as "an enduring belief that a specific mode of conduct or end-state of existence is personally or socially preferable to an opposite or conserve mode of conduct or end-state of existence" (Rokeach, 1973: 05). Place values for natural and iconic places can be highly diverse and widespread among communities at scales ranging from local to international (Gurney et al., 2017). Such values can guide human beliefs (Winter, 2007), and how people value a place forms the basis for public engagement in environmental policies to preserve or restore the place (Scholte et al., 2016; Ford et al., 2014). Opposing opinions towards conservation/restoration initiatives are often caused by value differences between different interest groups. In this case, effective communication and relationship building are important to reconcile the conflicting value assumptions (Ford and Williams, 2016).

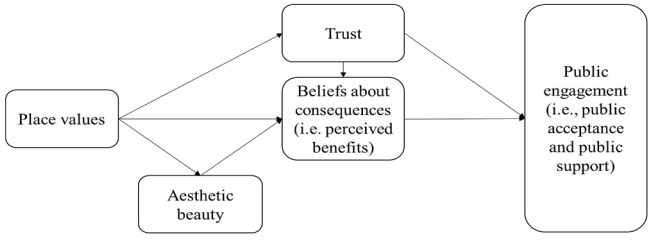

Fig. 1. Psychological determinants of public engagement in ecological restoration.

In the context of the GBR, place values have been widely examined in previous research (GBRMPA, 2019; GBRMPA, 2018), including through economic value (Stoeckl et al., 2011; Marshall et al., 2019b), biodiversity value (De Valck and Rolfe, 2019), and tourism and recreation value (Esparon et al., 2015). Studies also examined intangible values such as aesthetic value (Le et al., 2019; Marshall et al., 2017; Pocock, 2002) and social-cultural value (Jarvis et al., 2017). Measuring the monetary value of the entire GBR ecosystems is difficult and an estimate of $15 to $20 billion AUS per annum has been advanced using statistical techniques (Stoeckl et al., 2014).

2.2.2. Beliefs about consequences (i.e. perceived benefits)

Human beliefs about restoration consequences – that is costs or benefits – are the main rational path to gain public engagement. Many empirical studies show that perceived benefits of a particular policy (e.g., green energy, forest management strategy, restoration project) increase both the public's favorable attitude toward projects and their willingness to pay/donate/volunteer for these projects (Strazzera et al., 2012; Hartmann and Apaolaza-Ibáñez, 2012; Ford et al., 2014; Gobster et al., 2016; Bright et al., 2002; Kim and Petrolia, 2013). Also, place values enhance perceived benefits of restoration projects, leading to higher levels of public acceptance and support (Ford et al., 2009; Ford et al., 2014).

2.2.3. Trust in restoration scientists and managers

Building a trusting relationship with the public is essential to motivate engagement in environmental management (Westoby et al., 2020). Trust is an important driver of stakeholder collaboration which is developed through repeated interactions between parties (Stern and Coleman, 2015). By far, the best predictor of public acceptance in earlier studies is trust in the ability of environmental management organizations to implement restoration practices (Gordon et al., 2014). Trust also significantly strengthens willingness to pay for restoration success (Metcalf et al., 2015; Bakaki and Bernauer, 2016; Cologna and Siegrist, 2020). Further, trust has indirect influences on public engagement by reducing beliefs about environmental risks or enhancing beliefs about the benefits of environmental interventions (Metcalf et al., 2015). Therefore, lack of trust is the fundamental barrier for restoration planning and implementation (McCool, 2000).

2.2.4. Aesthetic beauty

Preserving the aesthetic beauty of natural environments has been one of the key arguments to engage the public in restoration projects (Buijs, 2009). People are motivated to protect aesthetically pleasing places that provide restorative and recreational benefits (Brady, 2002; Saunders, 2013), and aesthetic appreciation significantly enhances support and willingness to pay for conservation programs (Lee, 2017; Biénabe and Hearne, 2006; Schläpfer and Witzig, 2006). There is a strong link between aesthetic beauty, concerns about environment changes and public support for restoration (Le et al., 2020). Therefore, images of aesthetically attractive restoration sites are often used in conservation campaigns by environmental organizations (Foale and Macintyre, 2005).

2.3. Dual-process theories and the importance of emotions

Dual-process theories provide a theoretical basis to argue for the importance of emotions in gaining public engagement. The theories

suggest that human behavior results from the interactions of two distinct but supplementary cognitive systems: System 1 is rational, controlled, effortful and related to analytical thinking, while System 2 is automatic, effortless and related to emotional factors (Evans, 2008). These two systems are referred to as fast and slow thinking (Kahneman, 2011). In accordance with the dual-process theories, some empirical evidence suggests that discrete emotions such as worry, interest, hope and guilt associated with climate change policy can influence public support or opposition (Smith and Leiserowitz, 2014). Other studies show that negative emotional appeals (e.g., fear) can be counterproductive in motivating public support (O'Neill and Nicholson-Cole, 2009) because when fear is combined with the belief that individuals would not make a difference, self-efficacy drops and people 'give up' (Smith and Leiserowitz, 2014). Therefore, the influence of emotions on public engagement in environmental management policies remain an ongoing subject of debate (Skurka et al., 2018; Curnock et al., 2019).

3. Methods

In order to examine the psychological determinants of public engagement in coral restoration projects in the GBR regions, a mixed-method approach involving two related empirical studies was employed. Study 1 was an exploratory study to identify relevant psychological factors that are associated with public engagement for coral restoration projects in GBR regions. Study 2 served to test the model derived from Study 1, and to examine the relative contributions of each psychological factor to public engagement.

3.1. Study 1: Exploratory qualitative method

Study 1 was conducted in July and August 2019. A total of 63 participants were recruited for individual interviews using a convenient sampling and snowballing method. There was an approximate gender balance in the sample: 33 (52%) were female and 30 (48%) were male. Most participants were between 18 and 24 years old (n = 37, 58.5%), and 20.6% (n = 13) were aged 26–44. The remainder (n = 13; 20.6%) were aged 45 years and above. All participants were living on the Gold Coast, Queensland, Australia when participating in this study. Several of the participants have family roots in the GBR regions and thus provided rich insights into local and visitor views of coral restoration efforts. Given that the GBR is the biggest reef in the world, stretching along a large part of the Queensland coast, the distances from Gold Coast to different GBR cities vary significantly (e.g., between 400 km to Bundaberg and 2766 km to Cape York). Compared to participants living in other states in Australia, the GBR is easily reachable and also psychologically close due its prominent position in the Queensland community.

Prior to their in-depth interview, participants signed the consent form to agree that their interview discussion will be used for research purpose only (Ethical approval granted). Participants viewed a short video published by Reef Restoration Foundation (2018) explaining coral restoration activities and sequences of coral restoration states (from initial planning to more natural regrown habitat) before sharing what they understood, thought and felt about coral gardening as part of coral restoration program at the GBR. Each interview was audio-recorded and later transcribed by REV Ltd. The length of each interview was about 15–30 min. Participant interviews were coded and analyzed using Leximancer software to identify psychological determinants of public engagement in coral restoration projects and develop a conceptual framework to be tested in Study 2.

3.2. Study 2: Quantitative method

Study 2 involved the use of a quantitative survey, implemented in April 2020. The questionnaire included demographic questions and measurement scales for relevant constructs identified in Study 1 (Supplementary information 1). GBR place values were measured by five value items adapted from Apps et al. (2019). Three items to measure perceived need of human intervention and three items to measure benefits of coral restoration were developed based on outcomes of study 1 (Supplementary information 2). After answering these questions, participants viewed a picture showing the progression of coral restoration (Image 1) and evaluated the aesthetic beauty of coral restoration site on a 10-point scale (1-Not at all, 10-A great deal). The 10-point scale was also used for two questions related to the emotions of hope and guilt that participants feel after viewing the photo. Two levels of public engagement (acceptance and support) were each measured by one separate item: (1) I ACCEPT the implementation of coral restoration projects in the reef regions and (2) I am willing to SUPPORT the implementation of coral restoration projects by making donations or volunteer work. The questionnaire was trialed with six respondents to review its wording, scale and flow before the actual data collection. Accordingly, the measurement scales for GBR place values, perceived need of human intervention and perceived benefits of coral restoration were adjusted from 10-point scales to 6-point scales (agree/disagree).

Qualtrics data collection service was used to recruit survey participants living in Australia. Given the immerse investment needed to protect the GBR, it would require high levels of support from the federal government level, not only the state level. Sampling participants in all states of Australia would provide a better understanding of public engagement in coral restoration efforts. A total of 1693 questionnaires were recorded after one week. After deleting incomplete questionnaires, 1585 complete questionnaires remained for further analysis. The survey sample includes Australians of all age groups: 17% between 18 and 25 years old, 40.3% between 25 and 44 years old, 26.6% between 45 and 64 years old and 16.6% over 65 years old. More female participants (61.3%) participated in the survey compared to males (38%). Four participants belong to other genders group. Regarding education levels, 32.2% completed high schools, 29.4% held college diplomas, 37.4% held bachelor degrees or above.

4. Data analysis and results

4.1. Study 1: Identification of psychological factors

Leximancer software version 4 was used to perform thematic and content analysis. In contrast to a human coding process, Leximancer transforms textual documents into semantic patterns in an unsupervised manner that helps to reduce preconception bias found within a manual analysis process (Schweinsberg et al., 2017). Leximancer automatically identifies key concepts frequently mentioned within participants' conversation and generates meanings (i.e., themes) by creating visual concept maps (Scott et al., 2017). Several steps must be followed: (1) irrelevant words such as "during" or "able", "the" have to be removed; (2) similar concepts are merged together as a concept (e.g., "image" and "picture"); (3) a series of repeated functions are undertaken to explore and modify the main concepts within the text; (4) key concepts are mapped into themes based on the relationships between them.

Leximancer analysis produces concept maps, visualizing the key themes discussed in interviews (Fig. 2). The relative importance of a theme is indicated by the color of each theme and the number of concept occurrences (i.e., the number of text blocks in participants' interviews associated with the theme) (Leximancer, 2018). Hot colors such as red or orange denote more important themes, while cool colors such as blue and green denote those less important (Schweinsberg et al., 2017). The seven themes identified from the interviews are classified in order of their relative importance as follows: perceived benefits of coral restoration (531 concept occurrences), need of human intervention (201 concept occurrences), aesthetic beauty (186 concept occurrences), GBR values (158 concept occurrences), trust (68 concept occurrences), hope (23 concept occurrences) and guilt (9 concept occurrences). Key concepts associated with themes are presented in Supplementary information 3.

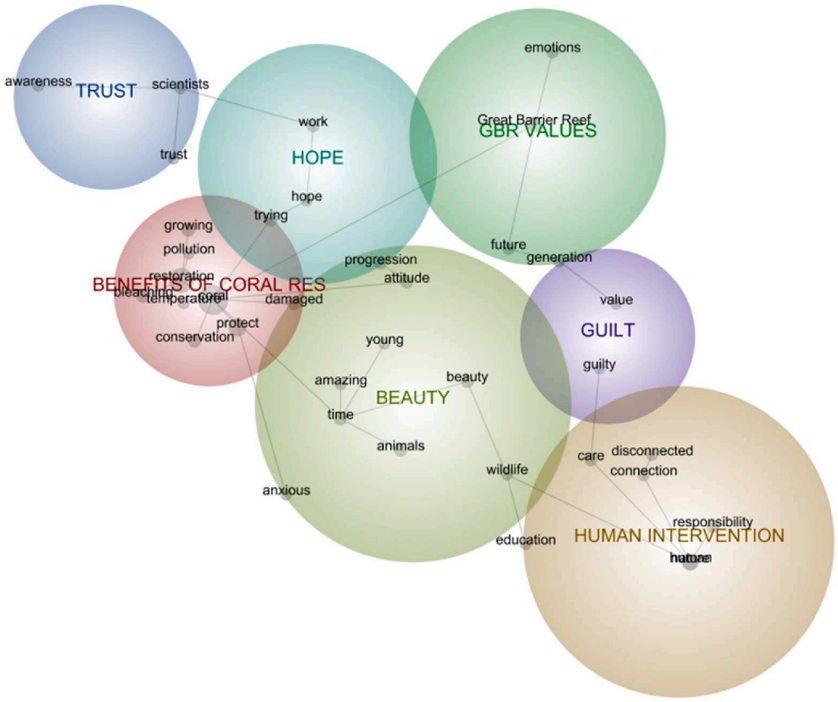

Fig. 2. Key themes emerging from participants' interviews.

Perceived benefits of coral restoration were frequently mentioned by participants to explain their attitudinal and behavioral engagement in coral restoration. Benefits included biodiversity enhancement, aesthetic beauty preservation and social-cultural benefits such as community involvement and education (Supplementary information 1). Benefits of coral restoration were illustrated in the following statement by participant 31 (female, 18–25 years old): "*I think it goes along with wanting to protect the reef that we protect the animals as well and we want to keep native animals and keep as many species as possible… And also for some Indigenous communities up north, the reef and tourism provide a lot of income. So there is a real inherent value to protect the reef and keep it as good as it can possibly be for next generations as well.*".

The second emerging theme in participant interviews was related to individual perception of the urgent need of human interventions in the GBR ecosystem (Fig. 2). Due to mass media coverage of coral bleaching events, most participants considered coral restoration as human responsibility to 'repair' damaged reef areas and reduce climate change impacts. For example, participant 55 (male, 18–25 years old) noted: "*We have to, intervene, on such a great scale to be able to fix it, that we destroyed it and now, we're responsible for fixing it*". Others, who doubted the necessity of human intervention in restoring the GBR, showed less support for coral restoration. For example, participant 25 (male, 25–35 years old) suggested: "*I don't know how much effect humans really have on it… maybe we should just let natural selection do it… we should just leave it alone*".

The third theme in interview discussions was the aesthetic beauty of coral restoration sites, especially as restoration progresses to more mature stages. Participant 57 (female, 15–25 years old) noted: "*So it was kind of interesting to see the way they did it and then it was at least moderately successful by the beautiful looks of it…anything to help its growth is something I support anyway*". By observing the aesthetic transformation of restored sites, the audience was not only rationally convinced regarding the ecological benefits (see above) of coral restoration, but also experienced the emotion of hope for a better future of the reef. This is made clear by the following response (Participant 54, male, 25–35 years old): "*I saw the progression photo of the little bits of coral that had just been put onto the thing and then X amount of time later when it was growing and it looked really nice. So it does kind of give me some hope that it'll become really beautiful again and that we can bring it back from death*".

Also, values of the GBR were discussed by participants from different aspects, such as aesthetic value, biological value, cultural value, economic value and educational value (see Supporting information 1). Most participants seemed to agree that "*(GBR) it's a great asset…It's a one-of-a-kind thing… Like the value of tourism and…the ecosystem kind of thing…I think it's like invaluable kind of thing*" (Participant 17, male, 18–25 years old).

Additionally, trust emerged as a critical factor that determines participants' favorable attitude and support, in particular, when participants have limited knowledge and understanding of coral restoration. When trusting scientists and restoration managers in doing the right thing to save the reef, participants were willing to support coral restoration, as described in the following: "*(Coral restoration) it's a great idea…I just don't understand the science behind it…but if scientists think it's going to work and the government decides to invest in this program, then I think it's going to work. I trust them*" (Participant 34, female, 25–35 years old). Also, it is found that trust increased participants' beliefs about the benefits of coral restoration.

During their interviews, participants expressed mixed emotions: sad/negative emotions that the reef got damaged in the first place but good/positive emotions that people are doing essential restoration. Two emotions frequently linked to coral restoration were hope and guilt (Fig. 2). Coral restoration brings hope about a better future as participant 24 (female, 35–45 years old) reflected: "*If there's no one in there doing that then we haven't got a chance at all. But with the restoration program, just by seeing it there, it brings hope*". Other participants shared their feelings of guilt toward the implementation of coral restoration because they felt responsible for the GBR damages: "*There's been a lot of damage to the reef, but that's on our behalf. I feel guilty that we haven't really done a lot to fix that…We need to take more care of it*" (Participant 19, female, 25–35 years old).

4.2. Summary of Study 1 and conceptual framework

The qualitative study confirms several important factors already identified in the literature and included in the models proposed by Ford and Williams (2016) and Cologna and Siegrist (2020). These are GBR

place values, perceived benefits of coral restoration, aesthetic beauty and trust. More importantly, the qualitative study demonstrates the involvement of specific emotions (hope and guilt) in engaging the public. Based on the literature and outcomes of Study 1, a conceptual framework is developed (see Fig. 3). In this model, public acceptance and public support are distinctively conceptualized and derived by perceived benefits, emotions and trust. Aesthetic beauty and participants' perceived need of human intervention, which emerged in Study 1, are also included as an antecedent of trust, perceived benefits and emotions.

The following hypotheses were developed for testing the conceptual framework in Study 2.

H1: GBR place values positively influence perceived need of human intervention through coral restoration.

H2: GBR place values positively influence individual perception of aesthetic beauty of coral restoration site.

H3: Perceived need of human intervention positively influences trust, perceived benefits and emotions.

H4: Aesthetic beauty of coral restoration site positively influences trust, perceived benefits and emotions.

H5: Trust positively influences perceived benefits.

H6: Trust, perceived benefits and emotions positively influence public attitudinal engagement (i.e. acceptance).

H7: Trust, perceived benefits and emotions influence public behavioral engagement (i.e. active support).

4.3. Study 2: Quantitative study

The proposed conceptual model was tested via partial least squares (PLS) path analysis in the SmartPLS 3.0 software package. The advantages of PLS path analysis are to (1) comfortably analyze metric variables, and proportions on different scales in the same model, and (2) have superior statistical power compared with more traditional covariance-based SEM approaches when testing more complex and often predictive models that include formative indicators as well as single-item measures (Hair et al., 2016).

Before testing the conceptual model, multiple-item constructs (i.e. place values, need for human intervention, perceived benefits) were assessed based on three main criteria (nature of construct, the direction of causality between items and latent construct, and characteristics of items used to measure the construct) to decide the use of reflective/formative measurement models (Hair et al., 2016). *Place values* of the GBR and *perceived benefits of coral restoration* were operationalized as formative constructs, while *perceived need for human intervention* was operationalized as a reflective construct. Using of formative construct in replacement of reflective construct for GBR place values and perceived benefits of coral restoration allows more accurate measurement of these multi-dimensional variables in structural equation modelling without overlooking any aspect (Coltman et al., 2008; Guyon, 2018).

There was no issue with multi-collinearity as evidenced in the variance inflation factor Table 1 (VIF) values all being below 5, meeting the general rule of thumb. As a reflective construct, *perceived need for human intervention* achieved good indexes of construct reliability ($\alpha = 0.752$) and convergent validity ($\rho A = 0.773$). The assessments of two formative measurements are based on the significance of outer weights, *t*-value and *p*-value. As can be seen from Table 1, all outer weights range from 0.574 to 0.920 were significant ($p < 0.05$), justifying the convergent validity and content validity of *GBR place values* and *perceived need of human intervention*.

The results of testing the structural equation model are introduced in Fig. 4. The key objective of PLS path analysis is prediction. Hence, the goodness of a model is evaluated via assessing the strength of the various structural paths in the model and the collective predictiveness (R^2) of exogenous constructs (Chin, 1998). All endogenous constructs in the research model exhibit acceptable levels of predictiveness ($R^2 > 0.1$), suggesting acceptable levels of nomological validity for the research model (Barnes, 2019; Falk and Miller, 1992). Overall, this model explains a sizeable 56.1% of the variance in public acceptance and 22.6% of the proportion of public support. The model also gains good fit indexes (SRMR = 0.787; NFI = 0.898) (Hair et al., 2016).

Bootstrapping in SmartPLS with 5,000 samples was conducted to verify the significance of hypothesized relationships in the conceptual model as well as the direct, indirect and total effects (Table 2). Based on the path coefficients, t-value and *p*-value, most relationships among variables in the model are significant, except the influence of guilt on public acceptance ($\beta = 0.040$, $p > 0.05$, $t < 1.96$) and hope and public support ($\beta = -0.069$, $p > 0.05$, $t < 1.96$). Among all psychological factors, *trust* was the strongest predictor of public acceptance (total effects = 0.464), followed by *perceived need for human intervention* ($\beta = 0.461$, $p < 0.01$). Public support was most strongly correlated with the emotion of guilt (total effects = 0.332), followed by *perceived need for human intervention* ($\beta = 0.271$, $p < 0.01$).

Results of hypothesis testing based on data analysis outcomes (see Table 2) are presented in Table 3 below, emphasizing the necessity of distinctively conceptualizing public acceptance and public engagement. As can be seen from Table 2, trust is the most important factor to influence public acceptance, while guilt is the most important motivating factor of public support. Hope has a significant impact on public acceptance but does not significantly influence public support. GBR place values, perceived benefits, aesthetic beauty and perceived need of human intervention are all critical antecedents of public engagement.

5. Discussion

This research was undertaken in response to declining biodiversity, especially in the context of coral reefs and repeated bleaching events at the GBR in a warming climate. Recognizing that we find ourselves in "a race against time" (Anthony et al., 2020), where more proactive interventions of restoration are required, our study sought to explore how to engage the public in coral restoration efforts. The focus of this study was on the predominant small-scale 'coral gardening' form, acknowledging rapid technological development that may lead to larger-scale

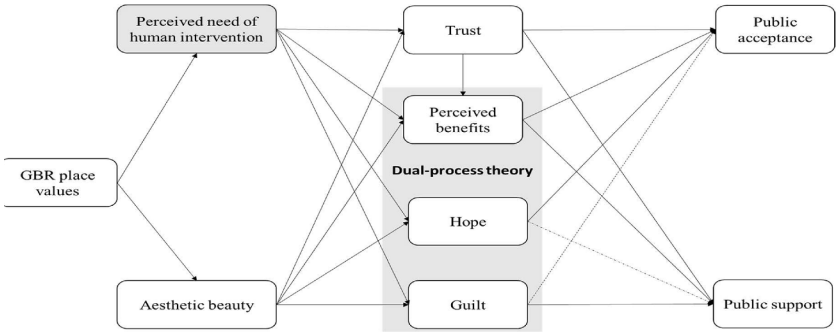

Fig. 3. Conceptual model of public engagement in coral restoration.

Table 1
Assessment of formative construct measures.

Formative constructs	Formative indicator	Outer weights	Outer Loading	*t*-value	*p*-value	Outer VIF
GBR place values	**Aesthetic value:** I value the GBR because of its OUTSTANDING aesthetic beauty (scenery, sights, smells, sounds, etc.).	0.309	0.858	4.963	0	2.711
	Biodiversity value: I value the GBR because the reef supports the DIVERSITY of coral, fish and sea animals.	0.245	0.841	4.088	0	2.789
	Cultural value: I value the GBR because the reef provides a place where people pass down the wisdom, knowledge, traditions and a WAY OF LIFE.	0.257	0.739	5.204	0.000	1.537
	Economic value: I value the GBR because of its great ASSET for the economy such as providing tourism benefits.	0.177	0.574	3.381	0.001	1.284
	Educational value: I value the GBR because it is a place where we can LEARN about marine environment.	0.282	0.839	5.046	0.000	2.069
Perceived benefits of coral restoration	**Biological enhancement:** Coral restoration enhances reef BIODIVERSITY, create natural habitats and improves reef resilience in the face of climate change.	0.432	0.887	7.36	0.000	2.024
	Aesthetic preservation: Coral restoration is essential to maintain the BEAUTY of the reef for recreation and tourism development.	0.173	0.772	2.559	0.011	1.889
	Socio-cultural benefits: The implementation of coral restoration improves COMMUNITY INVOLVEMENT and NATURE EDUCATION.	0.525	0.92	8.828	0	2.073

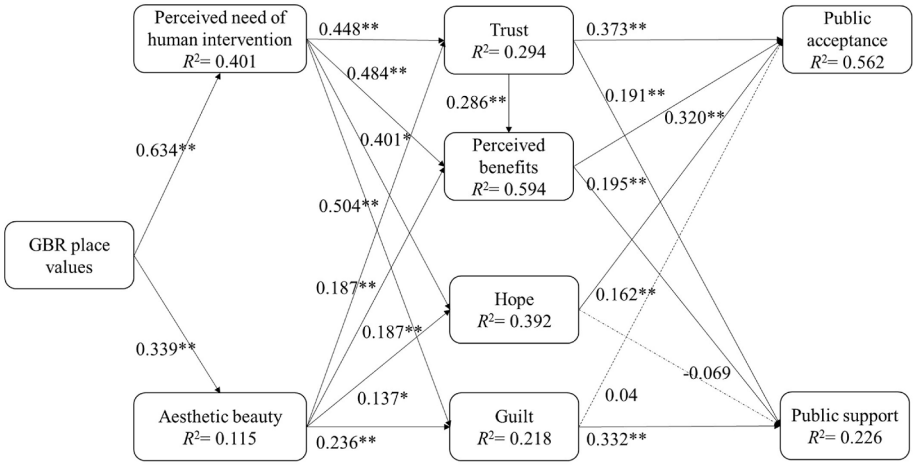

Fig. 4. Results of SEM using Smart-PLS.

Image 1. Image used in the survey to show the progress of coral restoration.

restoration interventions in coming years. Five main findings from our two studies are further discussed below.

First, the current research highlights the role of emotions in motivating public engagement in coral restoration projects, advancing an under-researched area in the current literature. Grounded on the dual-process theories from psychology, research outcomes demonstrate the significant impacts of both rational and affective factors on public engagement. In accordance with previous studies (Gobster et al., 2016; Trialfhianty and Suadi, 2017; Shwom et al., 2010), beliefs about the benefits of coral restoration lead to public engagement. In addition, the influences of specific emotions on public engagement are distinct. Guilt emerged as the most influencing factor of public support for coral restoration while having no significant impact on public acceptance. In contrast, hope significantly raised public acceptance but had no significant impact on support.

These different impacts of specific emotions can be explained by action tendencies associated with these emotions (Fredrickson, 2001). Guilt is associated with human sense of responsibility for environmental damages and can translate into actions to restore nature (Smith, 2014). A prominent example of the link between guilt and action is people's purchase of carbon offsets to address their greenhouse gas emissions (Bösehans et al., 2020). Hence, guilt is effective in motivating damage mitigation behavior, such as willingness to donate or volunteer (Harth et al., 2013; Ferguson and Branscombe, 2010; Rees et al., 2015). Meanwhile, hope is associated with an optimistic view of the GBR's future and the tendency to accept restoration projects but not taking further supportive actions. In the context that public optimism for the GBR future decreased in response to the 2016 and 2017 mass coral bleaching events (Curnock et al., 2019), hope might remain a necessary factor to ensure public acceptance of conservation and restoration efforts (Hobbs, 2013).

Second, the current research suggests that trust is an important determinant of public acceptance (Gordon et al., 2014) and an additional factor to strengthen public support (Metcalf et al., 2015; Bakaki

Table 2
The direct, indirect, and total effects of psychological factors on public acceptance and public support for coral restoration.

	Public acceptance			Public support		
	Direct effect	Indirect effect	Total effect	Direct effect	Indirect effect	Total effect
Guilt	0.040		0.040	0.332**		0.332**
Hope	0.162**		0.162**	−0.069		−0.069
Perceived benefits	0.320**		0.320**	0.195**		0.195**
Trust	0.373**	0.092**	0.464**	0.119**	0.056**	0.175**
CR_Beauty		0.190**	0.190**		0.098**	0.098**
Perceived need of human intervention		0.461**	0.461**		0.271**	0.271**
GBR place values		0.356**	0.356**		0.205**	0.205**

Note: ** $p < 0.01$, $t > 1.96$.

Table 3
Results of hypothesis testing.

Hypothesis	Outcomes	Key findings
H1: GBR place values positively influence perceived need of human intervention through coral restoration	Supported	(1) both rational and emotional factors influence public engagement;(2) trust is the most important factor to influence public acceptance and was significantly correlated with public support;(3) the perceived need for human intervention was found as an important factor influencing public engagement, mediated by trust, perceived benefits, hope, and guilt;(4) the perceived aesthetic beauty of restored sites enhanced public engagement by increasing trust, perceived benefits and emotions(5) public attitudinal and behavioral engagement (acceptance versus support) are conceptually and operationally distinct concepts.
H2: GBR place values positively influence individual perception of aesthetic beauty of coral restoration site.	Supported	
H3: Perceived need of human intervention positively influences trust, perceived benefits and emotions	Supported	
H4: Aesthetic beauty of coral restoration site positively influences trust, perceived benefits and emotions	Supported	
H5: Trust positively influences perceived benefits	Supported	
H6: Trust, perceived benefits and emotions positively influence public attitudinal engagement (i.e. acceptance)	Partly supported (except the emotion of guilt)	
H7: Trust, perceived benefits and emotions influence public behavioral engagement (i.e. active support).	Partly supported (except the emotion of hope)	

and Bernauer, 2016; Cologna and Siegrist, 2020). While building trusting relationships between scientists and policy-makers is critical in designing environmental restoration projects (Lacey et al., 2018), the success of these projects would depend largely on the establishment of trusting relationships between the project team (including scientists and managers) and the public, in particular local communities (Metcalf et al., 2015). This could be challenging where conservative media has spread doubt about the reality of climate change and divided the public over the trustworthiness of climate scientists (Carmichael et al., 2017; Thiault et al., 2021). The importance of trust in science has become particularly evident in the current coronavirus crisis (Agley, 2020).

Third, the research identifies and introduces the concept of perceived need of human intervention as a critical factor in gaining public acceptance and public support. Our qualitative Study 1 revealed some concerns among participants about the notion of interfering with natural processes within ecosystems exist. While some believe that human intervention through coral restoration is necessary to accelerate reef recovery, others think that ecosystems are able to self-regulate and adapt (Corner et al., 2013). Research outcomes echo the debate among conservationists regarding the necessity of human intervention (Nogués-Bravo et al., 2016; Van Meerbeek et al., 2019). Our quantitative Study 2 demonstrates that perceived need for human intervention is the second most influencing factor, after trust, on public acceptance and is also a significant determinant of public support. Therefore, restoration managers should emphasize the need for intervention in damaged environments for conservation purpose. As noted elsewhere, many technological innovations undergo processes of deliberation before being accepted by the public (e.g. in the context of food, see Siegrist and Hartmann, 2020). This could be the case for novel coral restoration initiatives as scientific and technological progress is made; noting that measures of success at this point remain underexplored (Westoby et al., 2020).

Fourth, our research contributes to the current discussion on how aesthetic beauty might relate to public engagement with restoration projects (Buijs, 2009; Lee, 2017). Personal perception of the aesthetic beauty of the restoration site seems to influence perceived benefits of such projects, enhance trust in restoration agencies and evoke emotions (hope and guilt). Compared to perceived need of human intervention, the influences of aesthetic beauty on public acceptance and public support were weaker but still significant. Our findings support the view that human aesthetic appreciation of natural environments inspires their intentions to support conservation and restoration projects (Le et al., 2019; Schuhmann et al., 2013; Biénabe and Hearne, 2006). Thus, giving people access to aesthetically beautiful places, for example through tourism, could be a pathway to engage the public in environmental conservation (Baddeley, 2004; Schuhmann et al., 2019).

Finally, this paper provides empirical evidence to emphasize the necessity of conceptualizing public acceptance and public support as two distinct concepts (Jansson and Rezvani, 2019). The interchangeable use of these two concepts might put public engagement research at risk of being misleading. Due to the attitude-action gap, people often accept an environmental protection policy without being willing to take further supportive/contributing actions (Batel et al., 2013; Devine-Wright and Howes, 2010). By exploring the emotional antecedents of public engagement, the current research offers possible explanations for the gap between two levels of engagement (passive acceptance versus active support) that has been overlooked in the current literature. Positive emotion of hope increases the tendency of acceptance while negative emotion of guilt motivates action to mitigate environmental damage.

Distinguishing public acceptance from public support suggest effective ways for restoration managers to frame their messages for better persuasion outcomes. When restoration practitioners require and seek public acceptance of their projects, our results suggest that messages of hope can be beneficial. There are various ways to stimulate hope as discussed by marketers (MacInnis and De Mello, 2005; MacInnis and Chun, 2007) and biologists alike (McAfee et al., 2019) such as emphasizing conservation outcomes or using aspiration groups. In the next stage of securing ongoing public support for coral restoration projects, an emotional appeal of guilt becomes critical. Guilt can be evoked by emphasizing human responsibility using environmental art (Sommer et al., 2019). People should be reminded that the reef has been continuously damaged by human development activities (i.e., coastal development, pollution, overfishing, and destructive fishing practices)

(Hughes et al., 2013). Our research emphasizes the importance of message framing for engaging the public in environmental projects (Gifford and Comeau, 2011; Whitmarsh and Corner, 2017; Chilvers et al., 2014).

6. Research limitations and future research directions

This research provides valuable insights into psychological constructs (i.e., perceived benefits, emotions and trust) that lead to public engagement in coral restoration programs that utilize coral gardening at small scales. There are limitations that could be addressed in future research. First, some variables such as trust, public acceptance and public support were measured using one single item to reduce questionnaire length and participants' mental fatigue. Using a single item measure does not capture various aspects of the key concept. Hence, future studies could explore multiple items to assess various dimensions of trust, for example trust in various groups of professionals (e.g., scientists, managers, regulators) (Cologna and Siegrist, 2020). Also, only two examples of active support actions were included in the measurement item of public support (donations or volunteer work), other forms of active support to conservation projects should be examined in the future (e.g. involvement in project design or taking coral planting tour).

Second, our research investigates the specific case of the GBR based on a sample of Australian participants. Further testing of the conceptual model in a wider context of large-scale restoration projects using a multi-cultural sample (e.g. including rights-holders, such as Indigenous Traditional Owners of the Great Barrier Reef, and global stakeholders) is needed to improve its generalizability. Third, only place values are examined here, and individual values toward the environment (anthropocentric versus biocentric) are not included due to survey limitations. Other researchers could employ the New Environmental Paradigm Scale (Dunlap et al., 2000) to measure individual values and explore how individual values form public attitudinal and behavioral engagement in future studies (Howell, 2013). Also, the conceptualization of values as, for example, "man in nature", "men with nature", or "man above nature" (Liburd and Becken, 2017) is helpful in understanding how people respond to either systemic changes or particular initiatives. Fourth, only positive messages were included in the current research; thus, future work should test the effects of negative messages on public acceptance/support. Finally, constraints of public engagement in coral restoration projects such as living areas or income should be explored in future studies (Sutton and Tobin, 2011).

CRediT authorship contribution statement

(Jenny) Dung Le: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Writing – original draft, Visualization, Writing – review & editing. **Susanne Becken:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Supervision. **Matt Curnock:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: This work was supported by National Environment Science Program Tropical Water Quality Hub [grant number NESP-Tropical Water Quality Hub project 5.5].

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gloenvcha.2022.102513.

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