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Perceived fairness of conservation decision-making more strongly influenced by absence than presence of procedural equity criteria

Melissa Hampton-Smith[1] ✉, Georgina G. Gurney[1,2,3], Matthew I. Curnock[4], Cristina Ruano-Chamorro[5] & Joshua E. Cinner[1,6]

People's perceptions about how fair conservation decision-making is can play a critical role in whether they support and comply with conservation efforts. Termed procedural equity, fair decision-making is emphasized in policy and practice due to its ethical and instrumental importance. However, limited understanding of what contributes to perceptions of fair decision-making may hamper efforts to foster procedural equity. We analyze quantitative survey data to examine how six criteria of procedural equity (accountability, correctability, voice, decision control, transparency, and trust) are related to perceptions of fairness in decision-making for 1799 residents of Australia's Great Barrier Reef Marine Park. We find that: 1) five out of six procedural equity criteria are related to perceived fairness of decision-making; and 2) the absence of procedural equity criteria has a generally stronger relationship to perceived (un)fairness in decision-making than the presence of procedural equity criteria. Rather than making assumptions about what constitutes fairness, we empirically demonstrate the relative importance of each criterion in promoting perceptions of fairness in conservation decision-making. Comparing the uneven relationship between absent and present criteria to perceived decision-making fairness highlights the strong negative impacts that ignoring procedural equity concerns can have for conservation projects.

Conservation and sustainability science is increasingly concerned with addressing issues of equity[1,2], with mandates for equitable practice evident throughout key global conservation policies[3]. For example, the 2022 Global Biodiversity Framework adopted under the world's most influential conservation agreement, the Convention on Biological Diversity, has references to equity throughout its goals, targets, and implementation advice[2]. Equity is related but distinct to the concepts of fairness and justice, and defined here as giving people the means they need to succeed, while recognizing heterogeneity in those needs[4]. Following Gurney et al.[5], we define fairness as subjective situational judgements. Equity, fairness, and justice are central to a large number of disciplines such as philosophy[6–8], behavioral science[9], economics[10], psychology[11], and environmental justice[12], and thus are conceptualized varyingly. Here, we align with an emerging body of work on equity in conservation that takes an empirical approach to understanding plural perceptions of fairness[13,14]. In the context of conservation, equity is the predominant term used in policy, science, and practice, and is therefore the term we adopt throughout our study[3,15]. In conservation practice, the importance of equitable decision-making cannot be overstated, as it upholds ethical principles[16] while also fostering positive social and ecological outcomes[17]. Stakeholder and rightsholder (hereafter stakeholder) perceptions of fairness in decision-making can shape subjective wellbeing and other important social outcomes of conservation[18], as well as increasing support for conservation interventions[19]. The positive effect of perceived fair decision-making on governance legitimacy[20] may be a mechanism through which equity can promote cooperation with management and compliance, and thus ecological success[21].

[1]College of Arts, Society and Education, James Cook University, Townsville, QLD, Australia. [2]Centre for Marine Socioecology, Institute of Marine Science, University of Tasmania, Hobart, TAS, Australia. [3]School of Geography, Planning, and Spatial Sciences, University of Tasmania, Hobart, TAS, Australia. [4]CSIRO Environment, ATSIP Building 145, James Cook University, Townsville, QLD, Australia. [5]Lancaster Environmental Centre, Lancaster University, Lancaster, UK. [6]Thriving Oceans Research Hub, School of Geosciences, University of Sydney, Camperdown, NSW, Australia. ✉e-mail: melissa.hamptonsmith@my.jcu.edu.au

Although there has been an increasing attention to equity in the conservation literature, distributional equity—the distribution of benefits and costs (e.g., see refs. 22,23)—continues to receive more attention than procedural equity, which addresses how decisions are made and by whom[24]. Paucity in understanding the role of procedural equity in conservation is partly due to a focus on participation in decision-making, rather than on the full breadth of procedural equity's multiple elements or criteria[24]. In research that does examine criteria of decision-making beyond participation, the emphasis remains on stakeholder involvement (e.g., see refs. 25,26). Friedman et al.[27] found that procedural equity is frequently operationalized as simply involvement in decision-making. However, it is increasingly recognized that procedural equity is composed of multiple criteria[28,29] (Table 1). Based upon seminal justice psychology studies (e.g., see ref.[30]) this view has identified diverse criteria – such as an authority's trustworthiness[31], transparency[32], and correctability[33] – that as a whole comprise procedural equity. However, the relative role of procedural equity criteria in contributing to perceived fair decision-making in conservation contexts is unclear. Moreover, of the existing literature that has examined various procedural equity criteria, most have focused on community conservation interventions with localized governance structures (e.g., see refs. 1,34), leaving conservationists working in large-scale interventions with little guidance as to how to best foster procedural equity[35]. For example, the direct accessibility of management to stakeholders, and thus how management is made accountable or how decisions may be appealed, may differ substantially between small- and large-scale conservation interventions.

When we explicitly examine the literature for how stakeholders perceive the fairness of conservation decision-making processes, we find few empirical studies (but see ref.[36]). This scarcity can be attributed to the underpinning of conservation equity in the environmental and social justice literatures[37], in which a focus on distribution and a normative standpoint prevailed[12]. Subsequent critiques to these views both broadened the lens of justice to include recognition, procedure and redistribution[38,39], and introduced plurality and contextuality[40]. Building on these developments, an empirical approach has begun to emerge in conservation, that embraces perceptions of fairness[13]. Stakeholder perceptions of fairness in a given situation are shaped by two components: their lived experiences with respect to that situation[11] and what they consider constitutes fairness[5], which in turn is influenced by their sociocultural context[41]. Failing to take such perceptions into account risks implementing decision-making processes that may be perceived as unfair, undermining public support, and jeopardizing conservation success. For example, non-compliance with agriculture run-off regulations in the Great Barrier Reef Marine Park catchment areas has been identified as a key area of concern[42]. Given that key criticisms of the regulation development process included a lack of trust, transparency, and stakeholder input, attention to procedural equity may be a means through

Table 1 | Six key procedural equity criteria, or elements of fair decision-making, recognized in the context of conservation[24]

Procedural equity criteria	Description	Relevance to conservation	Illustrative survey items
Accountability	Accountability means that decision-makers are made responsible for their actions and inactions. Fulfilling obligations to others is a critical part of social interactions, without which adverse impacts on relationships can occur[81].	When stakeholders perceive a lack of accountability, this can result in dissatisfaction, a loss of support for conservation, and reduced rule compliance[1].	"The leader accepts responsibility for his/her actions within the organisation"[82] "When issues arise related to management you know with whom and how to communicate?"[72]
Correctability	Correctability means that decisions may be reversed or corrected[24]. Having the ability to contest outcomes enhances procedural justice[33] because it provides individuals with recourse in the case of system or decision-maker error.	Formal complaint mechanisms are recommended to improve the perceived fairness of conservation law enforcement[83]. Conversely, the lack of right to appeal can negatively impact on stakeholder wellbeing in conservation[84].	"Do you know of any agency or organization to which you could complain about unfair treatment?"[51] "Decisions made by the management committee can be corrected and their impact evaluated"[46]
Voice	Voice means that stakeholder opinions, priorities and concerns are taken into account by decision-makers[30]. Voice contributes to perceptions of fairness in decision-making, even in the absence of outcome favourability[85].	Often referred to as participation, having a voice is an important component of equitable conservation[45]. Having a voice can promote local support of conservation, whereas a lack of voice has resulted in stakeholders actively undermining conservation initiatives[18].	"To what extent do [authorities]: 'Give people a chance to express their views before making decisions' and 'Take account of people's needs and concerns'"[86] "The process allowed ample opportunity for public input"[87]
Decision control	Decision control means the ability to influence decisions[30,88]. Decision control is often linked to voice under the terms 'participation' or 'representation', although voice and decision control are distinct[51].	A lack of real influence on decision-making can promote disillusionment with management and decrease the legitimacy of conservation authorities, particularly when promises of participatory governance are not fulfilled[57].	"Public comments were seriously considered"[89] "How much influence did you have over the decisions made by authorities?"[51]
Transparency	Transparency means that the public can see what is going on and how decisions are made[88]. Transparency is a requirement for free, prior, and informed consent[28].	A perceived lack of transparency in conservation decision-making can lead to perceptions of unfairness in decision-making[90], as well as distrust and reduced support for initiatives[91].	"How often do [authorities] explain their decisions and actions in ways that people can understand?"[92] "Is information about how decisions are made and the reasons for management decisions readily available?"[72]
Trust	Trust is the positive belief in the reliability, ability, or strength of another entity or person, and is related to but distinct from trustworthiness, the belief that a person or entity is deserving of trust[64,74]. Here, we acknowledge this distinction but use the term trust throughout to refer to an authority's trustworthiness.	An authority's trustworthiness, which has been measured in conservation settings by trust in the information they provide[93], has been shown to be a critical part of eliciting compliance in natural resource management[94]. Conversely, mistrust can foster perceptions of unfair decision-making as seen in Mexican forestry conservation settings[84].	The following items refer to the aspect of trust characterised as 'willingness to depend': "When an important issue arises, I would feel comfortable depending on the information provided by [entity]"[95] "When my supervisor tells me something, my level of confidence that can rely on what they tell me is …"[96]

Illustrative survey items included from studies that empirically examine procedural equity in the justice psychology and conservation literatures. Most survey items are rated using Likert-style scales. Context specific terms removed from illustrative survey items to improve readability.

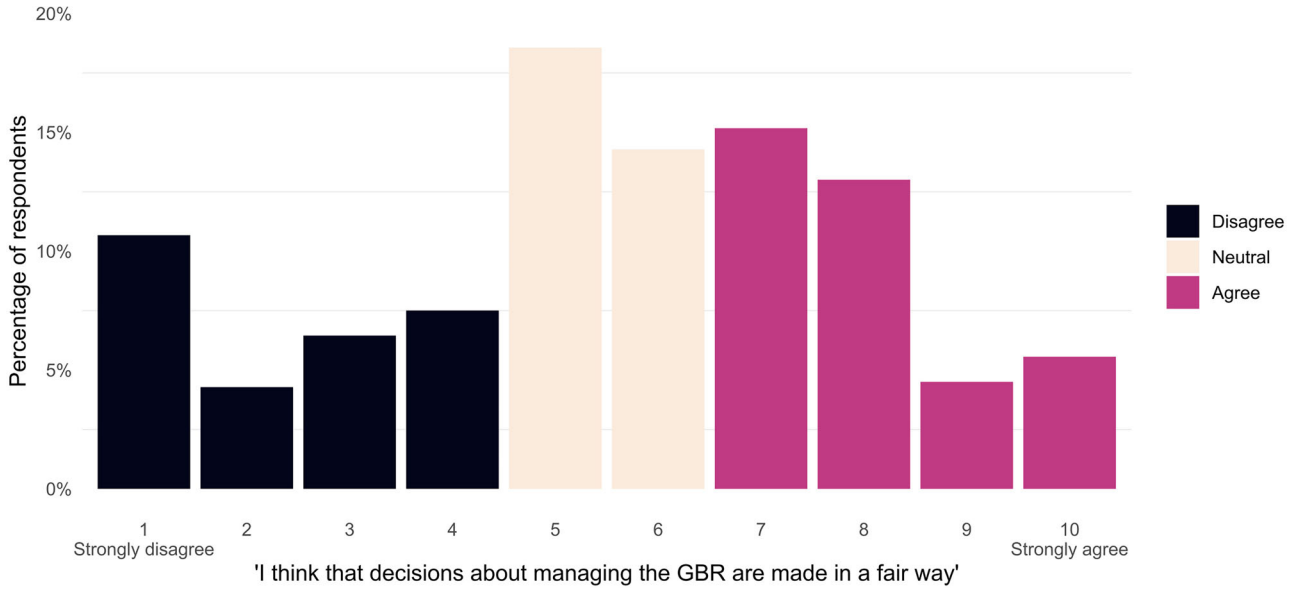

Fig. 1 | Distribution of perceptions of fairness in decision-making held by stakeholders ($n = 1799$) in the Great Barrier Reef Marine Park. Colours show the collapsed categories used in the ordinal regression analysis of the relationship between procedural equity criteria and perceptions of fairness in decision-making; black shows the category 'disagree' (i.e., unfair), cream shows the category 'neutral', and pink shows the category 'agree' (i.e., fair).

which greater compliance can be realized by increasing the legitimacy of management and encouraging public backing[21].

Here, we address the limited evidence base for both perceptions of fairness in conservation and procedural equity. We assess how procedural equity criteria are related to perceptions of fairness in decision-making in coral reef conservation for 1799 stakeholders living adjacent to Australia's iconic Great Barrier Reef. As a World Heritage Area, the Great Barrier Reef represents both a critical area of biodiversity under threat[43], and a large-scale conservation intervention governed by a complex polycentric system[44]. Given the central role of fair decision-making to ethical conservation[45] and the role that perceived fair decision-making plays in conservation outcomes[17], we (1) assess variation in perceptions of fairness in decision-making; and (2) examine how procedural equity criteria are related to perceptions of fairness in decision-making.

Results

Variation in perceptions of fairness in decision-making

We surveyed 1799 Great Barrier Reef stakeholders and found that their perceptions of fairness in decision-making varied considerably (Fig. 1). Using a collapsed 3-point scale from the original 10-point scale, more people agreed ($n = 520$, 29%) rather than disagreed ($n = 688$, 38%) that decision-making was fair, with 33% neither agreeing nor disagreeing ($n = 591$). However, approximately twice as many stakeholders disagreed strongly that decision-making was fair ($n = 192$, 11%) than those who strongly agreed ($n = 100$, 6%) (see Fig. S1 for the distribution of the perceptions held by stakeholders about our six procedural equity criteria).

Procedural equity criteria and perceptions of fairness in decision-making

Of the 1799 residents surveyed, 1266 answered all seven items related to procedural equity and were included in our regression analysis. We assessed whether perceptions of fairness in decision-making were related to the perceived presence or absence of six procedural equity criteria. Our Bayesian ordinal regression found strong evidence (i.e., where a predictor variable's 95% credible interval—using the mode and highest density interval—does not intersect zero) for relationships between the three criteria of trust, correctability, and voice and perceptions of fairness in decision-making. We found that for these three criteria, a shift from the 'neutral' reference category to both perceived absence and presence was related to perceptions of fairness in decision-making (Fig. 2) (see Table S3 for the levels of all variables). There was strong evidence for a relationship between the perceived presence of decision control and perceptions of fairness in decision-making, but not the perceived absence of decision control. For transparency, there was strong evidence only for perceived absence. We found little evidence for a relationship between accountability and perceptions of fairness in decision-making (Fig. 2) (see Table S1 for estimates and standard errors of regression coefficients).

In sum, we found asymmetry in how the perceived absence or presence of equity criteria were related to people's perceptions of fairness. A perceived absence of procedural equity criteria had between one-and-a-half to two times stronger relationship to perceptions of fairness than the perceived presence of procedural equity criteria, except for decision control. Considering the procedural equity criteria perceived as absent, trust had the strongest relationship with fairness in decision-making. From the procedural equity criteria perceived as present, correctability had the strongest relationship. Trust and correctability were followed closely by voice in magnitude of effect (see Fig. S2 for conditional effects of each predictor variable).

Discussion

An increasing focus on equity in conservation policy[3] reflects its essential role in ethical practice and acknowledges that perceived fairness can promote positive social and ecological outcomes[17,27]. Effectively advancing equitable conservation requires an empirically sound and holistic understanding of what shapes perceptions of fair decision-making. Our examination of how procedural equity criteria relate to perceptions of fairness in decision-making has two main findings: (1) not all procedural equity criteria affect perceptions of fairness in decision-making equally; and (2) the absence of procedural equity criteria has a generally stronger relationship to perceptions of (un)fairness in decision-making than the presence of procedural equity criteria.

First, we found that equity criteria were not equally related to perceptions of fairness in decision-making. In contrast to studies in which the presence of criteria is used as an indicator to determine whether decision-making is fair[46], our study empirically determined the contribution of each criterion to perceptions of fair decision-making. Of those criteria perceived as absent, trust was the most important, followed closely by correctability and voice. Our findings showed that trust in information provided by the

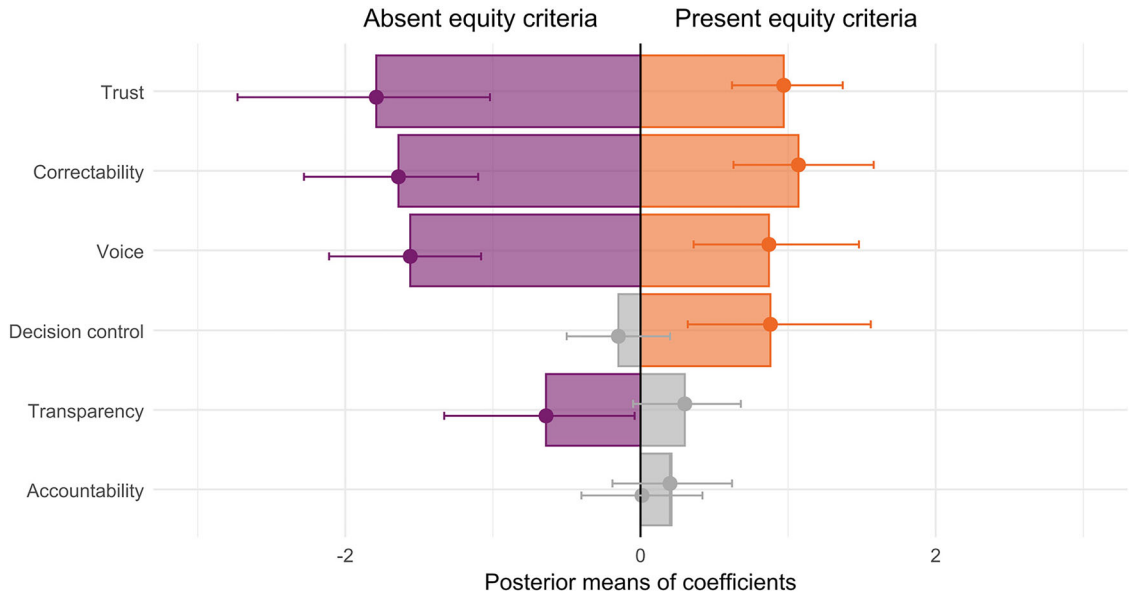

Fig. 2 | The influence of procedural equity criteria on perceptions of fairness in conservation decision-making. Relationships between the perceived absence and presence of procedural equity criteria (i.e., accountability, correctability, voice, decision control, transparency, and trust) and stakeholders' perceptions of fairness in decision-making regarding the Great Barrier Reef Marine Park. Relationships are displayed as coefficient estimates from Bayesian ordinal regression models, with error bars showing 95% credible intervals (using the mode and highest density interval). Grey indicates an intersection of the credible interval with the zero line and little evidence for a relationship between the coefficient and perceptions of fairness in decision-making. Purple indicates strong evidence for a negative relationship, and orange indicates strong evidence for a positive relationship. Note that the reference category for all coefficients is 'neutral'.

Reef Authority was particularly important in predicting perceptions of fairness in decision-making, which coincides with foundational psychology literature on the role of trust in authorities and procedural justice[31,47]. This is concerning in light of the observed decline in trust in the Reef Authority, state government, and scientists[48], a decline which may undermine public support for conservation[49,50]. Correctability proved nearly as important as trust. This was surprising, because although correctability is theorized to be an important precursor for perceptions of procedural fairness[33], empirical investigations into its relative importance have shown varying results[51]. To our knowledge, this is the first study to quantitatively demonstrate the importance of correctability in a conservation setting. As evidenced by well-established decision review and appeal processes, as well as a wealth of official documents and independent audits addressing this topic[52], correctability in the Great Barrier Reef Marine Park is a priority. We suggest that the ubiquitousness of these review processes has led to an expectation of correctability in decision-making among stakeholders, which could explain why a perceived absence of correctability played such a critical role in shaping perceptions of fairness in decision-making.

The third-most important predictor of perceptions of fairness in decision-making was voice. In the Great Barrier Reef Marine Park, promoting stakeholder voices has been identified as a priority[53]. Participatory processes in the Great Barrier Reef display strengths (e.g., high priority on community involvement[54]) as well as areas for improvement (e.g., ambiguous role of community input in final decision-making[55]). We want to emphasize that the current focus in the Great Barrier Reef Marine Park and global conservation more broadly on promoting stakeholder voices is vital. Greater stakeholder engagement and involvement in deliberative processes will improve the equitability of interventions and may therefore increase public acceptance and ease of implementation. However, restricting the lens of equitable governance to promoting stakeholder voices limits the potential to improve perceptions of fairness in decision-making and thus, potentially further social and ecological benefits. For example, the effect of voice on stakeholder cooperation is increased when trust, a key procedural equity criterion, is high[56]. We therefore recommend broadening the lens of governance in conservation practice to ensure a diverse range of procedural equity criteria are incorporated. This will bring conservation science in line with justice psychology literature, which has considerably advanced understanding of the relative role of different procedural equity criteria in promoting perceptions of fair decision-making[20].

Following the strong relationships found between trust, correctability, and voice, and perceptions of fairness in decision-making, we found that the presence of individual decision control had a strong positive relationship with perceptions of fairness in decision-making, while a lack thereof proved unimportant. Participatory governance in marine conservation has gained favor in Australian marine conservation as a solution to increasingly complex management issues, in which influence on actual decision-making is critical to legitimize decision-making processes[57]. The ambitious rezoning consultation in 2002–2003 undertaken in the Great Barrier Reef Marine Park demonstrated real receptivity and adaptability in response to community feedback, with positive effects on ecological goals[19]. However, stakeholders have expressed uncertainty about the true impact of their feedback on outcomes in the Great Barrier Reef[55], despite opportunities for community involvement in regional Plans of Management, permit permissions, and rezoning. The Reef Authority is located centrally in the reef catchment regions and has several regional offices. Nonetheless, these regional offices are not contactable by telephone, and some do not have physical addresses. We postulate that due to the relative infrequency of communication between managers and individual stakeholders[44], evidence of direct decision control is rare for residents of the Great Barrier Reef catchment regions, and indeed, perhaps not expected. This may explain why the perceived absence of decision control does not predict perceptions of fairness in decision-making as with other criteria. The separation between the Reef Authority and stakeholders during day-to-day operations may also explain why accountability—operationalized here as the individual accessibility of management to stakeholders—did not shape stakeholder perceptions of fair decision-making. We do not suggest that accountability in conservation is unimportant, nor that the Reef Authority does not fulfil its legal obligations to be accountable. Rather, we argue that the size of the Great Barrier Reef Marine Park may necessarily diffuse individual responsibility and preclude managers being made directly responsible for their actions to stakeholders. Our findings highlight how efforts to further procedural equity in large-scale conservation interventions should be approached differently

than in oft-studied small-scale interventions (e.g., see ref.[1]). Because decision control and direct management accessibility are resource-intensive to implement in large-scale conservation with regional level governance, focusing on promoting trust in combination with stakeholder voices may be a mechanism to scale up equity in conservation.

Our second key finding was that overall, absence of procedural equity criteria was more strongly associated with perceptions of fairness in decision-making than their presence. This implies that procedural equity effects are more likely to emerge in the absence rather than the presence of procedural equity criteria. For example, the negative effect of being denied a voice is greater in size than the positive effect of receiving a platform for one's voice. Our finding echoes the well-established negativity bias, in which individuals give greater weight to negative entities than positive ones across a broad range of domains, including social judgements[58] and decision-making[59], and aligns with previous research on procedural justice and negativity biases[60]. These biases regarding procedural equity have ramifications for management because they highlight how ignoring procedural equity may have strong adverse impacts for conservation projects. The reality faced by conservation managers is that stakeholders are more likely to perceive unfairness than fairness, be more sensitive to threats than benefits, and weigh governance failures more heavily than successes. To address this apparent negativity bias, we suggest two strategies. First, management should focus on communicating a balanced presentation of decisions, including outcomes that result in community benefits as well as those that may be perceived as deleterious, to offset negative domination and build trust[61,62]. Second, a strong commitment to visibility and transparency at every level of decision-making may assist in reducing misconceptions. Transparency is of especial importance because contamination through corruption and dishonesty is highly influential in shaping public perceptions[58], even in minor cases. In sum, actively addressing the inherent biases in stakeholder impressions may assist to promote perceptions of fair decision-making when warranted, and thus further conservation goals.

As the first study to empirically examine how procedural equity criteria are related to fair decision-making in conservation on this scale, our findings suggest several avenues for future research. First, future research should examine stakeholder notions of procedural equity—what they believe procedures ought to entail—by examining their preferences for different procedural equity criteria. The fairness perceptions we examined were comprised of people's lived experiences in this conservation context and their preferences for procedural equity criteria. Our study design did not allow us to separate the influence of context and preferences on perceptions of fairness, thus necessitating targeted attention to procedural equity criteria preferences. This will clarify not how stakeholders perceive fairness in a given context (such as the Great Barrier Reef Marine Park), but what they consider to be normative principles of fair decision-making. While some studies have examined preferences for different distributional equity criteria[5,22,23], thus far none have explicitly focused on procedural equity criteria (but see refs.[1,63]). Practically, understanding what constitutes fair decision-making for stakeholders may assist in addressing perceived inequitable disparities in conservation by allowing management to better align decision-making processes with stakeholder preferences. Second, because equity is plural and context-dependent[5,64], criteria that are important in shaping perceived (un)fairness in the Great Barrier Reef may not be applicable elsewhere, or may manifest in varying ways. The Great Barrier Reef Marine Park represents a large-scale conservation intervention with legitimate governance and well-established procedures[44]. Conservation interventions vary greatly in their governance and management structures[45], and this study therefore bears repeating in other governance systems and sociocultural settings. Examples of criteria that may be impacted by context include voice, decision control, and accountability. Cultural context can influence voice and decision control by raising cultural barriers to participation for certain groups, but also opening non-direct avenues for participation[36]. Accountability—when conceptualized as the direct accessibility of management to stakeholders—may be affected by the scale of the conservation intervention. Thus, we suggest further examination on how to foster important criteria in a context-appropriate manner, including the development of indicators specific to small- and large-scale conservation. Similarly, taking a socially differentiated approach may assist in understanding if and why perceptions of fairness vary among individuals (e.g., see refs. 5,36). Third, our study examined fair decision-making in conservation on a large but necessarily coarse scale by using single-item indicators for our seven covariates. Future studies could build on our findings by developing multi-item scales for these complex constructs of procedural equity criteria, which should improve robustness and interpretability.

In line with the "30 × 30" target under the influential Conservation for Biological Diversity Global Biodiversity Framework, countries across the globe are set to rapidly expand area-based conservation to reach 30% coverage by 2030. Moreover, expanding conservation interventions can lead to increases in the complexity of governance systems and the number and diversity of stakeholders that are affected, and therefore, enhanced likelihood of inequities[2]. Thus, the need for greater attention to governance processes to ensure that conservation is perceived as fair has never been greater. Our study reveals that overall, trust, correctability and voice play the greatest role in the perceived fairness of decision-making relating to the governance of the Great Barrier Reef Marine Park. Further, for most criteria, absence rather than presence of procedural equity criteria has the largest influence on perceived decision-making fairness. We hope that our findings develop a more nuanced and robust understanding of how procedural equity functions in conservation settings, allowing decision-makers to target issues where the greatest potential to effect positive change lies. This ultimately can enable conservationists to more effectively address the pressing environmental problems that confront humankind, for the benefit of both people and nature.

Methods

Study site

Designated in 1975, the Great Barrier Reef Marine Park covers approximately 348000 km^2 along Australia's northeastern coastline and encompasses the largest coral reef system in the world. The Great Barrier Reef was inscribed as a World Heritage Area in 1981 due to its exceptional cultural and natural value. From the date of its protection as a Marine Park in 1975, the Great Barrier Reef has been managed as a multiple-use Marine Protected Area, with a zoning plan enabling commercial and recreational fishing, tourism, and other commercial and recreational uses[65]. Approximately 1.2 million people live in the six Great Barrier Reef catchment areas adjoining the coastline, among them the Traditional Aboriginal and Torres Strait Island Owners of the area[66]. The Great Barrier Reef Marine Park is governed under a polycentric system by a series of federal, state, and local agencies, which interact but are formally independent from one another[44]. The Reef Authority, established via the 1975 Great Barrier Reef Marine Park Act, is the federal statutory authority charged with the protection and management of the Marine Park. In 2016, mass bleaching and emerging climate change threats prompted a regime shift towards a more active conservation role[67], although a diversity of governance perspectives among governance actors remains[68]. The most recent framework for managing and protecting the Great Barrier Reef is the Reef 2050 Long-term Sustainability Plan 2021-25 which provides objectives and responsibilities for local, state, and federal government and highlights stakeholder involvement in deliberative processes[53]. Many decisions undertaken by management require formal public consultation, such as the extensive consultation conducted before rezoning in 2002–2003[69]. Other opportunities for public involvement include the development of Plans of Management for catchment regions, the permit permission process, and community engagement in the Reef Restoration and Adaptation Program[70] (see Table S2 for specific examples of how procedural equity criteria manifest in the Great Barrier Reef Marine Park). Despite these opportunities, 35% of Great Barrier Reef catchment residents do not feel satisfied with management and decision-making processes[48]. With its complex governance arrangements and diverse stakeholder groups, the Great Barrier Reef Marine Park thus represents an ideal opportunity to explore perceptions of fairness in decision-making and procedural equity in a conservation context.

Sampling

The online survey as part of the Social and Economic Long-term Monitoring Program (SELTMP)[71] was conducted in 2023 and recruited 2317 respondents. Respondents were recruited either as an online panel participant through a market research provider ($n = 1510$), or through postcode-targeted advertising on social media ($n = 807$). Of these 2317 respondents, 1799 responded to the survey item "I think that decisions about managing the GBR are made in a fair way" and were included in our assessment of the variations of perceptions of fairness in decision-making, and 1266 responded to all seven procedural equity items and were included in our regression analysis (we excluded 'don't know/I am unsure' responses). Parallel recruitment via social media advertising was used to supplement the number of participants, and targeted advertisements with a link to the survey were used in preference over 'organic' sharing of the survey link, to minimize the risk of attracting respondents from outside the catchment regions and online 'bots'. While efforts were made to obtain a geographically and demographically representative sample of the region's residents, the final sample included slightly more older residents and females than the general population[48]. For further details on the demographics of the sample and summary statistics for the results, please refer to Hobman et al.[48]. The sampling protocol was reviewed and approved by the Commonwealth Scientific and Industrial Research Organization (CSIRO) Social Science Human Research Ethics Committee. All respondents gave informed consent to participate in the voluntary survey.

Survey instrument

We elicited perceptions of fairness in decision-making in the Great Barrier Reef Marine Park as well as perceptions of six procedural equity criteria: accountability, correctability, voice, decision control, transparency, and trust (Table 2). These criteria were drawn from a recent framework for procedural equity in the context of conservation[24] which was based on a review of three key literatures – environmental justice, psychology of justice, and participatory conservation. These criteria are consistently included in empirical evaluations of procedural equity in conservation (e.g., see ref.[72]), as well as equity frameworks[29,73] that have been applied across the globe. Respondents rated each item using a 10-point Likert-type scale (i.e., 1 = 'strongly disagree' to 10 = 'strongly agree').

We developed our survey items as part of the broad Social and Economic Long-Term Monitoring Program (SELTMP) in the Great Barrier Reef Marine Park, which collects data for monitoring a number of social, cultural, and economic themes relevant to management of the Marine Park (for further information refer to https://research.csiro.au/seltmp/ and Hobman et al.[48]). For the procedural equity criteria items, some survey items were developed specifically to assess procedural equity, whereas others, such as the indicator for trust, were developed to be used for multiple purposes. We drew upon the justice psychology and conservation literatures to develop single-item indicators for our seven variables (Table 2). In the case of trust, which can be measured across multiple domains (e.g., benevolence, integrity, and ability[74]), for our study (and for SELTMP's monitoring purposes) a single metric representing trust in information about the Reef from the Reef Authority was selected for long-term monitoring[48]. In our study, we took an empirical approach to determine the relative contribution of these criteria to perceptions of fairness in decision-making and thus included a single indicator as our response variable. This is in line with literature in which perceptions of fairness in decision-making are commonly viewed as summary judgements reflecting perceptions of individual criteria[75]. The choice to exclude some procedural equity criteria (e.g., neutrality and interpersonal treatment) and to use single item indicators reflects the constraints posed by data collection as part of a broader monitoring program. The single item indicators are a possible source of endogeneity in our analysis (where a predictor variable is correlated with the error term, i.e., the variable is influenced by factors not included in the model). We juxtapose these constraints against the large sample size and geographic spread made possible by such large-scale monitoring programs, which allow for greater statistical robustness and broader inference. We further highlight research demonstrating that in some cases, single-item indicators have comparable reliability and validity to multi-item scales when measuring perceptions of justice[76].

Analysis

To assess how perceptions of procedural equity criteria were related to fairness in decision-making, we used hierarchical Bayesian ordinal regression models with a probit link. We used the Hamiltonian Monte Carlo algorithm implemented in Stan through the brms package in R[77] with 5000 iterations, 1000 burn in, four chains, and weakly informative priors (i.e., the posterior distribution was informed only by our data). We set location (operationalized as postcode) as a random factor to account for non-independence of data arising from repeated sampling within each postcode; this models the dependency structure among respondents living in the same location[78]. We checked the predictor variables for (multi) collinearity by calculation of pairwise polychoric correlation coefficients (Table S4). Using variables with the original 10-point Likert-type scales resulted in non-convergence due to low amounts of data at some levels of the scale. We therefore created models with 5-point scales (i.e., 1-2 = 'strongly disagree', 3-4 = 'disagree', 5-6 = 'neutral', 7-8 = 'agree', 9-10 = 'strongly agree') and 3-point scales (i.e., 1-4 = 'disagree', 5-6 = 'neutral', 7-10 = 'agree') for response and predictor variables. The results between the two models were similar, in which strong evidence was found for a relationship between trust, correctability, and voice and perceived fairness in decision-making, little evidence for accountability, and varying evidence for transparency and decision control at different levels of the scale. We define 'strong evidence' as where the 95% credible interval (using the mode and highest density interval) of a predictor variable does not intersect zero and use the term 'importance' to refer to the practical implications of this evidence. Given that

Table 2 | Descriptions of response and predictor variables used to assess the relative importance of six key procedural equity criteria[24] in predicting perceptions of fairness in decision-making held by stakeholders in the Great Barrier Reef Marine Park

Variable	Survey item	Literature
Fair decision-making	"I think that decisions about managing the Great Barrier Reef are made in a fair way"	97
Accountability	"I know who to contact if I am concerned about management actions in the Great Barrier Reef"	28,29
Correctability	"Decisions made by Great Barrier Reef managers can be reviewed and corrected if required"	46,73
Voice	"I am satisfied that there are enough opportunities available to me to have a say in how the Great Barrier Reef is managed"	98
Decision control	"I feel I personally have some influence over how the Great Barrier Reef is managed"	98
Transparency	"I can access information about Great Barrier Reef management and planning"	28,29
Trust	"Considering the information you receive about the Great Barrier Reef, how much do you trust the information from the following groups? •The Great Barrier Reef Marine Park Authority" (among multiple options listed)	99

Survey items were adapted from the literature cited here and are taken from the 2023 Social and Economic Long-Term Monitoring Program (SELTMP)[71]. See Table S3 in Supporting Information for operationalization of the survey items.

our aim was not only to expand the theoretical understanding of procedural equity in conservation, but also provide practical guidance to conservation managers, we decided to use models with 3-point scales to improve the accessibility and actionability of our results (Table S3). Following Bürkner and Vuorre[77], we compared a series of ordinal regression models including cumulative, adjacent-category, and cumulative with unequal variance. Our cumulative ordinal model assumes that the observed ordinal response variable, a *rating* of the perceived fairness of decision-making in the Great Barrier Reef Marine Park, is a categorisation of a latent continuous variable, i.e., the opinions held by catchment residents which lie upon a continuous scale. By including adjacent-category ordinal models in our comparison, we determined whether category-specific effects were important, i.e., whether our predictor variables' effect on the response variable varied according to the perceived absence or presence of procedural equity criteria. By including cumulative ordinal models with unequal variance in our comparison, we determined whether the assumption of equal variance across all levels of the response variable was valid. We compared these three types of models using (1) ordinal predictors in which 'disagree' was the reference category; and (2) categorial predictors in which 'neutral' was the reference category. Predictor variables were naturally ordered from 'disagree' to 'neutral' to 'agree'. However, understanding the effects of a shift in the predictor variables from a 'neutral' reference category to either 'disagree' or 'agree' was useful and applicable to management recommendations, and we therefore included these two types of predictor variables in our comparison. To assess model fit, we used approximate leave-one-out cross validation[79] (Table S5). We selected the cumulative ordinal model with unequal variance using categorical predictors due to its goodness-of-fit, parsimony, and ease of interpretation. For our chosen model, all chains converged (r-hat≥1), all chains achieved high resolution (ESS ≥ 1000), and post-posterior checks demonstrated that our model usefully mimicked the data. All analyses were performed using R Statistical Software v4.2.2[80].

Data availability

Data analyzed for this study are available from the Commonwealth Scientific and Industrial Research Organisation under "Social and Economic Long Term Monitoring Program (SELTMP) for the Great Barrier Reef data, 2023. v1. ", https://doi.org/10.25919/sbrf-z111.

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Author contributions

M.H-S.: Conceptualization, Methodology, Validation, Formal Analysis, Visualization, Writing – Original Draft, Review & Editing. G.G.G.: Conceptualization, Methodology, Supervision, Writing – Review & Editing. M.I.C.: Funding Acquisition, Investigation, Writing – Review & Editing. C.R-C.: Methodology, Writing – Review & Editing. J.E.C.: Conceptualization, Supervision, Writing – Review & Editing.

Competing interests

The authors declare no competing interests.

Additional information

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Correspondence and requests for materials should be addressed to Melissa Hampton-Smith.