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Abstract: The Reef 2050 Long-Term Sustainability Plan (Reef 2050 Plan) aims to protect and manage the resilience of Australia's Great Barrier Reef (the Reef). It explicitly recognises that strengthening governance is key to achieving its targeted outcomes. To date, a lack of evaluation of the complex system of polices, programs, plans and other arrangements under the Plan has hindered its adaptive governance. This paper presents a first benchmark of the health of the Reef 2050 Plan governance system. A novel framework was built to do this. It was built and populated through multiple lines of evidence, including global theory and evaluation practice, case studies, and primary data from interviews and workshops with Traditional Owners, experts across government, industry, non-government organisations and governance systems experts. It found the health of governance system to be emergent to maturing yet strong by global standards. Strengths include robust global engagement, the integrative nature of the Reef 2050 Plan, crisis response systems and Marine Park management. Weaknesses include the need for: (i) power sharing with Traditional Owners; (ii) rebuilding governmental trust with the farming and fishing sectors; (iii) more contemporary spatial planning for Reef resilience; and (iv) greater subsidiarity to deliver government programs. Regular benchmarking of Reef governance arrangements would mature the system toward better outcomes.

Keywords: Great Barrier Reef; governance; governance system; Reef 2050 Plan; framework; health; management; monitoring; knowledge

1. Introduction

Renowned globally as one of the most precious ecosystems on the planet, the Great Barrier Reef contributes to the wellbeing of local, regional, state, national and international communities and plays a vital role in the lives of its Traditional Owners and coastal communities. The current trajectory of coral reefs, including the Great Barrier Reef, is one of intensifying loss. This is both an ecological and human rights issue and requires deep and systemic consideration of governance [1]. Outcomes for ecological, social, and economic health in any environmental context are mediated by human actions, and most of these occur within wider governance systems that drive individual and collective efforts [2]. Such spatially-based 'governance systems' comprise a wide range of both collective, institutional and individual arrangements that set the context for who makes decisions and how decisions are made and applied [3]. Achieving desired ecological and social outcomes in complex 'governance ecosystems' [4] requires coordinated action across multiple layers of intersecting institutions, policies, plans and cultures [5,6] and collective action by institutional and non-institutional actors in intersecting spheres of policy and normative action [7].

The health (or functionality) of any governance system is determined by the combined decision making and implementation delivery-related activities of different institutions and actors. This

includes state and polity entities, with roles and accountabilities for lawmaking, public policy, and delivery. It also includes non-institutional actors such as political parties, corporations, business organisations, public interest groups, non-governmental organisations (NGOs), the mass media, and individual citizens. All such actors apply diverse resources and strategies to influence public policy outcomes [8,9]. A governance system can be considered healthy when it provides the foundations, across different scales, for achieving shared societal goals, mediated across desired environmental, cultural, social, and economic outcomes, that are associated with a specific spatial context.

Frameworks for analysing 'healthy or good governance systems' have emerged to measure whether public decision making and resources are achieving societal goals [10]. Measuring the 'good' of a governance system can identify areas for improvement against core evaluative principles such as transparency, accountability, equity, and effectiveness [11]. The International Union for Conservation of Nature's (IUCN), for example, applies principles of legitimacy and voice, subsidiarity, fairness, and transparency in protected areas across four typologies of governance (e.g. government, shared, private, Indigenous Peoples and local communities [12]. The United Nations Development Programme [13], The World Bank and The Council of Europe [14–16] have apply similar governance principles.

These global evaluative frameworks, however, often struggle to support adaptive governance in systems characterised by overlapping institutions, conflicting regulations, and limited coherence across scales [17]. Top-down evaluative frameworks make it difficult to embed the principles of inclusive participation and responsiveness when adaptive governance demands greater recognition of the importance of power differentials within complex systems [18,19]. A lack of consensus on how to define and assess 'good governance' at the global level further constrains their practical application in guiding collective action toward locally tailored and planned outcomes [20]. Overcoming these limitations requires more systemic, context-sensitive, and adaptive approaches to governance analysis [21].

To achieve better, more integrated societal outcomes from complex governance systems, more adaptive approaches to governance analysis need to be able to focus on positively guiding collective action for system improvement. Such approaches encompass dynamic processes that can enable institutional flexibility, learning, and transformation. This is the case as key elements of adaptive governance systems include improved power sharing at all levels, from local to national and between all actors, and multilevel collaboration. Such effort is needed to enhance community resilience and reduce capacity gaps [22,23]. To support adaptive governance in and for complex spatially-based governance systems, new frameworks are needed that can combine the application of theoretically informed evaluative criteria about good governance with more deliberative approaches to determining system strengths, weaknesses and opportunities to systemic improvement.

A healthy governance system must be coherent to ensure that wider societal priorities are well aligned across multiple institutional arrangements, enabling many diverse actors to cooperate toward common goals [24]. Systems must contain sufficient capacity, at institutional and actor levels, to address defined problems effectively and to avoid failure in the execution of decisions [25,26]. To avoid effort duplication and maximise efficiency, policies and delivery arrangements across these institutional arrangements must be well connected, integrated and coordinated [25,27]. Finally, diverse forms of knowledge (Indigenous, scientific, local expertise, and policy knowledge) must be well-infused within policy development, planning and the shaping of delivery action [28–30].

Australia's Great Barrier Reef is a prominent global example of a complex governance system within a defined spatial context. The governance system associated with the Reef aims to uplift targeted ecological, social, and economic outcomes; particularly protecting and enhancing its globally important Outstanding Universal Value (OUV). Like other complex governance contexts, the Reef is impacted by intersecting and often overlapping policies, processes, agreements, entities, and other mechanisms that influence decision-making and action at multiple scales. Polycentric relationships and arrangements between various levels of government, community, and industry effort are typical (Morrison, 2017). Nested decision making systems influence behaviour and outcomes of diverse

institutions and actors [31]. Consequently, the outcomes are diverse, contributing to the achievement of globally important outcomes (such as World Heritage protection) to outcomes which are deeply significant to local users of the Reef [32]. The Reef 2050 Plan establishes an overarching, integrated and evolving framework for guiding actions in the Reef [33] and a healthy governance system is critical for achieving these outcomes.

This paper presents a benchmark assessment of the governance system associated with the development, delivery and review of the plan. We first outline the mixed methods approach that were used to develop an evaluation framework and then apply it to the Reef 2050 Plan governance system. We then present the results and summative outcome of the assessment. We end by discussing implications of these findings for adaptive governance in the Reef.

2. Methods

This benchmark assessment combined multiple lines of evidence in a collaborative and deliberative action research methodology to build consensus with Reef actors on a fit-for-purpose evaluation framework which was then collectively applied to benchmark governance health. While this deep methodological approach is described in detail in Vella et al (also submitted to this special issue), to give context to the results in this paper, the below summarizes the multiple methods employed in two major phases of research action.

First, a fit-for purpose framework to monitor and evaluate governance system health was developed between 2022-2023 through:

- Literature review of governance theory to identify concepts, principles and frameworks for evaluating governance systems health;
- Twenty-one interviews with actors from the Reef Authority, Australian and State government, Reef industries, marine park managers, and scientific experts and seven interviews with members of the Traditional Owner Steering Group for the Reef 2050 Traditional Owner Implementation Plan to understand knowledge needs and requirements of an evaluation framework. Interviews were conducted online (using Zoom) and in person, transcribed and coded into themes;
- Two in-person workshops in two Queensland locations with 16 diverse Reef actors and Traditional Owners to gain deeper perspectives on governance health and provide feedback on an emerging evaluation framework. A third online workshop was held to accommodate participants who could not attend in person. A further six conversations were held with members of the Reef Traditional Owner Steering Committee separately to assist with framework development.
- The complex Reef governance system was mapped using the program 'R', to define the scope of the policy and planning arrangements auspiced by the Reef 2050 Plan to identify connections between Reef actors and instruments (e.g. funding programs, legislative actions, formal partnerships, etc.); and
- The research team developed a theory of change drawing on Funnell and Rogers [34], Reinholz and Andrews [35], and Thornton, et al. [36] using multiple lines of evidence to establish causal links and sequences of action impacting on governance outcomes in the Reef 2050 Plan system.

Rich insights into the knowledge needs of rights holders and governance system actors resulted in a novel framework of 20 attributes across four clusters for evaluating the Reef 2050 Plan system (Table 1), and a rating scheme framed by appreciative inquiry (Table 2).

Table 1. Overview of identified attributes of governance system health underpinning the Reef 2050 Plan.

Coherence	Connectivity and capacity	Knowledge	Operational governance
Shared Vision	Process transparency and trust among actors	Knowledge quality,	Efforts deliver effective and efficient outcomes

		availability, and access	
Integrated legal framework	Actor capacities and skills	Informed consent about knowledge use	Sustainability of Actions Taken
Integrated legal framework	Equity in collaboration and genuine partnerships	Diversity of knowledge	Application of risk management
Cohesive implementation	Open and diverse communication flows	Knowledge integration and decision support	Timeliness of effort
Monitoring, Evaluation, Reporting and Improvement (MERI) systems	System subsidiarity	Knowledge storage and management systems	Adequacy of Resources

Table 2. The rating scale applied to assessment of all governance system attributes.

Rating Scale	Definition
Healthy	The attribute is functioning effectively and consistently across the Reef 2050 Plan governance system, with strong coordination, implementation, and continuous improvement evident at all levels.
Maturing	The attribute is generally working well within the Reef 2050 Plan governance system, though some areas show room for enhancement in consistency, integration, or effectiveness.
Emergent	The attribute is only partially functional across the Reef 2050 Plan governance system, with limited application, coordination gaps, or inconsistent implementation undermining overall performance.
Underdeveloped	The attribute is largely absent or ineffective within the Reef 2050 Plan governance system, with significant deficiencies in structure, coordination, or practical application.

In the second main phase, multiple lines of evidence gathered across 2023-2024 were combined into a benchmark assessment of governance system health. Methods included:

- A thematic analysis of academic and grey literature (reports, evaluations) that provided perspectives and data points on aspects of attribute health;
- In depth qualitative analysis of case materials leading to a detailed governance case study for of each attribute;
- Key actor interviews (n=20) in which participants used a Likert scale (based on Table 2) to rate each attribute and provided narratives to support their scores; and
- A series of three workshops with Reef governance experts in multiple Queensland locations to review a draft consolidated evaluation (interviews + case studies + literature) and discuss findings of the benchmark. Separate conversations were held with members of the Reef Traditional Owners Steering Committee.

The entire process was supported by an independently chaired steering committee and a technical working group

3. Results

We begin with a brief overview of the Reef 2050 Plan context and its adaptive governance needs. This is followed by the summative results of the first benchmark assessment.

3.1. The Reef 2050 Plan and Adaptive Governance Needs

Reef planning and 'institutional layering' through regulatory and policy arrangements has occurred since the 1970s on land, water, and coastal areas of the Great Barrier Reef by the Australian and Queensland Governments [25,37]. Over time, has led to complex, multi-scalar, interacting networks of actors (state and non-state), institutions, and instruments across multiple 'domains' and 'subdomains' of governance in what is best characterised as a 'polycentric' or 'nested' (non-hierarchical) governance system [25,32,38]. Consequently communities, Traditional Owners, non-government organisations, research institutions, industry (tourism, mining, fishing, agriculture), the Australian and Queensland Governments, GBRMPA, councils and local governments, and regional bodies, who are all important actors in the GBR governance space. They develop and implement instruments (policies, plans, and programs, as well as regulatory and compliance tools) to address activities that impact on the health of the Reef.

In 2012, concerns about the protection of the OUV led to a joint monitoring mission by the World Heritage Commission (WHC) and International Union for Conservation of Nature (IUCN) [39]. In response, the Australian government undertook a strategic assessment of management in the GBR World Heritage Area, and the Queensland government undertook a strategic assessment of management of the GBR coast and catchments. Though disconnected, the assessments, together with the 2014 Reef Outlook Report, culminated in the development and financing of a joint Reef 2050 Long Term Sustainability Plan by both governments in 2015 [40,41]. This Plan provided the first overarching framework to guide actions for the Reef across the catchment and marine environment [33]. It was supported by the Reef 2050 Integrated Monitoring and Reporting Program (RIMReP), which was established in 2014 to tracks progress toward achieving the Plan's goals and objectives and support the adaptive management of the Plan [42,43]. It informed the five-yearly 'Outlook' Reports of the state, health and trend in Reef health and management [44].

In 2021, the second version of the Reef 2050 Plan added a key governance objective, namely that 'governance systems are inclusive, coherent and adaptive' [45]. However, there was no explicit monitoring system in RIMReP's monitoring program to assess the health of governance underpinning the development, delivery and review of the Reef 2050 Plan [46].

To inform the adaptive governance of the Reef 2050 Plan, a benchmarking and monitoring system suitable for inclusion in RIMReP and Outlook Reporting was needed. The literature review, interviews, and mapping identified four key dimensions for monitoring and measuring governance, namely, the strategic focus and flow of the governance system surrounding the Reef 2050 Plan (**coherence**); the extent to which the system is equitable, inclusive, and fosters the development and maintenance of partnerships within and across sectors (**connectivity and capacity**); considerations of how the system manages knowledge from its creation and retention, through to its sharing via appropriate channels, to its translation to drive innovation and change (**knowledge**); and the governance system's accountability, effectiveness, sustainability and efficiency (**operational governance**). This formed the basis of the evaluation framework of twenty attributes across four clusters: (i) coherence; (ii) connectivity and capacity; (iii) knowledge; and (iv) operational governance.

3.2. The First Benchmark of Reef Governance Health

Overall, the assessment found that the health of the Reef 2050 governance system is *emergent* to *maturing*. At the cluster level, the health of the **coherence cluster** was found to be *maturing*, reflecting improvements in shared vision making, the development of more integrated legal frameworks, and adaptive monitoring evaluation and reporting under the Reef 2050 Plan. Governance system health would be further strengthened by improving strategic partnerships programs between government and key actors (e.g., regional NRM bodies and catchment organisations, local governments, industry, and Traditional Owners).

The health of the **connectivity and capacity cluster** was also found to be *emergent to maturing, r*eflecting growing actor capacities and skills, open and diverse communication which together supports plan implementation. This cluster would be strengthened by a stronger approach to building subsidiarity within the system, as well as processes to further build transparency, trust, equity, and genuine partnerships with key actors.

The health of the **Knowledge cluster** was also found to be *emergent to maturing*, reflecting recent improvements in knowledge quality, availability and access, informed consent, knowledge diversity, integration and decision support, and the improved development of knowledge storage and management systems. It was considered that the incorporation of more diverse biocultural and human dimensions knowledge sets in decision making would also further mature the health of this cluster.

Finally, the health of the **operational governance** cluster was found to be only *emergent to maturing*. Though the overall governance system is well positioned to respond quickly and effectively to short-term problems, our assessment has found that it not well positioned to address the bigger and more urgent problems such as climate change and to a lesser extent water quality. The study found a need to strengthen operational governance structures to support more effective, timely, and sustainable responses to changing environmental conditions in ways that would ensure the long-term sustainability of the Reef.

Table 3 summarises the assessment for each of the 20 attributes in each of the four clusters with some examples to illustrate the findings.

Table 3. Findings from the first Reef 2050 Plan governance system benchmark.

Coherence: How cohesive is the governance system across vision goal setting, strategy development, implementation, and monitoring and review?			
Attribute	Assessment	Case Study	Some Examples of Key Findings
Shared Vision All actors involved in development and implementation of the Reef 2050 Plan share complementary visions for the GBR.	Maturing	The Reef 2050 Traditional Owner Implementation Plan [47]	More efforts are needed to better involve key industries (e.g. farming), Traditional Owners and Councils in vision setting beyond a consult/engage based mode and towards genuine partnership building. Collective vision setting is less cohesive at lower scales within the system (e.g. catchment scales versus the Reef wide scale).
Integrated legal framework From global to the state scale, there is an impactful set of legislative and policy instruments integrated across key issues affecting the GBR, and across global, national, state, and local scales.	Maturing	The GBRMP Act and the Reef Authority [48]	Foundation legislative frameworks underpinning management of the Reef from as far back as 1975 require adaptation to ensure they can address the magnitude and extent of the current accumulated and increasing stressors on Reef health. For example, there is no direct links between policies developed under the original *Great Barrier Reef Marine Park Act 1975* and those developed for climate/emissions reduction. Greater legislative linkage is needed across multiple legislative instruments that contribute to the Reef 2050 Plan.

Aligned multiscale and prioritised strategies Reef 2050 strategies and associated delivery arrangements are diverse and well targeted enough to achieve Plan goals.	Emergent/maturing	The Reef Credit Scheme [49]	While there are a wide range of strategies and actions being implemented under the Reef 2050 Plan, investment priorities could be more accurately and transparently determined through more rigorous and inclusive decision-support processes that determine strategy priorities. This will reduce siloed decision-making and fragmentation of multi-scalar efforts.
Cohesive implementation Strategies are effectively coordinated, delivered and maintained on the ground.	Emergent	Project 25 [50]	While some programs such as the Reef Guardian initiative and the GBR Water Quality Implementation Plans have had positive impacts on ecosystem health, a decline in collaboration between the Australian and State governments in the coordination of wide-scale implementation efforts was identified.
Monitoring, Evaluation, Reporting and Improvement (MERI) systems Active monitoring, evaluation, and review of Reef Plan efforts across scales, resulting in continuous improvement.	Maturing	Reef Water Quality Report Cards [51]	RIMReP coordinates all monitoring and evaluation efforts to track progress against the achievement of Plan goals and objectives and is considered an effective coordinating instrument for monitoring. Sometimes, however, monitoring's influence on management and action taking is subject to significant delays due to RIMReP's complexity and slow-moving nature.
Connectivity and Capacity: Are the system components deeply connected vertically and horizontally, with equitable capacity across all actors?			
Attribute	Assessment	Case Study	Some Examples of Key Findings
Process transparency and trust among actors Across scales, decision making processes are transparent and accountable and there are high levels of trust between the actors involved.	Emergent/maturing	Cane Changer [52]	While moderate degrees of public trust exist in the agencies responsible for the delivery of the Reef 2050 Plan, fractures in public trust persist in relation to government institutions. There has, however, been progress in relation to enhanced transparency and trust between Traditional Owners and lead GBR agencies.

Attribute	Assessment	Case Study	Some Examples of Key Findings
Actor capacities and skills All key actors in the GBR have the capacities and skills needed to fulfil their responsibilities and they are actively supported.	Maturing	Regional NRM: The Australian Business Excellence Framework for NRM [53]	The Reef Authority continues to demonstrate good management capability, however the development of long-term subsidiary relations with lower-scale institutions is limited in the Reef, especially in community, industry and Traditional Owner sectors.
Equity in collaboration and genuine partnerships There is demonstrable power sharing across all GBR actors leading to genuine partnership effort.	Emergent/maturing	Girringun TUMRA [54,55]	There is evidence of increasing collaboration between the Commonwealth, the State, and the Reef Authority. The stability of such collaboration, however, remains weak, and improved partnerships are required between the Australian and State governments with Traditional Owners, local governments and farming sectors across scales.
Open and diverse communication flows Policies, plans, information, and progress is freely shared across all actors and the broader community.	Maturing	GBR Representative Areas Program [56]	The use of large-scale surveys, social research, rich conversations and independent moderators can prompt improved linkages between people and institutions, but there is a need to lift the level and quality of two-way communications between key institutional agencies and non-governmental Reef actors. More effort is needed to continue to lift societal wide trust in Reef science.
System subsidiarity The power to make the right decisions rests with those actors closest to the policy, planning, or delivery problem being addressed.	Underdeveloped/emergent	Burdekin Major Integrated Project [57]	The principle of subsidiarity is poorly recognised, understood and conceptualised within the design of the Reef 2050 Plan governance system and its associated delivery programs. Systemic investment in the capacity of, and integrated cooperation between regional and localised groups is needed to increase the chances of success for major policies and programs emerging from the Reef 2050 Plan.
Knowledge: Are all forms and knowledge, data and research, development and innovation appropriately considered in decision making?			
Attribute	Assessment	Case Study	Some Examples of Key Findings

Knowledge quality, availability, and access The knowledge needed in decision making at all scales has high integrity, is readily available and can be accessed.	Maturing	Social and Economic Long-Term Monitoring Program (SELTMP) for the GBR [58]	The Reef benefits from a sophisticated system for broad knowledge generation and real-time information sharing. This enables rapid and responsive management responses. However, significant gaps remain in understanding the management of cumulative impacts of multiple stressors on the Reef.
Informed consent about knowledge use Free, prior informed consent is well negotiated when collecting and using knowledge and data from human sources.	Emergent/maturing	Establishment of Free Prior and Informed Consent (FPIC) [59]	Increased use of high-tech tools for data collection presents new challenges as data may be accessed without informed consent. The use of Free Prior Informed Consent (FPIC) agreements with Traditional Owners is gaining traction and will mean major changes within Reef management. Industry sectors remain concerned about government use of enterprise data.
Diversity of knowledge Decision making in the governance system uses a diverse range of social, cultural, economic, biophysical, traditional, historical, and industry knowledge.	Emergent/maturing	RRAP Collaborative Monitoring Project [60]	Knowledge of the biophysical components of the Reef is ever-expanding and is used effectively to inform management. Knowledge of the human dimensions of the Reef are becoming better integrated into management, but there remain gaps in its application. More effort is needed to include the knowledge and perspectives of farmers, traditional owners, and fishers into decision making. Citizen science monitoring programs could increasingly be better used to enable timely management responses. Co-production of knowledge needs to be context-specific, goal-oriented and interactive.
Knowledge integration and decision support Data and knowledge are well integrated in effective modelling and decision support systems.	Emergent/maturing	RIMReP's Human Dimensions Monitoring [61]	Integration of different knowledge sets for collective decision-making occurs at different spatial scales for GBR management. Climate change modelling and scenario building linked to decision-systems are becoming a priority. There are however still many knowledge gaps and the use of interactive decision support tools for the negotiation of broader societal trade-offs is often limited.

Attribute	Some Key Examples of Findings	Case Study	Assessment
Knowledge storage and management systems There are strong knowledge management and sharing platforms in place, enabling effective decision making.	Emergent/maturing	Summer Snapshot for the GBR [62]	Sophisticated but siloed knowledge storage and management systems are in place, but there are major barriers such as accessibility and consent issues within and between agencies. Barriers may be due to organisational cultures, a lack of trust and a lack of inter-linked knowledge management systems.
Operational Governance: Operationally, is the system adaptive and robust enough to achieve is vision?			
Attribute	Some Key Examples of Findings	Case Study	Assessment
Efforts deliver effective and efficient outcomes The Reef Plan governance system delivers the right (effective) interventions well (efficiently), delivering intended Plan outcomes.	Underdeveloped/emergent	Cost-Effective Measures to Improve Water Quality in Reef Catchments [63]	It has been difficult to evaluate comprehensively whether key Reef 2050 Plan efforts deliver effective and efficient outcomes in the GBR. While some programs, such as the Crown-of-Thorns Starfish (COTS) control initiative show improvement, for example, concerns remain around the effectiveness of other programs, such as the water quality improvement efforts.
Sustainability of Actions Taken Reef 2050 Plan actions can be continued adaptively until they achieve their goals and targets.	Underdeveloped/emergent	Evolution of NRM arrangements and plans in Queensland [64]	While the Queensland and Australian governments allocate significant resources to many aspects involved in managing Reef health, the continuity and sustainability of such funding in the long-term remains uncertain.
Application of risk management Risks are adequately considered and managed across scales within the design and implementation of GBR interventions.	Emergent/maturing	Framework for Governance Systems Analysis (GSA) [65]	The overall Reef 2050 Planning and review process represents a wider form of risk analysis, but it lacks the transparent application of risk-based principles. Within the Reef 2050 Plan governance system several specific applications of risk analysis exist, including risk assessment, response and monitoring. Generally, however, here is little evidence of consideration of the social and cultural dimensions of risk.

Timeliness of effort Interventions across the Reef 2050 Plan are timed to maximise successful goal achievement.	Emergent/maturing	Response to Extreme Weather: The Wet Season 2010–2011 [66]	With climate change impacts increasingly affecting the Reef, there is a need to improve overall intervention responsiveness to these impacts. Building improved resilience planning approaches and system subsidiarity could enhance the timeliness of effort through greater non-institutional actor involvement across all levels at the right intervention points, especially local ones.
Adequacy of Resources Sufficient resources are allocated to enable the success of all Reef 2050 Plan interventions.	Underdeveloped/emergent	The regional NRM sector in the GBR [67]	Despite a notable increase in government investment in Reef management, resource gaps remain for the delivery of actions under the Reef 2050 Plan (e.g. the high costs associated with water quality improvement programs and marine restoration.

Overall, the findings reveal that the governance system health of the Reef 2050 Plan is undergoing a transition toward maturation, and that it is indeed world leading by global comparisons. While significant strategic actions and associated delivery infrastructures and are currently in place, the health of the overall governance system is weakened by consistently identified issues of fragmented implementation, weak program integration, limited local capacity building, resource and knowledge gaps, and a resistance to application of subsidiarity principles. We now discuss these more synthesised findings and suggest a pathway forward for the use and replication of the monitoring framework that has been developed.

4. Discussion

The broad system strengths characterising the Reef 2050 Plan governance system suggest that efforts to build a governance framework are, so far, generating positive outcomes for the Reef. Healthy aspects of the system worth continuing to strengthen include:

1. **Global Leadership in Emission Reduction**. The Reef 2050 Plan governance system is strengthened by Australia's engagement with the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the IUCN. This engagement enables Australia to work toward protecting the Reef through regular reporting, monitoring, and commitments to policy improvements. This is evident in UNESCO's calls for adopting concrete and consistent management measures to address escalating Reef decline and improve reef resilience. In 2014 this led to the initial drafting of the Reef 2050 Plan and its subsequent updates through monitoring and review cycles [68]. The original listing to the Reef for its World Heritage status has supported efforts toward Reef conservation and fostered alliances between the tourism industry, the public sector, and national and international organisations and stewardship programs, all built on shared values of protecting the Reef [69,70];

2. **The Emerging Reef 2050 Planning Process**. The very existence of a strong and evolving Reef 2050 Planning system demonstrates the existence of shared vision, an integrated legal framework, and aligned, multi-scale, and prioritised strategies across the wider governance system. The development of the Reef 2050 Plan as the overall integrative mechanism for the governance system is a key system feature that should be maintained and enhanced into the future. Sponsored

by the Australian and State Governments, the Reef 2050 Plan concerns the primary institutional arrangements for coordinated GBR planning and delivery;

3. **Crisis Monitoring and Response Systems**. There is evidence for the stronger emergency of more adaptive and real-time monitoring and response systems for crisis and disaster response, including bleaching events, and the application of strong risk-oriented approaches in a wide range of reef related activities. In the Reef, adaptive approaches are developing through the emerging Reef Resilience and Adaptation Program (RRAP), which globally leads the development of new coral reef restoration and adaptation solutions [71,72]. As adaptive governance approaches are crucial to respond to emerging climate crises, the establishment of the RRAP represents an innovative and holistic focus of Reef management toward long-term outcomes [73,74];

4. **A Long-Term Focus on Fisheries, Marine Parks Management and Compliance**. While Queensland has generally had a relatively robust and well legislated fisheries planning and management system, the development of a strong representative areas management approach in the 1990s was also a strong governance innovation in GBR management. There is considerable evidence concerning the success of such approaches. Fisheries management continues to be a strong focus of continuous improvement in association with the Reef, though continued effort is needed to ensure strong industry based and co-managed approaches to these improvements. These arrangements are complimented by a long-institutionalised system of solid marine park management, though again, more co-managed approaches need to evolve;

5. **Progress on Integrated Monitoring and Reporting**. To enable responsive and adaptive actions with the delivery of the Reef 2050 Plan, and to ensure that such efforts can be maintained over time, it is crucial that there is progress on integrated monitoring and reporting systems that emphasise cooperation across scales. As argued by Dale, et al. [75], while the development of Reef-wide monitoring frameworks is progressing, less effort has been made at the regional levels, weakening the ability of regions to influence Reef-wide policymaking [76]. In alignment with the literature highlighting improved Reef management through zoning and land use regulations, our findings also identified significant progress in the governance and management of the marine park itself, with a long-term focus on fisheries and parks management and compliance [77–79].

Overall, our findings align with broader discussions in the governance literature focused on stakeholder trust, participatory governance, and adaptive management for sustainable environmental outcomes. The contemporary strengths of the Reef system highlight successful adoption of adaptive governance principles, especially in relation to crisis response and monitoring and reporting systems. Continuous improvement approaches within the Reef 2050 Plan governance system should continue to build on these system strengths.

Our analysis also revealed several priorities important for system improvement and reform, including matters related to power sharing among key Reef actors, poor levels of program coordination, and a lack of commitment to principles of subsidiarity and poorly integrated knowledge systems. Our more detailed synthesis of weaknesses and priority areas for improvement include the need for:

1. **Genuine power sharing with key Reef actors.** While there is promise for improvement, there remains a lack of genuine power sharing with Traditional Owners, government, and industry [80,81]. Healthy governance requires inclusive participation of diverse actors to foster a genuine sense of co-management of the Reef. It is therefore a priority for the Queensland and Australian Governments to rebuild trust and stronger partnerships with Traditional Owners, the farming, agricultural and fishing sectors and local governments across the Reef catchment;

2. **Improved trilateral relations with local government**. Poor coordination of efforts across different governance levels has also been a long-standing issue for the Reef, particularly at the lower scales [82,83]. In this regard, our results have highlighted continued fragmentation in program implementation and the weak application of trilateral approaches (combining the efforts of federal, state, and local governments). This is particularly the case in relation to land-based action and community-based education. An opportunity for reform these approaches lies in prioritising the

strengthening of trilateral approaches to Reef governance, with more support provided to local governments across the Reef [84]. More trilateral approaches would facilitate improved co-design of delivery effort, including at regional, catchment, local, traditional owner estate, and farm scales;

3.   **Building a culture of subsidiarity.** It is a priority for the Reef to foster a stronger culture of subsidiarity to improve cohesive implementation of multi-scale strategies which are currently problematic due to fragmented and short-term funding, and limited integration of place-based strategies [85]. If subsidiarity issues are not addressed, they will impact on the strength of organisations involved in catchment scale action, including regional NRM bodies, farming and research bodies, community-based land care groups, and traditional owner institutions. Unfortunately, the strength of such organisation is often declining, impacting the effective implementation of aligned and multi-scale Reef 2050 Plan strategies, and particularly those related to water quality improvement. Some improvement in this sense could occur through emerging reforms that the federal Environment Protection and Biodiversity Conservation (EPBC) Act that explore bioregional planning approaches to protecting catchment value and facilitating large scale restoration.

4.   **Towards integrated knowledge systems.** Greater integration between Australian and State government knowledge systems is also needed to improve decision making across the region and to improve trust in data storage and management [86]. Communication issues were similarly highlighted by traditional owner communities, which emphasised the need for developing culturally appropriate knowledge systems at the sea country estate scale [87];

5.   **Cross sectoral collaboration of decarbonised regional development**. A major governance challenge exposed through our analysis is a lack of integrated consideration about the combined importance of social, economic, cultural, and environmental values of the GBR and its catchments. Climate change is one of the greatest threats to the future of the GBR, and it is increasingly important that the Reef 2050 Planning process turns more attention to being supportive of, and engaged in, regional economic transition in Reef catchments. To replace its very significant reliance on coal royalties, Queensland will need to undergo a major social and economic transition over the next 30 years. Several key economic and transformational reports of importance in recent years have stressed that this will particularly involve the significant increase in higher value manufacturing and agriculture in Reef catchments, major steps towards the decarbonisation of the economy, and more diversified and greater forms of energy production, feeding both more vertically integrated agricultural production, value adding and manufacturing. This could be done in ways that massively increase the economic productivity of these catchments while at the same time reducing greenhouse gas emissions and improving Reef water quality. Doing so, however, will require strong Australian, State and local government cooperation, very effective land use and infrastructure planning, and the full integration of new science and technologies;

6.   **Communicating Positive Government and Reef Resilience Successes**. More work needs to be dedicated to communicating positive governance and Reef resilience outcomes to prevent misleading global narratives which heavily impact on the tourism sector [88,89].

5. Conclusions

Our goal in this work has been to create a replicable framework to assess governance system health underpinning the Reef 2050 Plan. We did this to allow progress towards monitoring the achievement of the Plan's goals and objectives related to governance for a more resilient Reef. Our exploration of 20 attributes (across four attribute clusters) highlighted broad system strengths worth maintaining, as well as key priorities for improvement. We found whole-of system strengths form a foundation upon which the governance system can build, fostering a collaborative and adaptive approach essential for the long-term resilience and health of the Reef.

Overall, our assessment found the health of the governance system underpinning the Reef 2050 Plan is 'emerging to maturing', reflecting more recent progress in policy and plan development and capacity building efforts. This aligns to the wider Reef governance literature which identifies specific

areas for system improvement, such as weak coordination of multi-scalar effort and limited partnership building with key community and industry sectors. However, while several studies focus on governance failures, our study was framed within an appreciative inquiry approach and provides a more balanced perspective of governance system strengths, weaknesses, and progress in the Reef. We suggest that this more balanced picture is key to understanding governance of the Reef and identify pathways for further improvement and reform.

Our findings point to significant opportunities to enhance and implement the strengthening of governance efforts to ensure the long-term sustainability of the Reef, especially in the light of emerging climate risks. Given that these challenges can only be resolved through healthy and effective global, national, and local governance, overall, our assessment of the health of the Reef 2050 Plan's governance system is rated as 'emerging to maturing'. Our assessment reflects the concerted efforts of governments, traditional owners and other key actors in collectively building policies, programs and capacity enhancing initiatives; all better contextualised against the scale of the contemporary challenges facing the Reef's future.

To conclude, this theoretically grounded, actor-engaged framework and approach to benchmarking and monitoring of the health of the Reef 2050 Plan governance system has enabled dialogue about the governance components of the Reef as an independent exercise embedded within the overall governance system. This first round of benchmarking has established an important asset of global significance for governance assessment; it provided a practical approach to governance assessment based on theoretical strength and analytical depth, and one that could be repeated and maintained at a relatively low cost. Through regular and adaptive benchmarking, this monitoring system could interface with future Outlook reporting by 2029, and with the coming cycles of Reef 2050 Plan review to evaluate the health of this spatially-based governance systems and to monitor progress toward the achievement of desired outcomes for a more resilient Reef by 2050 Plan and beyond. Such an approach be applied to effective governance system improvement in complex ecosystems across the globe.

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Abbreviations

The following abbreviations are used in this manuscript:

COTS	Crown-of-thorns Starfish
EPBC Act	Environment Protection and Biodiversity Act
FPIC	Free, Prior and Informed Consent
GBR	Great Barrier Reef
GBRF	Great Barrier Reef Foundation
GBRMP	Great Barrier Reef Marine Park
GBRMPA	Great Barrier Reef Marine Park Authority
GSA	Governance Systems Analysis
IUCN	International Union for the Conservation of Nature
JCU	James Cook University
MERI	Monitoring Evaluation Reporting and Improvement
NGOs	non-governmental organisations
OUV	Outstanding Universal Value
RRAP	Reef Restoration and Adaptation Program
Reef 2050 Plan	Reef 2050 Long-Term Sustainability Plan
RIMReP	Reef 2050 Integrated Monitoring and Reporting
QUT	Queensland University of Technology
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
WH	World Heritage
WHC	World Heritage Commission

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