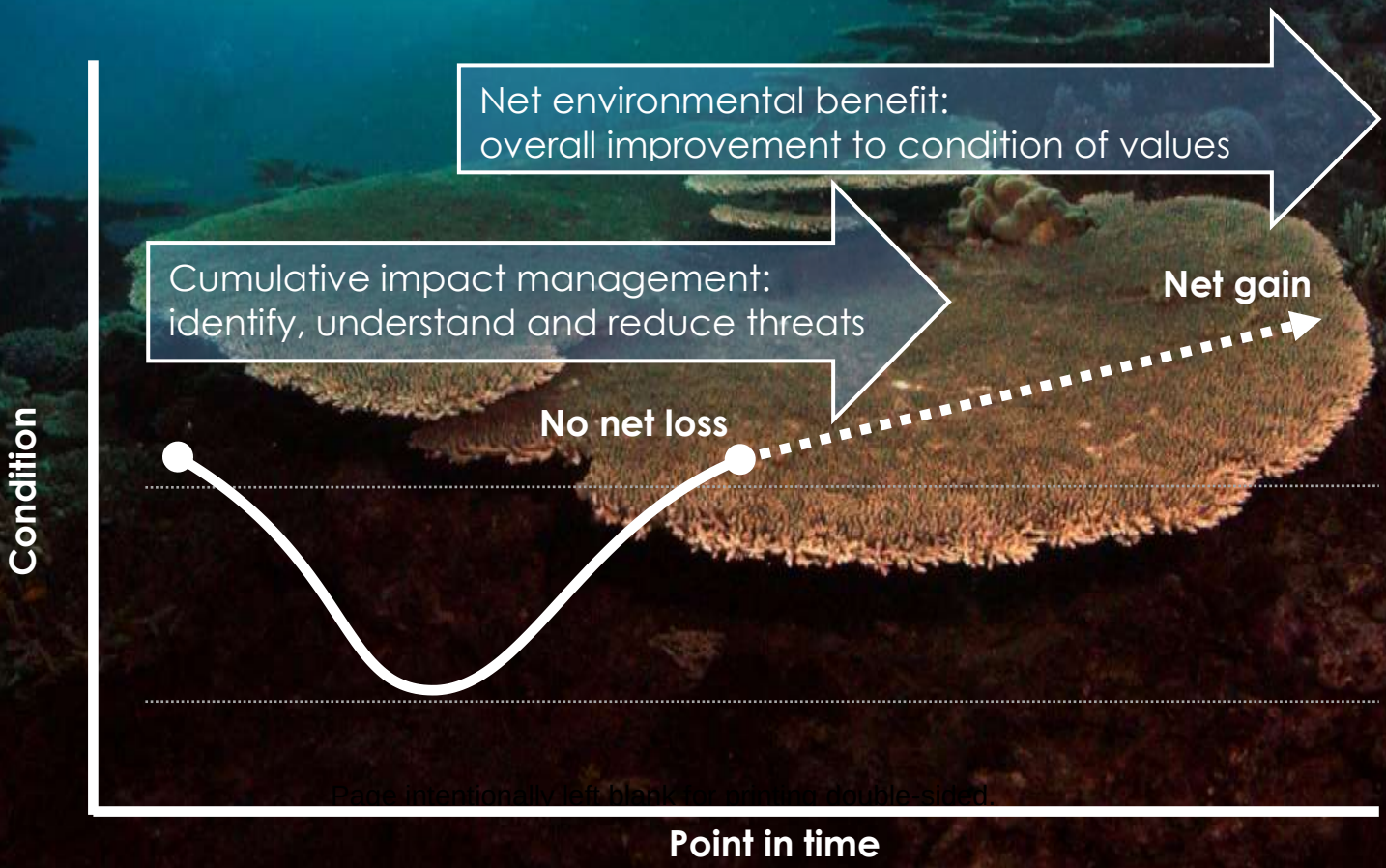
Managing cumulative impacts and achieving no net loss and net benefit outcomes for the Great Barrier Reef

a review of current understanding and application for management



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Published by the Great Barrier Reef Marine Park Authority 2017

National Library of Australia Cataloguing-in-Publication entry
Managing cumulative impacts and achieving no net loss and net benefit outcomes for the Great Barrier Reef : a review of current understanding and application for management / Great Barrier Reef Marine Park Authority.

9781922126931 (ebook)

Includes bibliographical references.

Marine parks and reserves—Queensland—Great Barrier Reef—Management.
Environmental impact analysis—Queensland—Great Barrier Reef Region.
Great Barrier Reef Marine Park (Qld.)—Management.
Great Barrier Reef Region (Qld.)—Environmental conditions.
Great Barrier Reef Region (Qld.)—Economic conditions.
Great Barrier Reef Region (Qld.)—Social conditions.

Great Barrier Reef Marine Park Authority, author.

333.7809943

This publication should be cited as:
Great Barrier Reef Marine Park Authority 2017, *Managing cumulative impacts and achieving no net loss and net benefit outcomes for the Great Barrier Reef: a review of current understanding and application for management*, GBRMPA, Townsville.

Acknowledgements
This publication has been based on a report prepared by Cameron Strategies Pty Ltd on behalf of the Great Barrier Reef Marine Park Authority

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Executive summary

The Great Barrier Reef Marine Park Authority (the Authority) is working with its Australian and Queensland government partners, Traditional Owners and stakeholders to develop policies for managing cumulative impacts and achieving no net loss and net benefit outcomes for the Great Barrier Reef. This paper is a review of current Australian and international literature relevant to these policies. Considerations and principles of contemporary theory and practice in the literature are applied to provide a foundation for developing policy guidance.

The concepts of cumulative impact assessment and management, offsets and net 'environmental' benefit evolved from environmental impact assessment processes used worldwide since the 1970s. Now there is an international focus on developing guidelines and principles to assist decision-makers.

Rigorous impact assessment is the basis for considering cumulative impacts and offsetting of any residual adverse impacts, after full application of avoidance and mitigation of likely impacts. Generally, the purpose of offsets is 'no net loss'. The purpose of net benefit is to improve the condition and trend of environmental values. The reduction of cumulative impacts and delivery of net environmental benefits requires the use of comprehensive and systematic assessment processes across strategic, regional and local levels.

While the literature and consensus for incorporating cumulative impacts and offsets is well-developed, analysis of net benefits is less well-defined. There is discussion regarding conservation gains or net gains, but there is limited discussion on a broader holistic approach to net benefits - incorporating social and economic objectives as well as environmental opportunities and benefits.

Two programs provide the most relevant and synthesizing discussion of the concepts of net benefits and offsetting:

- the Business and Biodiversity Offsets Program (2009 and subsequent) [1,2,3,4,5,6,7,8]
- the International Union for Conservation of Nature (IUCN) Policy on Biodiversity Offsets – September, 2016. [9]

The IUCN policy is the culmination of several years of analysis and consolidated technical papers that examine technical and governance issues associated with developing and implementing effective biodiversity offsets [10,11,12].

The Great Barrier Reef is one of the most-studied and best-managed reef ecosystems in the world. It provides an advanced platform for reducing pressures through effective cumulative impact assessment and management and undertaking actions to maintain and improve the condition and trend of values. This literature review uses the Great Barrier Reef Region Strategic Assessment [13,14] and Great Barrier Reef Outlook Report 2014 [15] to focus options from international authors and explore their application to the Great Barrier Reef World Heritage Area (GBRWHA). This review also incorporates relevant legislation and highlights implementation issues for consideration in developing the policies.

Principles are identified throughout this document to guide the development of a policy framework for consultation with key stakeholders on cumulative impact assessment and management and actions to deliver no net loss and net benefit outcomes.

Draft policy documents have been based on this literature review. This paper incorporates a review of literature up to June 2016, with an update after the IUCN Congress decision on the Policy on Biodiversity Offsets in September 2016. It is being released as a working paper and we encourage feedback on its content, including any additional references or guidance material relevant to managing cumulative impacts and delivering net environmental benefits – particularly within a marine or coral reef context.

Authors worldwide agree there are many challenges to effectively implementing cumulative impact and net benefit policies for the environment. However, never before has there been a more critical need to tackle these challenges than now – on our Great Barrier Reef.

Introduction

Ongoing and growing concerns over the decline in the health of the Great Barrier Reef and the benefits it provides have led to a call for measures to drive the reduction of cumulative impacts and actions to restore ecosystem health and function. Loss of biodiversity and continual development has put pressure on government and industry to introduce policies and voluntary commitments aimed at achieving 'no net loss' scenarios and compensatory protocols for activities within their areas of responsibility [20].

These calls led to the commitment to develop cumulative impact and net benefit policies and offset guidelines for the GBRWHA.

This document is a review of current Australian and international literature relevant to net benefits, cumulative impacts and offsetting for the environment. It includes a review of literature up to June 2016, with an update after the IUCN Congress decision on the Policy on Biodiversity Offsets in September 2016. The focus of the review is on highlighting elements and principles of contemporary theory and practice as a basis for developing an effective policy framework for the Great Barrier Reef.

The overall objective of the policies is to reduce cumulative impacts and improve the health and resilience of the GBRWHA.

Great Barrier Reef World Heritage Area context

The Great Barrier Reef has been managed jointly by the Australian and Queensland governments and its many partners for more than four decades. The GBRWHA is considered to be a leading example of world's best practice management[21]. However, the effectiveness of management is challenged by complex factors that have their origin beyond the Great Barrier Reef.

The Australian populace and the global community, more generally, are already aware of the potential threats to the Great Barrier Reef from climate change, coastal development, and impacts of land use and management [15]. There is significant scientific, social and political discussion underway on the future of the Great Barrier Reef in the twenty-first century.

The outlook for the Great Barrier Reef ecosystem is at a crossroad, and it is decisions made in the next few years are likely to determine its long-term future [22].

The extracts below from key reports set the scene for linking the findings of this literature review with considerations for developing and implementing policies and guidelines to improve local, national and international decision-making influencing Great Barrier Reef health.

Great Barrier Reef Outlook Reports 2009 and 2014

The *Great Barrier Reef Marine Park Act 1975* requires that every five years a report be prepared assessing the outlook for the Great Barrier Reef [23]. The Great Barrier Reef Outlook Report 2014 concluded that:

> *Even with recent management initiatives to reduce threats and improve resilience, the overall outlook for the Great Barrier Reef is poor, has worsened since 2009, and is expected to further deteriorate in the future. (p.vi)* [15]
>
> *Greater reductions of threats at all levels, Reef–wide, regional and local, are required to prevent the projected declines in the Great Barrier Reef to improve its capacity to recover. (p.vi)* [15]

Comprehensive Strategic Assessment 2014

The Authority is the Australian Government statutory agency responsible for protecting and managing the environment, biodiversity and heritage values of the Great Barrier Reef Region (**Figure 1**).

In managing the Great Barrier Reef Region, the Authority must have regard to, and seek to act in a way that is consistent with the objects of the *Great Barrier Reef Marine Park Act 1975* (the GBRMP

Act), the protection of the world heritage values of the GBRWHA, and the principles of ecologically sustainable use.

In 2012 the Authority commenced a strategic assessment to examine impacts on the Great Barrier Reef, including its outstanding universal value. At the same time, the Queensland Government conducted a similar strategic assessment of the Great Barrier Reef coastal zone. Together these assessments provided a comprehensive strategic assessment of the condition and trend of attributes, drivers, pressures and management responses to ensure protection of the outstanding universal value of the GBRWHA.

The Authority's strategic assessment utilised a range of best practice approaches to:

- analyse the Great Barrier Reef Region's values and identify a suite of key attributes and environmental processes
- analyse drivers, activities and impacts acting on key attributes and environmental processes
- assess the condition and trend of key attributes and environmental processes
- examine the successive and combined effects of some of the key impacts on water quality, coral reefs and seagrass meadows, including the direct, indirect and cumulative impacts of activities
- assess the effectiveness of current management arrangements to manage the impacts of activities on values, identify problematic issues and areas for improvement
- identify key knowledge gaps and priorities for research, modelling and monitoring to address information needs critical to management
- assess future risks to the Great Barrier Reef ecosystem posed by identified impacts and project the future condition of the Great Barrier Reef, based on the assessment of the current condition of key attributes and environmental processes, effectiveness of management and ecosystem resilience.

The strategic assessment concluded that that the Great Barrier Reef remains one of the most resilient tropical ecosystems in the world, however, the accumulation of impacts through time and over an increasing area was diminishing the Reef's health.

Figure 1 - Great Barrier Reef Region, GBRWHA and Great Barrier Reef Marine Park (Marine Park)

Critically, it identified that managing cumulative impacts needs to be improved and mechanisms developed that will deliver net environmental benefits across the Great Barrier Reef Region. Five main initiatives for improvement were nominated (p.iii) [14]:

- a management framework focused on clear outcomes for the future of the Reef's values and driven by specific measurable targets
- cumulative impact guidelines and regional standards to improve assessment and management of cumulative impacts from all activities within and adjacent to the Region
- a net benefit policy to guide decision-making and actions required to deliver an overall or 'net' improvement to ecosystem health and the condition of the Region's values
- a program of regionally-based Reef recovery actions to support restoration of critical habitats, functioning of coastal ecosystems and sustainable multiple use
- a Reef-wide integrated monitoring, modelling and reporting program, linked to outcomes and targets, to evaluate performance and drive adaptive management.

Reef 2050 Long-Term Sustainability Plan

The Australian and Queensland governments responded to the findings of the comprehensive strategic assessments, Outlook Report 2014, and continuing concerns of international heritage bodies by working with a multi-stakeholder partnership group to develop the Reef 2050 Long-Term Sustainability Plan (Reef 2050 Plan), a 35 year plan to improve the resilience of the Great Barrier Reef. The Reef 2050 Plan was adopted by Australian and Queensland Ministers in March 2015 and added as a schedule to the Intergovernmental Agreement in June 2015. The Reef 2050 Plan vision is

> *To ensure the Great Barrier Reef continues to improve on its Outstanding Universal Value every decade between now and 2050 to be a natural wonder for each successive generation to come.* (p.iii) [24]

The vision is being delivered through identified outcomes for biodiversity, ecosystem health, heritage, water quality, community benefits and economic benefits, underpinned by transparent governance. Measurement against specified targets for 2020 and medium-term objectives for 2035 were defined as a measure of progress toward the nominated outcomes.

Developing a net benefit policy, cumulative impact and offset guidance for the Great Barrier Reef are specific actions in the Reef 2050 Plan.

Incorporation into policy development

The findings, definitions, recommendations, targets and outcomes of these foundational documents, along with the legislative basis for policy development, are critical elements in developing policy guidance for managing cumulative impacts; providing guidance on offsets; and achieving net benefits. The review highlights key considerations for policy development.

Shared responsibility for policy development and implementation

Although the intent is for policies to guide Australian and Queensland governments' decision making, a wide range of Traditional Owners, local governments, conservation, industry and natural resource management associations, research institutions, communities and land managers are actively involved in managing the Great Barrier Reef through their everyday activities. Continuing to work together on stewardship programs, and in developing and implementing key initiatives such as the net benefit policy, will foster stakeholder ownership and ongoing involvement in actions to deliver positive outcomes for the Great Barrier Reef.

Cumulative impact management

The effects of cumulative impacts on the health of the Great Barrier Reef, together with the need to improve their management, are well recognised. The independent assessment of management effectiveness conducted for the 2014 Great Barrier Reef Outlook Report identified:

> *. . . the extent to which cumulative impacts are being addressed as the weakest indicator across the entire management effectiveness assessment (p.260).* [15]

The Outlook Report, the World Heritage Centre Mission to the Great Barrier Reef and the Great Barrier Reef Region Strategic Assessment Program Report, recognised cumulative impacts from a number of pressures are combining to reduce the condition of values, and the present system of managing and mitigating cumulative impacts is insufficient to halt decline in condition of values.

Mandate for cumulative impact management policy and assessment guidelines

The Great Barrier Reef Region Strategic Assessment outlines a 25-year program for future management of the Marine Park. The Program outlines measures required to '*achieve a healthy Great Barrier Reef for future generations'*, including measures to reduce cumulative impacts and build resilience. One of the key initiatives identified in the Program to achieve this is development of *cumulative impact guidelines and regional standards to improve assessment and management of cumulative impacts from all activities within and adjacent to the Region (p.iii).*[14]

The Reef 2050 Plan reflects the findings from the 2014 Great Barrier Reef Outlook Report and the Great Barrier Reef Region Strategic Assessment. Specific actions and targets have been included in the Reef 2050 Plan to address and report on aspects of cumulative impacts. Examples include:

- EHA19 - Develop guidelines for assessing cumulative impacts (including climate change pressures) on matters of national environmental significance including ecosystem and heritage values in the World Heritage Area.
- EHT4 - Key direct human related activities are managed to reduce cumulative impacts and achieve a net benefit for the Reef.
- BA15 - Reduce cumulative impacts on coastal dolphin populations and their supporting habitats especially Australian humpback and snubfin dolphins.
- EBA3 - Introduce a guideline for port master planning for the ports of Gladstone, Hay Point/Mackay, Abbot Point and Townsville that optimises infrastructure and considers operational, economic, environmental and social relationships as well as supply chains and surrounding land uses.
- EBA6 - Implement commitments for best-practice commercial vessel operation including those aimed at undertaking further research and investigating appropriate measures to reduce cumulative impacts from shipping.
- EBT3 - Cumulative impacts on the Reef from human activities are understood and measures to ensure a net environmental benefit approach for the Reef are in place.

Definitions and terminology

The literature provides a number of definitions that describe how cumulative impacts affect values, what is to be assessed, and what is to be managed. Halpern et al. state:

> *The generic concept of cumulative impacts has been part of environmental policy for many years under the U.S. National Environmental Policy Act and other authorities, as well as in scientific literature. According to the U.S. EPA (1999) "the cumulative impacts of an action can be viewed as the total effects on a resource, ecosystem, or human community of that action and all other activities affecting that resource no matter what entity (federal, non-federal, or private) is taking the actions." (p.205)* [67]

Connelly et al. and Canter et al. cite the Council on Environmental Quality (CEQ), where the 1979 EIA related regulations defined cumulative impact as the

> *. . . impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what*

> *agency (federal or non-federal) or person undertake such other actions. Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time* (p.261). [68]

Connelly et al. also cites the European Union 1997 definition for cumulative effects as

> *. . . the likely significant effects of the proposed project on the environment . . .*[which includes] *. . . the direct effects and any indirect, secondary, cumulative, short, medium and long-term, permanent and temporary, positive and negative effects of the project.* (p.453) [68]

The Canadian Environmental Assessment Agency (CEAA), suggests a simple definition

> *. . . cumulative effects are changes to the environment that are caused by an action in combination with other past, present, and future human actions* (p.262).[68]

The Great Barrier Reef Outlook Report 2014 identifies the analysis of cumulative effects as taking into account the

> . . . *direct, indirect and consequential impacts and the incremental and compounding effects of these threats over time, including past, present and reasonably foreseeable future pressures* (p.260). [15]

All these definitions separate human effects contributing to cumulative impacts from natural effects and variability. Each of the definitions has similar temporal and incremental considerations; some include concepts of the broader environment (ecological and social), and consider both positive and negative effects from an activity or action.

The implementation of cumulative impact assessment and management has been progressively refined across multiple applications since the 1970s, but the concept itself has evolved little since its earliest description. From Gunn and Noble's paper on integrating cumulative impact management into strategic management

> *One of the most basic challenges to assessing cumulative effects in a strategic context concerns the level of understanding and agreement on the nature and definition of a 'cumulative' environmental effect (p.156).* [69]

Duinker et al. summarise the evolution of understanding of cumulative impacts in their recent review of progress in scientific developments associated with cumulative environmental assessment (p.42) [70]:

- Many practitioners have a weak conception of cumulative effects.
- Present use of cumulative effect definition reflects earlier published definitions of cumulative effect, which are now considered weak.
- There is not a universally accepted definition of cumulative effect.

They suggest a way forward may be to elaborate strong principles and protocols for cumulative impacts assessment and management, rather than try to capture the direction, diversity of understanding and management of cumulative impacts under one definition.[70] Using this approach, the development of policies to drive improved management of cumulative impacts on the Great Barrier Reef would need to consider:

- the difference between individual verses cumulative impacts and effects
- what constitutes a cumulative impact assessment, and
- what is the scale and scope of cumulative impact management.

Concepts critical to effective cumulative impact management

Valued Ecosystem Component (VEC)

While the literature recognises that cumulative impact assessment and management is based on principles and procedures for EIA, what is different is the focus on the Valued Ecosystem Component

(VEC) as the unit of analysis that experiences cumulative impacts. Effective cumulative impact assessment and management requires an understanding of the condition and trend of relevant VECs for comparison against the scale, magnitude and location of impacts likely to be associated with proposed changes to the environment. [78]

Thresholds and baselines

The International Finance Corporation highlights the critical role of establishing and monitoring thresholds of relevant receptors or indicators, with the significance of the cumulative impacts judged in the context of thresholds or limits of acceptable change[78].

The concept of basing cumulative impact assessment and management on valued ecosystem components continues into developing and using appropriate thresholds for key VECs. However, *acceptable threshold levels for valued ecosystem components rarely exist for local scale assessment, and may often be seen as an afterthought rather than focusing on valued ecosystem components as a key aspect of the assessment*[78].

Understanding and applying thresholds analysis is challenging because natural baselines are increasingly subject to major perturbations such as climate change induced events forcing consideration of *What are likely to be the adverse impacts of natural events, such as groundwater movement, storms and floods, when combined with the products of the action, the disposal of wastes from the action and the changes caused by the action*[73].

The baseline used by the Great Barrier Reef Outlook Report and the strategic assessment is the condition and trend of values and ecosystem processes at the time of World Heritage listing in 1981 – unless there had been improvement in the period to 2008 – when the first Outlook Report was being drafted.

Vulnerability, Resilience and Adaptive Capacity

> *Vulnerability is defined as the outcome of exposures (pressures), sensitivity and adaptive capacity . . . and is broadly defined as the capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same function, structure, identity and feedback. (p. 16-17)* [71]

The terms identified by Johnson et al. for social resilience draw on similar terminology for ecosystems, so are applicable across social and ecological dimensions of the Great Barrier Reef.[72] In identifying an integrative definition for vulnerability

> *. . . vulnerability is a function of exposure (the risk of experiencing a hazardous event) and coping ability (which they equate with social vulnerability), that is, in turn, a function of resistance (ability to absorb impacts and continue functioning) and resilience (ability to recover from losses after an impact). (p.747)* [72]

Johnson et al. identified the following for resilience:

> *. . . the potential of a system to absorb change and remain in a functioning state including the ability to reorganise itself following change.(p.748)* [72]

Resilience thinking provides a focus on what can be done to enhance the system's intrinsic ability to cope with exposure and to recover (or reorganise) faster between disturbances (high adaptive capacity), thereby reducing the vulnerability of the ecosystem and dependent societies. (p.17) [71]

Consequently vulnerability has a non-linear relationship with resilience.

Resilience includes the ability to resist (ability to absorb impacts and continue functioning), recover (or reorganise), or build capacity for learning and adaptation between disturbances (**adaptive capacity**), reducing the vulnerability of the ecosystem and dependent societies.

Resilience theory

Halpern et al. state *Resilience theory provides some insight into why and how these interactions are so important. The resilience perspective emphasizes that ecosystems (as well as related social systems) are characterized by complex dynamics, multiple thresholds, uncertainty, and surprise. Systems affected by a single activity may be able to absorb a disturbance by an additional activity, but be vulnerable to that same level of additional activity if the system was initially affected by multiple threats. For example, coral reefs in Australia have been shown to recover from the physical damage caused by recurrent cyclones, while Jamaican reefs subject to similar physical damage from repeated hurricanes have not yet recovered, in part because of the additional stresses posed by overfishing of herbivores and outbreaks of disease. Essentially, thresholds exist beyond which ecosystems cease to maintain their original functions, and these thresholds can be exceeded either through interactive effects or the cumulative impacts of multiple stressors. A convergence of natural disturbances can push systems past such thresholds, but it is much more likely to occur with the addition of stress brought on by human activities. (p.207)* [74]

Adaptive capacity is the capability of a system to modify or change its characteristics or behaviour to cope better with actual or anticipated pressures or stresses. [72]

Marshall et al. use a modification of the vulnerability model commonly used by the Intergovernmental Panel on Climate Change to allow for assessments of sensitivity and adaptive capacity to be undertaken for both social and ecological subsystems (**Figure 2**). In the diagram, 'ecological vulnerability' becomes 'exposure' for the social subsystem. Social sensitivity is the extent to which the social system depends on the resource. Metrics that estimate ecological exposure, sensitivity, and adaptive capacity include the magnitude of the physical change (Exposure), life history variables for the species in question, including ecological thresholds (Sensitivity), and the magnitude of stressors (Adaptive Capacity).

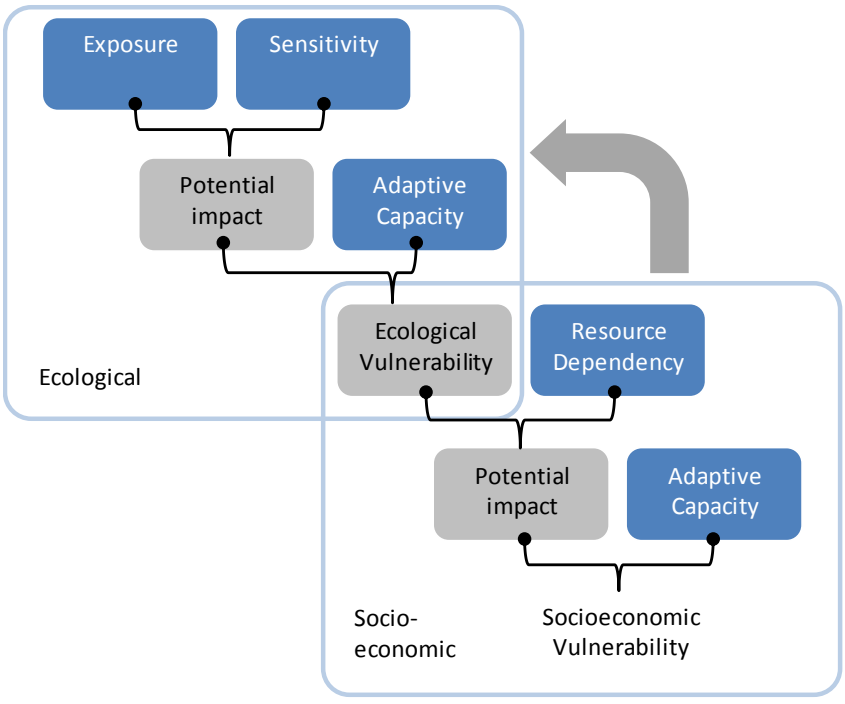

Figure 2 - A conceptual framework for assessing vulnerability to climate change in climate-sensitive socio-ecological systems. The co-dependency of ecological and socio-economic subsystems means that their vulnerabilities are intrinsically linked. The ecological vulnerability enters the socio-economic sub-model as the equivalent of ecological exposure.

Systems thinking

Concepts and definitions related to cumulative impact assessment and management highlight the need to take a 'systems' (social, ecological, economic etc.) approach, rather than focusing on just individual transactions, to assess cumulative impacts and implementing effective management measures. Effective cumulative impact assessment and management requires an increase in scientific understanding of complex ecosystems characterised by multiple stressors. [78]

In Gunn and Noble's discussion on integrating strategic and project-based cumulative impact assessment, they suggest systems thinking needs to be built into the foundation of project-based impact assessment to enable this level of assessment on individual values to relate to strategic assessment of cumulative impacts and effects. Similarly, strategic level assessment must take into account local trends and project interactions, and relate these to regional, national and international issues. [69]

Canter et al.'s list of fundamental consideration for strategic cumulative impact assessment (refer to page 18 of this report) constitutes the aspects needed to be considered in a systems context *(p.265).*[78]

Scale

Understanding the appropriate scale for cumulative impact assessment and management is one aspect that differentiates cumulative impact management from conventional EIA. Cumulative impact assessment and management must specifically identify the spatial scale and temporal scale in which the pressures, impacts and effects are occurring. Both project-based and regional or strategic assessment of impacts may be required to manage the zone of influence of the pressure, impact or effect.

Gunn and Noble in their discussion about more strategic approaches to cumulative impacts assessment and management suggest

> *there is a need to develop an understanding of when aggregation tells us something important about the effects being assessed, and when it obscures and potentially masks individual stressors that deserve detailed attention . . . scale does matter – particularly when aggregating and interpreting the significance of cumulative effects.(p.157)* [69]

This builds on Noble's earlier analysis regarding scale:

> *A major challenge in adopting such an effects-based approach is that 'as the potential scale increases, some local issues (e.g. noise, townscape) are likely to fall out and others (e.g. climate change, biodiversity) are likely to become more important'. . . if broad regional and strategic analysis are to inform the scope of downscale project-based assessment, then localised point source problems should not be overlooked. (p.88)* [76]

The main point is the assessment should focus on impacts on the VEC, whether it is at the local or region scale. Cumulative impact assessment and management provides greater range of opportunities for mitigating point source impacts on affected VECs, while recognising the range and scale of the various impacts affecting the VEC (such as that described in **Text box 1**). This translates to considerations for good cumulative impact assessment and management practice of [76]:

- recognising the scale at which effects are occurring
- local impacts need to be recognised, and must not be lost in the background of larger scale impacts that may mask other effects
- assessing cumulative impacts at a regional scale may provide a broader range of opportunities to mitigate impacts
- iImpacts should be assessed in relation to the impact on VECs
- assessment and management of impacts should be outcome focused against the relevant VECs.

The following sections will expand on these and explore potential principles for managing cumulative impacts on the Great Barrier Reef.

Effective cumulative impact assessment and management

Duinker et al.'s analysis demonstrates the practice of cumulative impact assessment (referred to by Duinker et al. as Cumulative Effects Assessment – CEA) is based on the protocols of EIA. *In essence CEA can be seen as EIA done right*. *CEA merely presents additional complexity to most of the steps in scientifically competent EIA.* [70]

Canter and Ross agree when they state

> *Based upon the review of various cumulative impacts assessment and management informational sources, it can be concluded that many of the current and developing methods and tools are similar to those used for EIA practice. The primary difference is related to the need to address other actions and their contributions to the collective effects on specific VECs.* [78]

Along with the definitions in use for cumulative impact assessment and management, Connelly et al. notes that internationally, guidance on cumulative effects assessment is also consistent, and is effectively just an extension of environmental impact assessment processes. Identified steps include (p.454) [68]:

- *scoping to identify the key issues*
- *identifying spatial (the regional study area) and temporal (past and future activities) boundaries in order to identify other future activities that may also affect the valued ecosystem components*
- *collecting baseline data and analyzing the effects on each valued ecosystem component;*
- *determining the significance of those effects after mitigation; and*
- *identifying follow up and monitoring requirements.*

Since 2010 the Australian mining industry has been documenting approaches to incorporate cumulative impacts in decision-making processes. The Centre for Social Responsibility in Mining and Centre for Water in the Minerals Industry, Sustainable Minerals Institute, University of Queensland released Cumulative Impacts, A Good Practice Guide for the Australian Coal Mining Industry in 2010 [79]. In 2015, the Minerals Council of Australia released their Cumulative Environmental Impact Assessment Industry Guide. These guides highlight additional considerations in project-based EIA assessments to incorporate cumulative impacts and opportunities for more strategic approaches. Of particular focus is clearly describing and delineating what past, present and future issues and aspects should be considered in project-level impact assessment and strategic assessment [80].

Steps for effective cumulative impact assessment and management

Canter and Ross promote a six step process for cumulative effects assessment and management [78]:

> Step 1: Identify VECs and the incremental direct and indirect effects of the proposed project, policy, plan or program, on valued ecosystem components within the projects location.
>
> Step 2: Identify other past, present, and reasonably foreseeable future actions that could contribute to cumulative effects and identify appropriate spatial and temporal study boundaries for each VEC (such as a historical reference point of condition).
>
> Step 3: Assemble indicator information, and describe and assess past, present and future conditions and trend and thresholds of significance.
>
> Step 4: 'Connect' the proposed project (or plan, program or policy) and other actions in the cumulative impact assessment and management study area to the selected VECs and their indicators and consider aggregation of effects.
>
> Step 5: Assess the significance of the cumulative effects on each VEC over the relevant spatial and temporal study boundaries.

> Step 6: For VECs or their indicators that are expected to be subject to negative incremental impacts from the proposed project and for which the cumulative effects are significant, develop appropriate action or activity-specific 'mitigation measures' for such impacts. Uncertainty can also be factored in by including monitoring and applying adaptive management.

Canter's approach is 'fit-for-purpose' focusing on VECs while making assumptions that effects and scale have been dealt with adequately. Adaptive Strategies lists similar considerations for effective cumulative impact assessment in the Australian mining industry context [80].

In addition to Canter's focus on VECs, Halpern et al. expand the concept to incorporate ecosystem services by considering

> *clear measures of the environmental impacts of activities on ecosystem services - loss of seafood production, water filtration capacity, sediment capture, storm barriers, etc. - must be made and the cumulative consequences of different activities on these services assessed. Such a shift in focus, however, will require explicit consideration of trade-offs among the services supplied by an ecosystem. (p.205)* [74]

Project-based cumulative impact assessment

Understanding of cumulative impacts at the project scale is important for managing cumulative impacts within the landscape. However, much of the literature discusses the many issues associated with translating between project-level cumulative impact assessment and management to strategic level impact assessment and management, summarised in the following points [68,69,75,76,78,70]:

> Presently, project-based impact assessments
> - are widely used for assessing cumulative impacts
> - are critical in identifying, assessing and predicting impact on VECs and mitigating individual impacts associated with the proposed activity
> - can contribute to assessing the effect of impacts accumulating or interacting with each other
> - use monitoring in identifying and describing the relative contributions of the project to the total cumulative effects on values and for identifying effective management responses when environmental thresholds are exceeded.

Best practice requires, at a minimum, project proponents to assess whether their development may contribute to cumulative impacts and whether cumulative impacts will affect the future condition of values.

In Australia, consideration of cumulative impacts in project-based assessments has been tested in the Federal Court ruling in *Minister for the Environment and Heritage v Queensland Conservation Council* (the Nathan Dam case) finding

> *. . . that the Minister of the Environment must give the widest possible consideration to any project under the Act, having regard to the sensitivity, value and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts, including its 'whole, cumulated and continuing effect'.(p.454)* [73]

McGrath considers the key principle to emerge from the Nathan Dam case is the impacts of an action must include consideration of direct and indirect effects, including third party impacts. [73] Using the learnings from the Nathan Dam case, McGrath lists the following questions that could help in determining the direct, indirect and cumulative impacts from an action (p.7) [73]:

- Upstream impacts - *What are likely to be the adverse impacts of supplying the raw materials and manufactured products needed to carry out the action?*
- On-site impacts - *What are likely to be the adverse impacts to the site at which the action will take place and the surrounding area?*
- Downstream impacts - *What are likely to be the adverse impacts of the use of the products of the action, the disposal of wastes from the action and the changes caused by the action?*

- Third party impacts - *What are likely to be the adverse impacts of third parties who use the products of the action and the changes caused by the action?*
- Cumulative impacts - *What are likely to be the adverse impacts of the action when combined with the impacts of other (related and unrelated) actions?*
- Baseline changes - *What are likely to be the adverse impacts of natural events, such as groundwater movement, storms and floods, when combined with the products of the action, the disposal of wastes from the action and the changes caused by the action?*

McGrath concludes the question becomes whether, cumulatively, the direct and indirect adverse impacts of an action have, will have or are likely to have a significant impact.

Many limitations of project-based cumulative impact assessment are obvious – including understanding and using appropriate scale(s) for assessment and effective management, and accessing scientifically robust baselines for VECs[79,80] .

In addition, the literature suggests project-based cumulative impact assessment does not effectively mitigate against declining trends caused by cumulative impacts. This is due to the present limited ability at the project level to deal with broad, interrelated issues contributing to ecosystem health, such as climate change and biodiversity loss.

Strategic assessment of cumulative impacts

Strategic-level cumulative impact assessment and management has the ability and scope to consider the interactions between many environmental stressors and drivers of landscape change, including population, economy, and cultural values, as well as natural environmental processes [69]. The recent strategic assessment of the Great Barrier Reef can be considered a strategic level cumulative impact assessment, discussing the effects of impacts on the Great Barrier Reef, the key drivers of impacts on condition and potential management measures at various scales that can be implemented within the Marine Park. **Appendix 1** lists 10 principles for managing environmental impacts within the Great Barrier Reef Region, are all influenced by cumulative effects.

Gunn and Noble's summary description of SEA effectively encapsulates many of the elements discussed below for effective SEA, where SEA provides a

> *. . . planning-type framework and decision-making context necessary within which cumulative effects may be addressed at a broader, comprehensive and future-based context. Under this model, the focus of CEA shifts away from the individual project and its localised stressors to allow questions of a broader nature related to desired outcomes, alternative development paths, ecological thresholds and synergistic effects. (p.155)* [69]*. . . [and] . . . When SEA is working effectively, knowledge and cumulative effects, including standards and thresholds, should . . . trickle down to the project level so as to avoid potentially adverse cumulative environmental change (p.159).* [69]

Noble and Canter et al. identify and cite more 'holistic' principles to underpin good practice for strategic cumulative impact assessment, and begin to frame the changes required in underlying strategic cumulative impact management objectives (p.81 and p.267) [76,78]:

- valued ecosystem component-based perspectives used in planning and conducting cumulative impact assessment studies
- better integration of socio-economic and cultural values as part of the assessment process
- use of multiple assessment scales, including a coarse or landscape scale as the basis for ecological assessment
- consideration of the cumulative ecological impacts of human activities to date as the basis for considering the type and extent of future activities with impact assessments using scenario planning
- using tools for project-based impact assessment that effectively communicate with strategic cumulative impact assessment
- minimising human footprint in the short term, while focusing also on emerging techniques for longer-term solutions
- protecting sensitive areas from development, including areas of cultural significance, and restoration of already disturbed areas to their original plant communities

- facilitating short and long-term monitoring of human impacts and restoration areas based on clear objectives, targets, and early warning indicators of undesirable change
- sustainability is used as a tool for describing the significance of cumulative effects
- data, information and learnings are publicly available and shared
- adaptive management is used.

Decision support tools

Using models, decision support tools and scenario analyses are useful perspectives to focus attention on the trajectory of critical VECs and test options in a systems context. Noble cites the suggested approach by Therivel and Ross for dealing with complex future scenarios:

> *. . . strategic and regional approaches to CEA are likely to benefit from more complex causal chains or modelling approaches.*
>
> *. . . an integrative and highly structured spatial analytical model capable of integrating biodiversity, focal species, land use and climate data and, furthermore, interpolating that data across space and time for each scenario under a range of VEC objectives and targets – the results of which could then be fed to economic and social impact assessment processes. This structured framework and spatial analytical model enables methodical identification of scenario choice sets; supported explicit analysis of trade-offs scenarios to arrive at a 'satisficing' solution; could be repeated under alternative scenarios, at different spatial scales, and for different objectives and targets; and provided quality assurance that the assessment was derived based on an explicit set of decision rules . . .* (p.88) [76]

Gunn and Noble consolidate these concepts in putting forward a proposed path for integrating project-based impact assessment into SEA by [69]:

- identifying ecosystem limits, targets, and indicators
- accepting uncertainty in impact assessment practice
- adopting an explicitly adaptive approach, and
- focusing less on impact prediction and predictive science and focusing more on scenario analysis and future possibilities.

Anthony et al. developed a framework for cumulative impact and structured decision-making for the GBRWHA that relies on scenario assessment using probability analysis to inform cumulative impact consequences in decision-making. For this framework to be effective, Anthony et al. noted that

> *. . . the framework will be dependent upon clear definition of management objectives, refinement of the qualitative modes, and the availability of key datasets and integration with current decision-making processes*. (p.8) [71]

The position taken by the authors in using the framework is that trade-offs among objectives for management of VECs can only be considered once effort has been made to avoid and mitigate impacts on individual VECs. (p.13) [71]

The framework for cumulative impact and structured decision-making has six steps (p. 14-15) [71]:

1. Defining the environmental problem and the management objectives for valued ecosystem components. This step considers the cumulative impact scenarios without management interventions, and the acceptability of risk and impact on valued ecosystem components. This is followed by consideration of alternatives for risk mitigation, and characterisation of expected consequences and trade-offs.
2. Use of qualitative and probabilistic ecosystem models to show links between drivers, activities, pressures and impacts on value ecosystem components from different spatial scales, sensitivity analysis and make predictions about change under varying impacts and intervention scenarios. Results of monitoring programs can be incorporated into this step.
3. Qualitative assessment of the direction of change in drivers, activities, pressures and values, and an estimate of risk to affected values (exposure spatially identified as the zone of influence).

4. Identify options for management interventions and mitigation that could reduce risk across the identified suite of drivers, activities, pressures, impacts and spatial scale. A cost benefit analysis could be conducted at this stage.
5. Identify alternatives based on scenarios and options and analyse the consequence of trade-offs between objectives.
6. Communicate results and identify monitoring needs to enable adaptive management.

In the context of the GBRWHA and Marine Park, and noted by the authors, trade-offs will likely be required for other values and objectives when ecosystem values are at risk, or the consequence of an action reduces the long-term viability of an ecosystem. (p.15) [71]

Cumulative impact considerations for the Great Barrier Reef

In 2012, the Authority and the Queensland Government conducted a comprehensive strategic assessment of the GBRWHA and adjacent coastal zone to analyse the impacts affecting the Great Barrier Reef. The assessment considered cumulative impacts — multiple pressures from multiple sources — and how these affect the marine environment in the short and long term.[14]

Key aspects of the Great Barrier Reef Region Strategic Assessment included:

- examination of the drivers of change, including climate change, economic growth, population growth, technological developments and societal attitudes
- assessment of impacts of activities undertaken within the GBRWHA, and those conducted beyond its boundaries
- assessment of attributes and ecosystem processes which underpin the functioning of the GBRWHA and its rich mosaic of values, and the cumulative effects of impacts on their state
- an assessment of management effectiveness and risk.

The comprehensive strategic assessment used a modified 'DPSIR' (Driver, Pressure, State, Impact and Response) framework to assist in understanding the cause-and-effect relationships between pressures arising from drivers and activities and their impacts on the Reef's ecological system and human dimensions. The DPSIR framework is used internationally to understand and manage cumulative impacts and underpins the development of the Reef 2050 Plan's Integrated Monitoring, Modelling and Reporting Program to drive adaptive management (**Figure 3**).

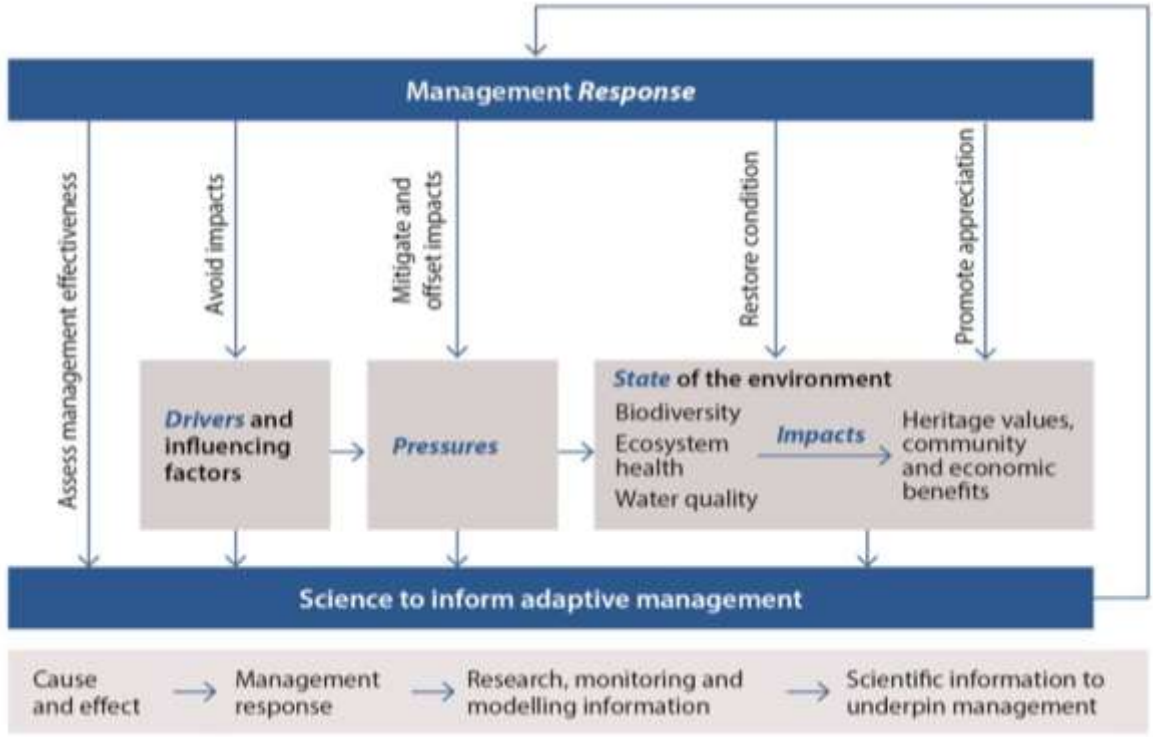

Figure 3 - Reef 2050 Plan adaptive management framework. The Reef 2050 Plan and the Reef 2050 Integrated Monitoring and Reporting Program provide an adaptive management framework to assess progress towards outcomes and targets, and reduce impacts, using the Driver Pressure State Impact Response framework.

The Great Barrier Reef Region Strategic Assessment identified that interventions that target ***D****rivers* and ***P****ressures* are the most effective form of cumulative impact management as they enable ***I****mpacts* to be avoided. Management ***R****esponses* that reduce ***I****mpacts* through mitigation are useful to keep the environmental effects of activities above known standards and thresholds for environmental health. Restoration, focused on improving the ***S****tate* of the value, is least effective and often most costly

The Strategic Assessment also identified a suite of attributes and ecosystem processes, the ***S***tate of which are affected by the individual and cumulative effects of ***D***rivers, ***P***ressures and ***I***mpacts together with the effectiveness of management ***R***esponses. It recognised that the condition of biodiversity, geomorphological and heritage values determined the quality of the cultural, social and economic value and collectively the Reef's outstanding universal value. The objective of the overall management ***R****esponse* is attainment of the desired ***S****tate* (outcome) for the condition and trend of the Reef's values (**Figure 3**).

The Strategic Assessment's comprehensive and systematic analysis of drivers, pressures and impacts together with the analysis of the Reef's values and ecosystem processes, provides a sound basis for operationalising the management of cumulative impacts within a range of tools and approaches.

The Great Barrier Reef Marine Park Authority's five-yearly Outlook Report, which assesses the State of the Reef's values and risks (see below) to the Reef's outlook, provides an effective means to evaluate the effectiveness of policy measures to reduce cumulative impacts.

Risk

Management of the Great Barrier Reef, including establishing future investment priorities, focuses on addressing impacts predicted to be of highest risk to the Reef's values, individual and collectively.[15] The Great Barrier Reef Outlook Report systematically assesses the risks to the Reef's values every five years and is one of the best examples of where the risk from cumulative threats is embedded in an assessment approach.

The Great Barrier Reef Region Strategic Assessment and 2014 Outlook Report used the Australian Standard for Risk Assessment (AS/NZS 31000:2009) (**Figure 4**). [13] Highest risk areas, which included the need to improve management of cumulative impacts, were then prioritised for management action.

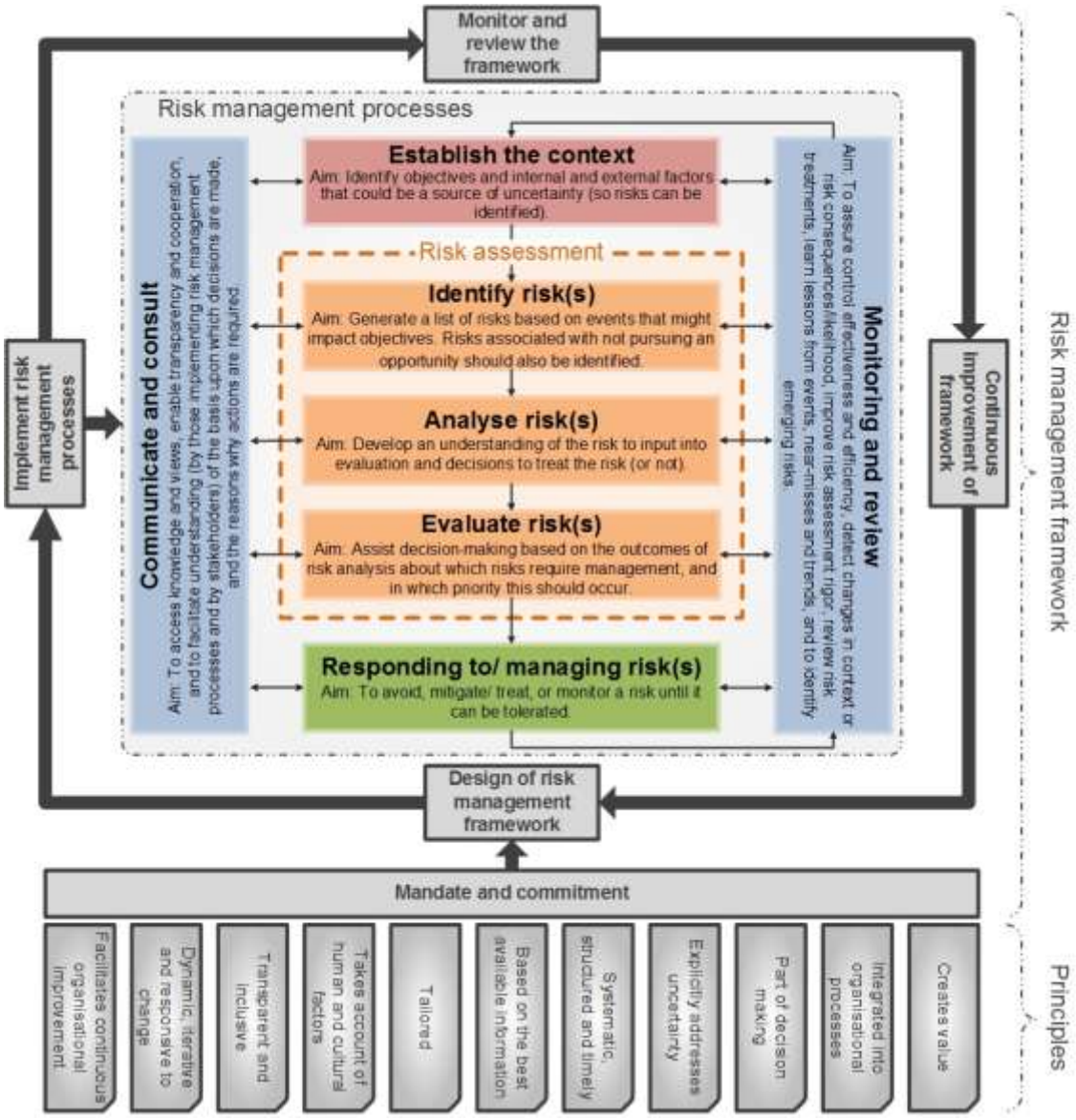

Figure 4 – The Great Barrier Reef Region Strategic Assessment adopted the Australian Standard for Risk Assessment to assess future risks to the Great Barrier Reef (AS/NZS ISO 31000:2009)

When identifying and analysing risks the following factors should be considered: [90,91]

- time lags which may exist between cause and effect
- diversity, complexity and connectivity between structures, components and processes, including cumulative or synergistic effects
- effects that are prone to change if the context changes
- natural variation, where the likelihood of an outcome may depend on a variety of factors and the vulnerability of components of a system
- uncertainties likely to have a material impact on decision making, including reliability of data.

Cumulative risk is where the risk is expressed in terms of likely effect of uncertainty on objectives for VECs. Risk is assessed as the likelihood that a particular consequence will be experienced. Cumulative past, present and reasonably foreseeable future effects on VECs will influence the assessment of likelihood or consequence, and be recognised through an assessment of the magnitude of the effect, the baseline condition and trend in condition of values, relevant condition thresholds and desired state objectives.

To effectively manage cumulative impacts, risk assessment processes, such as those used in Great Barrier Reef Region Strategic Assessment and Outlook Reporting should be integrated into planning and assessment decision making processes at a range of scales.

This literature review, together with the outcomes from the Great Barrier Region Strategic Assessment, suggests the following overarching principles to guide cumulative impact assessment and management for the Great Barrier Reef:

Proposed principles for cumulative impact management

The ultimate goal for management of the GBRWHA in contemporary literature is to be found in the vision for the Reef 2050 Plan and reads as follows:

> *To ensure the Great Barrier Reef continues to improve on its Outstanding Universal Value every decade between now and 2050 to be a natural wonder for each successive generation to come. (p.iii)* [24]

The principles that are adopted for the cumulative impact management policy should necessarily reflect and contribute to the achievement of that goal. The following key principles described in **Table 1** have been derived, the 2014 Great Barrier Reef comprehensive strategic assessment documents [13,14,47,48], the Reef 2050 Plan [24] and best practice programs and examples available in the international literature outlined in this review.

Table 1 - Proposed principles for managing cumulative impacts

Proposed cumulative impact management principles	Discussion
Adoption of the Driver, Pressure, State, Impact, Response framework to understand causal relationships between the multiple impacts on the Great Barrier Reef and the effectiveness of management responses Effective cumulative impact management requires a systems approach to provide an understanding of the cause-and-effect relationships of factors influencing the Great Barrier Reef system and inform the implementation of appropriate management measures.	Assessing cumulative impacts in large, interconnected systems such as the Great Barrier Reef is complex. The DPSIR framework is used internationally to understand linkages between drivers, activities and pressures on the state of the environment and the benefits it provides. This framework was used in the Great Barrier Reef Region Strategic Assessment Report and Great Barrier Reef Outlook Report 2014 and will provide the foundation for the Reef 2050 Integrated Monitoring, Modelling and Reporting Program.

Proposed cumulative impact management principles	Discussion
Systematic and consistent approach to cumulative impact assessment terminology and methods The assessment of cumulative impacts should be based on a comprehensive and systematic approach to: • identifying affected values and processes, including their current status and trend • identifying drivers, pressures and impacts operating across the Great Barrier Reef, including direct, indirect and consequential impacts • considering the spatial and temporal scales (zones of influence) at which direct, indirect and consequential impacts are operating • using methods, including modelling, to assess cumulative impacts, including the cause-and-effect relationship of relevant multiple and compounding impacts on values • applying appropriate standards and guidelines and assessing risk • monitoring standards, data management protocols and review.	Implementation of effective cumulative impact management is hindered by inconsistent use of terminology and methods. The strategic assessment of the Great Barrier Reef Region systematically identified drivers, pressures and impacts affecting the Reef's environment. These are reported on five-yearly in the Great Barrier Reef Outlook Report. Adoption of terminology and methods consistent with these reports is fundamental to understanding and reporting on cumulative impacts at a range of scales.
Avoiding impacts The highest priority is to avoid impacts. This includes consideration of prudent and feasible alternatives to proposed actions[1], projects, plans and programs, as well as the alternative of not carrying out the proposed action, project, plan or program.	The avoid-mitigate-offset hierarchy is widely used across Australian and Queensland government agencies. Avoiding impacts is a critical step in the decision-making process, and is widely recognised as the most cost effective measure for managing impacts on values and processes.
Scale Assessment of cumulative impacts should clearly specify the spatial and temporal scales in which the drivers, pressures and impacts are affecting Reef values and processes.	The 'zone of influence' is used to describe the scale of an action, project, plan or program's impact on the values and processes. Project-based, regional or strategic assessment of cumulative impacts may be required to manage the zone of influence of the driver or pressure.

[1] Actions and activities are used describe projects and project parts under the EPBC Act and GBRMP Act. For this policy actions are used, assuming activities comprise action, or a subset of an action.

Proposed cumulative impact management principles	Discussion
Outcome-focused Results from cumulative impact assessments should be compared with appropriate standards and guidelines, including desired outcomes for the state of the environment to inform the acceptability of the proposed action. This should include consideration of the principles of ecologically sustainable use.	The adoption of an outcomes-based approach is a key recommendation of the comprehensive strategic assessment and underpins the delivery of the Reef 2050 Plan. Outcomes for the state of the Reef's environment are reported every five years through the Great Barrier Reef Outlook Report.
Information sources Decision-making should be based on the best available information including where available, historical information, monitoring data, Traditional Owner and stakeholder knowledge, observation, modelling, forecasts and expert judgement. Information should also specify possible limitations of data and modelling, divergence in expert judgement, or uncertainty, availability, quality, quantity and ongoing relevance of information.	The basic premise is that the best available information from the most appropriate sources is used, and that limitations in the use of information are recognised and described.
Assessing risk Risk management processes should be integrated into cumulative impact management decision-making and demonstrate consistency with the Australian/New Zealand/International Standard, AS/NZS ISO 31000:2009 Risk management - Principles and guidelines (published by Standards Australia and available for purchase through SAI Global http://infostore.saiglobal.com/store/).	When identifying and analysing risks the following factors should be considered: • time lags which may exist between cause and effect, and theories which may be uncertain • diversity, complexity and connectivity between structures, components and processes, including cumulative or synergistic effects • effects that are prone to change if the context changes • lack of reliable data • possibility of human error. The level of risk to the Great Barrier Reef from drivers, pressures and activities is reported on every five years through the Great Barrier Reef Outlook Report.
Transparency Decision-making and implementation should be supported by effective, transparent and accountable governance measures so relevant stakeholders have their views taken into account, where appropriate.	Methods of communicating information and consulting with relevant stakeholders should facilitate accurate and understandable exchanges of information, taking into account relevant information security requirements (such as privacy and confidentiality).

Proposed cumulative impact management principles	Discussion
Monitoring and review Monitoring and review should be integrated systematically into the cumulative impact management process to detect change, maintain understanding of cumulative impacts, and evaluate the effectiveness of management interventions.	The Reef 2050 Integrated Monitoring and Reporting Program is establishing standard protocols for information collection, storage, accessibility and reporting. Monitoring and review activities undertaken should be appropriate to the nature and level of risk.
Integrated approaches Cumulative impact management should be integrated into planning and assessment decision-making at all scales (strategic, tactical and operational) and applied proportionately to the nature and scale of likely impacts. Management interventions should be mapped explicitly to the DPSIR framework to reduce risk across drivers, pressures and impacts.	Cumulative impacts are best managed at the system scale. Management should be guided by assessment processes which use scenarios of alternative outcomes, and ideally are integrated in broader management tools, such as planning. Tools for project-based cumulative assessments need to communicate effectively with regional and strategic assessments. Decision support tools can assist to identify the most sustainable and effective option for managing cumulative impacts.
Adaptive management Cumulative impact management should be dynamic and adapt responsively to new information, changes in the state of the environment and emerging risks and drive continuous improvement.	The Reef 2050 Plan, together with the Reef 2050 Integrated Monitoring and Reporting Program, provide an adaptive management framework to assess progress towards outcomes and targets and reduce impacts. The results of targeted research, monitoring and modelling will be used to evaluate the Plan's performance and adapt management responses.

Net benefits

In order to meet Australia's international obligations to protect the Great Barrier Reef for future generations there is a need to restore and improve the condition of its values and ecosystem function. The focus of net benefits is to restore and enhance Great Barrier Reef values. While offsets are focused on addressing residual impacts associated with development actions under regulatory processes, net benefits are focused on delivering a broader range of actions which will restore or improve the condition of Great Barrier Reef values.

Mandate for a net benefit policy

The requirement for a net benefit policy for the GBRWHA evolved as a key action of the Great Barrier Reef Region Strategic Assessment to develop:

> *a net benefit policy to guide decision making and actions required to deliver an overall or 'net' improvement to ecosystem health and the condition of the Region's values. (p.iii)* [14]

This task was given further prominence in the Reef 2050 Plan for the GBRWHA as one of the four key principles in decision making of:

> *Delivering a net benefit to the ecosystem (p.35)* [24]

The Reef 2050 Plan commits to developing guidelines for assessing cumulative impact and a net benefit policy to guide future planning and development decisions. Many of the actions and targets in the Plan are aimed at reducing impacts to the Reef to ensure cumulative impacts are managed below threshold levels and ensure protection and transmission of the Reef's outstanding universal value. Two actions in particular spell out the requirement for this policy, and identify the agencies with primary responsibility for its development and implementation:

> *Ecosystem Health Action 8 - Develop a net benefit policy to restore ecosystem health, improve the condition of values and manage financial contributions to that recovery. (p.91)* [24]
>
> *Governance Action 14 - Develop, implement and maintain mechanisms and policies to enhance investment in delivering on-ground activities based on good science and evidence that support the Plan's outcomes and targets. These will contribute to a net benefit policy to ensure the Outstanding Universal Value and integrity of the Reef is maintained or enhanced. (p.102)* [24]

Definition of net benefit

Throughout the literature the terminology around the concept of net benefit is inconsistent. Similarly, interpretations are equally convoluted as they reflect the various origins of the concept. Relevant documents have been reviewed to provide a common definition and narrative for the net benefit policy for the GBRWHA.

The Authority has identified that the purpose of net benefits is to improve and enhance the condition of the Great Barrier Reef's values. While offsets are focused on a range of residual impacts associated with development actions, net benefits are focused on delivering actions (more broadly across planning and management decision-making) that will restore the Great Barrier Reef's values to a good condition.

The following section outlines the various interpretations around the concept of net benefits and indicates variances in the terminology throughout the literature.

Current interpretation and terminology

In most cases, net benefit theory and application in a natural resource management context has been limited to biodiversity. Given the broader remit of the Reef 2050 Plan with its seven themes from ecosystem health to community benefits, the GBRMP Act, the various legislative and policy instruments that provide the management framework for the GBRWHA, the definition of net benefit is

broader than just biodiversity. This is best described through the GBRMP Act and EPBC Act definition for the environment:

> *Ecosystems and their constituent parts, including people and communities, natural and physical resources; the qualities and characteristics of locations, places and areas, heritage values of places and the social, economic and cultural aspects of the above. (p.97)* [14]

The Business and Biodiversity Offsets Program (BBOP), which is an international collaboration of more than 75 organisations from government, business and civil society, is testing and developing best practice management of biodiversity and conservation banking worldwide. From the available literature they appear to have driven the theory, and more recently practice of offsetting for biodiversity, and have progressed the concept further to consider social and cultural considerations. The BBOP does not, however, delve into the concept of net benefit for the broader definition of environment as described under the GBRMP Act and EPBC Act. They do intiate some discussion around net gain, which may be interpreted as net benefit, but they do not develop the dialogue on this subject.

The BBOP goal of biodiversity offsets is to achieve no net loss and preferably a net gain of biodiversity on the ground with respect to species composition, habitat structure, ecosystem structure, ecosystem function and people's use and cultural values associated with biodiversity [1]. In this context they are providing the opportunity for net benefits (net gains), but only as a secondary priority to a no net loss objective. The BBOP also emphasises the 'no worse off' approach, which implies a neutral or improved state of identified measures.

The Belize Coastal Zone Management Authority et al. cite the International Finance Corporation Sustainability Framework performance standard 6 [25], noting that:

> *clients with an impact on natural habitat are required, where feasible, to demonstrate no net loss of biodiversity, and those affecting critical habitat are obliged to demonstrate net gains in biodiversity (p.3)* [26].

In the United States of America, biodiversity offsets were also known as compensatory mitigation under the *Clean Water Act 1977* [20], however no further reference to this terminology could be found in the reviewed literature.

In describing their framework for Net Environmental Benefit Analysis (NEBA), Efroymson et al. introduced their interpretation of net environmental benefit as being:

> *. . . the gains in the value of environmental services or other ecological properties attained by remediation or ecological restoration minus the value of adverse environmental effects caused by those actions.(p.315)* [27]

This interpretation adopts the very discrete concept as being solely related to environmental impact assessment. This has been the common theme amongst the general literature. Indeed the NEBA framework highlighted in numerous papers originated from, and continues to be related to, remediation following oil contamination.

The offsets framework for Belize recognised that in recent times offsetting has become more cognisant of the need to also consider broader environmental and social impacts and potential offsets [26]. This expansion of application is, however, not yet widespread in the literature. The focus remains on avoiding, minimising and offsetting protocols to attain a neutralisation or balance of impacts.

In 2011, the International Journal of Impact Assessment and Project Appraisal, collated an entire edition on *enhancement.* Joao et al. defined enhancement as

> *deliberate attempts taken in the design and subsequent phases of projects, policies, plans and programmes to ensure the success of a wider range of direct and indirect benefits that could possibly flow from the project or policy. (p171)*[85].

The Australian Government, through the EPBC Act Environmental Offsets Policy, has identified that the use of offsets to compensate for adverse impacts to heritage values is appropriate in some

circumstances [16]. It identifies that offsets for impacts on heritage values should improve the integrity and resilience of the heritage values involved. So while the BBOP definitions and principles relate to social and cultural aspects of any assessment, they still directly tie it to biodiversity, whereas the EPBC Act Offsets Policy at least identifies '*The use of offsets to compensate for adverse impacts to heritage values is appropriate in some circumstances'* as a stand-alone component (p.5) [16].

Theory of net benefits

It is clear from the literature that there has been limited development of the theory of net benefits and even less application or testing of the concept [1]. Globally, it appears that there has been general acceptance that some reflection of replacement value of the immediate impact has been the priority for governments, managers and most communities [20].

The IUCN Biodiversity Offsets Policy points out that the nature of legal tools used in the offset system will in part define the organisations and relevant stakeholders with responsibilities for enforcement and ensuring compliance [9]. As stated, this will 'in part' define how a net benefit policy may also be applied. In reality, to ensure net benefits are achieved, legal instruments, working in conjunction with voluntary codes of practice, implementation of best management practice, and community action, will all be necessary.

The simplest explanation of the theory of net benefits is evident in Belize [26], however, the authors in this case use the term net gain or net positive impact. In simple terms, a net gain means that biodiversity gains exceed a specific set of losses caused by any action or impact. This represents the most common approach to net benefit, that being a benefit to a particular characteristic, in this instance biodiversity. The authors do also highlight, however, the consideration of other context specific factors, such as

> *. . . the local biodiversity, human use and cultural values of biodiversity, background rates of loss, the ecological condition of potential offset sites, as well as legal, technical and socio-economic constraints on the kinds of offsets that can be developed (p.16)* [26].

Underpinning the development of no net loss and net benefit actions is the need to establish a benchmark against which outcomes can be monitored and reported. These will need to be ascertained through development and application of appropriate metrics and consultation with affected communities and, where appropriate, other stakeholders [26].

In describing *enhancement* Joao et. al indicated it was not just about strengthening probable benefits but broadening the scope of potential beneficiaries (**Figure 5**); going beyond what is the *probable* future to what is a *preferrable* future. The example they used was not only mitigating the biophysical impacts associated with building a road but also extending future uses of the new road for greater community connectivity (**Figure 5**).[85]

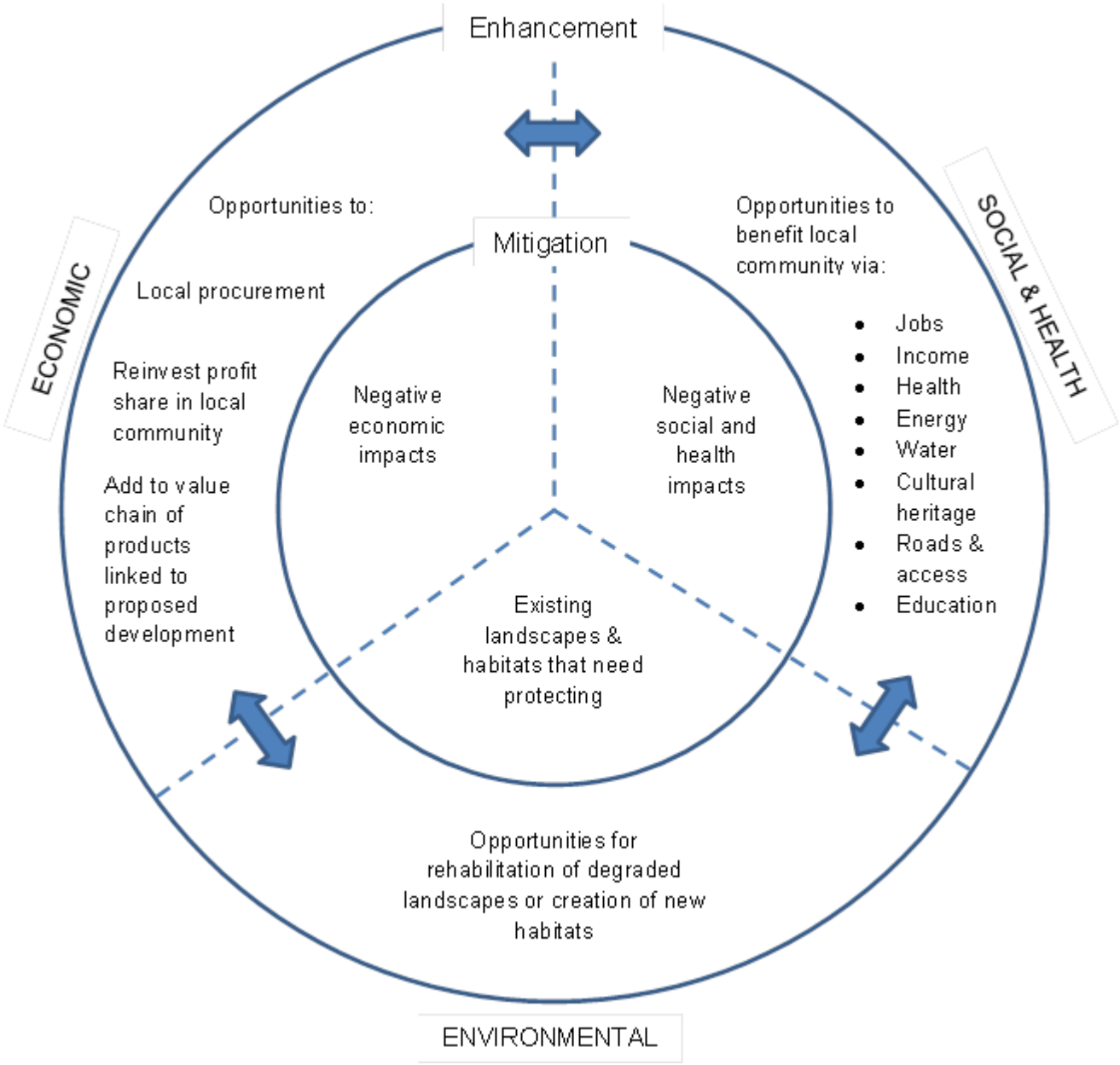

Figure 5. Enhancement as an extra layer to impact assessment. ***Note:*** **The arrows indicate that economic, social & health, and environmental impacts are interlinked. (Adapted from Joao et al., p.173 [85])**

Bos et al. in their paper on offsets for the GBRWHA, provided a conceptualisation (shown in **Figure 6**) that depicts the various components of net benefits from offsets as it relates to biodiversity [19]. This graphic is useful in understanding the relative components of the avoid, minimise, offset hierarchy and the simplicity (at least conceptually) of moving beyond this paradigm to a net benefit outcome. Rajvanshi et al. highlight three junctures to incorprorate enhancement measures[86]:

- proactively, by continually seeking opportunitues to improve and make a positive diference to the receiving environment through better design and/or implementation
- reactively, by going beyond no net loss offsets to achieve a net gain
- actively, through effective monitoring, evaluation and adaptive management.

The other key discussion by Bos et al. relates to the importance of a rigourous monitoring program, with appropriately long monitoring timeframes to help move towards stronger evidence-based decision making. Joao et al. discuss expanding conventional data collection beyond what is there to what could be there (potentialities or aspirations). Monitoring needs to move beyond compliance to reporting on any unintended consequences[85].

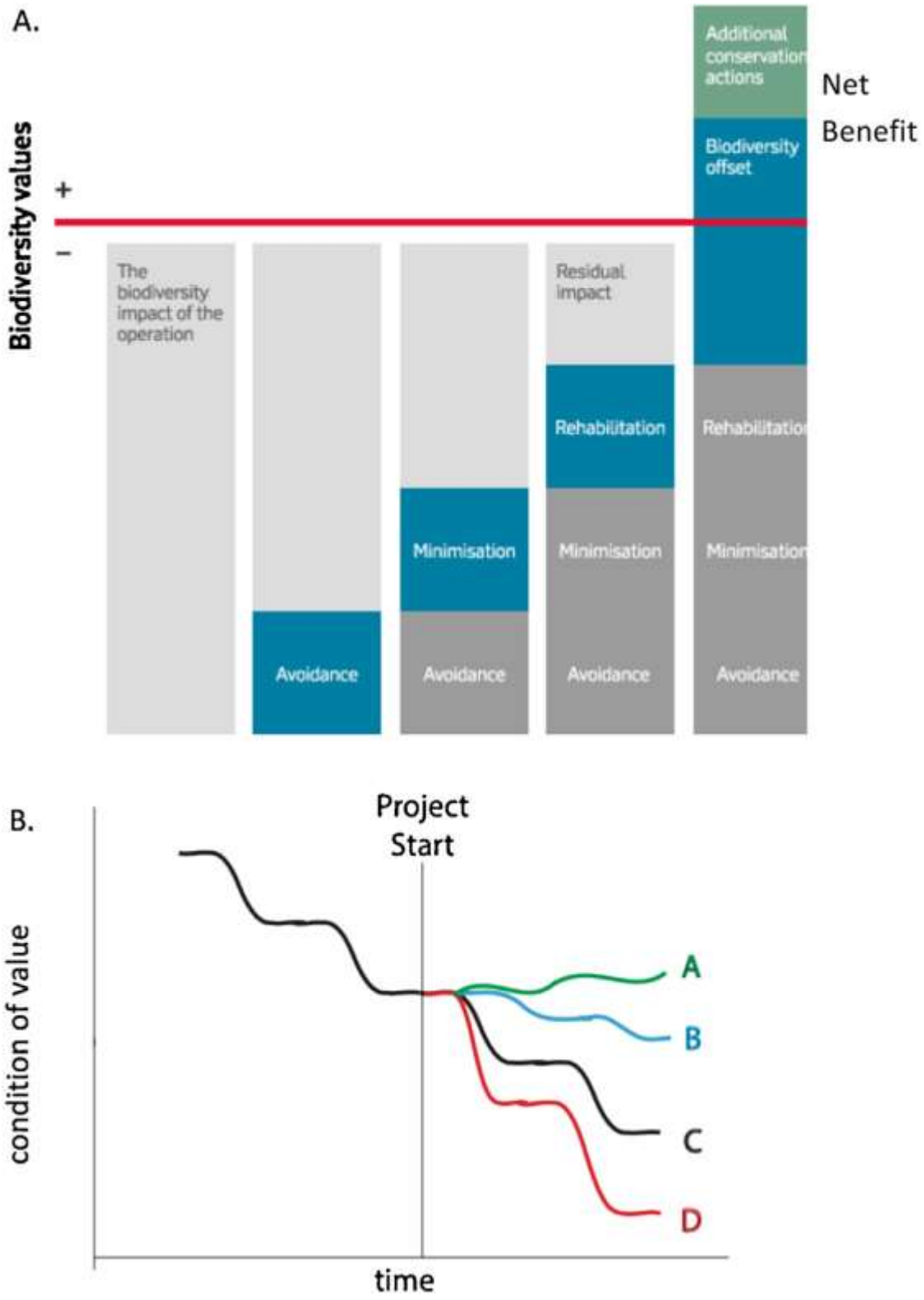

Figure 6 - Conceptualisations of net benefits from offsets that (A) are commonly used globally and (B) account for dynamic counterfactual baseline and variation in efficacy. In (B), line D represents a net loss; line C represents no net loss and lines A and B represent net benefit with an improving trend and a net benefit with declining trend, respectively [19].

Alternatively, Joao et al. argue that enhancement should not be seen as one of the mitigation stages but rather a separate but complementary stage, such as in using impact assessment to advance sustainability goals [85]. One of the main objectives of sustainable development regarding biodiversity and habitat loss, is the opportunity for environmental enhancement through positive impacts [86].

Direct and indirect benefits

The BBOP makes a distinction between direct use values, indirect use values and non-use values, again limited to biodiversity [1]. From an anthropogenic perspective, this distinction can also be applied to net benefits - there can be direct, indirect and non-use benefits [1]:

- Direct benefits can be benefits that provide or improve the value and or availability of a resource for production, consumption or use (in its broadest definition)
- Indirect benefits support and protect the resource and its functions and can be accrued (e.g. ecosystem services)
- Non-use benefits include intangible benefits derived from the existence of the resource and its services (e.g. spiritual beliefs, personal values).

Ecosystem services and supply

The natural resources provided by the earth's ecosystems serve as the building block upon which human well-being flows [29]. Ecosystems represent a complex and dynamic array of animals, plants and microbes along with non-living physical elements interacting as a functioning unit [30]. This gives rise to many benefits, known as ecosystem services, which are the benefits people obtain from naturally-functioning systems.

For decision making, Nicolette et al. argue that it is not necessary to quantify the entire suite of ecosystem services, only to understand:

> *(1) those services that will change, given an action and (2) the level to which those services will change in comparison to the baseline condition. (p.2155)* [29]

They go on to posit that the net change (positive or negative) can be used to determine the overall environmental sustainability and stewardship of an action, a process they refer to as Net Ecosystem Service Analysis (NESA) [29]. The overarching premise of this approach is that human well-being is directly related to changes in ecosystems and associated services. What it fails to interpret is that human well-being is not the only component the decision maker is required to, or should, take into consideration.

Rajvanshi et al. recognised improved ecosystem services as one of four possible outcomes from *enhancement* actions. The other complementary measures were better ecosystem management, improved protection, and enhancing areas for biodiversity conservation [86].

Wainger and Mazzotta identified that government agencies are seeking to quantify policy options in terms of ecosystem service benefits (outcomes) but conflicting definitions and ad hoc approaches to measuring these outcomes have created confusion regarding how to rigourously link ecological changes to change in human well-being [31]. In a similar way, direct correlative links between impact/action and outcome, both positive and negative, are rarely clear and unambiguous. More commonly the attribution of cause to effect are, at best, predictable but more commonly conceptual or perceptual. Increased data, information and knowledge of the processes of linkage in some cases are leading to a better understanding of likely incomes, but robust and rigorous testing is rarely undertaken and reported. As Carpenter et al. identify the challenges to implementing an ecosystem services framework for linkage and attribution of actions to impacts, although continuously evolving, remains incomplete [32]. This creates significant difficulty for GBRWHA decision makers as they must take into account the broader suite of components to fully consider their definition of environment that includes

> *Ecosystems and their constituent parts, including people and communities, natural and physical resources; the qualities and characteristics of locations, places and areas, heritage values of places and the social, economic and cultural aspects of the above.(p.97)* [14]

Liability and Compensation

The IUCN has identified compensation as a measure to recompense, make good or pay damages for loss of biodiversity caused by a project [9]. It further explains that compensation may achieve no net loss / net gain, but in other cases, compensation can involve reparation that falls short of achieving no net loss. Again, this process specifically relates only to biodiversity.

> *To be successful, offsets should compensate indigenous peoples, local communities and other local stakeholders for any residual impacts of the project on their biodiversity based livelihoods and amenity. (p.3)* [3]

In the United States of America, reparation for environmental damages has primarily been economic compensation. Quantifying economic damages and restoration measures for coral reefs has proven difficult and has largely been limited to specific incidents (e.g. ship groundings) in a defined spatial context. The major point of contention in these instances is in the measurement of the physical extent of the damages and the determination of the appropriate rate of compensation:

- Milon and Dodge provide a discussion of the technique known as Habitat Equivalency Analysis (HEA) [34] which can provide an alternative to direct economic measures. HEA combines biological and economic information to scale compensatory replacement projects for marine damage, with the conceptual basis of the HEA process centred on a 'replacement ratio concept'. This concept seeks equivalency but could easily be amended to support a net benefit assessment and determination
- Moilanen et al. posed the question, "How much compensation is enough?" In their research article they offered a framework for incorporating uncertainty and time discounting offset ratios for impacted habitat [35]. The substance of their framework follows the avoid-mitigate-offset approach and focuses on replacement value (termed fair offsets) rather than providing the opportunity for a net benefit. As with most other offset approaches, however, it would be a relatively straightforward adjustment to incorporate the precept of a net benefit outcome.

Practical examples and concepts

There are few examples evident in the literature that provide guidance to a net benefit policy as broadly-defined as that required for the GBRWHA. The most relevant examples include the following:

1. The best example to date appears to be contained within the BBOP[1], highlighting that many of the approaches described have not yet been robustly tested and may not be the most useful or appropriate approaches in some contexts. The BBOP has been thoroughly reported in numerous documents and is readily identified in the reference section of this document [1,2,3,4,5,6,7,8].
2. The Queensland Environmental Practice Reporter volume provides professional critique and commentary on net environmental gain (benefit) and offsetting in Queensland [36]. This same volume also included a report from the Environmental Law Roundtable of Australia and New Zealand and the Biodiversity Offsets Project, as well as a summary of the elements of an environmental offsets policy that included an environmental banking scheme for Queensland [36]. Key findings of this volume include a discursive chapter that addressed the measurement of net benefits of offsetting in Queensland. The discussion was supported with a case study that examined the Meridien Marinas Horizon Shores development in the far northern sector of the Gold Coast. The paper provides an overview of the methods and techniques by which environmental benefits may be obtained from the use of offsets, particularly through enhanced private sector involvement, and briefly outline the case for an environmental bank [36].
3. The South Australian Department of Environment, Water and Natural Resources and the Native Vegetation Council assess all applications to clear native vegetation in South Australia. Reportedly, in most situations when a clearance application is approved, conditions are attached to ensure that the clearance is offset by restoration work that provides a significant environmental benefit [39].
4. The Victorian Department of Sustainability and Environment has developed and implemented an Environmental Systems Modelling Platform (EnSym) to estimate the impact of actions on the landscape. This allows natural resource managers to understand and quantify the

environmental benefits of on-ground conservation and revegetation works. The EnSym Site Assessment Tool is designed to ensure the consistent and objective calculation of the change in environmental service expected as a result of management actions across a landscape. The tool has been used for ranking sites for environmental repair, assessing sites for grant programs, generating management plans, site monitoring, and program evaluation [40].

5. Another program that provides useful insight into net benefits is the Early Mitigation for Net Environmental Benefit part of the US National Cooperative Highway Research Program reported by Venner [37]. Even though the program relates specifically to highways, there is some learning within the report that could prove useful in the current GBRWHA situation. In particular, this report describes how early mitigation/conservation under section 404 of the United States *Clean Water Act* and *Endangered Species Act* had proven to be a powerful tool to provide net benefits for the environment [37]. It also provided greater predictability in the regulatory process and for conservation outcomes. Venner describes the limits of standard project-by-project approaches and common trade-offs with, and benefits of, pursuing earlier, integrated planning and programmatic conservation/mitigation measures [37]. Venner highlights how regulator-proponent partnerships are accomplishing better conservation outcomes, with less, and its acceptance in an era of tighter economic positions and increasing government attention to stewardship [37].

The absence of clear definitions and adequate biodiversity accounting frameworks and lack of evidence of actual effectiveness have been highlighted by Gardner as providing substantial challenges for offsetting and for achieving the goal of a net benefit [38]. Gardner suggested that without these features, net benefit approaches become largely symbolic in neutralising environmental concerns regarding development, while providing little real protection for our resource [38]. In order to achieve no net loss, Gardner et al. posited that three main conditions had to be met [20]:

1. Biodiversity losses and gains are comparable in type and amount
2. Biodiversity gains are additional
3. Biodiversity gains are lasting.

These conditions could be simply rewritten as follows to reflect both a goal of net benefit and to include all components of the environment as defined

1. Net benefits accrue when gains exceed losses in type and amount
2. Net benefits are gains that are additional (to those that would have been achieved without the project/program/plan)
3. Net benefits are lasting.

Wainger and Mazzotta present a framework for benefit assessment that has, at its core, an idealised determination from human action through ecosystem stressor, ecological outcome, ecosystem goods and services, to social benefits [31]. While this framework identifies environmental, social and economic vectors in the process, it remains limited by two key components: It only deals with financial considerations, and it is only focused on human well-being. The authors themselves comment that it is relatively rare to find case studies that meet all of the information requirements and include all of the necessary quantitative relations to calculate even social benefits from a management change [31].

Principles guiding net benefit

While the literature has revealed few examples of principles that are applicable in developing a net benefit policy for the suite of Great Barrier Reef values, there are key considerations in discussions of offset programs that can be augmented for net benefits. There is a general understanding of, and agreement on, the base principles of offsetting and the need for achievement of net benefit outcomes.

- The offset guideline and the net benefit policy need to provide more than a reporting framework.
- The guideline needs to be a decision-making tool that is integrative, adaptive and clear enough for decision makers, policy developers, managers, investors and the broader community to understand and apply.
- They must be based on best available research and information and must be capable of evolving and adapting as circumstances change.

To date, there are few examples of where this has been successfully developed and applied, however, in considering the management outcomes established for the GBRWHA, the following two key programs provide the most relevant principles.

The Business and Biodiversity Offsets Program

The BBOP has at its heart a set of 10 principles relating to biodiversity offsets – these are compiled in Appendix B of the BBOP resource paper [1]. Of these, principle 1 offers guidance for achieving a better than break even policy, but even here it limits its focus to biodiversity and is only limiting its consideration to the offset, and not to the broader suite of actions and impacts associated with the action:

> *No net loss: A biodiversity offset should be designed and implemented to achieve in situ, measurable conservation outcomes that can reasonably be expected to result in no net loss and preferably a net gain of biodiversity. (p.30)* [1]

Belize Coastal Zone Management Authority and Institute and Australian-Caribbean Coral Reef Collaboration also use these 10 BBOP principles in the development of the Marine and Coastal Biodiversity Offsets Framework for Belize [26].

The IUCN Biodiversity Offsets Policy

In the IUCN *Biodiversity Offsets Policy* [9], the IUCN outlines 15 fundamental principles that identify the proposed role of biodiversity offsets within the mitigation hierarchy [9]. Of these, there are two that relate specifically to net environmental benefits for the GBRWHA context [9]:

> 8. *Design offsets to achieve at least No Net Loss and preferably a Net Gain of biodiversity* [9]. . . [In this instance the term net gain is synonymous with net benefit]
>
> 11. *Follow a Rights-based Approach, as defined by IUCN resolution WCC-2012-Res-099* [9] . . . [such as] . . .(pg.4 - 5) [41]:
>
> - *Respect, protect, promote and fulfil all procedural and substantive rights, including environmental and customary rights, for just and equitable conservation*
> - *Consider and realize the rights of people that can . . . benefit from rights-inclusive and socially sensitive development measures (such approaches may provide tools to secure/address issues related to cultural conservation and diversity, community-based conservation in the context of (new) protected areas, the protection of the customary rights of local communities vis-à-vis the state, and the restitution of forfeited rights)*
> - *In line with UNDRIP standards, require free, prior and informed consent when IUCN projects, activities, and/or initiatives take place on indigenous peoples' lands and territories and/or impact natural and cultural resources, sites, assets etc.*

The IUCN also offers insight into good design of offset and net benefit management (p.3) [9]:

> *10. Use approaches that are science-based, transparent, participatory, and address the effects of the project and mitigation actions on livelihoods.*
>
> *12. Identify and put in place the legal, institutional and financial measures needed to ensure long-term governance of all mitigation actions (including any biodiversity offsets).*
>
> *13. Apply a rigorous monitoring, evaluation and enforcement system that includes independent verification of all mitigation actions.*

These principles are critical to ensure that net benefit (and offset) mechanisms are trusted and enduring.

Other principles

A number of other references provide contextual relevance and guidance around approriate principles for the development of a net benefit policy. The definition of sustainable development endorsed by the United Nations is

> . . . *development that meets the needs of the present without compromising the ability of future generations to meet their own needs. (p.41)* [42]

As Nicolette et al. point out,

> . . . *Inherent in this definition is the incorporation of not only environmental issues associated with development but also economic and social issues*. (p.2153) [29]

Nicolette et al. also detail how environmental sustainability (described as 'green business') is defined as

> . . . *an action that is directly or indirectly aimed at improving the net environmental benefit associated with a project including consideration of the life cycle of its product* . . . [hence] . . . *the purpose of implementing a green practice is to improve the overall flow of ecosystem service benefits.* (p.2153) [29]

This definition provides a logical construct of the primary purpose of net benefits that is generally accepted in the literature (refer to **Text box 2**). However, it requires careful dissection, analysis, and reconstitution to be understandable by the broader community.

Example of net benefit implementation

Net environment benefit was discussed by Godin et al. in the context of the design of a life cycle assessment of wastewater treatment plants. In their assessment, they perform a life cycle analysis based on an evaluation of overall net benefit outcomes, such as assessing the potential impact of releasing wastewater with and without treatment compared to the impact of constructing and operating a wastewater treatment plant over its commissioned life.

The use of net benefit consideration through a life cycle analysis of impacts allowed an assessment of the environmental trade-offs between avoided impact and induced impact by an actions life cycle [28].

This concept of benefit from foregone action/activity is worthy of more detailed consideration in current decision-making processes. Existing permit assessment processes in the Great Barrier Reef Marine Park require a delegate to consider likely and potential future options, and a life cycle assessment of impacts may help the delegate to understand where net benefits could be attained within timelines relevant to impacts and ecosystem resilience.

In 2008 the Canadian Parks and Wilderness Society released a policy brief on interpreting the principles of net environmental benefit [43]. In context, 'net environmental benefit' was incorporated into first of five principles underlying the design of Canada's Offsets System for Greenhouse Gases, stating that offset projects achieve greenhouse gas reductions and a net environmental benefit [44]. They considered that this principle be broadly interpreted to avoid unintended perverse outcomes and to consider other environmental matters. The brief also offers a number of policy implementation options for government. Of these, the one pertinent recommendation for the purpose of this literature review is that the eligibility for offsets should be restricted to activities that are expected to have a neutral or beneficial impact on biodiversity [43]. A similar construct could also apply in offset or net benefit principles for the GBRWHA. Another of the Canadian Parks and Wilderness Society concepts is that projects should have no negative effects on species included in the IUCN Red List of threatened species or species on a nationally-recognised list [43]. Again, a similar principle may be considered for the GBRWHA.

Net benefits in the context of the GBRWHA

The only contemporary and directly relevant literature on marine offsets and net benefits in the context of the GBRWHA is the review article by Bos et al.[19]. Their paper focused exclusively on mandatory biodiversity offsets that were required of proponents as part of legal approvals for development projects that affect the GBRWHA. Section 2.3 of Bos et al. is dedicated entirely to 'net benefits' [19]. It is limited in the broader application of net benefit as required for this policy, but is nevertheless instructive in some key foundations of the policy under consideration. The following takes their conclusions into consideration.

Bos et al. made a number of primary recommendations and developed principles for the application of offsets for the GBRWHA. Of these, Principles 3 and 7 identify net benefits as a goal for all affected values, such as social, cultural, and heritage, not just biodiversity values, and that net benefits should be maintained in perpetuity [19]. Bos et al. also highlighted the need for a clear definition of the goal of any required offset [19]. Taking this further, it is imperative to clearly identify any expected net benefit and then take steps to ensure they are independently tested, monitored over an appropriate timeframe and reported.

Major considerations for a net benefit policy

It is imperative to define the scope of the effects/impacts for which a project/program/plan should be held accountable. It is only then that an equitable offset/benefit can be determined. Pilgrim et al. have developed a generic framework that could be considered illustrative in developing a net benefit policy[45]. Their framework establishes the burden of proof necessary to confirm the appropriateness and achievability of offsets, given varying levels of: conservation concern for affected biodiversity, which are drawn from existing conservation planning tools; residual impact magnitude; opportunity for suitable offsets; and feasibility of offset implementation in practice. This framework may provide a suitable start point for development of an assessment and implementation guideline for understanding net benefit contributions.

Disturbances on land can translate to disturbance in the marine environment but the reverse is rare. Marine environments are much more prone to impacts from distant pollution sources and cumulative effects originating from the land [26,46]. This also means that the greatest benefits for the GBRWHA may be derived from the adjacent catchments, not the marine system itself.

As Gardner et al. point out, minimising the discrepancy between the aspirations and practical constraints of attaining no net loss of biodiversity requires acceptance of a high level conservation goal as the basis for selecting measured biodiversity components and strict adherence to a set of necessary conditions, along with transparent accounting procedures [20]. Within the GBRWHA the high-level goals are already in place (outlined in the Reef 2050 Plan) as is the trend and condition reporting of the components (encapsulated in the five-yearly Great Barrier Reef Outlook Report). At the scale of the Great Barrier Reef, the Outlook Report now guides adherence to a set of conditions and transparent accounting procedures with a focus on delivery of a net benefit to the environment as defined. Further work is required to apply this approach at the region and local scale, as committed through the Great Barrier Reef Region Strategic Assessment Program Report [14], and inferred through the Reef 2050 Plan [24].

Identifying specific linkages between damage to marine ecosystems and human activity is complex, costly and time consuming and has rarely been attempted [34]. Indeed, a process of promoting collaboration between ecologists, social scientists and economists will be essential [31] if the genuine aim is to determine the causal linkages and attributions and thereby enable decision-makers to truly consider the most approprirate net benefit for the GBRWHA in its broadest sense.

Monitoring and reporting of net benefit accrual is a fundamental requirement for a successful and acceptable program. Wherever possible, these requirements should be incorporated into existing programs. For clarity and ease of understanding by the broader community, losses and gains must be measured in the same metric [26].

Proposed net benefit principles for the GBRWHA

The ultimate goal for management of the GBRWHA in contemporary literature is to be found in the vision for the Reef 2050 Plan and reads as follows:

> *To ensure the Great Barrier Reef continues to improve on its Outstanding Universal Value every decade between now and 2050 to be a natural wonder for each successive generation to come. (p.iii)* [24]

The principles that are adopted for the net benefit policy should necessarily reflect and contribute to the achievement of that goal. The following key principles described in **Table 2** have been derived from current legal and policy instruments, the 2014 Great Barrier Reef comprehensive strategic assessment documents [13,14,47,48], the Reef 2050 Plan [24] and best practice programs and examples available in the international literature.

Table 2 - Proposed principles for delivering net benefits

Proposed net benefit principles	Discussion
Great Barrier Reef values and ecosystem processes The values and processes comprise the ecosystems and their constituent parts, including people and communities; natural and physical resources; the qualities and characteristics of places; and the social, economic and cultural aspects of the above. Foremost, healthy and resilient ecosystems are fundamental to the protection of biodiversity and heritage values, and the community and economic benefits they support.	Under the *Environment Protection and Biodiversity Conservation Act 1999* the definition of environment includes: *(a) ecosystems and their constituent parts, including people and communities; and* *(b) Natural and physical resources; and* *(c) The qualities and characteristics of locations, places and areas; and* *(d) Heritage values of places; and* *(e) The social, economic and cultural aspects of a thing mentioned in paragraph (a), (b), (c) or (d).* The comprehensive strategic assessment of the Great Barrier Reef Region and adjacent coastal zone systematically identified the values and ecosystem processes that support the Great Barrier Reef, consistent with this definition. The condition and trend of these values and ecosystem processes are reported on five yearly through the Great Barrier Reef Outlook Report. The use of a common set of terms to describe values and ecosystem processes across the range of management activities will facilitate a strategic and consistent approach to the delivery of actions across local, regional, catchment and Reef-wide activities.

Proposed net benefit principles	Discussion
Avoiding impacts The highest priority is to avoid impacts. This includes consideration of prudent and feasible alternatives to proposed actions[2], projects, plans and programs, as well as the alternative of not carrying out the proposed action, project, plan or program.	The avoid-mitigate-offset hierarchy is widely used across Australian and Queensland government agencies. Avoiding impacts is a critical step in the decision-making process, and is widely recognised as the most cost–effective measure for managing impacts on values and processes. Restoration, focused on improving the *state* of affected values is widely recognised as the least effective and often most costly option.
Improving the condition of the Great Barrier Reef values and processes is everyone's responsibility Achieving net benefits for the Reef's values and ecosystem processes is everyone's responsibility. Decisions and actions that affect the Great Barrier Reef's values and processes, regardless of whether they occur within or outside the Reef, including internationally, have the capacity to contribute to a net benefit outcome.	The Great Barrier Reef Outlook Report highlighted that climate change, poor water quality from land-based run-off, impacts from coastal development, and some remaining impacts of fishing remain the major threats to the Great Barrier Reef. These threats operate from local through to global scales; therefore to achieve an overall net improvement in the Great Barrier Reef, a local through to global response is required.
An interconnected landscape Net benefit actions recognise the Great Barrier Reef is a highly interconnected bio-cultural landscape underpinned by healthy ecosystems. Net benefits take into account short and long-term considerations, and recognise a healthy catchment and marine ecosystem supports cultural, heritage, economic and social values.	The Great Barrier Reef is a complex, dynamic and interconnected landscape.
Overall positive change Net benefit actions provide an overall positive change to the values and ecosystem processes of the Great Barrier Reef. Net benefit actions contribute to building resilience and restoring Reef health.	This principle reinforces that net benefit activities contribute to an improvement to the condition of the Great Barrier Reef. Research activities in themselves are not net benefit actions, as they are not directly providing a positive change to the condition of the value or process. However, research is pivotal to understanding cause and effect relationships and establishing thresholds, both of which are critical to identifying beneficial actions and informing adaptive management.

[2] Actions and activities are used to describe projects and project parts under the *Environment Protection and Biodiversity Conservation Act 1999* and the *Great Barrier Reef Marine Park Act 1975*. For this policy actions are used, assuming activities comprise action, or a subset of an action.

Proposed net benefit principles	Discussion
Consider scale Net benefits encompass a broad range of management activities that operate at a range of scales (strategic, tactical and operational).	Management activities include partner contributions at local, regional, Reef-wide/catchment, global scales.
Net benefit activities are delivered through a coordinated and collaborative approach Taking a coordinated and collaborative approach to delivering net benefits is fundamental to maximising net benefit outcomes.	The principle recognises the need to align efforts and share information between organisations and among partners and stakeholders to ensure outcomes are achieved in a timely and cost effective manner.
Adopt strategic and innovative approaches Net benefit outcomes will be maximised through the adoption of strategic approaches and innovative practices.	This principle recognises that innovation, underpinned by strategies that align effort to achieve positive changes in values and ecosystem processes, will be required to achieve an overall net environmental benefit outcome for the Great Barrier Reef.
Outcomes focused Net benefit activities should be linked explicitly to the delivery of outcomes and include consideration of the principles of ecologically sustainable use.	Activities that are not designed to deliver positive outcomes for Great Barrier Reef values and processes will not be recognised as net benefit actions.
Systems approach Analysing opportunities for achieving net benefit outcomes within a systems framework maximises the potential to deliver net multiple benefits across Reef 2050 Plan themes.	The Driver Pressure State Impact Response framework (DPSIR) is used internationally to understand linkages between drivers, activities and pressures on the state of the environment and the benefits it provides. This framework was used in the Great Barrier Reef Region Strategic Assessment Report and Great Barrier Reef Outlook Report 2014 and will provide the foundation for the Reef 2050 Integrated Monitoring and Reporting Program. Adoption of this framework will ensure a consistent approach to the delivery of net benefits and the reduction of cumulative impacts.
Information sources Net benefit actions should be based on the best available information including, where available, historical information, monitoring data, Traditional Owner and stakeholder knowledge, observation, modelling, forecasts and expert judgement.	The basic premise is that the best available information from the most appropriate sources is used, and that limitations in the use of information are recognised and described.

Proposed net benefit principles	Discussion
Assess risk Risk management processes should be integrated into net benefit decision–making and implementation, and demonstrate consistency with the Australian/New Zealand/International Standard, AS/NZS ISO 31000:2009 Risk management - Principles and guidelines (published by Standards Australia and available for purchase through SAI Global http://infostore.saiglobal.com/store/).	Acknowledging time frames for achieving outcomes, which may extend over decades, is an important consideration in assessing risk. This is particularly relevant for achieving an overall net benefit to the Great Barrier Reef.
Transparency Net benefit decision–making and implementation should be supported by effective, transparent and accountable governance measures.	Net benefit actions are delivered at a range of scales by a variety of partners. Clear governance arrangements are required to promote alignment, maximise efficient use of resources and reduce the potential for duplication of effort.
Adaptive management Decision–making and implementation is underpinned by agreed outcomes and targets, and effective monitoring, evaluation and reporting.	The Reef 2050 Plan provides an agreed outcome–based framework for improving the condition of Great Barrier Reef values and processes. It is underpinned by the Reef 2050 Integrated Monitoring and Reporting Program that will assess progress towards outcomes and targets and drive adaptive management.
Tracking success Net benefit activities should include monitoring, evaluation and reporting and adopt a consistent and systematic approach to reporting.	The basic premise is the ability to align programs and activities to improve efficiency and effectiveness across implementation, monitoring and reporting at all scales. This is required to inform management effectiveness and continual improvement. The Reef 2050 Integrated Monitoring, Modelling and Reporting Program is establishing standard protocols for information collection, storage, accessibility and reporting. Reporting should focus not only on the implementation of actions but the achievement of outcomes.

The policy will be guided by the desired outcomes for Great Barrier Reef values and processes as identified in the Great Barrier Reef Region Strategic Assessment Report. The condition and trend of these values and processes are reported on five-yearly in the Great Barrier Reef Outlook Report. This report will be used to evaluate the overall success of net benefit actions.

The relationship between Great Barrier Reef values and ecosystem processes has been mapped to matters of national environmental significance and the Reef's outstanding universal value. The desired outcomes for the Region's values and processes are outlined below in **Table 3**.

Table 3 - Desired outcomes for the condition of Great Barrier Reef values and ecosystem processes

Current condition*	Desired outcome	Management outcome
Very Good	The condition is maintained	No net loss
Good	The condition is maintained and enhanced	No net loss
Poor	The condition is restored to good	Net gain
Very Poor	The condition is restored to good	Net gain
Trend in condition*	**Desired outcome**	**Management outcome**
Improving	The trend is maintained	No net loss
Stable	The trend is maintained and improved	No net loss
Deteriorating	The decline is halted and reversed	Net gain

***** The condition and trend of values and ecosystem processes are benchmarked five-yearly in Great Barrier Reef Outlook Reports.

Achieving no net loss - offsetting for residual impacts on the GBRWHA

The key Commonwealth Act that includes consideration of offsets is the *Environment Protection and Biodiversity Conservation Act 1999*. In 2012 an EPBC Act environmental offsets policy was released to provide guidance on the role of offsets in environmental impact assessments, and how the suitability of proposed offsets is considered. In 2014 the *Queensland Government's Environment Offsets Act* and subsequent Policy [18] were adopted to coordinate procedures for offsets required under a number of Queensland laws. These legislative and policy frameworks set the basis for offsetting will continue to apply, however, there is a need for further guidance on how to apply offsetting that addresses specific characteristics of the Great Barrier Reef's unique ecosystem.

Decisions incorporating offsets are usually made at the end of an impact assessment process. Impact assessments nominally have three steps: avoidance of likely impacts; examination of mitigation opportunities; and offsetting any residual adverse impacts (**Figure 7**).

Figure 7 - The hierarchy of avoid, mitigate, offset, net benefit and adaptive management considered in the assessment of impacts of activities on matters of national environmental significance. [14]

Mandate for offset guidelines

The comprehensive strategic assessment of the Great Barrier Reef recognised thorough impact assessment as the foundation of decision making on development decisions along the coast and within the Great Barrier Reef Marine Park. Specifically the Great Barrier Reef Region Strategic Assessment recommends

> *The Authority will implement guidelines for the application of Great Barrier Reef offsets to maintain the condition of matters of national environmental significance and relevant attributes and environment processes, where impacts cannot be avoided or mitigated. The*

> *guidelines will seek to deliver an outcome equivalent to, or better than, the outcome that would apply if the EPBC Act Environmental Offsets Policy were applied.(p.62)* [14]

This commitment was reflected in the Reef 2050 Plan for the GBRWHA in action EB11 for improving sustainability:

> *Continue to refine and improve guidance and procedural requirements for avoiding, mitigating and offsetting impacts to the Reef from industry activities using standardised policies, procedures and guidelines (p.47).* [24]

Offsetting guidance will provide additional information for proponents and Commonwealth and Queensland government officers making decisions on activities that potentially impact the condition and trend of Great Barrier Reef values.

Definition

The BBOP has defined biodiversity offsets as

> *. . . measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from project development* [5] *after appropriate prevention and mitigation measures have been taken. The goal of biodiversity offsets is to achieve no net loss and preferably a net gain of biodiversity on the ground with respect to species composition, habitat structure and ecosystem function and people's use and cultural values associated with biodiversity (p.8).* [6]

This definition has also recently been adopted by the IUCN in its recent Policy on Biodiversity Offset [9]. The Australian Government's EPBC Act Environmental Offsets Policy defines offsets as

> *. . . measures that compensate for the residual adverse impacts of an action on the environment. (p.7)* [16]

The Authority slightly modified this in the Great Barrier Reef Region Strategic Assessment Program Report by defining offsets as

> *Measures intended to compensate for the residual adverse impacts of an action on the environment. (p.98)* [14]

Queensland's *Environmental Offsets Act 2014* defines environmental offsets as

> *. . . an activity undertaken to counterbalance a significant residual impact of a prescribed activity on a prescribed environmental matter (p.11).* [17]

Importantly, all these definitions include the concept of *residual [adverse] impacts.* A thorough and transparent impact assessment process based on the 'impact mitigation hierarchy' is required to establish any residual adverse impacts.

Impact Assessment

The International Association of Impact Assessment (IAIA) highlights on their webpage

> *Impact assessment, simply defined, is the process of identifying the future consequences of a current or proposed action.*[50]

Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) are the primary methodologies for environmental impact assessment. EIA, as an assessment of the environmental impacts likely to be associated with a specific proposal, has been undertaken worldwide since the 1970s. BBOP defines EIA as

> *A formalised process, including public consultation, in which all relevant environmental consequences of a project are identified and assessed before authorisation is given. The process of identifying, predicting, evaluating and mitigating the biophysical, social, and other*

> *relevant effects of development proposals prior to major decisions being taken and commitments made*. (p.17) [6]

SEAs examine impacts likely to be associated with implementation of a plan, policy or program and have been around since the late 1990s. Their purpose is to ensure that the environmental consequences of a proposed policy, plan or program are appropriately addressed at earlier stages or at higher tiers of planning and decision-making than would take place for a project through EIA [1].

BBOP explores considerations for integrating planning for offsets with development planning and assessment through linking offsetting with the steps in EIA [1].

Avoid, mitigate and offset of impacts

Both EIA and SEA approaches are based on the mitigation hierarchy of avoid, mitigate and offset. This approach has been embedded into impact assessment practice since its inception. IAIA provides FasTips for key areas of consideration in impact assessment. The extract below is from their FasTip on mitigation (p.1) [51]:

> *Mitigation was first defined in regulations (40 CFR 1508.20) related to NEPA (United States National Environmental Policy Act) as any activity that includes:*
>
> *(a) Avoiding the impact altogether by not taking a certain action or parts of an action.*
>
> *(b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation.*
>
> *(c) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.*
>
> *(d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.*
>
> *(e) Compensating for the impact by replacing or providing substitute resources or environments.*

BBOP defines avoidance as:

> *Measures taken to prevent impacts from occurring in the first place, for instance by changing or adjusting the development project's location and/or the scope, nature and timing of its activities*. (p.3) [6]

Hayes and Whitaker cite the Cross Sector Biodiversity Initiative's three types of avoidance (spatial, temporal and design) and provide practical examples of tools and application for all three. They recommend considering avoidance as early as possible in project development to facilitate full options for alterative location, timing and design [52].

Clare et al. identified five factors that are leading to the failure of decision-makers to prioritise wetland avoidance and impact minimisation ahead of compensation in the mitigation sequence in North America [53]:

- a lack of agreement on what constitutes avoidance
- current approaches to land use planning do not identify high-priority wetlands in advance of development
- wetlands are economically undervalued
- there is a ''techno-arrogance'' associated with wetland creation and restoration that results in increased wetland loss, and
- compensation requirements are inadequately enforced.

Rajvanshi highlights the 'no –go' option as a powerful method of avoidance (refer to the discussion on 'offsetability' later in this review) [54].

The Great Barrier Reef Region Strategic Assessment Program Report specifically gives the highest priority to avoiding impacts on the environment [13,14]:

> *Avoidance measures must consider prudent and feasible alternatives to a proposed activity. These should include, but not be limited to, consideration of alternative sites and alternate approaches to carrying out the activity*. (p.61) [14]

While the Queensland Offsets Policy requires avoidance, focused on-site, the Great Barrier Reef Coastal Zone Strategic Assessment recognised avoidance of impacts on the GBRWHA outstanding universal value is best achieved through broader planning to locate impacting activities away from high value areas, including setting aside terrestrial and marine protected areas [18,47].

While both EIA and SEA incorporate the mitigation hierarchy, the most effective opportunity for avoidance is associated with linking landscape-scale impact assessment through SEA with strategic and regional planning. This provides clear signals regarding opportunities for land use and where land use is restricted.

Mitigation refers to measures to reduce the likely impacts of the proposed activity on valued components in the landscape, again using spatial, temporal and technology design approaches. Having a 'systems perspective' in viewing the proposed development within its surrounding systems provides more opportunity for identifying effective solutions and reducing impacts.

IAIA's Mitigation FasTip proposed the following hierarchy for mitigation, once broadscale avoidance measures have been incorporated into project planning [55]:

1. enhance positive impacts
2. avoid negative impacts to the greatest extent possible
3. minimise (or reduce) what cannot be avoided
4. remedy (or restore) what cannot be reduced, and
5. compensate for what cannot be remedied.

Similarly BBOP includes minimisation and restoration as approaches for mitigation (p.28) [6]:

> *Minimisation: measures taken to reduce the duration, intensity and/or extent of impacts (including direct, indirect and cumulative impacts, as appropriate) that cannot be completely avoided, as far as is practically feasible.*
>
> *Rehabilitation/restoration: measures taken to rehabilitate degraded ecosystems or restore cleared ecosystems following exposure to impacts that cannot be completely avoided and/or minimised*.

The IUCN has developed a Biodiversity Offsets Policy, which includes principles for application of the mitigation hierarchy.

The rigour of application of the mitigation hierarchy has been queried internationally and in Australia. In 2014, an Australian Senate inquiry found that, although it considers that '…environmental offsets must be used only as an absolute last resort (p.97)', it had evidence the mitigation hierarchy is not being rigorously applied to decisions made under Australian national environmental law. It recommended (Recommendation 5) that the mitigation hierarchy be rigorously implemented, with a greater emphasis on avoidance and mitigation [56].

Gardner et al. concluded

> *. . .offsets are rarely, if ever, adequate for achieving no net loss of biodiversity alone. Rather, the appropriateness and potential success of an offset depend on the extent to which prior steps in the mitigation hierarchy (avoidance, minimization, and remediation of effects) are applied (p.5).* [20]

Bos et al. go further, suggesting proponents should document their proposal's residual impacts after each impact assessment stage (i.e. impacts after avoidance and after mitigation before moving to any consideration of offsets) [19].

Finally, IUCN considers that each of the steps of the mitigation hierarchy should be 'risk-based' [10]. This facilitates a more strategic approach to reducing risk across the mitigation hierarchy, allowing the

use of offsets more readily for low risk impacts while maintaining focus on avoidance and mitigation for elements that have higher conservation value:

> *For impacts with a low significance in terms of biodiversity conservation, a simplified approach is preferable to avoid transaction costs that are high, relative to the costs of mitigation measures, including offsets. (p.2)* [10]

Residual impacts: compensation and enhancement

The primary shared concept in the key definitions of offsets is for 'residual impacts' once the mitigation hierarchy has been applied rigourously.

Rajvanshi splits the response to residual impacts into *compensation* to achieve no net loss and *enhancement* where the objective is net gain [54]. Rajvanshi et al. further explores the potential for enhancement as an output from impact assessment, with enhancement actions achieving one or more of the following outcomes [57]:

- better ecosystem management
- improved protection
- areas enhanced for biodiversity conservation, and
- improved ecosystem services.

More broadly in the area of assessing and protecting ecosystem services in the United States of America, the nationally applied natural resource damage assessment process aims to balance compensatory restoration with adverse impacts so as to maintain ecosystem services.

No net loss and net gain in offsetting

The goal of no net loss is intended to relieve tension between conservation and development by enabling economic gains to be achieved without concomitant biodiversity losses [20]. The IUCN states that

> *The aim of biodiversity offsets is to achieve No Net Loss and preferably a Net Gain of biodiversity. Conservation actions intended to achieve offset outcomes must result in a direct measurable biodiversity gain equivalent to the residual loss arising from the impacts on biodiversity associated with a project in order to be considered a biodiversity offset (p.4).* [9]

The 'net' in 'no net loss' is indicative of the fact that some losses at the development site are inevitable and that exchanges may not be perfectly balanced whether in time, space or ecosystem component [20].

Many authors have discussed the concept of no net loss in the context of offsetting. In a recent review, Gardner et al. compiled three conditions for achieving no net loss and gains in biodiversity [20]:

- offsets are comparable to losses from residual effects in so far as they are both appropriate (similar in kind and type) and adequate (of an amount greater than or equal to the losses)
- they are additional to outcomes that would have resulted in the absence of an offset, and
- are lasting and protected from the risk of failure.

Relative offsetability of biodiversity impacts is fundamentally defined by what offsetting is intended to achieve. In the absence of appropriate policies or plans containing biodiversity goals at a global level, we make several assumptions in order to assess in a generally applicable way.

Fundamentally, no net loss is based on a premise of 'like-for-like' to ensure ecological equivalence [9]. However, strict interpretation of like-for-like is not always feasible and 'trading up' (or 'like-for-like or better') may sometimes be appropriate, particularly where lower biodiversity conservation can be offset to enhance higher order conservation values [9]. The background technical papers to underpin development of the IUCN policy on biodiversity offsets identified that one of the fundamental challenges with evaluating offsets is the baselines used as the reference against which no net loss and net gain are measured (**Figures 6 and 8**) [10].

Pilgrim et al. assessed offsetability of biodiversity impacts, and noted three issues affecting the availability of offset options [45]:

- there isn't a clear spatially and temporally referenced definition of no net loss
- 'like-for-like-or-better' offset strategy is constrained by lack of robust methods for quantifying exchanges of different biodiversity, and
- there is the lack of integration of ecological functions (service provided regardless of service values to humans) that are associated with biodiversity values, as ecological services vary widely among human societies and may be substitutable.

In practice, it is necessary to focus specific offset measures and measurement of losses and gains on good surrogates of broader biodiversity and on biodiversity of highest conservation concern [9] and against health baselines that represent sustainable population and condition thresholds of biodiversity values.

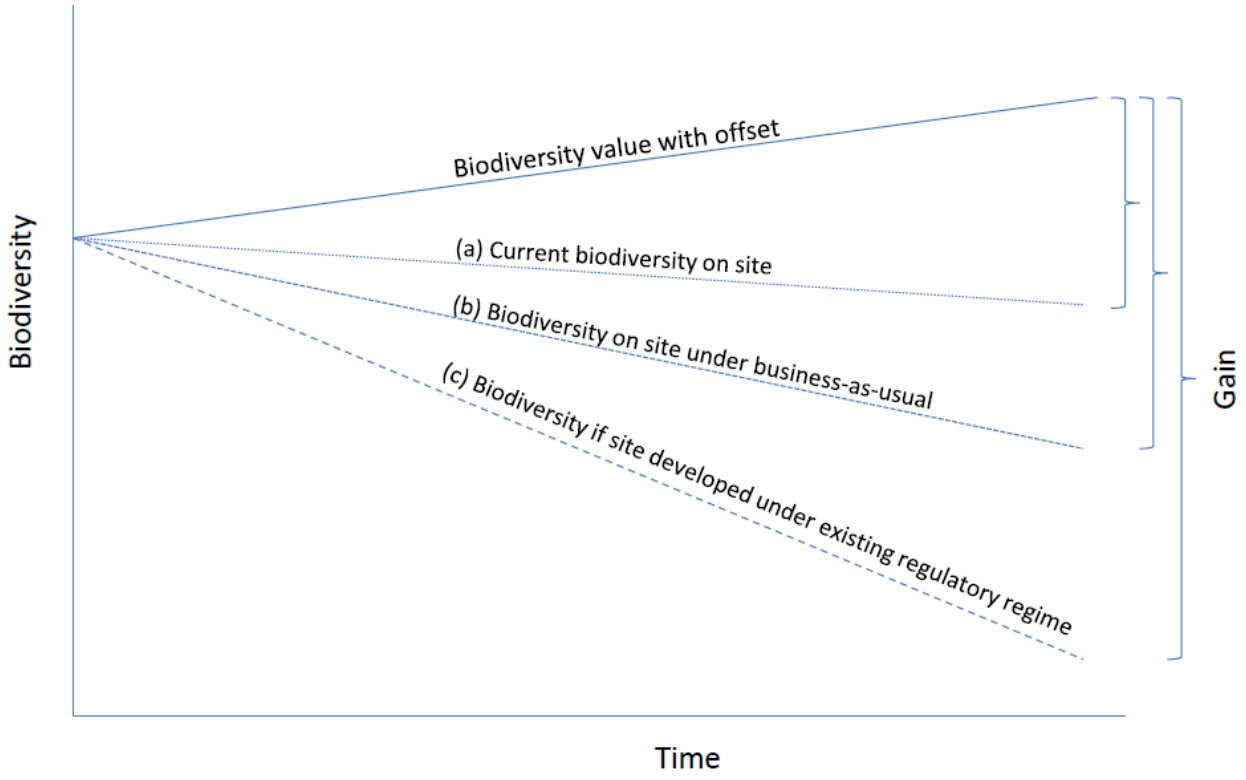

Figure 8 - Offsetting baselines - there are three possible alternative baselines: (a) existing biodiversity; (b) the existing trajectory of biodiversity on a site were development not permitted; and (c) the existing trajectory of biodiversity under a regulatory regime that does not include offsets (p.19) [10].

Metrics, accounting and exchange

Establishing a goal for offsets of no net loss requires clear rules and procedures for understanding the current baseline for affected biodiversity elements.

Policies that define a 'like-for-like' or 'like-for-like-or-better' exchange rule typically include some or all of the following criteria: type of biodiversity component, vicinity, timing, ecological function and quality or condition requirement [12]. The key elements in establishing the basis for measuring losses and potential gains are listed by ten Kate et al. as (p.28) [12]:

- what is being exchanged - choice of biodiversity component and applicable measures
- how much is being exchanged - currencies for what is being exchanged
- how much is needed to achieve no net loss - choice of an accounting model, and
- where - spatial information on patterns of biodiversity.

'Metrics' for what is being exchanged can be categorised into a few descriptive approaches: area based; area and condition; species based; measurements of population; measurements of economic valuation [12]. Surrogates may be used; however, they may not accurately reflect the real scale of the transaction or be transparent to stakeholders.

While the use of integrative concepts such as 'habitat hectares' has grown, this may need to be balanced with biotic (ecosystem function and process) considerations [11]. Concepts such as 'extent multiplied by condition' are increasingly coming under review because of how they may mask underlying complexity and therefore true measures of equivalency [11].

Authors worldwide agree establishing metrics for biodiversity to facilitate offsets is challenging:

> *The key discussion around measurement of biodiversity in offsetting has been the search for 'equivalence' – i.e. defining fungible currencies that facilitate exchange of the same types and amounts of biodiversity in offsets to that impacted* (p.18) [11].

Offsetability and irreplaceability

Nicolette et al. in their review of the Net Ecosystem Service Analysis approach state:

> *Offsets should not be incorporated into projects that may adversely affect ecosystem assets potentially nearing their environmental limits (p.2173)* [29].

This of course assumes that environmental limits are known. Gardner et al. consider offsets most appropriate for discrete projects with a predictable footprint, such as mining and infrastructure. Conversely they go on to state:

> *As currently conceived offsets are unlikely to be appropriate for mitigating the effects of large-scale clearing of land for agriculture (p.5)* [20].

Pilgrim et al. identify four tests for offsetability [45]:

1. biodiversity conservation concerns
2. residual impact magnitude
3. theoretical offset opportunity and
4. practical offset feasibility.

Biodiversity conservation concerns focus on irreplaceability and vulnerability, preferably within a systematic conservation planning framework. The severity of residual impact magnitude is determined by extent and duration. Decision-makers are likely to find it necessary to prohibit development altogether in situations of high conservation concern or where offsets have a low likelihood of success. Bos et al. recommends utilising the BBOP list of offsetability risks to flag projects that have offsets that are high risk [19]. The proposed risks are [7]:

- proportion and irreplaceability of biodiversity component affected
- condition and vulnerability of affected biodiversity components (referring to quantitative or available qualitative thresholds)

- opportunity for adding sufficient and additional conservation value through an offset (**Figure 6**)
- dependence on those ecosystem services underpinned by the biodiversity
- level of stakeholder support
- availability of offset sites and land tenure for securing offsets to achieve additional conservation outcomes
- legal, financial, technical and governance mechanisms and capacity for securing offsets.

They suggest high risk projects and offsets would need to return to the avoid and mitigate stages of impact assessment to reduce the residual risk of offsets from high to medium or low to be acceptable for offsets. IUCN's Biodiversity Offsets Policy identifies situations when offsets should not be used (p 5.) [9]:

> *Where impacts are likely to lead to a high risk of driving one or more previously non-threatened species and/or ecosystems into the IUCN Red List Categories of Vulnerable, Endangered, Critically Endangered, Extinct in the Wild or Extinct, or driving one or more previously threatened species and/or ecosystems into IUCN Red List Categories of higher threat;*
>
> *Where the success of the offset action is highly uncertain due to a lack of knowledge;*
>
> *Where there is a substantial risk that investment generated by offsets might substitute for, rather than add to, other investment for conservation (e.g. 'cost shifting');*
>
> *Where the exchanges involved in the project's residual losses and the predicted offset gains are considered socially or culturally unacceptable to relevant stakeholders;*
>
> *Where the values that will be lost are specific to a particular place, and therefore cannot be found elsewhere and adequately protected or recreated;*
>
> *Where the time lag between the residual loss of biodiversity caused by the project and the gains from the offset causes damage that cannot be remediated and/or puts biodiversity components at unacceptable risk;*
>
> *When impacts will occur in internationally and nationally recognized 'no-go' areas (For the purposes of this policy 'no go areas' have been defined as in [MOTION 026] of The World Conservation Congress, at its session in Hawai'i, United States of America, 1-10 September 2016, including: "RECOGNISING that the concept of areas being "'no-go'", or off-limits, to environmentally damaging industrial-scale activities, including such as industrial-scale mining, oil and gas, and agriculture, and environmentally damaging infrastructure, such as dams, roads and pipelines, is integral to conservation policy for protected areas and other sites of known importance for biodiversity and ecosystem services.")*
>
> *When such action is considered incompatible with IUCN policy and Resolutions.*

Additionality

The concept of additionality is widely used in the literature on offsets and refers to improvements in biodiversity values directly attributable to offsets that would have not occurred without the 'intervention'. This could be actively changing land management through restoration or upgrading protection status through changes to land tenure e.g. adding an area of biodiversity to the protected area estate.

One of three conditions Gardner et al. developed for achieving no net loss is that biodiversity gains are additional [20]. They suggest delivery of additional biodiversity gains could include removing threats or habitat restoration. In either case, the challenge is to demonstrate the quantum of improvement is in addition to what would have occurred with no offsetting action [20].

A particular challenge is quantifying additionality associated with offsets within an already protected area [11]. Here, there is the implicit consideration that the responsible government authority has the

adequate resources to develop and implement plans of management for the protected area. However, practical experience with vast and complex multiple use protected areas such as in Australia indicates resourcing for protected area management is finite, and sometimes inadequate, for the scale of the task [87].

Direct offsets and compensatory mitigation

A related topic is the question of direct and compensatory mitigation. Direct offsets result in clear, measurable outcomes that would not have occurred without the offsets. In specific cases, direct offsets could take the form of compensatory payments where

> *. . . financial payments intended to achieve offset outcomes must result in a direct measurable biodiversity gain equivalent to the loss arising from the impacts on biodiversity associated with the project in order to be considered a biodiversity offset* (p.3) [9]

IUCN indicates measures to address residual impacts that cannot demonstrate 'no net loss', or are not secured for the long-term, are compensatory mitigation, not offsets [9]. Similarly, research into the affected biodiversity or ecosystem has been used in the past as offsets but would not fit the IUCN definition. Bos et al. concur because the risk involved in funding research is that it may not result in measurable benefits to the affected biodiversity value [19].

To ensure offsets for biodiversity result in direct benefits for threatened species and ecological communities, the Australian Government EPBC Act Environmental Offsets Policy limits consideration of indirect contributions to a maximum of 10 per cent [16].

Landscape context

While SEA often is based on a larger regional analysis, EIA is limited to assessing the likely impacts of a proposed project, often without proper linkage to broader natural systems [59]. IAIA developed guidance for EIA and SEA practitioners on properly considering biodiversity, including highlighting a fundamental principle to adopt an ecosystem approach:

> *The ecosystem approach is participatory and requires a long-term perspective based on a biodiversity-based study area and adaptive management to deal with the dynamic nature of ecosystems, uncertainty and the often unpredictable nature of ecosystem functions, behaviour and responses (p.2)* [60]

The establishment of the Marine Park is a good example of this approach. In establishing the Marine Park, the object of the *Great Barrier Reef Marine Park Act 1975* is ecosystem-based management, with SEA regional analysis informed through the Great Barrier Reef Zoning Plan 2003 and region scale Plans of Management. The *Great Barrier Reef Marine Park Act 1975* encourages community based planning approaches, with the Great Barrier Reef Zoning Plan, Traditional Use of Marine Resources Agreements and Plans of Management developed by and with relevant communities.

IUCN suggests first applying the mitigation hierarchy at the landscape level and then at the project or site level:

> *This is essential for moving beyond a reactive project-by-project approach to an approach that is pro-active in applying the mitigation hierarchy, supports mitigation actions at the right ecological scale, recognises cumulative effects and delivers better outcomes for conservation and sustainable development (p.4)* [9]

Partidario argues applying the mitigation hierarchy at a landscape context is achieved through effective proactive SEA, where the SEA is fundamental to developing and testing workable alternatives for the plan, policy or program [59]. This is similar to Pilgrim et al., suggesting offsets should be integrated into a wider conservation planning framework that specifies conservation goals and addresses cumulative impacts [45]. In attempting to achieve no net loss, Pilgrim and Ekstrom advocate for establishing biodiversity conservation goals and societal development goals in advance[11].

Gardner et al., in their pursuit of no net loss, recommend comparing regional significance and opportunities for securing ecologically viable biodiversity gains and fully understanding the underlying landscape systems to ensure long-term gains [20].

The issue of landscape context was also discussed at the Australian Senate Inquiry into the history, appropriateness and effectiveness of the use of environmental offsets, where the Environmental Institute of Australia and New Zealand and the Wentworth Group advocated for greater strategic planning and consideration of cumulative impacts [56]. Dr Gibbons stated:

> *It is incorrect to blame offsets for ongoing loss of matters of national environmental significance. It is like blaming the fuel gauge when the tank is empty (p.66)* [56]

The proposed offsets framework for Belize recognises both impact assessment and any potential offsets should be informed by relevant plans and strategies prepared by government authorities and other parties that set strategic conservation direction and maximise community well-being [26].

In their focus on the GBRWHA, Bos et al. identified the selection of strategic sites for offsets as very important, particularly in a marine context [19]. They cite Gane as preferring consolidated offsets:

> *Implementation of offsets in a few, large areas rather than small fragmented sites throughout a region is more cost-effective because it consolidates capital expenses, management, and monitoring and is more likely to achieve ecological outcomes because multiple offset activities can be combined into an ecosystem-based approach. (p.5)* [61]

Timing

Throughout the literature there is agreement that it is preferable to secure offset outcomes prior to impacts in order to address temporal loss and reduce the risk of offset failure [10]. Moilanen et al. recognise that while loss is certain the effectiveness of offsets is not, and may not be achieved for a very long time into the future [35]. In this context, refer also to the discussion below on uncertainty.

The challenge of demonstrating offset gains before impact occurs [10] may be addressed by providing for advanced offsets, before any development loss [20]. Advanced environmental offsets are defined in the EPBC Act Offsets Policy as a

> *. . . supply of offsets for potential future use, transfer or sale (p.9)* [16].

Considerations of additionality and assessment of overall conservation gain are fundamental in reviewing advanced offset proposals.

Identification and protection of advanced offsets can occur through landscape scale assessments such as SEAs and be delivered through biobanking schemes like those utilised by the New South Wales and Victorian state governments. Following a range of testimony and submission, the Senate Environment and Communications References Committee inquiry recommended

> *. . . a more strategic approach to offsets, including encouraging greater use of 'advanced offsets' (p.ix)* [56].

It is recommended that offsets should last at least as long as the impact. With land clearing, this often means in perpetuity [1,10].

Offsets in the marine environment

The majority of discussions about offsets focus on responding to terrestrial impacts. Particular challenges associated with offsets for the marine environment are discussed below.

The Australian Government Environmental Offsets Policy applies to both the terrestrial and aquatic (including marine) environments. In discussing conservation gain in the marine environment, improved protection of protected species habitat such as seagrass meadows or reducing pressures on a protected matter such as removing marine debris may be considered as direct offsets [16].

The 2014 Australian Senate Inquiry Report into environmental offsets explored the issue of marine offsets from a range of perspectives concluding with a recommendation that:

> *…the Department of the Environment develop a separate offsets policy in relation to the marine environment (p.viii)* [56].

In the United Kingdom, Dickie et al. found that, despite potential challenges, biodiversity offsets in the marine environment could provide an effective mechanism to provide compensation for residual impacts within a consistent, transparent and efficient framework [62]. Metrics of ecological equivalence and appropriate regulatory instruments were two of the issues raised in the study.

Belize Coastal Zone Management Authority et al. in their offsets framework for Belize highlight the need for recent environment and social data to establish baseline conditions and properly assess what is being lost as a result of residual planning and development impacts [26]. They identify three clear potential strategies for offsets (p.15) [26]:

- protection of equivalent habitat - recognising that while this approach is well-suited to terrestrial habitats where land can be bought and managed, it is only a limited option in aquatic environments
- threat abatement through addressing key threats to biodiversity and habitats affected by the proposed development, and
- surrogate measures - essentially involves providing funds to support priority conservation-related action. The use of surrogate measures needs to be applied cautiously to ensure that the conservation actions are clearly defined, that they are sufficient to meet the criteria for an offset (no net loss or better) and that the finances are adequate to obtain the desired outcomes.

Due to the nature of aquatic systems and habitats, Belize Coastal Zone Management Authority et al. advocate for the threat abatement and surrogate measures as potentially appropriate offsets in marine environments [26].

Bos et al. specifically focused on effective marine offsets for the GBRWHA. They suggest prioritising strategic offsets because

> *Marine offsets present even more challenges than terrestrial offsets, related to the different relationship in the sea between ownership of areas and flows of impacts and values (p.5)* [19].

Their analysis focuses on eight principles which are compared and contrasted with other authors' principles below.

Offsets in the context of the GBRWHA

The recommended principles for offsetting of BBOP [1], IUCN [9], Commonwealth of Australia [16], State of Queensland [18] and Bos et al.[19] are identified and compared in **Appendix 2**. These principles are relevant to developing a framework for offsets in the GBRWHA because they have been developed by either standard-setting authorities such as BBOP and IUCN, relevant regulatory authorities of the Australian Government and Queensland Government, or a contemporary researcher focused on the GBRWHA.

There is a high degree of similarity between the lists, providing a clear basis for proposed principles for offsets in the GBRWHA. The comparison in **Appendix 2** found all principles sets agreed on:

- rigorous application of the avoid and mitigation hierarchy
- acknowledging that there are limits to what can be offset, and
- providing a long-term outcome from offsetting (which is to be managed in an adaptive management framework).

Other core concepts such as identifying offsets in a landscape context, no net loss and additionality are identified in most sets of principles.

Uncertainty

The IUCN Policy on Biodiversity Offsets specifies that any offsetting must account for uncertainty by clearly documenting data sources, assumptions and knowledge gaps [9]. Pilgrim and Ekstrom categorise uncertainty regarding the ultimate outcome from biodiversity offsets into three main types (p.32) [11]:

(i) *uncertainty over precision (e.g. of the exact quantity of residual impacts or offset gains)*
(ii) *uncertainty over offset success (i.e. whether offsets will actually succeed in providing any gains at all) and*
(iii) *uncertainty over whether offset gains can be sustained (i.e. whether gains that are provided can be sustained over time).*

Applying a risk assessment approach to these uncertainties would, in many circumstances, require ensuring offset gains are produced in advance of impacts to reduce uncertainty risk to acceptable levels. Also, rather than just using multipliers (which does not remove the underlying risk of offset failure), Pilgrim and Ekstrom discuss 'bet hedging' - adopting a portfolio of different offsets in different locations – to reduce the risk of total failure, and insurance/ bonds to protect against longer term failure [11].

These concepts are underpinned by the rationale that, given the importance of decisions being made on the future of the landscape, managers and stakeholders are well-informed and their decisions based on sound science.

Linkage to monitoring and reporting

Monitoring of offset delivery is a fundamental requirement of a successful offset scheme:

> *Shortcomings in monitoring, evaluation and enforcement account for a significant proportion of the case where mitigation measures, including offsets, have failed to deliver their goals (p.3)* [10].

To properly assess the effectiveness of an offset over time, a monitoring and evaluation regime needs to be developed and applied prior to and at key future dates to determine the success [10]. Contextual information is vital to establish causality (e.g. did other nearby populations of a particular species also suffer or grow over a specified timeframe?).

The Reef 2050 Plan will require the development of both qualitative (expert-opinion-based) and quantitative (numerical modelling, including economic models) decision support tools to test and evaluate alternative future scenarios for the Great Barrier Reef and catchments.

Proposed offset principles for the Great Barrier Reef

Principles for managing environmental impacts within the Great Barrier Reef Region [14] in **Appendix 1**, provides a set of broad principles for decision-making for the Great Barrier Reef. As the source of these principles is the comprehensive strategic assessment, with a parallel strategic assessment process with the Queensland state government for the Queensland coast, these concepts are pivotal in identifying further principles for the Great Barrier Reef offset guideline. They include:

> *Avoiding impacts is the highest priority. Every effort should be made to avoid impacts on the Region's values, including considering prudent and feasible alternatives to a proposed activity. In considering alternatives…* [the decision-maker] *…will have regard to any alternative sites for the activity, any alternative approaches to the activity, as well as the alternative of not carrying out the proposed activity.* (p.23) [14]

Avoidance is particularly pertinent in the context of the GBRWHA, where values considered in very good or good condition are to be maintained (p.23) [14]:

> *Mitigation measures should be employed. Potential impacts on the Region's values that cannot be avoided should be minimised — addressing direct, indirect and cumulative impacts.*

> *Mitigation measures should consider and explicitly account for the likely spatial and temporal scales of impacts.*
>
> *Offsets will only be considered where impacts cannot be avoided or mitigated and where residual impacts will not exceed critical thresholds in the short, medium or long term. Historically, environmental offsets have addressed 'significant' residual impacts. Given the declining health of the Reef…. offsets now need to be more widely applied to compensate for all residual impacts. They need to produce measurable conservation outcomes within timeframes relevant to affected values or processes.*

As such, any proposal for offsetting will need to establish how it delivers outcomes for the condition and trend of GBRWHA values.

Additionally, where environmental impacts are potentially significant, public consultation on impact assessment is required by law [23,33]. Good practice models incorporate stakeholder knowledge and ongoing community dialogue on issues of concern, risk assessment and identifying aspects for monitoring and public reporting.

Proposed principles for achieving no net loss for the GBRWHA

The literature has highlighted a number of key considerations for the assessment and delivery of no net loss outcomes through the use of offsets. The following principles are proposed to inform the development of offsetting guidance for the Great Barrier Reef:

Table 4 - Proposed principles for achieving no net loss

Proposed no net loss principles	Discussion
Proposals for offsets must achieve a no net loss outcome for affected values and ecosystem processes Any proposal for offsets needs to demonstrate how it will deliver a no net loss outcome for impacts on the condition of Great Barrier Reef values and ecosystem processes.	The no net loss principle is consistent with the IUCN biodiversity offset policy, and the Australian and Queensland government offset framework. Focusing on the condition of the Reef's values and ecosystem processes in impact assessment supports identification of offsets that achieve no net loss. Where legislation allows, an improvement in the condition of values and ecosystem processes may also be applied.
Outcomes–focused Offsets should be linked explicitly to the delivery of outcomes and include consideration of the principles of ecologically sustainable use.	The adoption of an outcomes–based approach is a key recommendation of the comprehensive strategic assessment and underpins the delivery of the Reef 2050 Plan. Outcomes for the state of the Reef's environment are reported every five years through the Great Barrier Reef Outlook Report. The adequacy of offsets should be considered within this context.

Proposed no net loss principles	Discussion
Avoid-mitigate-offset hierarchy The highest priority is to avoid impacts. This includes considering prudent and feasible alternatives to proposed actions[3], such as alternative sites and approaches to the action, as well as the alternative of not carrying out the proposed action.	The avoid-mitigate-offset hierarchy is widely used across Australian and Queensland government agencies. The Great Barrier Reef Region Strategic Assessment Program Report reinforced that avoiding impacts is a critical step in the decision–making processes. It is widely recognised as the most cost–effective measure for managing impacts on values and processes.
Systematic and consistent approach to impact assessment Determining the level of residual impact should be based on a comprehensive and systematic approach to: • identifying affected values and processes, including their current status and trend • identifying drivers, pressures and impacts operating across the Great Barrier Reef, including direct, indirect and consequential impacts • considering the spatial and temporal scales (zones of influence) at which direct, indirect and consequential impacts are operating • using methods, including modelling, to assess cumulative impacts, including the cause-and-effect relationship of relevant multiple and compounding impacts on values • applying appropriate standards and guidelines and assessing risk • monitoring standards, data management protocols and review.	The strategic assessment of the Great Barrier Reef Region systematically identified drivers, pressures and impacts acting on the Reef's environment. These are reported on five-yearly in the Great Barrier Reef Outlook Report. Adoption of these approaches will ensure a consistent approach to determining the level and acceptability of offsets for the Great Barrier Reef. Adoption of this approach is consistent with that proposed for the cumulative impact management policy.

[3] Actions and activities are used to describe projects and project parts under the *Environment Protection and Biodiversity Conservation Act 1999* and the *Great Barrier Reef Marine Park Act 1975*. For this policy actions are used, assuming activities comprise action, or a subset of an action.

Proposed no net loss principles	Discussion
Great Barrier Reef values and ecosystem processes Offset requirements should consider all aspects of the environment likely to be affected by a proposed action. Foremost, healthy and resilient ecosystems are fundamental to the protection of biodiversity and heritage values, and the community and economic benefits they support.	Under the *Environment Protection and Biodiversity Conservation Act 1999* the definition of environment includes: *(f) ecosystems and their constituent parts, including people and communities; and* *(g) Natural and physical resources; and* *(h) The qualities and characteristics of locations, places and areas; and* *(i) Heritage values of places; and* *(j) The social, economic and cultural aspects of a thing mentioned in paragraph (a), (b), (c) or (d).* The comprehensive strategic assessment of the Great Barrier Reef Region and adjacent coastal zone systematically identified the values and ecosystem processes that support the Great Barrier Reef, consistent with this definition. The condition and trend of these values and ecosystem processes are reported on five yearly through the Great Barrier Reef Outlook Report. The use of a common set of terms to describe values and ecosystem processes across the range of management activities will facilitate a strategic and consistent approach to the delivery of offset actions across local, regional and catchment-wide activities.
An interconnected landscape **Offset actions should recognise the Great Barrier Reef is** a highly interconnected bio-cultural landscape underpinned by healthy ecosystems. Offset actions take into account short and long-term considerations, and recognise that a healthy catchment and marine ecosystem supports cultural, heritage, economic and social values.	The Great Barrier Reef is a complex, dynamic and interconnected landscape. This principle is consistent with the IUCN biodiversity offset policy statement for landscape and seascape application of offsets, as values and processes represent the multiple interactions between biological, social and cultural aspects of the environment. This principle allows for an offset to be implemented strategically, or be an innovative approach, as long as it is addressing the impacts on the impacted value or process.

Proposed no net loss principles	Discussion
A strategic approach in designing and implementing offsets Adopting a strategic approach to offsets is more likely to maximise outcomes as these initiatives can address: • the multiple scales at which ecosystem processes and impacts occur; and • the potential time lags in the system's recovery.	This principle is consistent with the IUCN biodiversity offset policy statement for landscape and seascape application of offsets. It addresses local scale values, by considering affected values and processes, while considering the best approach to achieving offset success may be at the strategic level.
Staging of offsets must be relevant to the affected value or process Any offsets need to produce measurable outcomes within timeframes relevant to affected values or processes and take into consideration time lags.	This principle is consistent with the IUCN biodiversity offset policy and best practice methods as described through the Business Biodiversity Offset Program. The principle accounts for the temporal scale of cause-effect relationships as described by the cumulative impact management principles. Offsets must account for the time lag between the impact on the value or process and the gains from the offset to ensure remediation is achievable and doesn't place the value or process at unacceptable risk. Offset design and implementation must account for value or process condition and trend in condition, health thresholds, resilience and rate of recovery. In many cases by taking these into account, the offset may need to achieve its outcome prior to the actual impact taking place. Where value or process condition, resilience and rate of recovery can be demonstrated to be good (relevant to the affected value or process), then the offset can be implemented in parallel with the impact.
Offsets must be additional activities Offsets must be additional to other programs designed to: • improve the condition and trend of Great Barrier Reef values and ecosystem processes; or • reduce pressures and impacts on Great Barrier Reef values and ecosystem processes.	Given the broad range of government and non-government programs already underway within the Great Barrier Reef and its catchments, offset initiatives must demonstrate additionality to existing programs.

Proposed no net loss principles	Discussion
Information sources Decision making should be based on the best available information including where available, historical information, monitoring data, Traditional Owner and stakeholder knowledge, observation, modelling, forecasts and expert judgement. Information should also specify possible limitations of data and modelling, divergence in expert judgement, or uncertainty, availability, quality, quantity and ongoing relevance of information.	The basic premise is that the best available information from the most appropriate sources is used, and that limitations in the use of information are recognised and described.
Transparency Decision making and implementation must be supported by effective, transparent and accountable governance measures focused on ensuring delivery of offsets in accordance with approval conditions.	This is particularly relevant to regulatory processes that utilise offset measures for protecting Great Barrier Reef values and processes.
Assessing risk Risk management processes should be integrated into offset decision–making and demonstrate consistency with the Australian/New Zealand/International Standard, AS/NZS ISO 31000:2009 Risk management - Principles and guidelines (published by Standards Australia and available for purchase through SAI Global http://infostore.saiglobal.com/store/).	When identifying and analysing risks the following factors should be considered: • time lags which may exist between cause and effect, and theories which may be uncertain • diversity, complexity and connectivity between structures, components and processes, including cumulative or synergistic effects • effects that are prone to change if the context changes • lack of reliable data • possibility of human error. The level of risk to the Great Barrier Reef from drivers, pressures and activities is reported on every five years through the Great Barrier Reef Outlook Report.
Offsetability and irreplaceability Offsets should not be considered where there is a likelihood that: • ecosystem thresholds may be exceeded; or • the values that may be lost are irreplaceable; or • the values are specific to a particular place; or • the success of the offset action is highly uncertain.	Offsets should only be considered where proposals demonstrate health thresholds for Great Barrier Reef values and processes will not be exceeded. Using the Great Barrier Reef Marine Park Water Quality Guidelines as a model, regionally–based ecosystem health thresholds and standards are being developed progressively. This principle is consistent with the IUCN biodiversity offset policy statement where, under certain circumstances, offsets are not appropriate.

Proposed no net loss principles	Discussion
Offsets should demonstrate success Offset proposals should demonstrate a high likelihood of success in addressing impacts on the condition of affected Great Barrier Reef values and processes. Offset proposals should clearly describe what they will deliver for the condition of the affected Great Barrier Reef value or process, together with any uncertainty and related risk assessment.	This principle would address a critical issue identified by the World Heritage Centre's Reactive Monitoring Mission to the Great Barrier Reef (6-14, March 2012) that offsets, in their current form, do not appear to be achieving their intended outcome. The Mission Report is available at http://whc.unesco.org/en/documents/117104/.
Monitoring and reporting The delivery of offset activities should be accompanied by transparent monitoring and reporting to enable evaluation of outcomes.	Monitoring and reporting should not only focus on the implementation of actions but the achievement of outcomes. Monitoring and reporting should be consistent with protocols being developed under the Reef 2050 Integrated Monitoring, Modelling and Reporting Program.
Adaptive management Decision making and implementation are underpinned by agreed outcomes and targets, and monitoring, evaluation, and reporting.	The Reef 2050 Plan provides an agreed outcome-focused framework for improving the condition of Great Barrier Reef values and ecosystem processes and reducing impacts. The delivery of offsets should be monitored by existing regulatory processes which will in turn feed into the Reef 2050 Integrated Monitoring and Reporting Program. Actions may need to be modified in response to new information, emerging issues or changing circumstances.

Implementation considerations

The ultimate effectiveness of any policy depends on the quality of implementation. The literature raises a number of considerations for improving implementation of policies on net benefits, cumulative impacts and offsets.

Enabling conditions for implementation

Pilgrim and Ekstrom discuss four enablers for achievement of an offsets program and, indeed, most conservation initiatives [11]:

- regulatory clarity
- technical and financial capacity including monitoring and enforceability
- free and transparent markets, and
- oversight and stakeholder engagement.

They highlight that stakeholder engagement strengthens the offsetting approach if the affected community is involved in scoping, setting the scale and location of offsets and in development of exchange rules around no net loss or net gain objectives.

Adaptive management

Contemporary biodiversity conservation planning is usually based on an adaptive management approach. There are multiple reasons for this (including many cited previously in this review) such as uncertainty, lack of clarity about baselines and the probable effectiveness of offsetting for no net loss and striving for net gain. For example, in Figure 3 the adaptive management cycle from the Reef 2050 Plan (p.66)[24] has been enhanced through the Reef 2050 Integrated Monitoring and Reporting Program to illustrate the elements of an adaptive management framework:

Challenges for adaptive management are exacerbated where natural systems are undergoing stresses, such as those associated with climate change or man-made alterations. For example, global sea levels have already risen by 20cm since 1870 and are predicted to rise a further 5-15cm by 2030 [63].

Many of the pressures facing coastal ecosystems and the Great Barrier Reef stem from past decision-making. These include broad-scale clearing, estuarine saltmarshes being converted into pasture land, the exposure of acid sulphate soils in estuarine areas, floodplain levelling for cropping, dams and water extraction, ports and coastal development, and infrastructure development along the coast [13,15,48].

Evaluation and review

Foremost, understanding how the effectiveness of a policy is to be measured is critical in implementation. The environmental and social impacts should be identified in the context of the action/project's area of influence [26]. A spatial definition of the impact is important to assist evaluation of social, environmental and cultural impacts.

The identification of impacts should also take into account the priorities established by relevant plans and strategies prepared by governments and other relevant parties that set strategic objectives for the environment and its communities. In the case of the GBRWHA, this includes the Great Barrier Reef Region Strategic Assessment and Program reports[13,14], the Great Barrier Reef Coastal Zone Strategic Assessment and Program reports [47,48], Reef Water Quality Protection Plan [65], and the Reef 2050 Plan [24].

Further development

A number of tools and resources are required to further develop and implement effective approaches to reduce cumulative impacts and achieve no net loss and net benefit outcomes.

A key component of the Reef 2050 Plan is the establishment of the Reef 2050 Integrated Monitoring and Reporting Program (the Program). The Program will provide a comprehensive and up-to-date understanding of the Great Barrier Reef — the values and processes that support it and the threats that affect it. This knowledge is fundamental to informing actions required to protect and improve the Reef 's condition and to drive adaptive management.

There are currently over 90 monitoring programs operating in the Great Barrier Reef World Heritage Area and adjacent catchment. These programs have largely been designed to address and report on specific issues, location or management initiatives. The need to ensure these programs align with each other and management objectives was identified through the comprehensive strategic assessments of the Great Barrier Reef World Heritage Area and adjacent coastal zone.

The Program will report across the seven themes which make up the Reef 2050 Plan Outcomes Framework. The themes are ecosystem health; biodiversity; water quality; heritage; community benefits; economic benefits and governance.

Chapter 5 of Belize Coastal Zone Management Authority et al. discusses the basis for the next stage of development and implementation of an offsets framework for the Marine and Coastal Biodiversity of Belize. The authors identify the need for financial offset administration, an appropriate assessment framework and a mapping and planning system for strategic prioritisation of offset opportunities. The authors further discuss operational sustainability issues and program delivery mechanisms [26].

Duinker et al.'s recent review on progress in scientific developments associated with cumulative impact assessment sees the following elements as key to the contributions that we should expect from science in support of CEA practice (p.43) [70]:

- investigative protocols for questions of both retrospective (empirical, e.g. Dubé [88]) and prospective (predictive, e.g., Strimbu et al.[89]) natures.
- knowledge of natural history, ecological processes, and the condition of ecosystem components (including ecological characterisations of places and regions).
- effects knowledge that shows how valued ecosystem components respond to various stress agents (human and non-human).
- tools and methods, especially integrative ones, for scientific investigation.
- development of an ecological basis for threshold conditions of valued ecosystem components
- strengthened analytical competency from researcher–practitioner collaboration.

Compared to the volume of data, availability of information and depth of knowledge and understanding of the biological and physical components of the Great Barrier Reef, it could only be concluded that both economic and social understanding of the Reef and its users has lagged.

While there have been a number of research activities focused on socio-economic understanding, until quite recently they have been focused on specific issues or industry sectors and generally have been relatively short-term in nature.

Stoeckl et al. highlighted that most Great Barrier Reef valuation studies concentrate on a narrow range of ecosystem services (e.g. tourism and fishing) and little is known about other ecosystem services or about the social, temporal and spatial distribution of those services [81].

The tourism industry in particular has over the years sponsored significant components of this research. Although there has been some significant progress and learning from these endeavours, very little has evolved into strategic long-term socio-economic policy for the Great Barrier Reef.

Of significance is the ongoing development of the Socio-Economic Long-Term Monitoring Program (SELTMP) [82]. This program represents the most significant attempt to date to bring together academics and professionals from a range of institutions to design and develop a long-term social and economic monitoring programme. Benefits of SELTMP include:

- coverage of all major social groupings and industries within the Great Barrier Reef region

- development of a management system for program implementation
- compilations of socio-economic data for the Great Barrier Reef
- the social and economic valuation of environment assets in the GBRMP from the point of view of the ecosystem's ability to supply sustainable ecological goods and services.

Most of the economic and social data currently available does not explicitly link social and economic values to changes in the extent and condition of the Great Barrier Reef. SELTMP is clearly attempting to bring together the key socio-economic data and provide valuable information to enable the development of forecasting trajectory models.

Dissemination and application of the knowledge gained from these activities will inform policy and decision-makers, investors, land managers, Great Barrier Reef users and society more generally. This knowledge should support informed choices about the management of cumulative impacts, the suitability of offsets and how best to deliver a net benefit for the Great Barrier Reef.

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Appendix 1. Principles for managing environmental impacts within the Great Barrier Reef Region [14]

Conservation of biodiversity and ecological integrity should be the fundamental consideration in decision making The natural environment is the foundation of the Region's values and there are limits to the amount of disturbance it can absorb without compromising its integrity. Decisions about managing impacts should support the outcomes of maintaining and restoring the condition of values and processes. Improvements in biodiversity and ecological integrity also represent the best opportunity to protect Indigenous heritage values and community benefits for generations to come.

Decision making should integrate long-term and short-term environmental, economic, social and equity considerations The full suite of values relevant to matters of national environmental significance is identified in the strategic assessment. They provide the basis for comprehensive decision making about impacts. Decisions now should ensure that these values are maintained, enhanced or restored for the benefit of future generations.

Avoiding impacts is the highest priority Every effort should be made to avoid impacts on the Region's values, including considering prudent and feasible alternatives to a proposed activity. In considering alternatives, the Authority will have regard to any alternative sites for the activity, any alternative approaches to the activity, as well as the alternative of not carrying out the proposed activity.

Mitigation measures should be employed Potential impacts on the Region's values that cannot be avoided should be minimised — addressing direct, indirect and cumulative impacts. Mitigation measures should consider and explicitly account for the likely spatial and temporal scales of impacts.

Offsets will only be considered where impacts cannot be avoided or mitigated and where residual impacts will not exceed critical thresholds in the short, medium or long term Historically, environmental offsets have addressed 'significant' residual impacts. Given the declining health of the Reef and the Authority's goals of protecting and restoring the Reef's condition and ensuring ecologically sustainable use, offsets now need to be more widely applied to compensate for all residual impacts. They need to produce measurable conservation outcomes within timeframes relevant to affected values or processes.

Management arrangements should incorporate systems for continually improving practices across the life of activities Ongoing adaptive management is critical to ensuring ecosystem values and processes are maintained and enhanced over time. Environmental management plans and approval processes need to be flexible and responsive to changing circumstances, and linked to best practice standards.

Best practice standards should be employed in managing impacts Recognising the world heritage status of the Region, management of impacts should always be to best practice standards. Innovative approaches which improve environmental outcomes and operational efficiency and provide incentives to achieve best practice will be promoted. Planning and assessment decision making will be based on best practice assessment methods and the best available information. This will include the use of modelling and mapping to help understand the cause-and-effect relationships between impacts and values.

Impacts should be managed such that ecosystem thresholds are not reached Management of impacts should be based on current and forward projections of condition for the Region's values and processes. As many values and processes have been assessed to be in poor condition, impacts deemed acceptable in the past may not be acceptable in the future. Where ecosystem thresholds have been exceeded, any further development activity should be able to demonstrate a net improvement in the condition of relevant values and processes.

A risk-based approach should be adopted in managing impacts Assessing and managing for risk is an important part of effectively managing impacts. A comprehensive risk assessment should consider all likely impacts and the likelihood and consequence of those on the full suite of the Region's values and processes.

In assessing impacts, uncertainty should be recognised and specified, but not delay protective actions Environmental assessment and planning processes should identify: the extent to which the limitations of available information may influence conclusions; any poorly understood variables or assumptions made; and the reliability of the information considered. This includes where ecosystem thresholds or trigger levels have not been established. In addition, the precautionary principle requires that the Authority not delay measures to prevent degradation in cases where there is a lack of certainty. This principle is particularly relevant to inshore areas in the southern two-thirds of the Region where, while there is still a high degree of uncertainty about impacts and their effects, there is a clear need to address environmental degradation from a range of sources.

Appendix 2. Comparative Offsets Principles

BBOP [1]	IUCN [9]	DOE [16]	QLD [18]	BOS et.al. [19]
1. Adherence to the mitigation hierarchy: A biodiversity offset is a commitment to compensate for significant residual adverse impacts on biodiversity identified after appropriate avoidance, minimisation and on-site rehabilitation measures have been taken according to the mitigation hierarchy.	Give priority to avoiding any damage to biodiversity. Clearly distinguish impact avoidance, minimisation and on-site restoration measures from offsets.	Not a principle but policy states: Offsets will not be considered until all reasonable avoidance and mitigation measures are considered or acceptable reasons are provided as to why avoidance or mitigation of impacts is not reasonably achievable.	Environmental impacts must first be avoided, then minimised, before considering the use of offsets for any remaining impact.	Offsets should be considered only after impacts are avoided and mitigated
2. Limits to what can be offset: There are situations where residual impacts cannot be fully compensated for by a biodiversity offset because of the irreplaceability or vulnerability of the biodiversity affected.	Thoroughly examine lower impact alternatives in the project design, including not proceeding with the project at all, recognising that not all impacts can be offset to achieve no net loss.	[be in proportion to the level of statutory protection that applies to the protected matter]	Offsets will not replace or undermine existing environmental standards or regulatory requirements, or be used to allow development in areas otherwise prohibited through legislation or policy.	The offsetability risk profile should be considered before offset design.
3. Landscape context: A biodiversity offset should be designed and implemented in a landscape context to achieve the expected measurable conservation outcomes taking into account available information on the full range of biological, social and cultural values of biodiversity and supporting an ecosystem approach.	Explicitly consider the project within a broader landscape or seascape context. Take full account of direct, indirect and cumulative impacts, geographically and over time.			[Offsets should be direct and specific to the impacted values.] Offsets should be consolidated into regionally strategic implementation sites with long-term legal protection.

BBOP [1]	IUCN [9]	DOE [16]	QLD [18]	BOS et.al. [19]
4. No net loss: A biodiversity offset should be designed and implemented to achieve in situ, measurable conservation outcomes that can reasonably be expected to result in no net loss and preferably a net gain of biodiversity.	Design offsets to achieve at least no net loss and preferably a net gain of biodiversity.	Be of a size and scale proportionate to the residual impacts on the protected matter, and / or deliver an overall conservation outcome that improves or maintains the viability of the aspect of the environment that is protected by national environment law and affected by the proposed action	Offsets must achieve a *conservation outcome* that achieves an equivalent environmental outcome. Offsets must provide environmental values as similar as possible to those being lost.	Offsets should aim to achieve net benefits to all affected values measured against the counterfactual baseline
5. Additional conservation outcomes: A biodiversity offset should achieve conservation outcomes above and beyond results that would have occurred if the offset had not taken place. Offset design and implementation should avoid displacing activities harmful to biodiversity to other locations.	Ensure any biodiversity offsets used as part of the mitigation hierarchy secure additional conservation outcomes that would not have happened otherwise.	Be additional to what is already required, determined by law or planning regulations or agreed to under other schemes or programs (this does not preclude the recognition of state or territory offsets that may be suitable as offsets under the EPBC Act for the same action, see section 7.6).	Offsets must provide additional protection to environmental values at risk, or additional management actions to improve environmental values.	Offset strategies should minimise the time to achieve net benefits and maintain net benefits in perpetuity.
6. Stakeholder participation: In areas affected by the project and by the biodiversity offset, the effective participation of stakeholders should be ensured in decision-making about biodiversity offsets, including their evaluation, selection, design, and implementation and monitoring.	Follow a rights-based Approach, as defined by IUCN resolution WCC-2012-Res-099.			

BBOP [1]	IUCN [9]	DOE [16]	QLD [18]	BOS et.al. [19]
7. Equity: A biodiversity offset should be designed and implemented in an equitable manner, which means the sharing among stakeholders of the rights and responsibilities, risks and rewards associated with a project and offset in a fair and balanced way, respecting legal and customary arrangements. Special consideration should be given to respecting both internationally and nationally recognised rights of Indigenous peoples and local communities.	Follow a Rights-based Approach, as defined by IUCN resolution WCC-2012-Res-099.			
8. Long-term outcomes: The design and implementation of a biodiversity offset should be based on an adaptive management approach, incorporating monitoring and evaluation, with the objective of securing outcomes that last at least as long as the project's impacts and preferably in perpetuity.	Identify and put in place the legal, institutional and financial measures needed to ensure long-term governance of all mitigation measures (including any biodiversity offsets). Apply a rigourous monitoring, evaluation and enforcement system that includes independent verification of all mitigation measures.	Effectively account for and manage the risks of the offset not succeeding.	Where legal security is required, offsets must be legally secured for the duration of the impact on the prescribed environmental matter.	Financial liability for offsets should be determined by the costs to achieve and maintain net benefits in perpetuity. Offsets should be subject to monitoring and adaptive implementation over appropriate durations.

BBOP [1]	IUCN [9]	DOE [16]	QLD [18]	BOS et.al. [19]
9. Transparency: The design and implementation of a biodiversity offset, and communication of its results to the public, should be undertaken in a transparent and timely manner.	Use approaches that are science-based, transparent, participatory, and address the effects of the project and mitigation actions on livelihoods.	Be efficient, effective, timely, transparent, scientifically robust and reasonable. Have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced. Be informed by scientifically robust information and incorporate the precautionary principle in the absence of scientific certainty. Be conducted in a consistent and transparent manner.	1. Offset provision must minimise the time-lag between the impact and delivery of the offset.	
10. Science and traditional knowledge: The design and implementation of a biodiversity offset should be a documented process informed by sound science, including an appropriate consideration of traditional knowledge.				
		[third parties can be used to deliver offsets]		Offsets should be designed and implemented by specialist third-party entities.
		Be built around direct offsets but may include other compensatory measures.		
	Identify and put in place the legal, institutional and financial measures needed to ensure long-term governance of all mitigation measures (including any biodiversity offsets).			

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