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How to Protect the Great Barrier Reef?

A Possible Shift Towards More Integrated Land-Sea Planning

MASTER THESIS

by

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Abstract

As of today, the Australian Great Barrier Reef is declining and mostly threatened by climate change, land-based run-offs, coastal development and fishing activities. Marine protected areas are considered more and more insufficient, especially in protecting coral reefs from impacts that arise outside their spatial boundaries. This study focused on land-based run-offs as one of those threats and examined to what extent these are considered in Australia's policies and current coral reef management. Furthermore, it was investigated how land-based threats can be minimised and better integrated into the current coral reef management in the wider Great Barrier Reef area. The theoretical framework under study incorporated the concepts of Ecosystem-Based Management, Marine Spatial Planning and Integrated Coastal Zone Management. Based on these three concepts as well as on additional literature, principles for a future land-sea planning approach were established. To find answers to the research questions under study, a document analysis and semi-structured interviews were carried out. The findings reveal that agricultural activities on land are the main cause for poor water quality due to excess nutrients, sediments and pesticides, which are discharged into the waterways. The study identified scope for improvements through the implementation of a superordinate and sector overarching governance system, a closer cooperation with key stakeholders, the relocation and buy-out of farming properties close to critical water bodies and the reinforcement of stronger regulations. Beyond that, the study emphasised the importance and benefits of a land-sea planning approach that considers both realms, the land and the sea, to protect the Great Barrier Reef from future land-based threats. The findings highlight that land-sea planning is already done to some extent in Australia. However, it is expected that even a fully integrated land-sea planning approach will not save the Great Barrier Reef in the future, but it certainly can contribute to its resilience.

KEYWORDS

Coral Reef Management | Ecosystem-Based Management | Great Barrier Reef | Integrated Coastal Zone Management | Land-Sea Interactions | Land-Sea Planning | Marine Spatial Planning

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List of Abbreviations

BMP	Best Management Practice
EBM	Ecosystem-Based Management
GBR	Great Barrier Reef
GBRMP	Great Barrier Reef Marine Park
GBRMPA	Great Barrier Reef Marine Park Authority
GBRWHA	Great Barrier Reef World Heritage Area
ICZM	Integrated Coastal Zone Management
LSI	Land-Sea Interactions
LSP	Land-Sea Planning
MPA	Marine Protected Area
MSP	Marine Spatial Planning
QCA	Qualitative Content Analysis
Reef 2050 Plan	Reef 2050 Long-Term Sustainability Plan
Reef 2050 WQIP	Reef 2050 Water Quality Improvement Plan
SSI	Semi-Structured Interview

1. Introduction

1.1. Background

Coral reefs are among the most diverse and valuable ecosystems of our planet. They occur in 80 countries worldwide, occupy around 284,300 km^2 globally and cover less than 0.1 per cent of the entire global ocean surface area (Sheppard et al., 2012). Coral reefs support some of the most diverse communities in the marine environment and their ecosystem functions include energy flow, material cycle and productivity (Kaiser et al., 2011; Li, 2019). Additionally, they also function as coastal protection due to the limestone skeletons, which are formed by scleractinian coral species (van Oppen & Lough, 2018; Sheppard et al., 2012). Furthermore, coral reefs supply protein for millions of people living close to these ecosystems (Sheppard et al., 2012). Still, there are several threats, which can cause temporary or permanent damage to coral reefs (Corinaldesi et al., 2018; Sheppard et al., 2012). Many of these threats are directly or indirectly related to human activities (Li, 2019). In the past decades, coral reefs have been negatively affected by global warming. As a result of rising water temperatures, bleaching events occur worldwide (Hughes et al., 2018). Coral bleaching refers to the symbiosis between the coral animal, called polyp, and its single-celled photosynthetic algae, called zooxanthellae, which live in the coral tissues. The symbiosis is essential for the coral's survival, since the coral host is provided with photosynthetic products while the zooxanthellae receive protection and nutrients from the polyp. This endosymbiosis between coral animal and zooxanthellae can be found especially in scleractinian or hard corals, which are famous for their reef-building skeletons (van Oppen & Lough, 2018). Due to certain environmental stressors such as marine heat waves, the algae can get expelled from the tissues of their coral host and, therefore, the affected corals will lose their colour, which they have only because of photosynthetic pigments of the algae (Voolstra, 2020). If this happens, the white coral skeleton appears, as the tissue layers of the polyps are translucent (van Oppen & Lough, 2018). Besides global warming, there are several other threats, which can lead to the degradation of coral communities. Mass bleaching events can be caused, among others, by temperature and salinity changes or the input of pollutants. Nutrient enrichment through terrestrial run-offs can become problematic too, as corals are well adapted to thrive in very low nutrient concentrations (Kaiser et al., 2011). Overall, it is assumed that over 60 per cent of the global coral reefs experience damage from local activities, which include overfishing, coastal development and the pollution of adjacent water bodies (Carlson et al., 2019). This stresses the importance of efficient coral reef management because coral reefs are highly valuable for planet Earth and provide various ecosystem functions, but at the same time reef communities are highly endangered by a whole range of human activities.

The most common form of coral reef management was and still is the designation of marine protected areas (MPAs), which enforce restrictions either on fishing or on other extractive and non-extractive activities. These restrictions are in place within a bound spatial area (Makino et al.,

2013). However, the protection of coral reefs with the help of one-realm management measures such as the designation of MPAs is not always ideal as globally, coral reefs are threatened by human activities from both realms, the land and the sea (Beger et al., 2010; Makino et al., 2013). These human activities also include land-based pollutants, which eventually find their way into the marine environment (Kroon et al., 2016). Marine regulations which do not integrate land-based activities are prone to fail in protecting vulnerable marine ecosystems. Hence, an additional focus on land use planning is considered fundamental for the protection of coral reefs (Carlson et al., 2019). Reefs that are located downstream of land disturbances are often degraded by various factors such as diseases, low larval recruitment and survival or mortality from hypoxia (Álvarez-Romero et al., 2011; Carlson et al., 2019; van Oppen & Lough, 2018). Furthermore, changes in land use and land cover affect coral reefs through different ecological processes such as freshwater regulation or contaminant retention, which can influence coral communities as land spaces serve either as sinks or sources for surface and groundwater contaminants (Carlson et al., 2019). These contaminants can be nutrients, sediments, pesticides or pathogens such as faecal bacteria (Carlson et al., 2019; Delevaux et al., 2019). Contaminants negatively affect coral reefs worldwide regarding their reproduction, growth rates and post-disturbance recovery (Sheppard et al., 2012). Based on ocean hydrodynamics, such pollutants can persist and undergo periodic resuspension on reefs for a long period (Carlson et al., 2019). Overall, coral reefs worldwide are threatened by various pollutants that originate on land, whereby MPAs as the most common form of protection have reached their limits.

Agriculture displays a land use type that has negative impacts on coral reefs and further, it is estimated that at least 25 per cent of coral reefs are threatened by pollutants, which are caused by agriculture purposes. Intensive agriculture is a highly erosive process, which can transmit sediment, organic and inorganic nutrients and other contaminants to waterways and aquifers and, therefore, also towards vulnerable coral reefs (Carlson et al., 2019). Wolanski et al. (2004) argue that corals show poor recovery after agricultural expansion because heavy sedimentation prevents new larvae from seeding damaged reefs and deters herbivorous fish from grazing down algae as they compete with corals. Apart from agricultural land use, other important impact categories are urban land use and industry, which include industrial hubs or major infrastructure like ports and other land uses designed to support concentrated human settlement. Considering urban land use, impacts such as habitat loss from nearshore earthmoving, industrial pollution from factories, sewage water from sewer outfalls and underground storage tanks, stormwater run-off from impervious pavement and marine debris can negatively impact coral reefs (Carlson et al., 2019). Besides agricultural and urban land use, there are also other land use types, which should be considered in future reef management and conservation strategies, such as mines, quarries or roads (Carlson et al., 2019; Rude et al., 2016). Mines discharge heavy metals, which lead to the decline of coral density, calcification and tissue layer thickness. Like other contaminants, some of these heavy metals, such as zinc or lead can remain in reef communities for numerous years after mining ceases. However, the actual effects of the different land use types and of possible contamination

on coral species can vary between recruitment, juvenile and adult stages (Carlson et al., 2019). Overall, today's coral reefs are not only threatened from the marine side or by climate change in general, but also more and more by poor water quality, which can be caused by land activities such as agriculture.

These facts stress the need for a shift from traditional conservation measures, which address marine and terrestrial ecosystems in isolation, towards a more integrated approach, which considers the connectivity of land and sea. An integrated land-sea planning (LSP) approach could improve today's coral reef management to incorporate land-based threats into planning. Especially in the face of today's climate crisis, coral reefs worldwide are in a critical state and, therefore, threatening cumulative impacts must be reduced as much as possible.

1.2. Societal and Scientific Relevance

There is a high societal value to coral reefs as they are responsible for high biodiversity, are highly productive and provide protein to many millions of people that live close to these ecosystems (Sheppard et al., 2012). Due to their calcium carbonate skeletons, scleractinian corals provide coastal protection from wave energy (Kaiser et al., 2011). Beside human dependence on coral reefs in terms of food source, coastal protection as well as ecological and biological benefits, there also exists high economical interest in coral reefs (McCoshum et al., 2016). Coral reefs are a major tourist attraction and destination. The colourful reefs attract many visitors from all around the world and create a growing industry for recreational activities such as diving, snorkelling or cruise trips (Kaiser et al., 2011). Hence, research that aims to investigate future LSP approaches is of special interest for the overall society, since its goal is to improve future decision-making and planning to further protect ecosystems such as coral reefs.

Currently, LSP is mostly discussed in academia, where a call has been made to change current coral reef management practices (Álvarez-Romero et al., 2011; Álvarez-Romero et al., 2015; Boersma & Parrish, 1999; Carlson et al., 2019; Kroon et al., 2016; Makino et al., 2013; Rude et al., 2016). Yet, even in academia, LSP is not researched to a large extent, which is why this research is of relevance for the overall academic debate in this field. The findings of this study could help to identify knowledge gaps and further research possibilities in order to improve this area of research. Global warming, among other threats, has massive impacts on the health of coral reefs (Kaiser et al., 2011). Terrestrial anthropogenic changes and their impacts on the marine environment must be monitored and analysed to find suitable scenarios for conservation, ecosystem health as well as economic viability (Rude et al., 2016). Therefore, recommendations or improvements which are drawn from this study, especially in terms of LSP and coral reef management in the wider Great Barrier Reef (GBR) region, can be applied to other coral reefs in the world. This study will highlight current policies and management measures as well as identify

their possible weaknesses. The results of this study can therefore provide important insights in current land use practices and water management in Australia and might, therefore, be of interest for other countries or regions that manage coral reefs and wish to enhance its protection.

1.3. Great Barrier Reef Marine Park

The Great Barrier Reef Marine Park (GBRMP) and the state of Queensland in Australia are the geographical scope of this study. The GBRMP is the area of consideration on the seaside, whereby the North East Coast drainage division including the catchments of Cape York, Wet Tropics, Burdekin, Mackay Whitsunday as well as the Fitzroy catchment is the considered area on the landside (figure 1). The GBR is the largest coral reef system in the world and extends over 2,000 km along the north-east coast of Australia, located off the coast of Queensland (Kroon et al., 2016). The Australian government enforced the *Great Barrier Reef Marine Park Act (1975)* to achieve its conservation and sustainable management. The Act's main objective is to provide long-term protection and conservation measures of the environment, biodiversity as well as heritage values for the GBRMP. Besides the GBRMP itself, the Act also established a statutory authority with the Great Barrier Reef Marine Park Authority (GBRMPA) (Hassan & Alam, 2019). In 1981, the 348,000 km^2 sized area was listed as GBR World Heritage Area (GBRWHA) by the United Nations Educational, Scientific and Cultural Organization (Kroon et al., 2016). As of today, the GBRWHA is regulated by numerous Australian and Queensland government acts, as well as by regulations that are directly relevant for the management, use and protection of the area (GBRMPA, 2022c; Jacobs Group, 2014). Besides all efforts that were made, managing a large area such as the GBR remains a challenge.

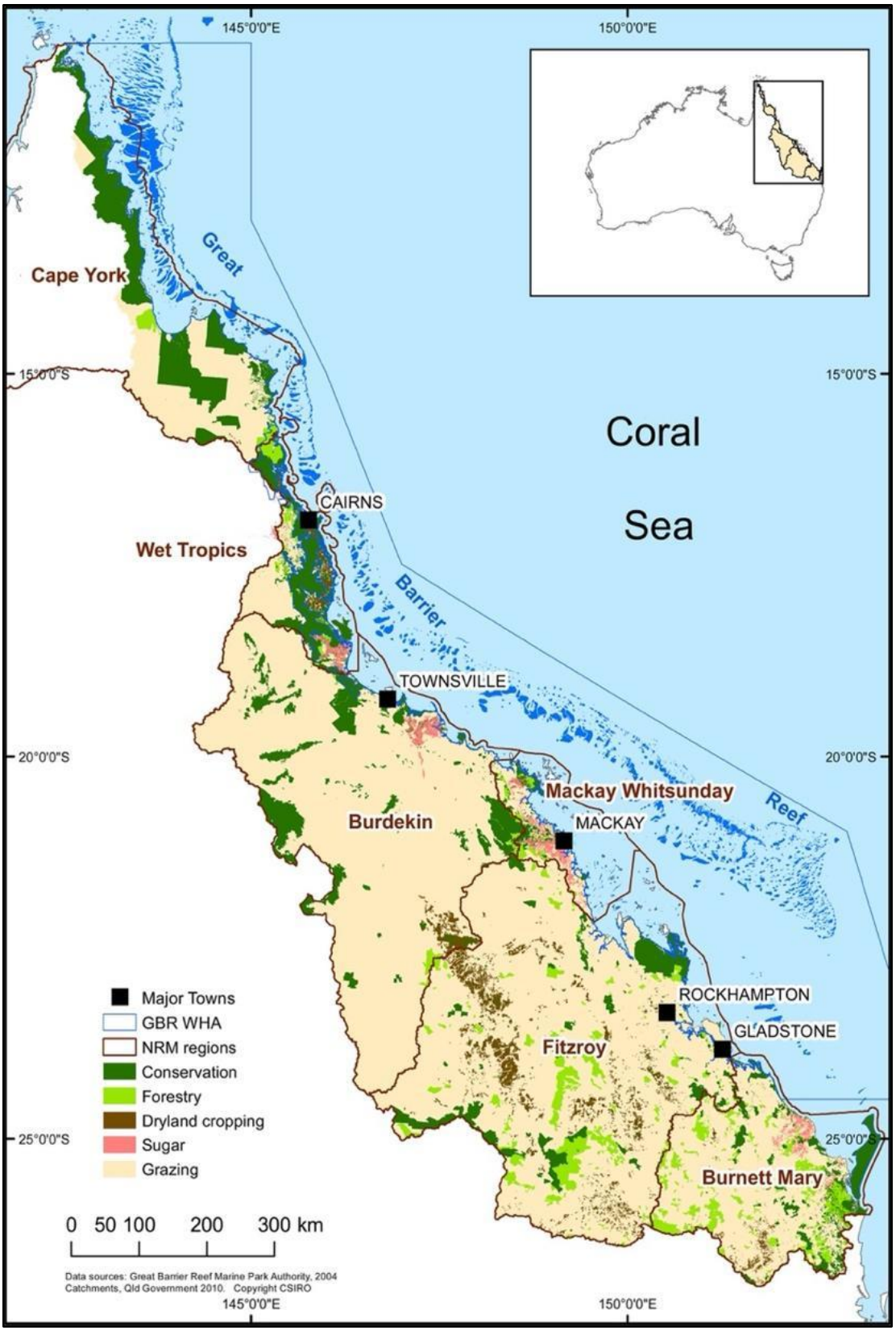

Figure 1: Map of land uses in the adjacent catchments along the GBRWHA (Source: Kroon et al., 2016; licence obtained from John Wiley & Sons).

Currently, the GBR is in a critical state. It has experienced the warmest temperatures on record for its region and for years the coral cover declines (GBRMPA, 2019; Stuart-Smith et al., 2018). This is not only an ecological tragedy, but also a social and economic one. The cultural integrity of Indigenous peoples is closely linked to the health of ecosystems like the GBR, which highlights the importance of its protection beyond ecological or economic values (Ban & Frid, 2018). The GBR receives around ten million visitors each year and according to the *Reef 2050 Water Quality Improvement Plan* (Reef 2050 WQIP), it supports 64,000 jobs and contributes 6.4 billion dollars annually to the Australian economy (Kaiser et al., 2011; State of Queensland, 2018a). The GBR is therefore commercially one of the most important ecological sites on planet Earth (Kaiser et al., 2011). Yet, the coral cover continues to decline (GBRMPA, 2019). As of today, the GBR is mainly impacted by climate change, coastal development, remaining fishing activities and poor water quality from land-based run-offs that introduce sediments, excess nutrients, pesticides and other pollutants through Queensland's catchments into the GBR (GBRMPA, 2022a). Research that focused on agricultural impacts on the GBR has shown that some of the affected watersheds are covered by around 95 per cent agriculture activities as indicated in figure 1 (Carlson et al., 2019). Furthermore, Carlson et al. (2019) carried out a literature review, which highlights that at higher rainfall, river basins with intensive cropland, such as sugarcane, are primarily responsible for dissolved nutrient and pesticide and/or herbicide run-off into the GBR. However, agricultural impacts also vary significantly in time and space based on their soil erodibility, rainfall, oceanic resuspension as well as on other biophysical factors (Carlson et al., 2019). In total, there are 35 major catchments that discharge water into the GBRMP, of which many were modified for agriculture purposes and land development. In fact, grazing is the major source for fine sediment as well as particulate nitrogen that reaches the GBR (GBRMPA, 2020; Rolfe et al., 2021, State of Queensland, 2018a). Carlson et al. (2019) revealed that sugarcane crops are the main source of excess nutrients and pesticides that reach the GBR. Besides agriculture in general, there are other sources of pollution like mining, aquaculture facilities, urban areas, sewage treatment plants, industrial areas, ports and defence activities that pollute and negatively impact the water bodies. Besides nutrients, sediments and pesticides, contaminants such as petroleum hydrocarbons, heavy metals, coal dust, marine debris and microplastics, personal care products or pharmaceuticals have negative impacts on the GBR (GBRMPA, 2020). Overall, the coral cover of the GBR continues to decline and its reef communities are currently in a critical state due to various threats such as land-based sources of pollution.

At the end of 2020, the GBRMPA (2020) published a position statement on water quality in the GBR, whereby it is stated: "Poor water quality is a major threat to the Great Barrier Reef, particularly inshore areas. Improving the quality of water entering the Marine Park is critical and urgent" (p. 1). The statement emphasises the urgency for a change in management strategies to improve the water quality in the GBR. Recently, on the 25th of March 2022, the GBRMPA published a reef health update, stating: "Coral bleaching has been observed at multiple reefs in all four management areas (…), confirming a mass bleaching event, the fourth since 2016"

(GBRMPA, 2022b, para. 2). And further on the 8th of April 2022, the GBRMPA stated: "Despite the fact that summer is now over a month behind us, the coral bleaching event, and our understanding of it, are still unfolding" (GBRMPA, 2022b, para. 22). The reef updates that are published by the GBRMPA highlight the urgency for taking actions and to further improve protection measures to save the GBR for the future. Even though climate change is the main driver that causes the GBR to decline, land-based impacts put additional pressure on it (GBRMPA, 2019; Schaffelke et al., 2017). The continuous decline of the GBR and the amount of mass bleaching events it experienced in the past years underline the urgency to improve coral reef management practices and to find new planning frameworks such as an integrated LSP approach.

1.4. Presentation of Research Questions

The purpose of this study is to identify new ways on how to protect the GBR from land-based threats and, therefore, contribute to its resilience. For this purpose, this study was developed and the following primary and secondary research questions were formulated. The secondary research questions under study will help to find answers to the primary research question and to gain additional in-depth information.

Primary Research Question

How can land-based threats be minimised and better integrated into coral reef management in the Australian Great Barrier Reef?

Secondary Research Questions

(1) *To what extent are land-sea interactions and land-based threats already integrated into current coral reef management and policies at the Australian Great Barrier Reef?*

(2) *What are the causes for possible failures of the responsible authorities and for the progressing decline of the Australian Great Barrier Reef?*

(3) *How, if at all, can current policies and coral reef management be improved in addressing land-based sources of pollution in Queensland and in the Great Barrier Reef Marine Park?*

1.5. Thesis Outline

The following study will examine how land-based run-offs from land activities, which are discharged into the GBR, can be minimised and better integrated into the coral reef management. For that reason, this study will examine the current management strategies that are applied in the GBR and identify improvements. Chapter 2 will introduce different theoretical concepts. Based on these and on additional literature, principles for a future LSP approach will be worked out. In chapter 3, the overall research design of this study will be introduced and methods for data collection, selection and analysis will be presented. Chapter 4 summarises the major findings, which will be further discussed in chapter 5. Finally, the conclusion in chapter 6 will present answers to the research questions under study and provide recommendations for future coral reef management.

2. Theoretical Framework

In this chapter, the theoretical concepts of Ecosystem-Based Management, Marine Spatial Planning and Integrated Coastal Zone Management will be introduced, and important aspects and principles will be carried out for the purpose of this study. Since the designation of MPAs alone is insufficient to protect coral reefs from land-based threats, a new approach, which considers the interconnectivity of both realms, the land and the sea, is needed. The most important aspects of the three concepts for the development of a future LSP approach will be examined and LSP principles will be carried out and further analysed.

2.1. Ecosystem-Based Management

Ecosystem-Based Management (EBM) represents an environmental management approach that takes the entire spectrum of interactions within an ecosystem into account, instead of considering single issues, species or ecosystem services alone. Hence, EBM considers human actions as part of the ecosystem (Katsanevakis et al., 2011). The philosophy on which the concept is based, has been practised by Indigenous peoples for a long time already (Long et al., 2015). Douvere (2008) argues that "Concepts regarding both integrated and ecosystem-based management are often too broad, too abstract and too complex for resource managers to enable effective implementation" (p. 763). Long et al. (2015) define EBM as: "an interdisciplinary approach that balances ecological, social and governance principles at appropriate temporal and spatial scales in a distinct geographical area to achieve sustainable resource use" (p. 59) and further: "EBM recognises coupled social-ecological systems with stakeholders involved in an integrated and adaptive management process where decisions reflect societal choice" (p. 59).

Through a marine perspective, EBM aims to maintain marine ecosystems in such a condition that they stay healthy, productive and resilient. Consequently, EBM can sustain uses of the ocean by humans and provide the services and goods they need (Day et al., 2019; Long et al., 2015). Hence, a comprehensive EBM approach acknowledges that activities in the adjoining coastal and oceanic areas have impacts on the wider marine environment and on other marine activities (Day et al., 2019). Vince and Day (2020) interpret EBM as: "the overarching approach that uses spatial and nonspatial tools across terrestrial and marine realms to achieve effective conservation" (p. 2). For a successful implementation of EBM, best available sciences are required and new tools like remote sensing or geographic information systems are needed, since these tools provide a better understanding of the marine environment and its population dynamics (Katsanevakis et al., 2011). Overall, the concept of EBM is relevant for this study because it acknowledges the interconnectivity of land and sea and puts emphasis on a cross-realm planning approach.

2.2. Marine Spatial Planning

Marine Spatial Planning (MSP) can be interpreted as a subset of EBM, which focuses on the marine realm only. It is therefore a fundamental method to deliver EBM in the marine environment and, therefore, indispensable for marine management (Vince & Day, 2020). In the past, MSP was seen as a form of zoning that resulted from MPA development. However, this perception changed over time and today, MSP is rather known as a management tool (Vince, 2014). In general, MSP can be understood as a process to implement a more rational and integrated approach to the use of marine spaces for humans (Ehler, 2013). According to Ehler and Douvere (2009), MSP is defined as: "a public process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that are usually specified through a political process" (p. 18). The process of MSP can incorporate an ecosystem approach to reach certain marine conservation objectives. Therefore, coastal planners can address land use issues for instance, to manage land-based pollution (Ehler, 2013). According to Ehler and Douvere (2009), effective MSP is in its characteristics ecosystem-based, integrated, area-based, adaptive, focused on the long-term and participatory by actively involving stakeholders into the planning process. Designating marine space for human activities is something that most countries already do (Ehler & Douvere, 2009). However, such activities can cause conflicts across different sectors, space and time, since human activities in the sea are increasing in numbers, intensity as well as distance to the shore (Collie et al., 2013). Conflicts among human uses, which are user-user conflicts and conflicts between human uses and the marine environment, user-environment conflicts, reduce the ability of the marine environment to provide the necessary ecosystem services (Ehler & Douvere, 2009). Overall, MSP can be seen as a management tool that is used to distribute the marine space and to manage different activities and interests within this space.

The implementation and development of MSP has economic, environmental, social and administrative benefits. It is a multi-use planning process, which aims to integrate and balance these objectives for all uses in the marine environment (Santos et al., 2019). Additionally, it provides an integrated framework for management and does not replace traditional single-sector planning (Ehler & Douvere, 2009). MSP identifies conflicts early and is therefore able to resolve conflicts among clashing uses through planning instead of legal action. It also offers an improved capacity to plan for new and changing activities. In terms of the environment, MSP identifies ecological and biological significant areas, helps to establish context to plan a network for MPAs and identifies and reduces the cumulative effects of human activities in the marine environment. As a result of MSP, local communities and citizens can participate in the planning process, which provides benefits for society as a whole. Beyond that, through the process of MSP, social, cultural and spiritual values that are related to the use of ocean space can be identified and preserved. In an administrative matter, MSP improves the speed, quality, accountability as well as the transparency of decision-making and improves the consistency and compatibility of regulatory decisions (Ehler, 2013). MSP evolved over time to an approach and management tool that manages

economic, environmental and social aspects and at the same time creates opportunities to involve the public into the planning process.

2.2.1. Marine Zoning

The GBRMP is one of the first examples of MSP in Australia and perhaps even in the world. As introduced earlier, the GBRMP was established through the *Great Barrier Reef Marine Park Act (1975),* which introduced the GBRMPA. The authority is responsible for managing and protecting the park and has specific governance arrangements, that coordinate policies between Commonwealth departments and the Queensland government (Vince, 2014). A fundamental part of the MSP approach in the GBRMP is the *Great Barrier Reef Marine Park Zoning Plan (2003),* which is a statutory plan that aims for high levels of protection and allows for sustainable uses to take place (Day, 2015). In fact, zoning is a spatial planning tool that is an important temporal and spatial measure for MSP (Ehler & Douvere, 2009). Zoning has its roots in land use planning where it is used to allocate rights but also responsibilities for the various uses of land. It can provide a legal framework, but it is just one legal layer for management, while MSP can comprise multiple layers. These different layers can then comprise different spatial plans with each of them having its own legal framework (Vince & Day, 2020). Over the past decades, marine zoning, which is also known as ocean zoning, became a foundation for the management of marine areas, for example for MPAs such as the GBRMP (Day et al., 2019).

Today, zoning provides a key layer of MSP in the GBRMP for integrating conservation as well as for a range of human uses and activities. In fact, the multiple-use zoning system of the GBRMP governs all human activities and it provides high levels of protection for certain areas. At the same time, through zoning, activities such as Indigenous traditional use, shipping, boating, tourism and recreation, aquaculture, commercial and recreational fishing, research, developmental work like dredging and spoil disposal and defence training activities can be managed. All of these human uses occur at the same time but are limited to or by specific zones and permits (Day et al., 2019). Marine zoning is an important management tool for MSP but also for EBM. Still, zoning plans must be reviewed to remain effective when considering changes over time. They have to be adapted if there are changing patterns of use, socio-economic or political changes, technological changes as well as environmental changes (Day, 2015). Hence, marine zoning is a management tool of a MSP framework that applies within marine waters and is limited when facing water quality issues, since they often originate on land (Day et al., 2019). Consequently, marine zoning is limited in managing water quality issues and, therefore, additional management strategies are needed.

2.2.2. Stakeholder Engagement

The involvement of stakeholders into the planning process is another important pillar for MSP. Stakeholder engagement is considered essential for MSP, since the success of planning processes depends on the identification and on the understanding of various stakeholders as well as their practices, interests and expectations (Santos et al., 2019). Stakeholder engagement is important because MSP aims to accomplish multiple objectives such as ecological, social, cultural and economic well-being (Ehler & Douvere, 2009). Therefore, stakeholder participation is crucial to balance these objectives in the MSP framework (Santos et al., 2019). However, the requirements for stakeholder participation depend heavily on the legal and cultural requirements of each country (Ehler, 2013). Today, there are different types of stakeholder engagement in MSP, ranging from simple communication towards negotiation in which the power of decision-making is rather shared among the various stakeholders. In fact, proactive and more interactive approaches result in a greater satisfaction among different stakeholders. Furthermore, these types of approaches lead to greater innovations and more long-lasting solutions. Stakeholder analysis is a valuable tool to identify the various stakeholders. It also highlights their interrelationships, objectives and future interests (Santos et al., 2019). Stakeholders should be involved from the beginning of the planning process when goals and objectives of the plan will be set. Further, they should be involved in the evaluation and selection of certain measures of management, since the consequences of these management measures are of interest for stakeholders, too. Besides the planning phase, the implementation phase of MSP is an important moment of stakeholder engagement. In this phase, stakeholders can understand certain problems that possibly occur during the planning process and hence, they might show more understanding for occurring problems but also benefit by taking actions. Therefore, management measures are more likely to be accepted. Moreover, stakeholders should also be involved in the monitoring and evaluation phase to discuss the effectiveness of MSP in terms of achieving the prior set objectives and goals. It is important to discuss the plan results and further evaluate them to improve the next round of planning (Ehler, 2013). Overall, stakeholder engagement is crucial for MSP, since different interests and opinions influence the use of marine space and, therefore, stakeholders should be included into the planning process to minimise possible conflicts.

As of today, there are still issues such as fragmented governance systems, poor communication and the perception that planning is deliberately biased, that lead to the exclusion or nonengagement of stakeholders in MSP (Santos et al., 2019). According to Santos et al. (2019), this questions the social equity, inclusivity and legitimacy of MSP. Stakeholder engagement should therefore be more considered in future decision-making in the marine environment.

2.2.3. Land-Sea Interactions

Marine ecosystems such as coral reefs are directly interconnected with the land and are therefore influenced by land-based activities. The integration of the terrestrial and marine environment should be achieved through policies, plans and decision-making (Ramieri et al., n.d.). The overall idea of land-sea interactions (LSI) in the planning domain is not new. LSI were already discussed during the sustainable development discourse, which also focused on integrated coastal and ocean management. The discussion of LSI thus goes back to the 1990s and led to a change in its perception (Morf et al., 2019). The interconnectivity of land and sea is also discussed in MSP and gained relevance over time. Yet, LSI are not always considered in MSP, even though multiple human actions and uses as well as environmental processes pass the land-sea boundary (Kidd et al., 2019; Morf et al., 2019).

The current academic discussions on the topic of LSI highlight that uncertainties still exist and that it is not clear yet how LSI should be understood. In literature related to coral reef management, LSI are often linked to approaches like 'ridge-to-reef' (Rude et al., 2016), 'integrated cross-realm planning' (Álvarez-Romero et al., 2015) or 'integrated land-sea conservation planning' (Álvarez-Romero et al., 2011). It is not defined what geographical range LSI and the related planning process should encompass. In fact, marine impacts can arise far inland and, therefore, the potential spatial extent of LSI can be immense. Another aspect that stresses the incorporation of LSI into MSP relates to the possible management of such interactions. Different areas in the world vary in terms of institutional and legislative arrangements and so does the geographical context. Therefore, different governance arrangements must be linked together to deal with these complex sets of interrelationships, which are context-specific and take place across several spatial dimensions (Morf et al., 2019).

LSI in MSP cover: "all natural and human-induced flows and processes between marine and terrestrial environments in both directions as well as how these interactions are perceived and managed by societies and their different actors through MSP and other governance frameworks and processes" (Morf et al., 2019, p.17). The authors highlight four dimensions of a systematic LSI perspective for MSP. (1) Uses and interactions with and within the environment are about the several sectors that act in the marine environment and, therefore, have LSI implications, whereby the nature of such LSI differs between the sectors. (2) Governance systems are important in this perspective. Different aspects of LSI need different governance systems to manage them accordingly. Morf et al. (2019) highlight that planning in the sea is a relatively new field and, therefore, MSP still needs to find links to marine sector management at various levels and a way to connect it with the wider spatial governance system. (3) Process management is important, since many stakeholders are involved along the way from land to sea and vice versa. Therefore, it is crucial to involve these actors into the process. (4) Knowledge, methods and tools are important to deal with LSI issues. Knowledge is further described as awareness and management of

uncertainties and knowledge gaps. Nevertheless, contextual circumstances like societal values, trends or the history of an area are important for how these dimensions occur (Morf et al., 2019). Overall, the perception of LSI is relatively new and so is the management of these interactions.

Currently, there are several challenges for linking LSI to MSP. To apply and implement LSI, various sectors, the broader planning environment as well as the specific governance setting and mandates, distribution of responsibilities and the capacity to arrange planning must be considered (Kidd et al., 2019; Morf et al., 2019). Beyond that, different coastal and marine planning systems face different challenges as well as different potentials to integrate LSI into MSP. Still, there are awareness gaps in terms of LSI and, therefore, specific LSI issues must be addressed to overcome these gaps. Additionally, there is a lack of communication, knowledge and capacity building within local and regional stakeholders and authorities. This needs to be solved to link LSI with marine planning (Morf et al., 2019). It is crucial to better understand LSI and further incorporate them into today's planning systems to improve the protection of marine ecosystems such as coral reefs from land-based threats.

2.3. Integrated Coastal Zone Management

Increasing needs and interests of the complex environmental systems that are located at the land-sea interface led to a global call for improving coastal management to cope with these. These interfaces between the land and the sea are called coastal zones and have several characteristics. They consist of habitats and ecosystems such as coral reefs, which supply goods and ecosystem services to the coastal communities. Furthermore, coastal zones often result in conflicts and destruction to the functional integrity of these systems, since a wide range of stakeholders compete for land and sea uses (Thia-Eng, 1993). Besides that, coastal zones are an important factor for state economies, since coastal activities have a high economic value due to activities such as agriculture, trade and shipping, industry, nature conservation or tourism and recreation (Ahlhorn, 2018). Coastal zones are characterised by high concentrations of humans and are of interest for urban settlements (Thia-Eng, 1993). There are positive and negative effects that are associated with these different forms of human development. Especially, the negative impacts such as contamination by terrestrial run-offs or marine sediments with toxic components, loss of biological diversity, deployment of fish stocks or increasing natural hazards through anthropogenic induced climate change led to the call for Integrated Coastal Zone Management (ICZM) (Burbridge, 2004; Warnken & Mosadeghi, 2018).

According to Sorensen (1993), ICZM: "is a dynamic process in which a coordinated strategy is developed and implemented for the allocation of environmental, socio-cultural, and institutional resources to achieve the conservation and sustainable multiple use of the coastal zone" (p. 49). ICZM was also discussed and approached during the United Nations Earth Summit in Rio de

Janeiro in 1992. In Agenda 21 it is stated: “Coastal States commit themselves to integrated management and sustainable development of coastal areas and the marine environment under their national jurisdiction” (UNCED, 1992, s. 17.5). In comparison to the United Nations Earth Summit in Rio de Janeiro, the European Parliament and Council have developed the concept of ICZM even further. In fact, they emphasised the importance of LSI in the Recommendation 2002/413/EC, which makes ICZM relevant for LSP. In Recommendation 2002/413/EC it is stated: “improved coordination of the actions taken by all the authorities concerned both at sea and on land, in managing the sea-land interaction” (p. 25).

In general, ICZM is a concept that represents a holistic and integrative approach. It is an interactive planning process that addresses the multiplex management issues at the coast. Integration and coordination are fundamental elements of ICZM. The concept can be understood as system integration, which considers the temporal and spatial proportions of coastal resource systems. This type of integration incorporates the relevant management issues that originate from physical, social and economic aspects and addresses these adequately. Another type of integration is functional integration, which ensures that programs and projects are consistent with each other’s goals and objectives. Furthermore, policy integration is crucial to secure an internal consistency of the program regarding the actions of national and local government policies (Thia-Eng, 1993). However, Vince (2015) argues that large-scale integration is dependent on full jurisdictional support from all, national, state as well as local levels. Coordination is an important aspect for ICZM too, as it is about providing a better understanding and cooperation along a wide range of stakeholders in addressing management and coastal development issues. Therefore, institutional coordination must take place at the central and local level across the program planning phase and implementation. It is expected that coordination strengthens the policy and management integration (Thia-Eng, 1993). Even though ICZM only focuses on the coastal zone, it provides important aspects for the development and implementation of an integrated LSP approach.

2.4. Land-Sea Planning

The realms of land and sea cannot be considered isolated for effective coral reef management. By today, poor water quality is seriously threatening the GBR and puts additional pressure on the reef organisms that are already strongly impacted by climate change induced heat waves, which are likely to increase in the future (GBRMPA, 2019; State of Queensland, 2018a). In the beginning of 2022, the Australian government approved a one-billion-dollar reef protection package, whereby around 58 per cent of the investment is reserved for improving the water quality in the GBRMP (DCCEEW, 2022). According to the *Reef 2050 WQIP*, the Australian and Queensland governments have invested more than 2 billion dollars over 10 years to protect the GBR, whereby an unprecedented amount of investment was spent on improving the water quality (State of Queensland, 2018a). However, this raises the question if the Australian and Queensland

governments are doing well enough to protect sufficiently the GBRWHA or if current planning practices must be improved.

By today, LSP is not an official, widespread recognised approach such as MSP or ICZM. It is acknowledged that there is the need for a planning framework that considers the entire way from the inland, downstream to the marine environment to ultimately improve the water quality. For the purpose of this study, the term LSP will be used while the literature also refers to terms such as 'ridge-to-reef', 'integrated land-sea conservation planning', 'integrated cross-realm planning', 'summit-to-sea' or 'integrated planning', while all of these concepts stress the urge to consider and acknowledge the interconnectivity of both realms, the land and the sea (Álvarez-Romero et al., 2011; Álvarez-Romero et al., 2015; Carlson et al., 2019; Makino et al., 2013; Rude et al., 2016). The earlier introduced concepts of EBM, MSP and ICZM as well as various literature on the topic of coral reef management will build the base of what is considered as LSP under study to find answers to the research questions.

EBM can be understood as the overarching environmental management approach that considers the entire spectrum of interactions within an ecosystem that incorporates human actions as part of such (Katsanevakis et al., 2011). Therefore, EBM is crucial for LSP, since it combines the terrestrial and marine environment in its concept. However, MSP and ICZM are relevant approaches for future LSP as well, since they can be interpreted as subsets of EBM, which is also indicated in the conceptual model (figure 2). Both approaches deliver important aspects for future LSP. As discussed in the literature, MSP and ICZM provide incentives for considering LSI, and consequently, land and sea cannot be viewed as separate entities any longer. However, the two concepts do not provide clear guidelines about how to incorporate LSI into the planning process. Therefore, additional literature on LSP was retrieved and considered to establish principles for a future LSP approach.

Core planning components from the problem definition towards the implementation of a management strategy are essential for LSP. However, to make the shift towards LSP, it is necessary to expand core components to accommodate planning across realms (Álvarez-Romero et al., 2015). Based on the concepts of EBM, MSP and ICZM as well as on propositions from additional literature, the following six principles are considered crucial for future LSP. Moreover, they are of relevance for the data collection and analysis, which are introduced in chapter 3, and further for answering the research questions under study:

(1) An *integrated governance system,* which focuses on both the marine and terrestrial realms within state and federal jurisdictions. Therefore, governance arrangements must be expanded, while governance analyses can be helpful to discover these (Ahlhorn, 2018; Álvarez-Romero et al., 2015; Day, 2015; Morf et al., 2019; Vince, 2015; Vince & Day, 2020).

(2) *Stakeholder engagement* across both realms to extend the stakeholder base. The collaboration with institutions that can reach out to multiple stakeholders can be crucial for a greater engagement process (Álvarez-Romero et al., 2011; Álvarez-Romero et al., 2015; Carlson et al., 2019; Santos et al., 2019; Thia-Eng, 1993; Warnken & Mosadeghi, 2018).

(3) *Multiple objectives* across realms, as well as socioeconomic objectives across the two realms are important for LSP. Objectives must be reconsidered, since planning processes can produce benefits upstream and improve the situation downstream at the same time. Furthermore, the socioeconomic dimension is crucial for LSP, since actions in one realm can have impacts in another area and scenario planning can be used as a tool to envision multiple futures (Álvarez-Romero et al., 2011; Álvarez-Romero et al., 2015; Beger et al., 2010; Carlson et al., 2019).

(4) *Management of co-benefits and trade-offs* is of greater significance in LSP because it is more complex in terms of decision-making, since there is a greater geographical area with more space and more stakeholders involved. Therefore, it is crucial to understand how these different assets respond to certain actions and how these responses possibly interact (Álvarez-Romero et al., 2015).

(5) *Monitoring and modelling* are important to oversee management decisions, since they provide information about the number of pollutants in the water bodies for instance. Furthermore, modelling is a powerful tool for planners to understand how land use change possibly affects the marine environment (Álvarez-Romero et al., 2011; Álvarez-Romero et al., 2015; Beger et al., 2010; Delevaux et al., 2018; Rude et al., 2016).

(6) *Evaluation* is crucial for LSP, since it is a continuous process that measures performance and compares this with the program's goals and objectives. It should be carried out periodically during the planning process (Douvere & Ehler, 2009; Ehler, 2013; Santos et al., 2019).

These principles highlight the core of a future LSP as it is defined in this study. LSP as it is characterised in this chapter will be further operationalised for analysis to examine the extent of which Australia is including LSP in its management practices by today.

2.5. Conceptual Model

The conceptual model, which is illustrated in figure 2 highlights the relationship between the concepts of EBM, MSP, ICZM and of a future LSP approach. The six LSP principles are based on the three concepts as well as on additional LSP literature. To answer the research questions under study, the data corpus will be analysed on LSP, LSI and the reference to land-based threats in general to highlight the current situation of coral reef management around the GBR. Moreover, it will be investigated where authorities possibly fail to improve the overall water quality in the catchments. Finally, based on the findings as well as due to the overall data, recommendations will be drawn.

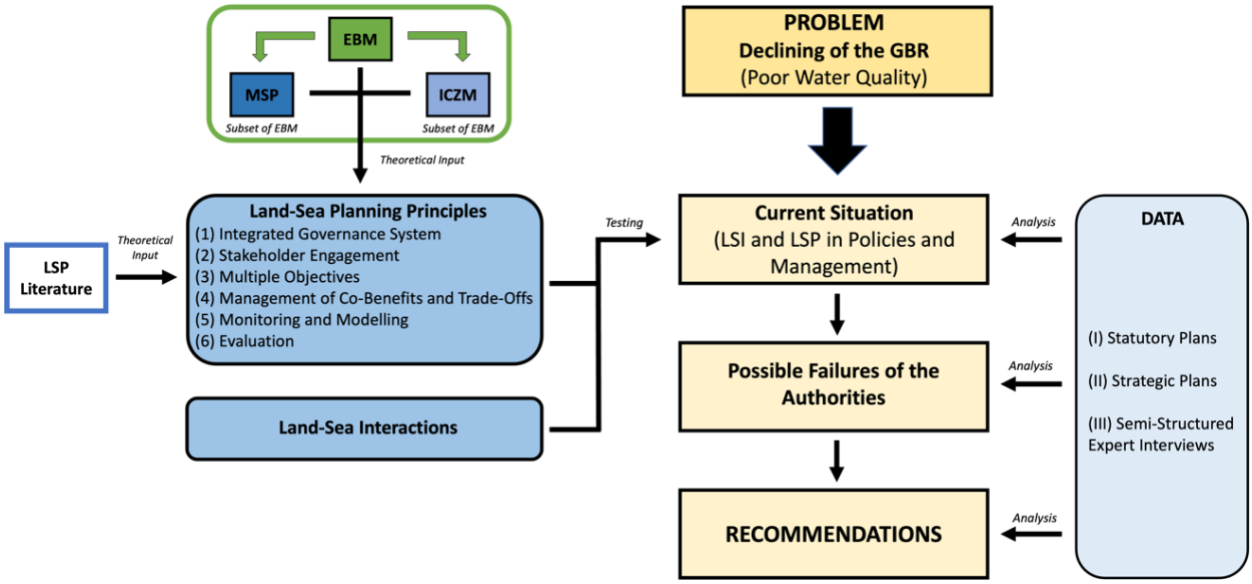

Figure 2: Conceptual model of this study (Source: Made by author).

3. Methodology

In this chapter, the methodology of this study will be introduced. To find answers on how land-based threats can be minimised and better integrated into the current coral reef management in the GBR in Australia, a qualitative research approach was applied. For the data collection and selection, a literature review, document analysis as well as semi-structured interviews (SSIs) were carried out to generate an in-depth data corpus. Moreover, by using qualitative content analysis, the data corpus was analysed for further interpretation.

3.1. Research Approach

For this study, a qualitative research approach was considered most suitable to answer the primary and secondary research questions under study. According to Ashley and Boyd (2006), qualitative research is based on the examination of people's words and actions. This research approach seems suitable for the purpose of this study, since it elaborates on an under-researched topic and focuses on qualitative data, which is expressed in words rather than numbers to get meaning from the data corpus (Ashley & Boyd, 2006). This is of interest for the document analysis but also for the expert interviews, since one goal of this research is to examine if LSP is already considered or mentioned in statutory and strategic plans in Australia.

The research started with an overall literature review to gather information and secondary data. This was necessary to get a fundamental understanding of the current situation in terms of LSP in Australia and in particular around the GBR. The literature review was an important step to build up a base for the following document analysis of statutory and strategic plans in Queensland and the wider GBR area. Subsequently, SSIs with experts from different domains were conducted to answer those questions that the document analysis could not give answers to. This was especially important for identifying improvements in the current coral reef management. Therefore, the document analysis was supplemented by SSIs and through both methods, primary and secondary data were generated.
However, choosing a qualitative research approach also has limitations, since it always involves the interpretation by the researcher (Greene, 1986). Still, to find answers to the research questions and especially in respect of LSP, which represents the backbone of this study, qualitative data collection seemed most suitable, since it provides opportunities to gather in-depth insights on subjects that are little researched (Schreier, 2012).

In terms of epistemology, this research makes use of deductive reasoning, since a new approach, namely LSP, is tested on data that was collected beforehand. However, it also relies on inductive reasoning, since it is also open to new findings that could be of relevance for this study. These findings could be information that were not approached in the theoretical framework but rather

collected during the document analysis or SSIs. This mixed approach of both deductive and inductive reasoning gave more room and flexibility for the development of important findings (Schreier, 2012).

3.2. Data Collection and Selection Methods

The data corpus for this research was generated through different methods, such as a literature review, a document analysis as well as SSIs.

3.2.1. Literature Review

An extensive literature review provides the basis for this study, since background information had to be gathered in the first place. The method is the fundament for the following research. The focus of the literature review was on the four key concepts, which were introduced earlier in chapter 2. Therefore, various literature that address EBM, MSP, ICZM and LSP were selected and studied. Since LSP is not a well-studied concept on its own, literature that refers to terms such as 'integrated cross-realm planning', 'integrated land-sea conservation planning', 'integrated planning', 'ridge-to-reef' or 'summit-to-sea' were reviewed as well. The literature was retrieved through web search engines, such as 'Google Scholar' as well as 'SmartCat', a service provided by the library of the University of Groningen.

3.2.2. Document Analysis

Data collection based on statutory and strategic plans in Australia was considered important to answer the research questions under study. The method was of value, since data from statutory and strategic plans can be examined and interpreted to gain understanding and to finally develop empirical knowledge. Moreover, documents are suitable because they can provide background information and give historical insights to a certain subject. Hence, documents can be analysed to get an understanding about the status quo (Bowen, 2009). The document analysis is also of great value for this research because it provides information about how, if at all, LSP is practised in Queensland and the wider GBR region, and if so, to what extent. According to Bowen (2009), the document analysis is efficient, since it is less time-consuming because it is based on data selection rather than on data collection. The method is beneficial in terms of availability, since most documents can be retrieved from the internet and are available on public domains such as the websites and e-libraries of the Australian government, Queensland government and the GBRMPA. Beyond that, the method is cost-effective and covers a long span of time, which is of interest for this research, since it shows how planning, particularly LSP, has possibly evolved in the study

area. Yet, document analyses often do not provide sufficient answers to research questions, which is why the document analysis under study is supplemented by expert interviews, which can counteract this limitation. In addition, a document analysis can be very relevant for expert interviews, since it can help to formulate further questions for the interviews (Bowen, 2009). The purpose of this study is not solely to examine if LSP is already carried out in the study area but also to draw recommendations for the future. Therefore, SSIs are considered an important addition for the document analysis, since experts can give their opinion about how to improve the current situation if necessary. Consequently, the expert interviews were conducted after the document analysis was performed.

For the mean of this study, statutory and, therefore, legal binding plans (table 1), published by the Australian government, Queensland government and GBRMPA as well as non-binding, strategic plans (table 2) were analysed. All documents were retrieved from official websites and online e-libraries from the respective authorities. Documents that were relevant and which related to the research topic and its research questions were selected for the analysis. The Jacobs Group (2014) highlights that there are 26 Federal and Queensland government acts and regulations that are directly relevant for the overall management of GBRMP and, therefore, they were considered for this study. Beyond that, other important statutory and strategic plans for the analysis were collected through snowball sampling. Therefore, emails, literature and official websites were used to get more information about important documents and were collected afterwards (Given, 2008). An entire list of all documents that were analysed can be found in table 1 and table 2, whereby appendix I and appendix II provide additionally the objectives or purposes of those documents.

Table 1: List of all statutory plans used in the document analysis including names, status and the responsible authorities.

Acts and *Instruments*	**Status**	**Responsible Authority**
Environment Protection (Sea Dumping) Act 1981	In Force	Federal Government
Environment Protection and Biodiversity Conservation Act 1999	In Force	Federal Government
Great Barrier Reef Marine Park Act 1975 *Great Barrier Reef Marine Park Zoning Plan 2003* *Great Barrier Reef Marine Park Regulations 2019*	In Force	Federal Government
Protection of the Sea (Prevention of Pollution from Ships) Act 1983	In Force	Federal Government
Sea Installations Act 1987	In Force	Federal Government
Sewage Discharge Policy 2005	In Force	Great Barrier Reef Marine Park Authority

Coastal Protection and Management Act 1995 *State Policy for Coastal Management 2011*	In Force	Queensland Government
Economic Development Act 2012	In Force	Queensland Government
Environmental Protection Act 1994 *Environmental Protection (Water and Wetland Biodiversity) Policy 2019*	In Force	Queensland Government
Fisheries Act 1994	In Force	Queensland Government
Great Barrier Reef Protection Amendment Act 2009	In Force	Queensland Government
Marine Parks Act 2004	In Force	Queensland Government
Maritime Safety Queensland Act 2002	In Force	Queensland Government
Nature Conservation Act 1992	In Force	Queensland Government
Planning Act 2016 *Planning Regulation 2017* *State Planning Policy 2017*	In Force	Queensland Government
State Development and Public Works Organisation Act 1971	In Force	Queensland Government
Sustainable Planning Act 2009	In Force	Queensland Government
Transport Infrastructure Act 1994	In Force	Queensland Government
Transport Operations (Marine Pollution) Act 1995	In Force	Queensland Government
Transport Operations (Marine Safety) Act 1994	In Force	Queensland Government
Vegetation Management Act 1999	In Force	Queensland Government
Water Act 2000	In Force	Queensland Government
Wet Tropics World Heritage Protection and Management Act 1993	In Force	Queensland Government

Table 2: List of all strategic plans used in the document analysis including names, years and the responsible authorities.

Document (Year)	Responsible Authority
Great Barrier Reef Intergovernmental Agreement (2015)	Federal Government
National Water Quality Management Strategy (2018)	Federal Government
Paddock to Reef Integrated Monitoring, Modelling and Reporting Program - Program Design (2018 - 2022)	Federal Government
Great Barrier Reef Marine Monitoring Program (2019 - 2020)	Great Barrier Reef Marine Park Authority
Great Barrier Reef Outlook Report (2014)	Great Barrier Reef Marine Park Authority
Great Barrier Reef Outlook Report (2019)	Great Barrier Reef Marine Park Authority
Reef 2050 Long-Term Sustainability Plan (2021 - 2025) *Reef 2050 Plan - Cumulative Impact Management Policy (2018)* *Reef 2050 Plan - Good Practice Management for the Great Barrier Reef (2018)* *Reef 2050 Plan - Objectives and Goals (2021 - 2025)* *Reef 2050 Plan - Water Quality Improvement Plan (2017 - 2022)*	Great Barrier Reef Marine Park Authority
Reef Snapshot - Summer (2020 - 21)	Great Barrier Reef Marine Park Authority
Water Quality Guidelines for the Great Barrier Reef Marine Park (2010)	Great Barrier Reef Marine Park Authority
Queensland's Protected Area Strategy (2020 - 3030)	Queensland Government
Queensland Reef Water Quality Program (2017 - 2018 to 2021 - 2022)	Queensland Government
Queensland Regional Natural Resource Management Investment Program (2018)	Queensland Government
Queensland Water Quality Guidelines (2009)	Queensland Government
Reef Water Quality Protection Plan (2003)	Queensland Government
Reef Water Quality Protection Plan (2009)	Queensland Government
Reef Water Quality Protection Plan (2013)	Queensland Government
Reef Water Quality Research, Development and Innovation Strategy (2014 - 15 to 2018 - 19)	Queensland Government
Wetlands in the Great Barrier Reef Catchments - Management Strategy (2016 - 21)	Queensland Government

3.2.3. Semi-Structured Interviews

Expert interviews were chosen as additional data collection method to gain more in-depth knowledge about the research topic, since the document analysis has limitations in this respect. SSIs have the benefit that the researcher has more control over the interview than in unstructured interviews for instance, but at the same time, the researcher has more flexibility than in structured interviews (Given, 2008).

Sampling

Sampling was an important step before the interviews were carried out. Sampling refers to the selection of specific subsets. In the case of this study, these are persons that are studied at specific times and places and which deliver a set of facts (Schatzman & Strauss, 1973). For that purpose, four interview partners were selected from three strains to gain more in-depth knowledge about the overall research topic (table 3). To cover the official and legal side, one representative from the Department of Environment and Science of the Queensland government was interviewed. A representative from the GBRMPA was interviewed as well, to get insights from the seaside of coral reef management and further, to gain information about the topic from the perspective of the GBRMPA. It was considered crucial to interview researchers from research institutions, to get a more neutral perspective on the topic. The opinion of the scientists was key to gain valuable information about LSP. Therefore, two experts from the James Cook University were interviewed (table 3). The interview partners were selected and contacted through official channels such as email or contact forms, which were provided on official websites. Snowball sampling was used to get additional contacts when there were no lists or other official sources to retrieve contact details from (Given, 2008).

Interview Guides

According to Given (2008), a written interview guide should be developed in advance, prior to the actual interviews. The guide should consist of carefully worded and as many kinds of open-ended questions. Based on the prior conducted literature review, document analysis and the standards for interview questions, four interview guides for each representative (appendix IV) were operationalised. The focus of the interview questions was about such topics, which could not be sufficiently answered by the literature review or document analysis. Therefore, the SSIs provided opportunities to get insights that could not be retrieved through the other applied methods.

Conducting Semi-Structured Interviews

All interviews were carried out through the video communication platform ‘Zoom’, since the research was carried out from Groningen in The Netherlands and all interviewees were located in Queensland, Australia. The interviews started with a warm welcome to establish a positive first impression. Besides that, the matter of confidentiality was addressed at the beginning of each of

the interviews (Adams, 2015). The interview consent form (appendix III) was sent to each of the interviewees within a reasonable period of time prior to the meeting. All interviewees signed and, therefore, confirmed the interview consent form beforehand. During the interviews, a specific interview question guide (appendix IV) was used for each interviewee. The actual interview started with an introduction about the project itself. Subsequently, the interviewees were asked to introduce themselves. Each interview (table 3) was conducted with a specific interview guide and afterwards, all recordings were transcribed.

Table 3: List of all interviews including IDs, interviewee shortcuts, categories, organisations, expertise, duration and date.

ID	Interviewee	Category	Organisation	Expertise	Duration	Date
#ID1	Interviewee 1	Authority	Great Barrier Reef Marine Park Authority	Water Quality	[01:12:34]	21/06/22
#ID2	Interviewee 2	Authority	Queensland Government (Department of Environment and Science)	Policies	[00:50:07]	04/07/22
#ID3	Interviewee 3	Science	James Cook University	Land-Sea Planning	[00:45:46]	05/07/22
#ID4	Interviewee 4	Science	James Cook University	Marine Spatial Planning	[00:45:35]	14/07/22

According to the APA 7th edition for author-date citation, all interview data are treated as personal communication. For the purpose of citation of the interviewees in this study, all interviews will be cited with their #ID, which corresponds to 'personal communication', 'Interviewee' and 'Date' provided in table 3. Therefore, for example, (#ID1) equals (Interviewee 1, personal communication, June 21, 2022).

3.3. Data Analysis

Primary and secondary data were conducted through a literature review, document analysis and SSIs. After the data was collected, it was analysed for further interpretation to determine relationships and trends within the data corpus. For this study, the method of qualitative content analysis was used for the overall data analysis.

3.3.1. Qualitative Content Analysis

According to Schreier (2012), qualitative content analysis (QCA) is a method that is suitable to describe the meaning of qualitative material in a systematic way, such as the qualitative data, which was collected through the document analysis and SSIs. This was done by assigning parts of the dataset to specific categories in a coding frame. The coding frame is useful to focus on the most important information of the dataset, since documents and transcripts of interviews will include a great amount of information. Therefore, QCA dimensions or main categories were built to create an overall coding frame (table 4). The coding frame helped to structure and differentiate between the contrasting meaning of the data, which consist of statutory and strategic plans, as well as interview transcripts. The main categories or dimensions will consist of subcategories to specify relevant meaning to it (Schreier, 2012).

According to Schreier (2012), the inductive nature of qualitative research provides the researcher with flexibility. In terms of data collection, this relates to the practice that a researcher does not pre-structure or standardise the applied measures. Data analysis as an inductive and data-driven way refers to the fact that codes and concepts emerge out of the data, which are analysed. Even if it is rather unlikely, a deductive and concept-driven strategy can also be used in qualitative research. During this type of data analysis, the researcher makes use of concepts or theories that are already known. The concept-driven or deductive strategy is based on subjects that are defined already. In QCA, it is rare to create a coding frame that is solely based on a data-driven or concept-driven strategy (Schreier, 2012). The coding frame (table 4) is therefore based on a mixed strategy both deductive and inductive and was created and further analysed with the software 'ATLAS.ti'.

Table 4: Coding frame including its different categories, codes and strategies.

Category	Code	Strategy
Contamination	Fertiliser	Inductive
	Litter	
	Nutrients	
	Oil	
	Pesticides	
	Pollutants	
	Sediments	
	Sewage	
Ecosystem-Based Management	Ecosystem-Based Management	Deductive
Integrated Coastal Zone Management	Coordination/Collaboration	Deductive
	Integrated Coastal Zone Management	
	Integration	
Land Use	Agriculture	Inductive

	Industry	
	Land Use	
	Mining	
	Tourism	
	Urban	
Land-Sea Interactions	Land-Sea Interactions	Deductive
Land-Sea Planning	Evaluation	Deductive
	Integrated Governance System	
	Land-Sea Planning	
	Management of Co-Benefits/Trade-Offs	
	Monitoring/Modelling	
	Multiple Objectives	
	Stakeholder Engagement	
Marine Spatial Planning	Adaptive Planning	Deductive
	Long-Term Planning	
	Marine Spatial Planning	
	Marine Zoning	
Water Quality	Measures	Inductive
	Targets	
	Water Quality	

Furthermore, the code book, a more detailed overview of the coding frame, which indicates what kind of statements were linked to the specific codes is provided in appendix V.

3.4. Ethical Considerations

Integrity in research is indispensable and considered a basic responsibility of the research community. For that reason, The European Code of Conduct for Research Integrity was chosen as the base for the ethical consideration of this research process. The Code introduces a couple of principles that guide researchers in their work and engagement with ethical, intellectual as well as practical challenges in research. The principles are namely: (1) reliability, (2) honesty, (3) respect and (4) accountability (ALLEA, 2017). All principles were considered and incorporated into the entire research process. Especially, for conducting the expert interviews as part of the data collection, the ethical consideration was of particular importance. Respect, honesty and transparency were the base for the interviews and, therefore, all interviewees were kept transparently informed about the steps, which are described in more detail in chapter 3.2.3.

4. Results

In this chapter, the results of the data collection and analysis will be presented. The data corpus consists of 29 statutory plans as well as of 22 strategic plans (table 1 & table 2). Beyond that, four SSIs were carried out. The data was analysed with a coding frame that comprises 33 codes in eight categories (table 4). An overview of all eight categories and the numbers of quotations that were identified per category of each dataset can be seen in figure 3. In total, 1,362 quotations were identified in the data corpus (appendix VI) and further analysed in the coding software.

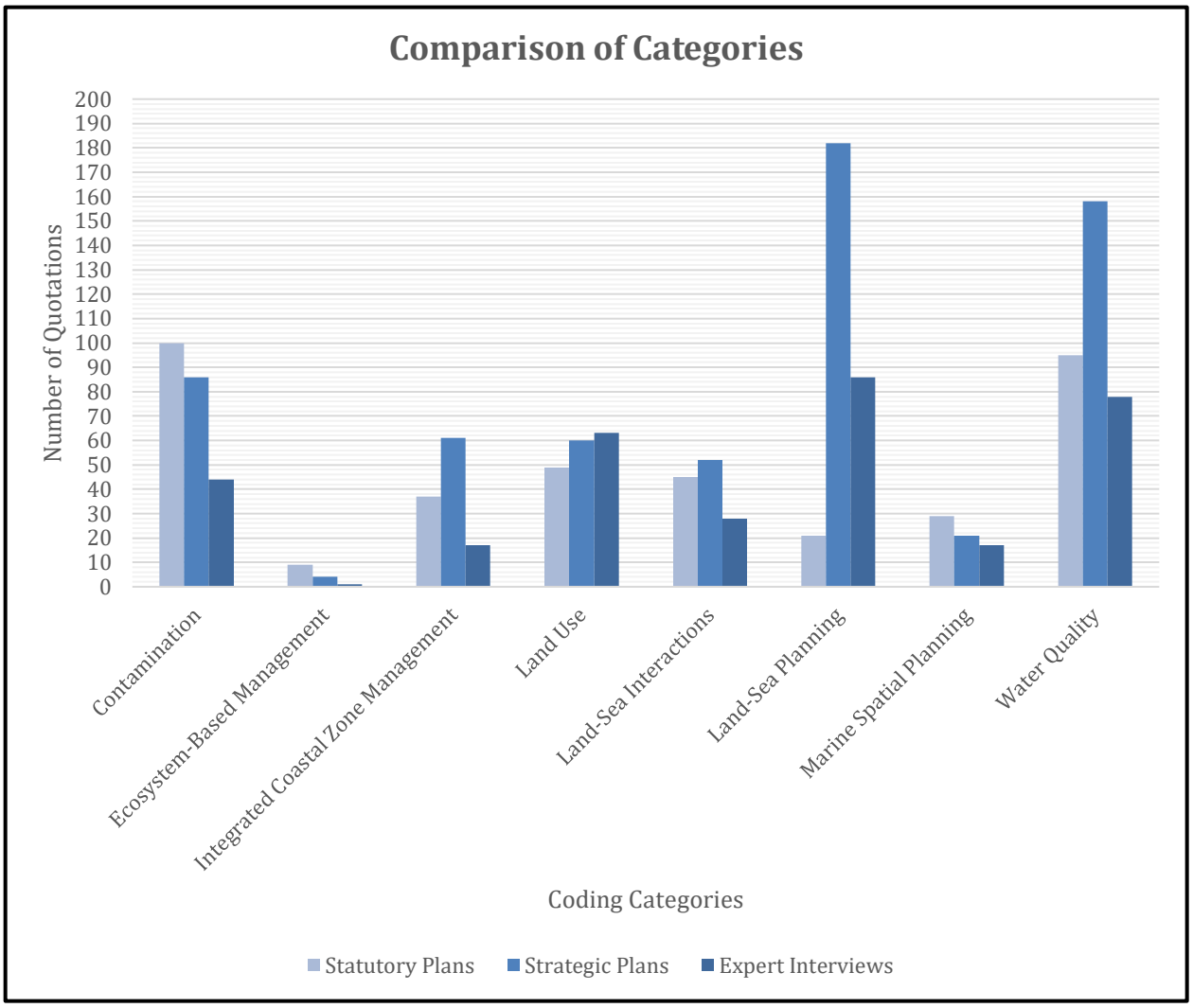

Figure 3: Direct comparison of the number of quotations per category between the data of statutory plans, strategic plans and SSIs (Source: Made by author).

The overall results will be introduced in the next three subchapters. Chapter 4.1. will address the general perceptions and the acknowledgement of LSI and land-based threats within the collected data. Beyond that, reasons for the decline of the GBR, which originate from land-based activities,

will be presented. In Chapter 4.2., the results of the six LSP principles that were established in the theoretical framework will be summarised. The chapter will provide insights into the current situation of LSP in Queensland and the wider GBR region and to what extent LSP principles are currently integrated into coral reef management. Moreover, in chapter 4.3., improvements in terms of policies and in respect to current coral reef management will be presented in order to provide recommendations.

4.1. Land-Sea Interactions

LSI are mentioned among statutory and strategic plans as well as during the expert interviews (figure 3). LSI relate to the connection of both realms, the land and the sea. Therefore, it is not only about the interconnectivity itself but also about pollution that occurs on land, which affects the marine environment at one point, since both realms are connected through water bodies. The potential contamination through LSI is highlighted in numerous statutory documents. The findings reveal that LSI are not directly named in such documents but rather indirect. The *Sewage Discharge Policy 2005* published by the GBRMPA, highlights the interaction of possible discharge of sewage treatment plants from coastal settlements with the GBRMP (GBRMPA, 2005). This type of LSI is also addressed in the *Great Barrier Reef Marine Park Regulations 2019* (Commonwealth of Australia, 2019). The *Great Barrier Reef Marine Park Act (1975)*, which is the backbone of the GBRMP and of the statutory GBRMPA, states that the health of the GBR and its surrounding ecosystems must be assessed on a regular basis. The *Coastal Protection and Management Act (1995)* refers to LSI when addressing the removal of quarry materials, which can lead to the supply of sediments to estuaries and to the sea. Beyond that, the *Environmental Protection (Water and Wetland Biodiversity) Policy (2019)* states that any threats to water-dependent ecosystems must be assessed and included into a water management plan. The *Environmental Protection Act (1994)* for example, names LSI much clearer as it states:

> "This section applies in relation to the entry of the following contaminants to the water of the Great Barrier Reef because human activity carried out on land in the Great Barrier Reef catchment" (s. 77.1).

The statutory plans under analysis highlight the interconnectivity of land and sea only to a small extent. 15 statutory plans mention some form of LSI, mostly related to contamination prevention. In the strategic plans however, the interconnectivity of both realms is mentioned in a less abstract way. The *Great Barrier Reef Intergovernmental Agreement* for example, stresses the possible impacts of land use activities in the catchment and urban development and, therefore, its adverse impacts on the quality of water entering the GBR (Commonwealth of Australia & State of Queensland, 2015). The *Queensland Regional Natural Resource Management Investment Program* addresses LSI more specifically as it states that increasing sediment and nutrient

deliveries to the waterways impact water processes and fauna habitats downstream (State of Queensland, 2019). Also, in the *Reef Water Quality Research, Development and Innovation Strategy* and in the *Water Quality Guidelines for the Great Barrier Reef Marine Park*, LSI are mentioned (GBRMPA, 2010; State of Queensland, 2014). Furthermore, the *Wetlands In The Great Barrier Reef Catchments Management Strategy* highlights the link between land and sea by stressing the importance of wetlands for many species that exist across both realms as well as for filtering catchment runoff (State of Queensland, 2016). Additionally, the plan points out the interdependencies between catchments, wetlands and the broader GBR ecosystem. The *Great Barrier Reef Outlook Report 2019*, which is the most recent series after the release of the *Great Barrier Reef Outlook Report 2014*, examines the health of the GBR, its pressures and its likely future and is updated every five years (GBRMPA, 2019). In this report, LSI are clearly described and stressed:

> "As water flows through the Catchment to the marine environment, the uses of the land it passes through and over have a strong influence on its volume, velocity and quality" (GBRMPA, 2019, p. 171).

Moreover, the *Reef 2050 Long-Term Sustainability Plan (2021 – 2025)* (Reef 2050 Plan) presents an overarching long-term strategy for managing the GBR. The *Reef 2050 Plan* and its subordinated documents (table 2) also address LSI (Commonwealth of Australia, 2021a). The *Reef 2050 Plan - Cumulative Impact Management Policy* as one of those subordinated documents states:

> "Consideration also needs to be given to any consequential impacts such as downstream consequences of altered connectivity between land and sea" (GBRMPA, 2018, p. 7)

and further in the Reef *2050 Plan - Objectives and Goals* document it is stated:

> "These catchment ecosystems and water quality outcomes in turn are in direct connection with the health of the marine environment to which they drain, and are impacted by factors such as pollution from transport, connectivity, and fish passages" (Commonwealth of Australia, 2021b, p. 24).

The *Reef 2050 WQIP*, which is also a subordinated plan of the *Reef 2050 Plan* highlights the interaction of land and sea to secure the GBR's health (State of Queensland, 2018a). Overall, LSI are mentioned in both document types (figure 3). However, in qualitative terms, the findings of the statutory plans show a more indirect or abstract way of addressing LSI. The strategic plans address more clearly how land and sea are connected and why such interconnectivity is essential to secure the GBR.

Based on the findings of the document analysis and of the analysis of the SSIs, numerous pollutants that result from land-based activities were identified. These are nutrients, also applied as fertilisers, pesticides, sediments, sewage, oil, litter and other pollutants (table 4). The analysis reveals that certain pollutants and, therefore, land-based threats, occur in both statutory and strategic plans. Nutrients, sediments and pesticides are the most common sources of land-based pollution in both types of documents (appendix VI). Also, the analysis of the expert interviews highlights the relevance of these types of pollutants. Similar to the findings of LSI, contaminants are mentioned to a higher extent in strategic plans than in the statutory plans under study.

The results show that the type of pollutant correlates with the type of land use. The data indicate that different land uses in the adjacent catchments of the GBR have certain impacts and lead to the discharge of specific pollutants into the marine environment. The findings address different types of land uses, which are mainly agriculture, industry such as ports, mining, tourism and urban development (table 4). The overall comparison shows that agriculture is by far the most addressed land use type among the strategic plans and the expert interviews (appendix VI). Mining for example, was mentioned to a higher extent in statutory plans, whereas the overall data analysis identifies agriculture as the most relevant land use type for current coral reef management. Besides land use in general, also Queensland's legacy of land development has negative impacts on the water quality. Interviewee 1 stated:

> "the change that happened in about the 1870s when the first, you know, grazing and clearing started to happen in large catchments" (#ID1).

Interviewee 2 pointed out:

> "it's from the legacy issue of, you know, introducing cattle 100, 200 years ago, and we're still sort of paying the price now" (#ID2)

and further the expert stated:

> "So, a lot of the work that we're doing to fix the catchments now is investing money into the gullying to regrade them and fix them up, so that they don't keep eroding" (#ID2).

The practice of certain land use types and the discharge of pollutants due to those land uses, lead to the deterioration of water quality. The issue of poor water quality is addressed in statutory as well as in strategic plans. The statutory *Environmental Protection (Water and Wetland Biodiversity) Policy (2019)* highlights:

> "water quality guidelines and water quality objectives for enhancing or protecting the environmental values of waters" (s. 5.2).

The *Environmental Protection Act (1994)* states:

> "The purpose of this chapter is to provide for measures to improve the quality of the water entering the Great Barrier Reef" (s. 74).

The strategic plans under analysis show a higher frequency with more documents mentioning water quality issues (figure 3). The *Great Barrier Reef Intergovernmental Agreement* highlights the need for joint action to halt and reverse the decline in water quality that enters the GBR (Commonwealth of Australia & State of Queensland, 2015). Furthermore, the *Great Barrier Reef Marine Monitoring Program* addresses the importance of long-term monitoring to assess and further improve the water quality in the GBR lagoon (GBRMPA, 2021). The *Queensland Regional Natural Resource Management Investment Program* states:

> "Activities that restore agricultural soils and improve water quality will support biodiversity and farm productivity, and reduce sediment loads entering the Great Barrier Reef" (State of Queensland, 2019, p. 9)

and further in the *Reef Water Quality Protection Plan 2013* it is written:

> "The quality of water entering the reef has deteriorated over the past 100 years and continues to have a detrimental effect on the marine ecosystem" (State of Queensland, 2013, p. 4).

The *Reef 2050 WQIP* states:

> "improving the quality of the water flowing from the land to the Reef is also critical for the Reef's health and, therefore, its ability to withstand and recover from extreme events" (State of Queensland, 2018a, p. 7).

All experts that were interviewed for the purpose of this study have also stressed the issue of poor water quality.

Overall, the data highlights that land and sea are connected and that poor water quality has negative impacts on the GBR. Even though climate change poses the most serious threat to the GBR, poor water quality due to land-based activities puts additional pressure on the GBR. Interviewee 4 referred to that as the expert stated:

> "It's the cumulative impact of a whole series of threats" (#ID4).

The results of the strategic plans and of the expert interviews indicate that most land-based threats are posed by nutrients, sediments and pesticides and, therefore, the key land use type is agriculture. The strategic plans highlight that the measures and targets that aim to improve the overall water quality are linked to the agricultural sector. However, this finding is not highlighted to the same extent in the statutory plans under analysis. Statutory plans do acknowledge the problem of poor water quality and point out the interconnectivity of land and sea to some degree but do not address specific measures like strategic plans do.

4.2. Land-Sea Planning

LSP can be understood as an approach and a way of making decisions that are more cost-effective and that consider values that exist in both realms (#ID3). Approaches such as ICZM or MSP do focus almost solely on the coastal zone or on the marine environment, whereby LSP considers the interconnectivity of both realms and emphasises, therefore, a larger area. However, Interviewee 3 (#ID3) pointed out that LSP has been more of a theoretical framework, which is discussed mostly in the realm of academia. This finding was also confirmed by the document analysis. While statutory plans do not acknowledge the importance or the need for LSP, strategic plans become more concrete in this respective as the *Reef 2050 Plan* addresses the need to:

> "Deliver an integrated catchment-to-Reef framework to manage the multiple environmental and cultural values of the catchment and wetlands" (Commonwealth of Australia, 2021a, p. 27)

and further:

> "Understanding the dynamics of managing the complex ecological and human interdependent Reef system through a whole-of-system approach" (Commonwealth of Australia, 2021a, p. 44).

The *Great Barrier Reef Intergovernmental Agreement* points out that:

> "The marine and land environments within and adjacent to the Great Barrier Reef World Heritage Area will be managed in an integrated manner consistent with ecosystem-based management and the principles of ecologically sustainable use" (Commonwealth of Australia & State of Queensland, 2015, p. 7).

The need for an integrated LSP approach is acknowledged and approached by some of the strategic plans and by the interview data. Six key principles for LSP were established under the scope of this study and introduced in the theoretical framework. The following chapters will summarise the

results of all analysed data for each principle to provide an overview to what extent LSP is already integrated into coral reef management in the GBR.

4.2.1. Integrated Governance System

The GBRMP is currently managed through an integrated governance system, which was confirmed by most of the statements that were retrieved through the SSIs. According to Interviewee 2 (#ID2), the Department of Environment and Science, which is part of the Queensland government, maintains a close cooperation with the federal counterpart, which is the Department of Climate Change, Energy, Environment and Water. Both government departments work together with the GBRMPA, which oversees the GBRMP. Interviewee 2 (#ID2) stated that the authorities cooperate in a joint team. There are executives from each authority with a work team operating under them. Based on this joint team, decisions can be made together and weekly meetings are held to discuss the work agenda that is coming up. The integrated governance system became even stronger, since the development of the *Reef 2050 Plan* (#ID2). The cooperation between the Commonwealth and Queensland authorities is strengthened by the *Great Barrier Reef Intergovernmental Agreement*, which states:

> "This agreement is to ensure an integrated and collaborative approach by the Commonwealth and Queensland to the management of marine and land environments within and adjacent to the Great Barrier Reef World Heritage Area" (Commonwealth of Australia & State of Queensland, 2015, p. 4).

Even though the agreement is not legislatively binding, Interviewee 4 stated that it is a:

> "very strong and very good way of getting the two governments to work together" (#ID4).

Beyond that, a lot of the water quality work is done under the agreement to minimise impacts, recognising that water quality has downstream impacts (#ID4). Statutory plans mention the integrated governance system to a lesser extent (appendix VI). The results indicate that only a few statutory documents acknowledge the need for such governance system. The purpose of the Queensland's *Marine Parks Act (2004)* is among others:

> "achieved by a comprehensive and integrated strategy that involves, among other things, each of the following (…) the cooperative involvement of public authorities and other interested groups and persons, including members of Aboriginal and Torres Strait Islander communities" (s. 5.2)

and further:

> "a coordinated and integrated approach with other environment conservation legislation" (s. 5.2).

The *Reef Water Quality Protection Plan 2013* as part of the strategic plans under analysis states:

> "Reducing the impacts of land use on reef water quality is not solely the responsibility of governments. Achieving the goals of Reef Plan will rely on a partnership involving all levels of government, industry, community groups and individual landholders" (State of Queensland, 2013, p. 31).

Even though the *Great Barrier Reef Intergovernmental Agreement* addresses a strong governance integration, criticism remains (Commonwealth of Australia & State of Queensland, 2015). According to Interviewee 3 (#ID3), there is still some disconnect between the authorities that manage the GBR and the ones that manage the land. Especially, in terms of LSI, the expert highlighted that the areas of responsibility for management are often not flexible enough. The expert elaborated on that by stating that people who manage the GBR are not the same who authorise land development. Interviewee 3 (#ID3) also acknowledged the complexity and the scale of the wider area and pointed out that authorities cooperate and talk to each other but that there are also limitations. Overall, the results highlight that there is currently some sort of integrated governance system in place, but limitations remain.

4.2.2. Stakeholder Engagement

The findings of the document analysis indicate that strategic plans stress the importance for stakeholder engagement more often than statutory plans (appendix VI). Nevertheless, stakeholder engagement is also considered important for the development of statutory plans. The *Sewage Discharge Policy 2005* for example, was developed in consultation with government representatives but also with other interested stakeholders (GBRMPA, 2005). The *Great Barrier Reef Marine Park Act (1975)* highlights the importance of stakeholder engagement as follows:

> "encourage engagement in the protection and management of the Great Barrier Reef Region by interested persons and groups, including Queensland and local governments, communities, Indigenous persons, business and industry" (s. 2a.2).

The *Environmental Protection (Water and Wetland Biodiversity) Policy (2019)* highlights ways to raise community awareness and community consultation in relation to water quality management and strategies to better inform the community when developing a plan. Beyond that, the *Nature Conservation Act (1992)* states:

> "encouraging the conservation of nature by the education and cooperative involvement of the community, particularly landholders" (s. 5a)

and further it underlines:

> "the cooperative involvement of landholders in the conservation of nature" (s. 5g).

Also, the *Water Act (2000)* highlights a broad community involvement when considering decisions and actions that would affect the community. Stakeholder engagement is of relevance for strategic plans as well. The *Great Barrier Reef Intergovernmental Agreement* states that a collaborative and cooperative approach is fundamental to achieve an effective long-term protection, conservation and management of the GBR, since this is beyond the remit and power of either jurisdiction (Commonwealth of Australia & State of Queensland, 2015). The *Paddock to Reef Integrated Monitoring, Modelling and Reporting Program* states:

> "Clear and transparent communication regarding the health of the Great Barrier Reef and the effectiveness of management initiatives is vital for decision-makers, the community and stakeholders" (State of Queensland, n.d., p. 24).

Furthermore, the program highlights the importance of regional natural resource management bodies, industry groups and government extension teams to extend information to landholders and communities in the agricultural sector. According to the program, local governments are important to address the urban setting and industry partners to deliver key messages to the wider community and important stakeholders (State of Queensland, n.d.). The *Queensland Reef Water Quality Program* highlights the ambition of the Queensland government to continue to collaborate with a range of stakeholders for the identification of new solutions (State of Queensland, 2018b). Also, the *Queensland Regional Natural Resource Management Investment Program* highlights the importance of collaboration as it states:

> "A long–term collaborative approach is required to manage Queensland's natural resources in a responsible way, to support the economic and social needs of the community, and to maintain healthy and resilient ecosystems" (State of Queensland, 2019, p. 2).

The *Reef Water Quality Protection Plan 2013* highlights the need for programs that proactively engage landholders (State of Queensland, 2013). The *Water Quality Guidelines for the Great Barrier Reef Marine Park* document emphasises that such collaborative approach is already in place, since:

> "The Australian and Queensland governments, working with scientists, stakeholders and the community, have initiated a number of key plans and strategies aimed at halting and

> reversing the decline in the quality of waters entering the Great Barrier Reef" (GBRMPA, 2010, p. 1).

In the same document it is stated that the GBRMPA acknowledges the importance of working with people and that the authority has already worked and will continue to cooperate with stakeholders and the community (GBRMPA, 2010). The *Great Barrier Reef Outlook Report 2019* states that the protection and management of the region is based on a partnership between the different governmental bodies, Traditional Owners, stakeholders and community members (GBRMPA, 2019). Further, the report states that one of the main management approaches to protect and manage the region is engagement, which is defined as:

> "management agencies work with Traditional Owners, scientists, the community, industry and local government to strengthen knowledge, ensure fit-for-purpose management and influence actions that will help improve the outlook for the Region" (GBRMPA, 2019, p. 197).

The *Reef 2050 Plan* highlights the focus on the improvement of integrated knowledge about the flow of water along the catchments to understand the land-sea connectivity (Commonwealth of Australia, 2021a). According to the plan, stakeholder engagement is crucial to reduce impacts of catchment activities on the GBR as it states:

> "Effective delivery requires collaborative understanding about how the catchment operates and the priorities for its management. This includes co-design and co-delivery of programs with Traditional Owners, community groups, local councils, and industry sectors such as tourism and farmers" (Commonwealth of Australia, 2021a, p. 25).

The *Reef 2050 WQIP* is even more specific as it states:

> "Partnerships across all sectors at all levels continue to be the key to making progress towards the water quality targets" (State of Queensland, 2018a, p. 7)

and further:

> "This includes governments working together and with agriculture, industry, urban development and construction, conservation, community, and natural resource management stakeholders" (State of Queensland, 2018a, p. 7).

According to the *Reef 2050 WQIP*, significant achievements were made, especially in the agricultural sector. The Best Management Practice (BMP) programs, which are in place for sugarcane and banana farming as well as for grazing, are examples for a strong partnership between

the agricultural industry, natural resource management, land managers and governments (State of Queensland, 2018a). This is also confirmed by the representative of the Queensland government, as Interviewee 2 stated:

> "we work with them very closely to help them work out how they can adopt the practices more easily and how it can work within their farming business" (#ID2).

Interviewee 2 also stressed the ambition to continue to work with farmers as the expert highlighted:

> "investing in individual farmers, trying to get them to adopt better practices, showing them with our on-ground trials, how they can make money and to be more sustainable at the same time" (#ID2).

There are still lots of challenges in terms of delivering the knowledge of the outcomes that are achieved at research level, to the farmer level (#ID1). According to Interviewee 4 (#ID4), it is important to work closely with the industry to achieve the targeted outcomes rather than just rely solely on regulations. Moreover, Interviewee 4 (#ID4) stressed the importance of educating the public. According to Interviewee (#ID4), it is crucial that there is an increasing understanding of LSI among society and that people understand that actions they take on their land, can negatively affect the marine environment (#ID4). Interviewee 3 (#ID3) stressed the overall missing link to social sciences. The expert highlighted the importance of increasing the efforts in understanding what motivates people to change their behaviour (#ID3). Overall, stakeholder engagement is mentioned to a higher extent in strategic plans compared to statutory plans (appendix VI). The results indicate that the importance of stakeholder engagement is acknowledged and that it is considered important in current coral reef management. However, the interview data also highlight limitations and scope for improvements, especially in addressing stakeholders across realms.

4.2.3. Multiple Objectives

Multiple objectives were almost not present in both statutory as well as strategic plans under analysis. Even though most of the documents have multiple objectives on their agenda, multiple objectives across the two realms of land and sea, as it was approached in chapter 2.4., could not be identified. The *Great Barrier Reef Marine Park Act (1975)* states:

> "The principles must cover the environmental, economic and social objectives of the proposed plan. The principles may cover other matters" (s. 34.2)

which can be interpreted as designation of multiple objectives across different disciplines or realms. Similarly, the *Environmental Protection (Water and Wetland Biodiversity) Policy (2019)* highlights the:

> "consideration of the economic and social impacts of protecting environmental values for the water" (s. 12.3).

Besides these two documents, terminology that could be linked to multiple objectives across realms was not identified.

4.2.4. Management of Co-Benefits and Trade-Offs

The management of co-benefits and trade-offs are only present to a lesser extent in statutory and strategic documents. The *Environmental Protection Act (1994)* defines serious environmental harm, among others, as environmental harm:

> "that causes actual or potential loss or damage to property of an amount of, or amounts totalling, more than the threshold amount" (s. 17.1).

In the *Queensland Reef Water Quality Program,* it is proposed:

> "ensure the best and most cost-effective approaches are used for the maximum Reef water quality benefit through trialling, research and ongoing monitoring and evaluation" (State of Queensland, 2018b, p. 3).

Furthermore, *the Reef Water Quality Research, Development and Innovation Strategy* stresses the importance of a better understanding of cost and benefits of changing farming systems to better support banana growers for example. The Strategy addresses a gap in extension services and decision support systems and highlights that banana growers are interested in better information of how their activities impact the GBR (State of Queensland, 2014). Overall, the management of co-benefits and trade-offs is lacking in both statutory and strategic plans. The GBR has not only a high intrinsic value but also an economic one. Therefore, the management of co-benefits and trade-offs is a strong argument, since the decline of the GBR is also linked to economic loss (#ID1). Interviewee 3 stressed the importance of incorporating co-benefits and trade-offs as follows:

> "sometimes it's more cost-effective to do something, either an economic activity or management or conservation action on the land, on the sea, to achieve benefits or to protect the values from both realms" (#ID3)

and further:

> "trade-offs are essentially ways of identifying what do you give and what do you take" (#ID3).

However, Interviewee 3 (#ID3) also stated that it gets more complicated when talking about gains and losses economically and socially that are addressed across both realms. The overall findings indicate that the management of co-benefits and trade-offs across both realms does not currently happen or, if at all, only to a small degree.

4.2.5. Monitoring and Modelling

The data highlight that monitoring and modelling are of higher relevance in strategic plans compared to statutory plans. However, there are still a couple of statutory documents that approach monitoring and stress its importance. The *Sewage Discharge Policy 2005* links the permission to operate a marine outfall to the necessity of monitoring (GBRMPA, 2005). The *Coastal Protection and Management Act (1995)* relates monitoring to examine the impact of quarry material removal or placement of spoil on coastal management. The purpose of the *Environmental Protection (Water and Wetland Biodiversity) Policy (2019)* is, among others, the monitoring and reporting on the condition of waters as the policy states:

> "A healthy water management plan for water must (…) identify ways to protect the environmental values for the water, and to monitor and assess the effectiveness of the protection" (s. 16.3).

Furthermore, the *Environmental Protection Act (1994)* addresses:

> "management, monitoring, planning and other measures proposed to minimise any adverse environmental impacts of the project" (s. 40a).

The *Nature Conservation Act (1992)* states that for the management of national parks, controlled scientific study and monitoring of the area's natural resources are allowed. The *State Policy for Coastal Management 2011* addresses as one of its overall policy outcomes the implementation of monitoring. It states that coastal land managers achieve effective coastal management through regular monitoring as well as reviewing and reporting (State of Queensland, 2011). Also, strategic plans like the *Great Barrier Reef Intergovernmental Agreement* acknowledge coordinated long-term monitoring and research as well as data collection and sharing as a guiding principle (Commonwealth of Australia & State of Queensland, 2015). In fact, there are entire monitoring programs among the strategic plans, such as the *Great Barrier Reef Marine Monitoring Program*,

which is a collaborative effort that is based on partnerships between governmental bodies, industry, community, scientists and managers. Monitoring partners are the Australian Institute of Marine Science, James Cook University, University of Queensland and Howley Environmental Consulting/Cape York Water Monitoring Partnership, while each of them has a different responsibility in delivering sub-programs. The monitoring under this program includes, among others, the measurement of dissolved and particulate nutrients (GBRMPA, 2021). Another monitoring program is the *Paddock to Reef Integrated Monitoring, Modelling and Reporting Program*, which is a joint commitment of the Australian and Queensland government. It is in place to improve the quality of water flowing from the catchments into the GBR (State of Queensland, n.d.). The program provides the main conditions for evaluating and reporting progress towards the *Reef 2050 WQIP* targets. Also, the *Reef 2050 WQIP* stresses the importance of monitoring as the plan states:

> "Its specific purpose is to identify management and monitoring requirements for all land-based pollution to improve the quality of water flowing from catchments adjacent to the Reef" (State of Queensland, 2018a, p. 11).

The *Reef 2050 Integrated Monitoring and Reporting Program* is the overarching reporting program for the *Reef 2050 Plan* and is in place to develop a knowledge system that provides managers with a comprehensive understanding of how the plan is progressing (State of Queensland, 2018a). The *Reef 2050 Plan* refers to monitoring by stating:

> "Management is adaptive and continually improving, informed by the outcomes of monitoring programs" (Commonwealth of Australia, 2021a, p. 14).

The plan highlights that monitoring is essential to determine if management actions are effective and if they need to be adapted (Commonwealth of Australia, 2021a). Besides that, a couple of other strategic plans under analysis, such as the *Queensland Reef Water Quality Program*, the *Queensland Regional Natural Resource Management Investment Program*, the *Reef Water Quality Protection Plan 2013*, the *Water Quality Guidelines for the Great Barrier Reef Marine Park* and the *Great Barrier Reef Outlook Report 2019* highlight the importance of monitoring to support decision-making and current coral reef management (GBRMPA, 2010; GBRMPA, 2019; State of Queensland, 2013; State of Queensland, 2018b; State of Queensland, 2019). Monitoring goes back to the '80s. The first monitoring program for the GBRMP and its catchments was set up along with the first Reef Plan. Monitoring and later also modelling were used to confirm what was assumed at that time and helped to implement water quality targets (#ID1). Nowadays, the water quality targets (one of them shown in figure 4) are prepared under the *Reef 2050 WQIP* (State of Queensland, 2018a).

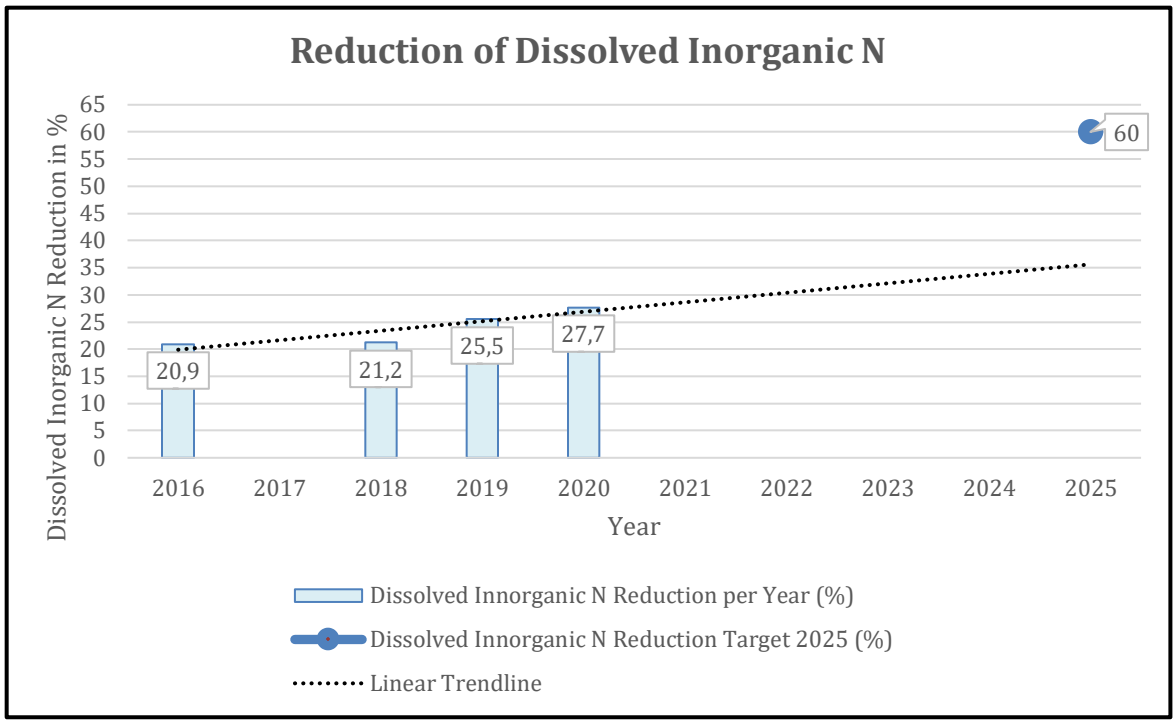

Figure 4: Current 2025 water quality target for the reduction in anthropogenic end-of-catchment dissolved inorganic nitrogen loads and its progress from 2016 to 2020 (missing data for 2017) (Source: Made by author - based on data from: Queensland Government, 2022).

Monitoring and modelling programs are used to understand how changes in practices affect the environment in the wider GBRMP and its adjacent catchments. Interviewee 2 (#ID2) and Interviewee 3 (#ID3) stressed the importance of monitoring to understand if current regulations are efficiently working. Monitoring and modelling are important as assessment tools to understand if progress is made in terms of water quality and further to take actions if necessary (#ID3). Overall, the results of this chapter indicate that the importance of monitoring and modelling are present along statutory plans but to a larger extent in strategic plans (appendix VI). The strategic plans and the interview data highlight especially the importance of monitoring and modelling for taking actions and to justify measures in current coral reef management.

4.2.6. Evaluation

The findings reveal that the necessity for the evaluation of planning processes does not receive too much attention in both statutory and strategic plans under study (appendix VI). The *Coastal Protection and Management Act (1995)* stresses the importance of evaluation in terms of efficiency and effectiveness of coastal management strategies in a coastal zone report. Also, the *Environmental Protection (Water and Wetland Biodiversity) Policy (2019)* highlights the importance of evaluation when addressing wastewater treatment. The *Environmental Protection Act (1994)* states:

> "An environmental evaluation is an evaluation of an activity or event to decide (…) the source, cause or extent of environmental harm being caused, or the extent of environmental harm likely to be caused, by the activity or event" (s. 321.1).

The *State Policy for Coastal Management 2011* mentions that the policy must be evaluated to examine the efficiency and effectiveness of coastal management strategies (State of Queensland, 2011). Strategic plans also highlight the relevance of evaluation. The *Great Barrier Reef Intergovernmental Agreement* for instance states in one of its objectives:

> "periodically review the condition of the Great Barrier Reef ecosystem and any need for further action" (Commonwealth of Australia & State of Queensland, 2015, p. 5).

The *National Water Quality Management Strategy* acknowledges the importance of evaluation to demonstrate if the strategy is efficient and effective and further to demonstrate if the management is achieving the desired water quality (Commonwealth of Australia, 2018). The *Wetlands in the Great Barrier Reef Catchments Management Strategy* emphasises the importance of evaluation to improve wetland management (State of Queensland, 2016). The *Great Barrier Reef Outlook Report 2019* provides a comprehensive and regular basis for evaluation on the management as well as condition of the region (GBRMPA, 2019). Besides that, the *Reef 2050 Plan* states:

> "Monitoring and evaluation are essential to determine if management actions are effective and if they need to be changed to achieve the desired objectives" (Commonwealth of Australia, 2021a, p. 47).

Moreover, the *Reef 2050 WQIP* points out that current water quality targets will not be met with current management initiatives and that it therefore needs improvements in evaluation systems (State of Queensland, 2018a). Also, Interviewee 2 (#ID2) mentioned the importance of evaluation in terms of current management measures. The expert stated that they carry out statutory reviews to examine if regulations that are applied work efficiently. Overall, the data corpus highlights that evaluation is not considered to a large extent in the analysed data. However, the results show that the importance of evaluation is addressed in all types of documents as well as in the SSIs to an almost equal extent (appendix VI).

4.3. Improvements

Currently, there are several targets addressed under the *Reef 2050 WQIP* to improve the water quality in the wider GBR region and in its adjacent catchments. This chapter provides an overview of the current measures and how they could be improved. Results for this chapter were mostly based on data collected through the SSIs.

As previously mentioned, the overall data highlights that nutrients, pesticides and sediments caused by agricultural activities pose the key threats that are related to land-based activities. Therefore, most of the measures to improve the water quality and to meet the water quality targets address the agricultural sector. Sugarcane and banana cultivation as well as cattle grazing are the target groups to reduce nutrients, pesticides and sediments in the GBR and its adjacent catchments (State of Queensland, 2018a). According to Interviewee 1, the whole process started with voluntary measures, since:

> "it was just trying to convince farmers and graziers to change practices" (#ID1).

Interviewee 2 (#ID2) stated that the focus on voluntary measures is still crucial and that the close cooperation with key farmers is essential to convince them to adopt BMPs. However, Interviewee 1 (#ID1) mentioned that voluntary measures have not brought major changes in the beginning. According to Interviewee 2 (#ID2), new regulations, which are namely the *Agricultural ERA standard for sugarcane cultivation*, the *Agricultural ERA standard for banana cultivation* and the *Agricultural ERA standard for beef cattle grazing*. They were enforced and created in accordance with the *Environmental Protection Act (1994)* and were adopted in 2019 to reduce the sediment and nutrient discharges by the specific farming activities (State of Queensland, 2022a; State of Queensland, 2022b; State of Queensland, 2022c). Interviewee 2 (#ID2) stated that the new regulations show positive effects, not only in terms of the water quality targets but authorities witness changes in practices during their compliance work. All interviewees stated that the close cooperation with the farmers is a key element in solving water quality issues and therefore, it needs to be continued as Interviewee 4 stated:

> "sometimes it's far better to work with industry to get the outcomes rather than just rely on regulation" (#ID4).

However, Interviewee 4 also approached:

> "I think we've, we've got to be stronger in the way we enforce regulations, we've got, we probably need to bring in better regulations, and then spend the Australian taxpayer's money more effectively" (#ID4).

The findings highlight that stakeholder engagement is of high relevance for all interviewees. The experts emphasised the importance of giving incentives to farmers to reduce the amount of fertiliser for instance but if the water quality does not improve in the way that it is targeted, the enforcement of stronger regulations could be a possibility to achieve improvements in the overall water quality.

Furthermore, Interviewee 4 (#ID4) stressed the importance of involving other sectors such as mining to a larger extent, because current regulations do not capture mining and its legacy impacts quite well. Also, Interviewee 3 (#ID3) highlighted issues of mining and the possible effects of coal dust on the marine environment. Moreover, Interviewee 4 (#ID4) addressed impacts of insufficient sewage treatments and of port development. Overall, the experts suggested to extend the focus also on other land use activities that have negative impacts on the water quality in the GBRMP.

Poor water quality is not only linked to current land use activities but also to those of the past. Three of the four interviewees mentioned the history of land development over the past 200 years. According to the experts, Queensland has a strong legacy in land development, the reason why it has to deal with issues such as gully erosion nowadays, leading to additional discharge of sediments and nutrients, into the water bodies (#ID2; #ID3; #ID4). Interviewee 2 (#ID2) explicitly mentioned the importance of fixing gullies and landscapes to reduce erosion. The expert also stressed the responsibility of the authorities to invest and fix gullies, as it would not be fair to enforce regulations and leave it to the farmers, since they might have not caused it in the first place. Therefore, it is suggested to continue to invest into restoring the landscape in order to reduce land-based pollution (#ID2).

The integrated governance system was especially highlighted by interviewee 3. The expert addressed the need for an overarching governance system, as:

> "higher level coordination across portfolios" (#ID3)

which incorporates several sectors such as energy, agriculture, fisheries and more at the same time. The expert highlighted that there are contradictory actions taken across portfolios, since different sectors have different interests. Interviewee 3 (#ID3) stressed that policies across sectors must better align with each other. The expert mentioned the example of a recent approval for a large coal mine standing in contradiction with environmental policies. A stronger high-level coordination across portfolios with policies in force that align across several sectors, to better coordinate actions and thus increase the protection of ecosystems, such as the GBR, is therefore strongly suggested by the expert (#ID3).

Interviewee 1 (#ID1) stressed the need for more ambition to achieve the water quality targets. The expert highlighted the goal of 'no more wetland loss' as one of the water quality targets. According to the expert, there was still a slight loss of wetlands, which was reported 'as good', even though the target is 'no loss'. Water quality targets should be taken seriously and the adherence for the targets must be more ambitious (#ID1). Beyond that, more radical steps were approached as well during the SSIs. Interviewee 2 (#ID2) suggested to set up a compensation scheme whereby farmers, which operate close to relevant waterways would have to be relocated further from critical water bodies. Therefore, nutrients, pesticides and sediments would not get too fast into the

waterways anymore. Consequently, farmers would have to be bought out accordingly and that would render some farming properties not viable (#ID2). Furthermore, the investments that were made in the past to improve the overall water quality and the in comparison small success in meeting the water quality targets was stressed during the SSIs, too. Therefore, it was suggested to refocus on how the money is currently spent and to evaluate current measures to spend it more efficiently in the future (#ID4).

Overall, the results of this chapter highlight that there is scope for improvement in addressing poor water quality in the GBR and its adjacent catchments, which is underlined by the insufficient progress in meeting the water quality targets.

5. Discussion

In the following discussion chapter, the findings of chapter 4 will be put in relation to the conceptual model (figure 2) of this study. The findings will be discussed, also through the lens of academic literature, to address each of the secondary research questions and, therefore, to find answers for the overall research question under study. Beyond that, limitations of the data collection and analysis techniques as well as of the overall research process will be discussed towards the end of the chapter.

5.1. Current Coral Reef Management

The results of the document analysis highlight that LSI and, therefore, also land-based threats are considered to a larger extent in strategic plans compared to the statutory plans that were analysed. Especially strategic plans, such as the *Reef 2050 Plan*, *Reef 2050 WQIP* or the *Great Barrier Reef Outlook Report 2019* stress the importance of land-based threats and how these affect the health of the GBR (Commonwealth of Australia, 2021a; GBRMPA, 2019; State of Queensland, 2018a). These findings highlight that the responsible authorities in Australia are very much aware of the negative effects of land-based impacts and of the interconnectivity of land and sea in general. However, the results also indicate that this overall perception is lacking in statutory plans. Kroon et al. (2016) highlight that even though there are statutory plans such as the *Great Barrier Marine Park Act (1975)* or the *Environment and Protection Biodiversity Conservation Act (1999),* which have the power to control land-based pollution, their provision has not been applied yet. Furthermore, Kroon et al. (2016) argue that there is a lack of effective regulatory and legislative instruments to govern agricultural run-offs from the catchments into the GBRMP. Still, the study was published six years ago and since 2019 stronger regulations for sugarcane and banana cultivation as well as for cattle grazing were enforced, since these land use practices are the main contributors for the input of nutrients, sediments and pesticides into the GBRMP (#ID2; Schaffelke et al., 2017). The findings reveal that land-based threats are already integrated to a significant extent into current coral reef management and to some extent in statutory policies. In opposition, Eberhard et al. (2021) state that Australian policies have failed to address land-based impacts originating from the agricultural sector and that these are still the leading cause for major water quality problems. Additionally, Interviewee 4 stated:

> "we've got to be stronger in the way we enforce regulations" (#ID4).

In fact, it can be argued that a stronger enforcement of regulations is needed, since most water quality targets (figure 4) under the *Reef 2050 WQIP* will most likely not be met by 2025 (Brodie et al., 2019). Another challenge arises, as changes in agricultural practices do not immediately lead to changes in nutrient levels in the waterways, for instance. Studies from Eastern Europe highlight

that it can take between 10 and 20 years to measurably reduce nutrient fluxes in the catchments (Kroon et al., 2014). This makes decision-making and the enforcement of regulations more complex but at the same time, highlights the importance of river and catchment monitoring to detect contaminant changes in the waterways at an early stage. Along with the argumentation of Interviewee 1 (#ID1), it is indispensable to be more ambitious in achieving the water quality targets and if necessary, to enforce stronger regulations. Still, it can be argued that it might be too early to enforce more regulations, since it is not certain what effects the new regulations of 2019 produce. Interviewee 2 stated that:

> "it's too soon to say let's ramp it up even more, because we haven't seen the impact of the current regulations" (#ID2).

Still, the expert also stressed that the authority notices behaviour changes during their compliance work at farming properties that are in favour to improve the water quality. Besides that, Interviewee 2 (#ID2) stressed that stronger regulations are hard to implement due to the overall resistance of certain sectors. Therefore, today's coral reef management depends to a large extent on voluntary measures that, among others, try to convince farmers to adopt BMPs.

Overall, the findings reveal that land-based threats and LSI are considered in current coral reef management and policies, but that statutory plans are still lacking on these subjects. The integration of land-based threats into the current coral reef management could be improved by incorporating LSI and land-based impacts to a larger extent into statutory plans. Currently, these are too few and the restrained enforcement of regulations in the past has probably led to only small progress towards the water quality targets. Besides that, decision-makers must be more ambitious about meeting those targets. Current management practices rely strongly on voluntary measures and on incorporating farmers, which is considered crucial and should continue. Healthy coral reef management cannot solely rely on regulations, collaboration is key.

5.2. Where Authorities Reach Their Limits

The GBR continues to decline, even though many efforts are made. Figure 1 highlights the scale and, therefore, the complexity of the GBR and its adjacent catchments. This complexity of scale was also highlighted by two interviewees who stressed the significant scale and complexity of land that must be managed. Therefore, a large extent of personnel for monitoring and compliance work is required and authorities might quickly reach their limits (#ID2; #ID3).

The responsible authorities were and still are, confronted with a strong resistance of industry representatives (#ID1; #ID2). According to Interviewee 2 (#ID2), the scientific consensus is denied to resist the enforcement of stronger regulations. Björnberg et al. (2017) argue that science

denial has a: “significant negative impact on societal debates and decision-making” (p. 239). This was also addressed by the representatives of the GBRMPA and the Queensland government who stated that water quality science denial has slowed down the process of enforcing stronger regulations onto the agricultural sector (#ID1; #ID2). Interviewee 2 elaborated on the enforcement of stronger regulations by stating:

> “That was a very big political battle, the farmers and their industry representatives did not want to be regulated. And they fought very hard politically against that regulation” (#ID2)

and further the expert stated:

> “And they are still fighting that and one of the ways they fight against it is by questioning the water quality science” (#ID2).

Eberhard et al. (2021) state that political lobbying by interest groups can have the ability to dilute regulatory standards. Furthermore, Kroon et al. (2016) argue that only legislation and regulations, which are supported by long-term political commitment can significantly reduce agricultural pollution. Interviewee 1 argued:

> “The political incentive to have a healthy Reef has always been there, the political incentive to have a healthy catchment has never really been there” (#ID1).

The political incentives to improve practices and the overall situation on land are similarly important due to the interconnectivity of both realms. Yet, long-term political commitment is lacking in Australia, especially in terms of reducing carbon emissions (#ID4). Svobodova et al. (2020) highlight that Australia is the biggest net exporter of coal, which accounts for 32 per cent of the global exports. The authors state that: “there is no existing policy that accelerates the phaseout of coal in Australia” (Svobodova et al., 2020, p. 8), which illustrates the tensions between economic viability and climate. However, this is not only the case for the reduction of carbon emissions but also for improving the water quality in the catchments. Both poor water quality as well as increasing carbon emissions are threats that arise outside the boundaries of marine zoning or MPAs and, therefore, highlight the limitations of one-sided approaches such as ICZM or MSP (Day, 2015).

In addition to the denial of science, the overall political setup has also impacts on the work of the authorities, next to the strong resistance of industry representatives and the missing political long-term commitment. Interviewee 1 stated:

> "Sometimes we can get them to work very well together. And sometimes, depending on the political nature of the different levels of government, they don't work as well together as you would hope" (#ID1).

Therefore, the overall governance system including the authorities, is limited in the effectiveness of decision-making even though it is considered best practice (Day, 2015). According to Vince and Day (2020), integrative capacity is the key to integrated policy success when referring to MSP in the GBRMP. Most interviewees highlighted the integrated governance system in terms of cooperation among the different governmental agencies such as the Federal and Queensland departments as well as the GBRMPA. Even though the governments work successfully together as agreed by the *Great Barrier Reef Intergovernmental Agreement*, there are still inconsistencies between land development and environmental protection (Commonwealth of Australia & State of Queensland, 2015; #ID3). The missing link between environmental policies and the approval of new land development sites, such as new coal mines in Queensland, is counterproductive and throws back the authorities in their work to improve the water quality (#ID3). Overall, the integrated governance system achieves positive outcomes and it is also perceived as such among the authorities, but certainly there is more needed than cooperation among environmental government departments.

The legacy of Queensland's land development over the past two centuries, highlights another challenge for the responsible authorities in protecting the GBR from land-based pollution. According to Lewis et al. (2021), due to the arrival of Europeans in the GBR catchments, changes to the landscape through activities like agriculture, mining, forestry or townships took place after Indigenous people occupied the coastline of Queensland for more than 45,000 years. Moreover, the authors state that industries like cotton, bananas and beef experience the highest annual numbers and occupied areas since 2010 and general increasing trends since 1860. Agricultural development in particular risks increasing gully erosion as well as cumulative sediment yields and could possibly increase in the future due to its growing numbers (Lewis et al., 2021; Shellberg, 2021). This is also confirmed by the representative of the Queensland government who stated:

> "a lot of the work that we're doing to fix the catchments now is investing money into the gullying to regrade them and fix them up so that they don't keep eroding" (#ID2).

Furthermore, the expert highlighted that:

> "it's a massive area, there's hundreds of kilometres of gullies that are gullying" (#ID2).

Moreover, Interviewee 2 confirmed that it costs millions of dollars to fix some of these gullies and it can take up to three years (#ID2). Especially cattle grazing, amplifies gully erosion because once the vegetation is reduced due to the livestock, the soil becomes more vulnerable for erosion

(Thorburn & Wilkinson, 2013). It is expected that this issue will become an even bigger problem in the future, since agriculture, in particular cattle grazing, will continue to occur to a large extent in the adjacent catchments of the GBR (Kroon et al., 2016). This will increase the pressure on the GBR and therefore also on the work of the responsible authorities.

It is crucial to understand at which point the responsible authorities reach their limits in order to identify how land-based threats can be minimised.

5.3. Improvements for Future Coral Reef Management

The most severe land-based types of pollution that enter the water bodies in Queensland and the GBRMP are nutrients, sediments and pesticides released from agricultural activities (Schaffelke et al., 2017). Therefore, most of the current management measures to improve the water quality, target the agricultural sector (State of Queensland, 2018a). However, the effectiveness of these measures must be questioned, since most of the *Reef 2050 WQIP* water quality targets, like the reduction of dissolved inorganic nitrogen (figure 4), will most likely not be met by 2025 (Brodie et al., 2019; Queensland Government, 2022). In fact, most of the current efforts to improve the water quality rely on voluntary programmes (#ID2; State of Queensland, 2018a). Yet, Kroon et al. (2016) argue that: "voluntary programmes alone are unlikely to deliver the scale of change required to protect the GBR" (p. 1,994). Also, Interviewee 1 (#ID1) stressed that voluntary measures alone have not brought the change that is needed. Kroon et al. (2016) highlight that only legislation and regulation through long-term political commitment brought significant reductions of agricultural pollution. As mentioned earlier, long-term political commitment for improving the water quality in the GBR's catchments is lacking so far in Australia. Contingent to the analysis of statutory plans as well as based on the statements of the interviewees, regulations were not enforced with commitment either. However, new regulations came in place in 2019 and it remains to be seen how effective these are (State of Queensland, 2022a; State of Queensland, 2022b; State of Queensland, 2022c). Overall, it is recommended to enforce stronger legislation and regulations if the process remains slow and targets continue to be missed. Still, the enforcement of stronger regulations must be handled carefully, since it can lead to the opposite effect and reinforce resistance (#ID2). Interviewee 3 (#ID3) highlighted the importance of understanding behavioural change. Moreover, Eberhard et al. (2021) argue that it is crucial to understand how policy instruments influence farmers behavioural changes. Therefore, it is also recommended to not solely enforce regulations but also examine how these influence the behaviour of the target groups, since this will lead to long-term changes. As mentioned earlier, the effects of practice changes are not always immediately visible, and it may take years to improve the water quality. Besides that, a stronger integration of LSI and land-based threats into statutory plans in general is recommended to improve the legal scope on this subject.

Besides agriculture, also other land use types such as mining, industries or urban townships have negative impacts on the GBR. Especially, mining is a threat and since 2012 at least six more thermal coal mines were approved, which are dependent on expansions in port infrastructure and dredging around the coastline of Queensland (Grech et al., 2015; Lewis et al., 2021). Adani's Carmicheal coal mine is among the new coal mines the most prominent example (Konkes et al., 2021). Even though mines might be located inland, far away from the GBR and its adjacent catchments, they can still have indirect effects on the GBR such as coal dust or the development and maintenance of ports or related infrastructure that is required to ship the coal (#ID3; #ID4; Konkes et al., 2021). Most of the sectors are considered in the *Reef 2050 WQIP* and even though those other sectors do not cause as much impacts as the agricultural sector does, they must be monitored and considered more closely in the future (State of Queensland, 2018a). For example, the approval of mines should be more carefully considered, since heavy metals can become an issue (Carlson et al., 2019; Lewis et al., 2021). Overall, climate change represents the greatest threat for the GBR and therefore, it is questionable in terms of carbon reduction, to which extent the approval of future coal mines is still justifiable. Therefore, it is recommended that future land development approvals have to align more with environmental policies and should take place under careful consideration of their long-term impacts on the GBR.

It is strongly recommended to continue and invest more into land repairing practices to fix gully erosion to reduce excess sediments in the GBR. Still, it has to be mentioned that measures are already taken to improve vegetation cover for instance (State of Queensland, 2018a). Still, gully fixing requires large investments, which can be a problem as mentioned by the representative of the Queensland government (#ID2).

MSP and ICZM as subsets of EBM, are acknowledged concepts to manage the marine environment or the coastal zone. Still, they have limitations, since they focus on their area of consideration only (Rude et al., 2016). Yet, both approaches address LSI but do not offer any guideline on how to incorporate these into the planning process. LSP however, poses an approach that allows to make decisions more cost-effective and to consider values in both realms, the land and the sea (#ID3). The findings highlight that LSP as it was defined under the scope of this study, is already done to some extent. It is not surprising that it is not yet fully implemented, since LSP mostly takes place in the realm of academia (#ID3). In terms of LSP in Australia, the findings highlight in particular the integrated governance system, stakeholder engagement across realms as well as monitoring and modelling as principles that are already considered in current coral reef management. Still, there is need for improvements, especially by incorporating all sectors or portfolios into the planning process. As the overall goal is the protection of the GBR, economic viability and environmental protection need to be better balanced in overall decision-making. Tsamenyi and Kenchington (2012) argue that: "the task of integration requires the overarching authority of the department of the head of government or an agency with specific legislation for integrated planning, monitoring and oversight but no direct sectoral regulatory responsibility" (p. 131).

Therefore, an overarching authority, which incorporates portfolios like energy, food, agriculture or environment could help to reduce inconsistencies between the sectors and therefore improve the protection of the GBR (#ID3). Besides that, the implementation of multiple objectives across realms as well as the management of co-benefits and trade-offs is little to not considered in current management. Álvarez-Romero et al. (2015) highlight the importance of objectives for multiple realms such as the protection of terrestrial and marine ecosystems and the reduction of land-based threats entering the marine environment at the same time. Yet, those are often not described or implemented, which was also the case in the documents that were analysed (Álvarez-Romero et al., 2015). A possible reason could be the complexity of scale, which was also stressed by Interviewee 2 (#ID2). However, it is recommended to make use of multiple objectives across both realms to improve the overall coral reef management. The identification and management of co-benefits and trade-offs due to multiple objectives is considered important as well in LSP (Álvarez-Romero et al., 2015). Similar to the findings regarding multiple objectives, there is almost no indication for the management of co-benefits and trade-offs in the dataset. According to Álvarez-Romero et al. (2015), this could be due to incomplete information on responses of certain assets regarding cross-realm actions and threats. Monitoring and modelling as well as stakeholder engagement across both realms is already happening to a large extent around the GBR. The findings show that evaluation processes do not get as much attention as they could and should. Ehler and Douvere (2009) argue that evaluation and monitoring help planners and managers to support the learning process. They highlight its importance by stating: "Evaluation is the element of management in which the greatest learning should occur" (Ehler & Douvere, 2009, p. 90). Therefore, it is highly recommended to expand LSP around the GBR by putting a stronger emphasis on evaluation processes. Especially statutory plans have the potential to be improved in this respect. Therefore, LSP represents a real opportunity to support the health of the GBR and to further protect it. Still, knowledge gaps remain and further research is needed to improve the process of LSP in the future (Álvarez-Romero et al., 2015).

Overall, the improvements that were discussed in this chapter can be drawn to recommendations to minimise land-based threats in the GBR and its adjacent catchments and, therefore, contribute to the overall goal of the study. Moreover, LSP as it was discussed during this research has the potential to integrate these land-based impacts into the current coral reef management in the GBR.

5.4. Limitations

This section discusses possible limitations of the study. Data collection has limitations that potentially restrict the findings and, therefore, partly also the research. Due to the high amount of content of the 51 documents (table 1 & table 2) that were analysed, essential information could possibly have been missed. Prior to the actual analysis of each document, a pre-scan was performed to find important sections in the documents. On top of that, the documents were scanned for

specific keywords, which should help to increase the hit rate for relevant information. Yet, some of the documents are extremely comprehensive such as the *Environmental Protection Act (1994)*, which consists of 785 pages. Therefore, the data collection has limitations, since some important information might have been overlooked. The dataset of the SSIs has limitations as well because only four experts were interviewed. It would have been beneficial to talk to more representatives of the responsible authorities to get a better overall picture. Besides that, no expert from the Climate Change, Energy, the Environment and Water department of the Australian government was available for an interview. This would have made the picture complete in terms of getting an overview of all three responsible authorities for managing the GBR. Additionally, it would have been advantageous to talk to representatives from the industry, since the information about this group are only retrieved through documents, literature and the perception of the interviewees. Since the research addressed the Australian context but was carried out from Groningen in The Netherlands, the SSIs were conducted digitally. Even though they were done by video-chat, there were less possibilities to achieve a good interview atmosphere in comparison to in person meetings and certain nonverbal communication might have been missed. Even though, limitations remain, the document analysis as well as the conducted interviews delivered important and relevant insights for this study. Therefore, useful and valid information about the perceptions of the relevant actors as well as improvements for current coral reef management in the wider GBR region were collected and sense was made of.

6. Conclusion

The GBR has been constantly declining in size and health over the last decades. Its main threats today consist in climate change, poor water quality, coastal development and remaining fishing activities (GBRMPA, 2019). Heat stress, or climate change in general, is by far the most severe threat for the GBR (State of Queensland, 2018a). Since 2016, the GBR has experienced four mass bleaching events, which massively impacted the health of the GBR (GBRMPA, 2022b). In the beginning of 2022, the Australian government released a one-billion-dollar package to facilitate additional measures, around 58 per cent of which go into water quality improvements (DCCEEW, 2022). Currently, the designation of MPAs is the most common form of coral reef protection. However, one-realm management measures such as MPAs are considered insufficient in addressing threats that arise outside of MPA's own boundaries, such as poor water quality that can originate on land (Beger et al., 2010; Makino et al., 2013). Agricultural activities in Queensland lead to excess nutrients, sediments and pesticides in the waterways, which ultimately reach the marine environment and, therefore, the GBR (Kroon et al., 2016). Despite well-established knowledge of the problem of poor water quality and already existing policies for its improvement (State of Queensland, 2018a), the current ecological state of the GBR raises the question, if current responses are sufficient. Therefore, the overall purpose of this study was to answer the research question:

How can land-based threats be minimised and better integrated into coral reef management in the Australian Great Barrier Reef?

Currently, LSI and land-based threats are already integrated to a good extent into the current coral reef management and related policies. The findings of this study highlight that these are especially relevant for strategic plans. Most of the strategic plans highlight the interconnectivity of both realms, the land and the sea as well as its importance. However, since strategic plans, in contrast to the statutory plans, have no legislative backing, stronger regulations cannot be enforced. Still, the overall findings emphasise that LSI and land-based threats are already integrated to some extent in policies and to a larger extent in the current coral reef management. However, statutory plans are lacking in this respect and should be improved to better integrate land-based threats into the legal system and to improve therefore the current coral reef management in the GBR (*Secondary Research Question 1*).

The management of land-based threats represents an immense task, especially as coral reef management approaches are not yet sufficient to incorporate these threats. Presently, the responsible authorities are operating at their limits and personnel capacities are restricted. Managing both land and sea around the GBR is complex because it covers a vast area. Overseeing this area and carrying out compliance work pose new challenges for the responsible authorities. Also, long-term political commitment has been missing, especially to improve the water quality in

the catchments. On top of that, the authorities were faced with strong resistance by industry representatives, in particular regarding the enforcement of stronger regulations. Denial of water quality science is considered another factor that led to a delay in decision-making. Although the authorities cooperate well with each other, the governance system reaches its limits in addressing various sectors at the same time and in balancing economic viability with environmental protection. It is not only today's problems but also the problems of the past, which drive the progressing decline of the GBR. Land development over the past 200 years has left its mark and by now, problems such as gully erosion increase the pressure on the GBR and let the authorities push the limits of what is possible. The study reveals that the responsible authorities encounter several throw backs, which hinder the process of improving the water quality in the GBR and its adjacent catchments. However, those setbacks also show what can be improved in the long term and how land-based threats can be minimised in the future (*Secondary Research Question 2*).

The findings of the study highlight scope for improvement in the current coral reef management and related policies, which address land-based threats in the GBR. The study recommends to improve statutory plans and to incorporate land-based threats and LSI. This way, the legal pressure can be increased to reduce land-based pollution to meet the water quality targets under the *Reef 2050 WQIP*. Moreover, other sectors besides agriculture need to be tackled to prevent land-based pollution in the future. This study highlights the need for an overarching governance system across portfolios, which can be seen as a missing link in aligning new land approval with environmental protection and which addresses the limitations of concepts such as MSP or ICZM. If the water quality remains to be poor and the GBR continues to decline, the Australian and Queensland governments might need to consider more radical steps. Compensation schemes to buy out farm properties that are directly located to a waterbody could be an option to improve the water quality. However, it is expected that this will go along with resistance and requires political commitment and high investments to properly pay off affected landowners. Although LSP is already practised to some degree in Australia, more emphasis on the setup of multiple objectives and on the management of cost-benefits and trade-offs is needed. Moreover, the establishment of further evaluation processes have the potential to improve the current coral reef management. Overall, the recommendations can help Australia to minimise land-based threats. LSP provides a valuable means to integrate land-based threats into the current coral reef management (*Secondary Research Question 3*).

This study reveals opportunities on how to minimise land-based threats and how to better integrate them into the current coral reef management in the GBR. Especially, a LSP approach that considers both realms, the land and the sea, represents a great opportunity to achieve the goal of reducing land-based threats. In the future, more focus should be placed on LSP to make better decisions and to acknowledge values in both realms.
Yet, it is rather unlikely that even an ideal LSP approach can save the GBR in the long run, as it is climate change that poses the greatest threat for coral reefs worldwide. More than ever, serious

thought must be given to phasing out fossil fuels and to reduce carbon emissions. It is recognised that these industries have an enormous economic importance, but not much is won if this happens at the expense of indispensable ecosystems such as coral reefs. Cumulative impacts, such as land-based pollution, put additional pressure on the GBR and hinder the recovery rate of corals. Therefore, although LSP might not be able to save the GBR alone, it can certainly contribute to its resilience. Due to its intrinsic value for humankind and for the well-being of the planet, nothing should be left untried to protect the GBR.

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Appendices

Appendix I – Table of Statutory Plans Incl. Objectives/Purposes

Acts and *Instruments*	Responsible Authority	Objective/Purpose
Environment Protection (Sea Dumping) Act 1981	Federal Government	The Act regulates the loading and dumping of waste at sea and the placement of artificial reefs within Australian Waters.
Environment Protection and Biodiversity Conservation Act 1999	Federal Government	The Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities, and heritage places - defined in the Act as matters of national environmental significance.
Great Barrier Reef Marine Park Act 1975	Federal Government	The main objective of this Act is to provide for the long-term protection and conservation of the environment, biodiversity and heritage values of the Great Barrier Reef Region.
Great Barrier Reef Marine Park Zoning Plan 2003		This Zoning Plan aims, in conjunction with other management mechanisms, to protect and conserve the biodiversity of the Great Barrier Reef ecosystem within a network of highly protected zones, while providing opportunities for the ecologically sustainable use of, and access to, the Great Barrier Reef Region by current and future generations.
Great Barrier Reef Marine Park Regulations 2019		The primary objective of the Great Barrier Reef Marine Park Regulations 2019 (the instrument) is to prescribe all matters required or permitted by the Act to be prescribed or necessary or convenient to be prescribed for carrying out or giving effect to the Act.
Protection of the Sea (Prevention of Pollution from Ships) Act 1983	Federal Government	The Protection of the Sea (Prevention of Pollution from Ships) Act 1983 implements Australia's obligations under the International Convention for the Prevention of Pollution from Ships, known as MARPOL 73/78.
Sea Installations Act 1987	Federal Government	The objects of this Act are: (a) to ensure that sea installations installed in adjacent areas are operated with regard to the safety of the people using them and of the people, ships and aircraft near them; (b) to apply appropriate laws in relation to such sea installations.
Sewage Discharge Policy 2005	Great Barrier Reef Marine Park Authority	The purpose of this Policy is to minimise the potential environmental impacts associated with the discharge of treated sewage via marine outfalls to the Marine Park.
Coastal Protection and Management Act 1995	Queensland Government	The main objectives of this Act are to: (a) provide for the protection, conservation, rehabilitation and management of the coastal zone, including its resources and biological diversity; (b) have regard to the goal, core objectives and guiding principles of the National Strategy for Ecologically Sustainable Development in the use of the coastal zone; (c) ensure decisions about land use and development safeguard life and property from the threat of coastal hazards; (d) encourage the enhancement of knowledge of coastal resources and the effect of human activities on the coastal zone.

State Policy for Coastal Management 2011		The State Policy for Coastal Management (management policy) is prepared under the Coastal Protection and Management Act 1995. It provides direction and guidance about the management of coastal land in Queensland to achieve the objectives of the Coastal Act.
Economic Development Act 2012	Queensland Government	The main purpose of this Act is to facilitate economic development and development for community purposes, in the State.
Environmental Protection Act 1994 *Environmental Protection (Water and Wetland Biodiversity) Policy 2019*	Queensland Government	The objective of this Act is to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development). The purpose of this policy is to achieve the object of the Act in relation to waters and wetlands.
Fisheries Act 1994	Queensland Government	The main purpose of this Act is to provide for the use, conservation and enhancement of the community's fisheries resources and fish habitats in a way that seeks to: (a) apply and balance the principles of ecologically sustainable development; (b) promote ecologically sustainable development.
Great Barrier Reef Protection Amendment Act 2009	Queensland Government	An Act to amend the Chemical Usage (Agricultural and Veterinary) Control Act 1988, the Environmental Protection Act 1994, the Integrated Planning Act 1997 and the Sustainable Planning Act 2009 for particular purposes.
Marine Parks Act 2004	Queensland Government	The main purpose of this Act is to provide for conservation of the marine environment.
Maritime Safety Queensland Act 2002	Queensland Government	The main purpose of this Act is to create an entity, Maritime Safety Queensland, to provide professional, specialist advice to and undertake particular functions of, the chief executive in relation to marine safety, ship-sourced pollution and related matters.
Nature Conservation Act 1992	Queensland Government	The objective of this Act is the conservation of nature while allowing for the involvement of Indigenous peoples in the management of protected areas in which they have an interest under Aboriginal tradition or Island custom.
Planning Act 2016 *Planning Regulation 2017* *State Planning Policy 2017*	Queensland Government	The purpose of this Act is to establish an efficient, effective, transparent, integrated, coordinated and accountable system of land use planning, development assessment and related matters that facilitates the achievement of ecological sustainability. This subdivision prescribes, for section 16 (2) of the Act, the regulated requirements for the contents of a local planning instrument. The policy expresses the state's interests in land use planning and development. Promoting these state interests through plan making and development decisions of state and local government, will help to secure a liveable, sustainable and prosperous Queensland.
State Development and Public Works Organisation Act 1971	Queensland Government	The Act provides for State planning and development through a coordinated system of public works organisation, for environmental coordination and for related purposes
Sustainable Planning Act 2009	Queensland Government	The purpose of this Act is to seek to achieve ecological sustainability by:

		(a) managing the process by which development takes place, including ensuring the process is accountable, effective and efficient and delivers sustainable outcomes; (b) managing the effects of development on the environment, including managing the use of premises; (c) continuing the coordination and integration of planning at the local, regional and State levels.
Transport Infrastructure Act 1994	Queensland Government	The overall objective of this Act is, consistent with the objectives of the Transport Planning and Coordination Act 1994, to provide a regime that allows for and encourages effective integrated planning and efficient management of a system of transport infrastructure.
Transport Operations (Marine Pollution) Act 1995	Queensland Government	The overall purpose of this Act is to protect Queensland's marine and coastal environment by minimising deliberate and negligent discharges of ship-sourced pollutants into coastal waters.
Transport Operations (Marine Safety) Act 1994	Queensland Government	The overall primary objective of this Act is to provide a system that achieves an appropriate balance between: (a) regulating the maritime industry to ensure marine safety; (b) enabling the effectiveness and efficiency of the Queensland maritime industry to be further developed.
Vegetation Management Act 1999	Queensland Government	The purpose of this Act is to regulate the clearing of vegetation in a way that: (a) conserves remnant vegetation that is: (i) an endangered regional ecosystem; or (ii) an of concern regional ecosystem; or (iii) a least concern regional ecosystem; (b) conserves vegetation in declared areas; (c) ensures the clearing does not cause land degradation; (d) prevents the loss of biodiversity; (e) maintains ecological processes; (f) manages the environmental effects of the clearing to achieve the matters mentioned in paragraphs (a) to (e); (g) reduces greenhouse gas emissions; (h) allows for sustainable land use.
Water Act 2000	Queensland Government	The main purposes of this Act are to provide a framework for the following: (a) the sustainable management of Queensland's water resources and quarry material by establishing a system for: (i) the planning, allocation and use of water; and (ii) the allocation of quarry material and riverine protection; (b) the sustainable and secure water supply and demand management for the south-east Queensland region and other designated regions; (c) the management of impacts on underground water caused by the exercise of underground water rights by the resource sector; (d) the effective operation of water authorities.
Wet Tropics World Heritage Protection and Management Act 1993	Queensland Government	An Act to provide for the protection and management of the Wet Tropics of Queensland World Heritage Area and for related purposes.

Appendix II – Table of Strategic Plans Incl. Objectives/Purposes

Document (Year)	Responsible Authority	Objective/Purpose
Great Barrier Reef Intergovernmental Agreement (2015)	Federal Government	The objective of this agreement is to ensure an integrated and collaborative approach by the Commonwealth and Queensland to the management of marine and land environments within and adjacent to the Great Barrier Reef World Heritage Area.
National Water Quality Management Strategy (2018)	Federal Government	The National Water Quality Management Strategy aims to assist water resource managers to understand and protect water quality so that it is 'fit for purpose' - that is, water that is suitable for the desired values and uses and the specific local conditions. The Strategy can also support the integration of water quality into water quantity planning.
Paddock to Reef Integrated Monitoring, Modelling and Reporting Program - Program Design (2018 - 2022)	Federal Government	This design document for the Paddock to Reef program provides an overview of the background and objectives of the program, an overview of the program delivery arrangements, a description of the program outputs including reporting and communication, an overview of each program area, data management and quality assurance protocols, issues of confidence and uncertainty and recommendations to support continuous improvement.
Great Barrier Reef Marine Monitoring Program (2019-2020)	Great Barrier Reef Marine Park Authority	This manual describes the quality assurance and quality control processes undertaken as part of the Great Barrier Reef Marine Monitoring Program (MMP) activities associated with the annual technical reports for the 2019–20 monitoring year. The MMP is a collaborative effort that relies on effective partnerships between governments, industry, community, scientists and managers.
Great Barrier Reef Outlook Report (2014)	Great Barrier Reef Marine Park Authority	This report provides a snapshot of current condition and examines progress in protecting the GBR since 2009. Importantly, it better encompasses the full range of values. It reflects the 2013 amendment of the Regulations, which requires explicit assessment of heritage values in future Outlook Reports.
Great Barrier Reef Outlook Report (2019)	Great Barrier Reef Marine Park Authority	This Outlook Report, like previous reports, plays a significant role in informing Australia's reports to the World Heritage Committee addressing the property's world heritage status, the review of the Reef 2050 Long-Term Sustainability Plan (Reef 2050 Plan) and effective management of the Great Barrier Reef.
Reef 2050 Plan - Long-Term Sustainability Plan (2021 - 2025)		The Plan addresses the local and regional pressures over which people in Australia and Queensland have direct control. It addresses the protection and management of both natural and cultural values of the World Heritage Area, including species and habitats, ecological processes, Traditional Owner values and historic heritage. This includes activities that affect the Reef but that are undertaken outside the World Heritage Area, including in the Reef catchment and adjacent marine areas of the Great Sandy Strait, the Torres Strait and the Coral Sea. It also includes

Reef 2050 Plan - Cumulative Impact Management Policy *Reef 2050 Plan - Good Practice Management for the Great Barrier Reef* *Reef 2050 Plan - Objectives and Goals (2021 - 2025)* *Reef 2050 Plan - Water Quality Improvement Plan (2017 - 2022)*	Great Barrier Reef Marine Park Authority	Australia's international engagement to influence the reduction of impacts on the Reef that come from international sources. This policy aims to provide a systematic and consistent approach to manage and reduce cumulative impacts on the Great Barrier Reef and it provides a framework to mitigate or reduce cumulative impacts on Great Barrier Reef values. Good Practice Management for the Great Barrier Reef sets out foundational considerations for making decisions or undertaking actions that may impact the Great Barrier Reef. The Reef 2050 Plan - Objectives and Goals is the key supporting document to the updated Reef 2050 Long-term Sustainability Plan. The desired outcome of the Reef 2050 WQIP is to ensure that 'Good water quality sustains the Outstanding Universal Value of the Great Barrier Reef, builds resilience, improves ecosystem health and benefits communities. The Reef 2050 WQIP provides an overarching framework to deliver strategic priorities across Reef catchments. Regional Water Quality Improvement Plans guide the implementation of projects within regions and specific catchments. The regional plans support the Reef 2050 WQIP by providing locally relevant information and guiding local priority actions within catchments.
Reef Snapshot - Summer (2020 - 21)	Great Barrier Reef Marine Park Authority	The Reef Snapshot provides a concise summary of how the Reef has fared over the past summer, what this means for corals and the actions being taken to help coral health.
Water Quality Guidelines for the Great Barrier Reef Marine Park (2010)	Great Barrier Reef Marine Park Authority	These guidelines were developed to support those initiatives and in particular, to compile the currently available scientific information to provide environmentally based values for water quality contaminants that, if reached, will trigger management actions.
Queensland's Protected Area Strategy (2020 - 3030)	Queensland Government	Enhance and maintain a system of world-class protected areas, guided by First Nations' knowledge and expertise, global best practice, and community needs, which ensures Queensland's exceptional nature and culture are actively supported to thrive for future generations.
Queensland Reef Water Quality Program (2017 - 2018 to 2021 - 2022)	Queensland Government	The Queensland Reef Water Quality Program delivers activities as part of implementing the Reef 2050 WQIP, which supports the water quality theme of the Reef 2050 Plan. The key objectives of the Queensland Reef Water Quality Program are to: • Improve progress towards the water quality targets under the Reef 2050 WQIP; • Ensure that Queensland Government Reef water quality investment is coordinated, effective and aligned to water quality outcomes;

		• Capitalise on activities that are proving successful across the Reef catchments; • Support landholder management practices to reduce nitrogen, pesticides and sediment run-off to the Reef whilst ensuring productivity, profitability and sustainability of farm enterprises; • Ensure the best and most cost-effective approaches are used for the maximum Reef water quality benefit through trialling, research and ongoing monitoring and evaluation.
Queensland Regional Natural Resource Management Investment Program - Final Report (2018)	Queensland Government	A long–term collaborative approach is required to manage Queensland's natural resources in a responsible way, to support the economic and social needs of the community and to maintain healthy and resilient ecosystems. Partners across all levels of government, industry and the broader community have contributed to the success of the Queensland Regional Natural Resource Management Investment Program.
Queensland Water Quality Guidelines (2009)	Queensland Government	The Queensland Water Quality Guidelines (QWQG) are intended to address the need identified in the ANZECC 2000 Guidelines by: • Providing guideline values (numbers) that are tailored to Queensland regions and water types; • Providing a process/framework for deriving and applying more locally specific guidelines for waters in Queensland.
Reef Water Quality Protection Plan (2003)	Queensland Government	The Reef Water Quality Protection Plan contains new actions, and proposals for building on existing government policies and industry and community initiatives to achieve a sustainable future for the Reef and the industries in the Reef's catchments. The overall aim is to halt and reverse the decline in the quality of water entering the Reef, within 10 years.
Reef Water Quality Protection Plan (2009)	Queensland Government	This updated Reef Plan helps redirect the focus to ensure that reef water quality is improved and that the Reef has the resilience to cope with the stresses of a changing climate. It includes the continuation and expansion of incentive schemes and extension work but also incorporates a regulatory safety net to accelerate uptake of better management practice. It also establishes an integrated monitoring and evaluation strategy so that the progress can be measured more effectively.
Reef Water Quality Protection Plan (2013)	Queensland Government	Building on existing government programs and community initiatives, Reef Plan resulted in a more coordinated and cooperative approach improving water quality. Reef Plan was substantially updated in 2009, with clear goals and targets for reducing pollutant levels.
Reef Water Quality Research, Development and Innovation Strategy (2014 - 15 to 2018 - 19)	Queensland Government	The Strategy focuses on: • Priority pollutants (nitrogen, pesticides and sediment) across reef catchments • The effectiveness of management practices, decision support systems for producers and prioritising investment and policy response • Agricultural production systems of grazing, sugarcane growing and banana production. However, the strategy can be reviewed and

		expanded as emerging issues arise; for example, increases in other cropping systems within reef catchments such as rice.
Wetlands in the Great Barrier Reef Catchments - Management Strategy (2016 - 21)	Queensland Government	The Strategy sets out a framework for the improved management of the wetlands of the Great Barrier Reef catchments. It builds on the achievements of the Queensland Wetlands Program and recognises wetlands as vital to the health of the Great Barrier Reef ecosystem and its catchments.

Appendix III – Interview Consent Form

university of groningen

CARL VON OSSIETZKY UNIVERSITÄT OLDENBURG

Interview Consent Form

Participant's Name **Interview Date**

Research Project
Master thesis as part of the Double-Degree Programme: Water and Coastal Management (University of Oldenburg) / Environmental and Infrastructure Planning (University of Groningen)

Interviewer/Student
Yannik Heisel-Sure

Research Question
How can possible land-based threats be minimized and better integrated into coral reef conservation management on the example of the Great Barrier Reef, Australia?

- ☐ I confirm that my participation in this research project is voluntary.
- ☐ I agree to take part in the project. Taking part in the project will include being interviewed and recorded (audio and video).
- ☐ I agree that the recorded interview will be stored on an external hard drive and will be deleted after the closure of the research.
- ☐ I understand that a transcript of the interview will be produced.
- ☐ I have the right to decline to answer any question or to end the interview.
- ☐ I confirm that the research interview will last approximately 30 to 60 minutes.
- ☐ I understand that I will not receive any payments for participating in this research interview.
- ☐ I understand that the researcher will not identify me by name in any reports using information obtained from this interview and that my confidentiality as a participant in this study will remain secure.
- ☐ I have been given a copy of the consent form.
- ☐ I agree that the researcher may publish documents that contain quotations by me.

By signing this form, I agree the terms indicated above.

Participant's Signature **Date Signed**

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Appendix IV – Interview Guides

Interview Guideline - Representative of the GBRMPA

Structure	Main Questions
Introduction *(≈ 5 min)*	Thank you very much for taking the time to do this interview with me today. Your perspective is particularly important for my research project. For this interview, I will follow a pre-set structure and guideline to ask questions regarding land-sea planning. As I have previously mentioned during our email contact, the focus of my study is the Australian Great Barrier Reef. I want to examine how land-based threats can be minimised and be better integrated into the current coral reef management in the research area. *(If the consent form was not signed prior to the interview, it will be read loud and asked for verbal confirmation)* ● I confirm that my participation in this research project is voluntary. ● I agree to take part in the project. Taking part in the project will include being interviewed and recorded (audio and video). ● I agree that the recorded interview will be stored on an external hard drive and will be deleted after the closure of the research. ● I understand that a transcript of the interview will be produced. ● I have the right to decline to answer any question or to end the interview. ● I confirm that the research interview will last approximately 30 to 60 minutes. ● I understand that I will not receive any payments for participating in this research interview. ● I understand that the researcher will not identify me by name in any reports using information obtained from this interview and that my confidentiality as a participant in this study will remain secure. ● I have been given a copy of the consent form. ● I agree that the researcher may publish documents that contain quotations by me. Do you agree with the terms indicated above? At this point, I would kindly ask you to introduce yourself and highlight your involvement in the Great Barrier Reef in Australia.

	Could you please elaborate on the organisational structure of the Great Barrier Reef Marine Park Authority? And how does the Great Barrier Reef Marine Park Authority relate and cooperate with the Queensland and Federal Government?
Current Situation *(≈ 10 min)*	The Great Barrier Reef is currently in a critical state. What are the major reasons for the continuous decline of coral cover and what role do land-based impacts take in this perspective? *(If major threats are not discussed: What are the major threats that arise from land and how do they impact the water quality and, therefore, the Great Barrier Reef?)* What measures (regulations/policies) are currently taken to reduce land-based threats? *(If MSP is not discussed: Which role does (marine) spatial planning take in this perspective?)* *Follow-up questions:* - *You said X, could you elaborate on that a bit more?* - *You mentioned X, how would that look like in practice?*
Policies *(≈ 15 min)*	In your opinion, if at all, to what extent are land-based threats already integrated into current policies (statutory and strategic plans) in terms of coral reef management at the Great Barrier Reef? What do you think is missing in current policies and where do authorities reach their limits in terms of preserving the Great Barrier Reef from land-based threats? How, if at all, can current policies be improved in addressing land-based sources of pollution in Queensland and in the Great Barrier Reef Marine Park? *Follow-up questions:* - *You said X, could you elaborate on that a bit more?* - *You mentioned X, how would that look like in practice?*

Land-Sea Planning *(≈ 15 min)*	Who are the responsible authorities and departments in protecting the Great Barrier Reef from land-sea interactions? How do you observe the cooperation and integration between the responsible authorities on land and sea? If at all, how can this cooperation be improved? Among the scientific community, there is a call for a new planning approach that incorporates both land and sea. For a future land-sea planning approach, what particular steps both proactive and reactive (e.g., a wider stakeholder engagement across land and sea) should be included to protect the Great Barrier Reef in the future? *(If not discussed: Do you think that a future land-sea planning approach can prevent water quality issues, and would that even be realistic to implement?)* *Follow-up questions:* - *You said X, could you elaborate on that a bit more?* - *You mentioned X, how would that look like in practice?*
Future *(≈ 15 min)*	What would you recommend doing to reduce land-based threats across Queensland and the Great Barrier Reef Marine Park and how could these ideas be integrated into coral reef management? If you could change something about the current situation to secure the Great Barrier Reef for the future, what would that be? *(If not discussed: What would you change to improve the water quality?)* Is there anything you would like to add to this topic, or do you have any further information that could help me to carry out my study? *Follow-up questions:* - *You said X, could you elaborate on that a bit more?* - *You mentioned X, how would that look like in practice?*

Interview Guideline - Representative of the Department of Environment and Science (Queensland Government)

Structure	Main Questions
Introduction *(≈ 5 min)*	Thank you very much for taking the time to do this interview with me today. Your perspective is particularly important for my research project. For this interview, I will follow a pre-set structure and guideline to ask questions regarding land-sea planning. As I have previously mentioned during our email contact, the focus of my study is the Australian Great Barrier Reef. I want to examine how land-based threats can be minimised and be better integrated into current coral reef management in the research area. *(If the consent form was not signed prior to the interview, it will be read loud and asked for verbal confirmation)* ● I confirm that my participation in this research project is voluntary. ● I agree to take part in the project. Taking part in the project will include being interviewed and recorded (audio and video). ● I agree that the recorded interview will be stored on an external hard drive and will be deleted after the closure of the research. ● I understand that a transcript of the interview will be produced. ● I have the right to decline to answer any question or to end the interview. ● I confirm that the research interview will last approximately 30 to 60 minutes. ● I understand that I will not receive any payments for participating in this research interview. ● I understand that the researcher will not identify me by name in any reports using information obtained from this interview and that my confidentiality as a participant in this study will remain secure. ● I have been given a copy of the consent form. ● I agree that the researcher may publish documents that contain quotations by me. Do you agree with the terms indicated above? At this point, I would kindly ask you to introduce yourself and highlight your involvement in the Great Barrier Reef in Australia. Could you please elaborate on the organisational structure of the Queensland Government? And how does the Department of Environment and Science

	(Queensland Government) relate and cooperate with the Great Barrier Reef Marine Park Authority and Federal Government?
Current Situation *(≈ 10 min)*	The Great Barrier Reef is currently in a critical state. What are the major reasons for the continuous decline of coral cover and what role do land-based impacts take in this perspective? *(If major threats are not discussed: What are the major threats that arise from land and how do they impact the water quality and, therefore, the Great Barrier Reef?)* What measures (regulations/policies) are currently taken to reduce land-based threats? *(If MSP is not discussed: Which role does (marine) spatial planning take in this perspective?)* *Follow-up questions:* - *You said X, could you elaborate on that a bit more?* - *You mentioned X, how would that look like in practice?*
Policies *(≈ 15 min)*	In your opinion, if at all, to what extent are land-based threats already integrated into current policies (statutory and strategic plans) in terms of coral reef management at the Great Barrier Reef? What do you think is missing in current policies and where do authorities reach their limits in terms of preserving the Great Barrier Reef from land-based threats? How, if at all, can current policies be improved in addressing land-based sources of pollution in Queensland and in the Great Barrier Reef Marine Park? *Follow-up questions:* - *You said X, could you elaborate on that a bit more?* - *You mentioned X, how would that look like in practice?*

Land-Sea Planning *(≈ 15 min)*	Who are the responsible authorities and departments in protecting the Great Barrier Reef from land-sea interactions? How do you observe the cooperation and integration between the responsible authorities on land and sea? If at all, how can this cooperation be improved? Among the scientific community, there is a call for a new planning approach that incorporates both land and sea. For a future land-sea planning approach, what particular steps both proactive and reactive (e.g., a wider stakeholder engagement across land and sea) should be included to protect the Great Barrier Reef in the future? *(If not discussed: Do you think that a future land-sea planning approach can prevent water quality issues, and would that even be realistic to implement?)* *Follow-up questions:* - *You said X, could you elaborate on that a bit more?* - *You mentioned X, how would that look like in practice?*
Future *(≈ 15 min)*	What would you recommend doing to reduce land-based threats across Queensland and the Great Barrier Reef Marine Park and how could these ideas be integrated in coral reef conservation management? If you could change something about the current situation to secure the Great Barrier Reef for the future, what would that be? *(If not discussed: What would you change to improve the water quality?)* Is there anything you would like to add to this topic, or do you have any further information that could help me to carry out my study? *Follow-up questions:* - *You said X, could you elaborate on that a bit more?* - *You mentioned X, how would that look like in practice?*

Interview Guideline - Representative of the scientific community (Scientist I)

Structure	Main Questions
Introduction *(≈ 5 min)*	Thank you very much for taking the time to do this interview with me today. Your perspective is particularly important for my research project. For this interview, I will follow a pre-set structure and guideline to ask questions regarding land-sea planning. As I have previously mentioned during our email contact, the focus of my study is the Australian Great Barrier Reef. I want to examine how land-based threats can be minimised and be better integrated into current coral reef management in the research area. *(If the consent form was not signed prior to the interview, it will be read loud and asked for verbal confirmation)* ● I confirm that my participation in this research project is voluntary. ● I agree to take part in the project. Taking part in the project will include being interviewed and recorded (audio and video). ● I agree that the recorded interview will be stored on an external hard drive and will be deleted after the closure of the research. ● I understand that a transcript of the interview will be produced. ● I have the right to decline to answer any question or to end the interview. ● I confirm that the research interview will last approximately 30 to 60 minutes. ● I understand that I will not receive any payments for participating in this research interview. ● I understand that the researcher will not identify me by name in any reports using information obtained from this interview and that my confidentiality as a participant in this study will remain secure. ● I have been given a copy of the consent form. ● I agree that the researcher may publish documents that contain quotations by me. Do you agree with the terms indicated above? At this point, I would kindly ask you to introduce yourself and highlight your involvement in the Great Barrier Reef in Australia and on Land-Sea Planning in general.

Current Situation *(≈ 10 min)*	The Great Barrier Reef is currently in a critical state. What are the major reasons for the continuous decline of coral cover and what role do land-based impacts take in this perspective? *(If major threats are not discussed: What are the major threats that arise from land and how do they impact the water quality and, therefore, the Great Barrier Reef?)* *Follow-up questions:* - *You said X, could you elaborate on that a bit more?* - *You mentioned X, how would that look like in practice?*
Policies *(≈ 10 min)*	In your opinion, if at all, to what extent are land-based threats already integrated into current policies (statutory and strategic plans) or into coral reef management in general at the Great Barrier Reef? *(If not discussed: How would you characterise the current coral reef management at the Australian Great Barrier Reef (integration, sectoral planning etc.?)* What do you think is missing in current coral reef management to preserve the Great Barrier Reef from land-based threats? *Follow-up questions:* - *You said X, could you elaborate on that a bit more?* - *You mentioned X, how would that look like in practice?*
Land-Sea Planning *(≈ 25 min)*	How would you describe Land-Sea Planning and how can it help to improve the water quality and, therefore, the health of the Great Barrier Reef? For a future land-sea planning approach, what particular steps both proactive and reactive (e.g., a wider stakeholder engagement across land and sea) should be included to protect the Great Barrier Reef in the future? What are possible limitations of Land-Sea Planning and is it even realistic to implement it on large scale areas such as the Great Barrier Reef and its adjacent catchments?

	Follow-up questions: - *You said X, could you elaborate on that a bit more?* - *You mentioned X, how would that look like in practice?*
Future *(≈ 10 min)*	If you could change something about the current situation to secure the Great Barrier Reef for the future, what would that be? *(If not discussed: What would you change to improve the water quality?)* Is there anything you would like to add to this topic, or do you have any further information that could help me to carry out my study? *Follow-up questions:* - *You said X, could you elaborate on that a bit more?* - *You mentioned X, how would that look like in practice?*

Interview Guideline - Representative of the Scientific Community (Scientist II)

Structure	Main Questions
Introduction *(≈ 5 min)*	Thank you very much for taking the time to do this interview with me today. Your perspective is particularly important for my research project. For this interview, I will follow a pre-set structure and guideline to ask questions regarding land-sea planning. As I have previously mentioned during our email contact, the focus of my study is the Australian Great Barrier Reef. I want to examine how land-based threats can be minimised and be better integrated into current coral reef management in the research area. *(If the consent form was not signed prior to the interview, it will be read loud and asked for verbal confirmation)* ● I confirm that my participation in this research project is voluntary. ● I agree to take part in the project. Taking part in the project will include being interviewed and recorded (audio and video). ● I agree that the recorded interview will be stored on an external hard drive and will be deleted after the closure of the research. ● I understand that a transcript of the interview will be produced. ● I have the right to decline to answer any question or to end the interview. ● I confirm that the research interview will last approximately 30 to 60 minutes. ● I understand that I will not receive any payments for participating in this research interview. ● I understand that the researcher will not identify me by name in any reports using information obtained from this interview and that my confidentiality as a participant in this study will remain secure. ● I have been given a copy of the consent form. ● I agree that the researcher may publish documents that contain quotations by me. Do you agree with the terms indicated above? At this point, I would kindly ask you to introduce yourself and highlight your involvement in the Great Barrier Reef in Australia.

Current Situation *(≈ 10 min)*	The Great Barrier Reef is currently in a critical state. What are the major reasons for the continuous decline of coral cover and what role do land-based impacts take in this perspective? *(If major threats are not discussed: What are the major threats that arise from land and how do they impact the water quality and, therefore, the Great Barrier Reef?)* What measures (regulations/policies) are currently taken to reduce land-based threats? *(If MSP is not discussed: Which role does (marine) spatial planning take in this perspective?)* *Follow-up questions:* - *You said X, could you elaborate on that a bit more?* - *You mentioned X, how would that look like in practice?*
Policies *(≈ 15 min)*	In your opinion, if at all, to what extent are land-based threats already integrated into current policies (statutory and strategic policies) in terms of coral reef management at the Great Barrier Reef? What do you think is missing in current policies and where do authorities reach their limits in terms of preserving the Great Barrier Reef from land-based threats? How, if at all, can current policies be improved in addressing land-based sources of pollution in Queensland and in the Great Barrier Reef Marine Park? *Follow-up questions:* - *You said X, could you elaborate on that a bit more?* - *You mentioned X, how would that look like in practice?*

Land-Sea Planning *(≈ 15 min)*	Who are the responsible authorities and departments in protecting the Great Barrier Reef from land-sea interactions? How do you observe the cooperation and integration between the responsible authorities on land and sea? If at all, how can this cooperation be improved? For a future land-sea planning approach, what particular steps both proactive and reactive (e.g., a wider stakeholder engagement across land and sea) should be included to protect the Great Barrier Reef in the future? *(If not discussed: Do you think that a future land-sea planning approach can prevent water quality issues, and would that even be realistic to implement?)* *Follow-up questions:* - *You said X, could you elaborate on that a bit more?* - *You mentioned X, how would that look like in practice?*
Future *(≈ 15 min)*	What would you recommend doing to reduce land-based threats across Queensland and the Great Barrier Reef Marine Park and how could these ideas be integrated in coral reef conservation management? If you could change something about the current situation to secure the Great Barrier Reef for the future, what would that be? *(If not discussed: What would you change to improve the water quality?)* Is there anything you would like to add to this topic, or do you have any further information that could help me to carry out my study? *Follow-up questions:* - *You said X, could you elaborate on that a bit more?* - *You mentioned X, how would that look like in practice?*

Appendix V – Codebook

Category	Code	Description	Strategy
Contamination	Fertiliser	Statements about the use or discharge of fertiliser	Inductive
	Litter	Statements about the discharge of litter into the environment	
	Nutrients	Statements about the discharge of nutrients into waterways	
	Oil	Statements about the discharge of oil into waterways	
	Pesticides	Statements about the use or discharge of pesticides into waterways	
	Pollutants	Statements about the use or discharge of pollutants in general into waterways	
	Sediments	Statements about erosion and the discharge of sediments into waterways	
	Sewage	Statements about the discharge of industrial or urban sewage into waterways	
Ecosystem-Based Management	Ecosystem-Based Management	Direct or indirect statements about the concept of Ecosystem-Based Management	Deductive
Integrated Coastal Zone Management	Coordination/ Collaboration	Statements about the coordination and/or collaboration between actors, authorities and stakeholders	Deductive
	Integrated Coastal Zone Management	Direct or indirect statements about the concept of Integrated Coastal Zone Management	
	Integration	Statements about integration into the planning and decision-making processes	
Land Use	Agriculture	Statements about practices and impacts of agriculture	Inductive
	Industry	Statements about practices and impacts of different industries	
	Land Use	Statements about land use in general and the land development legacy in Australia	
	Mining	Statements about practices and impacts of mining	
	Tourism	Statements about practices and impacts of tourism	
	Urban	Statements about the impacts of the urban environment	
Land-Sea Interactions	Land-Sea Interactions	Direct and indirect statements about the acknowledgement/perception of the interconnectivity of land and sea	Deductive
	Evaluation	Statements about the implementation or the need of evaluation processes to improve the current management practices	

Land-Sea Planning	Integrated Governance System	Statements about the need of a coherent and collaborative governance system between various governmental agencies or sectors	Deductive
	Land-Sea Planning	Statements about the acknowledgment/need of a land-sea planning approach, which connects both realms, the land and the sea	
	Management of Co-Benefits/ Trade-Offs	Statements about the acknowledgement of the incorporation of co-benefits and trade-offs into current management practices	
	Monitoring/ Modelling	Statements about the benefits and need of/for monitoring and modelling for improving the health of the GBR	
	Multiple Objectives	Statements about multiple objectives or the need for multiple objectives in current management practices	
	Stakeholder Engagement	Statements about the engagement or the need for engagement of relevant stakeholders	
Marine Spatial Planning	Adaptive Planning	Statements about the acknowledgment/need for adaptability in planning and decision-making	Deductive
	Long-Term Planning	Statements about planning for the long-term or for the achievement of long-term protection of the GBR	
	Marine Spatial Planning	Direct and indirect statements about the concept of Marine Spatial Planning	
	Marine Zoning	Statements about marine zoning in general and about the advantages/disadvantages of zoning	
Water Quality	Measures	Statements about certain measures and actions to improve the overall water quality	Inductive
	Targets	Statements about water quality targets in general and about those that are approached by the Reef 2050 WQIP	
	Water Quality	Statements about the quality of the water in the GBR and its adjacent catchments, as well as statements about the need to improve the water quality in those areas	

Appendix VI – Qualitative Content Analysis Quotation Statistic

Category	Code	Statutory Plans	Strategic Plans	Interviews	Total
Contamination		**100**	**86**	**44**	**230**
	Fertiliser	4	1	7	12
	Litter	1	3	0	4
	Nutrients	14	43	16	73
	Oil	3	0	0	3
	Pesticides	4	29	4	37
	Pollutants	53	22	11	86
	Sediments	11	43	20	74
	Sewage	19	0	2	21
Ecosystem-Based Management		**9**	**4**	**1**	**14**
Integrated Coastal Zone Management		**37**	**61**	**17**	**115**
	Coordination/Collaboration	19	55	14	88
	Integrated Coastal Zone Management	10	1	3	14
	Integration	10	8	1	19
Land Use		**49**	**60**	**63**	**172**
	Agriculture	19	43	45	107
	Industry	0	2	9	11
	Land Use	4	10	10	24
	Mining	26	4	5	35
	Tourism	1	2	2	5
	Urban	0	4	4	8
Land-Sea Interactions		**45**	**52**	**28**	**125**
Land-Sea Planning		**95**	**182**	**86**	**363**

	Evaluation	6	20	1	27
	Integrated Governance System	19	43	40	102
	Land-Sea Planning	20	17	21	58
	Management of Co-Benefits/Trade-Offs	6	3	8	17
	Monitoring/Modelling	22	58	14	94
	Multiple Objectives	2	0	0	2
	Stakeholder Engagement	28	64	21	113
Marine Spatial Planning		**21**	**21**	**17**	**59**
	Adaptive Planning	4	10	0	14
	Long-Term Planning	2	7	0	9
	Marine Spatial Planning	4	1	6	11
	Marine Zoning	12	4	12	28
Water Quality		**29**	**158**	**78**	**265**
	Measures	0	78	57	135
	Targets	0	48	13	61
	Water Quality	29	49	23	101
	Total	**390**	**626**	**346**	**1362**