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Newly-claimed seascapes: Options for repurposing inundated areas

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ABSTRACT

Sea-level rise is unstoppable. Communities worldwide are facing difficult choices in responding to changing coastlines and estuaries. Understandably, there is little attention on the potential for repurposing inundated areas because retreat and adaptation take precedence. Repurposing may be infeasible for newly-claimed seascapes in exposed and high energy coasts. Nevertheless, for sheltered coastal areas, shallow estuaries and harbours, there may be potential for repurposing some areas for aquaculture, fisheries, wetlands, and/or blue carbon. For example, abandoned and decontaminated structures may provide fish nursery habitat as artificial reefs. Here, we present the results of a systematic literature review of potential options, along with identified benefits and implementation barriers. Our purpose is not to examine the feasibility of such options because these will be place- and context-specific; rather, we explore whether the solution space can be extended beyond the point of impact. We suggest that repurposing could be added to the PARA management framework.

1. Introduction

Sea level rise (SLR) is a complex and ongoing societal and ecological challenge. Place-specific projections of the rate of SLR vary due to uncertainty, knowledge gaps, and biophysical contexts (Benveniste et al., 2020; Costa et al., 2023). However, in general the rate of SLR will continue to accelerate (IPCC, 2021). For some areas, SLR will result in salinisation of low-lying agricultural land, shoreline retreat, movement of coastal wetlands, alteration of ecological processes and complex changes within coastal food webs (Kleint et al., 2001; Schuerch et al., 2018; Elliott et al., 2019; Reed et al., 2022). Low-lying landscapes are particularly vulnerable to becoming permanently inundated (Elliott et al., 2019; Oppenheimer et al., 2019; Kirezci et al., 2020).

Emerging management and policy responses are focusing primarily on ameliorating the effects of SLR on human societies and built infrastructure through proactive and anticipatory planning (Haasnoot et al., 2013; Mallette et al., 2021), and adaptive, opportunistic and reflexive decision-making in the face of modelling uncertainty (Glavovic et al., 2015; Peirson et al., 2015; Lawrence et al., 2021; Lynch et al., 2021). Integrated planning for the movement and survival of coastal ecosystems is also necessary for long-term biodiversity maintenance and mitigation of greenhouse gas emissions via protection and restoration of ‘blue carbon’ (Abel et al., 2011; Schuerch et al., 2018; Powell et al., 2019; Macreadie et al., 2021; Reed et al., 2022; Rullens et al., 2022).

Communities and policymakers are therefore facing difficult choices in deciding what to protect by coastal hardening (Floerl et al., 2021), maintain or enhance by nature-based solutions (Powell et al., 2019; Macreadie et al., 2021), or abandon as the ‘solution space’ shrinks over time (Haasnoot et al., 2021). The solution space is place- and context-dependent given different social-ecological systems and what adaptation options are feasible, affordable, enabled by policy, and implementable (Haasnoot et al., 2020).

The framing of the ‘shrinking solution space’ may help incentivise collective action to proactively mitigate SLR impacts by engaging the ‘aversion to loss’ cognitive heuristic (Cinner, 2018). Whether this can be augmented by positively framed messaging (Kolandai-Matchett and Armoudian, 2020) that is centred on a restorative response to SLR, requires an assessment of whether there are feasible options for repurposing inundated areas.

Where coastal inundation occurs, the environment will change, and new seascapes will be created. For this paper, the term ‘newly-claimed seascapes’ refers to the coastal space that is not underwater at the current highest tide, but will be in the future as a result of SLR. Effective management and preparation for newly-claimed seascapes could realise

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potential options that may partially mitigate negative outcomes if the biophysical, socio-economic, and cultural context enables such planning to occur (Abel et al., 2011; Powell et al., 2019; Siders et al., 2019; Haasnoot et al., 2021).

In this article, we explore the 'solution space' for these newly-claimed seascapes by examining what options may potentially be available for repurposing some of these areas. We present the results from a systematic literature review to identify a range of potential options to adapt to, and prepare for, newly inundated spaces. In doing so, we acknowledge that nature-based solutions are amongst existing options for newly-claimed seascapes, in terms of landward migration of saltmarshes and mangroves (Enwright et al., 2016; Schuerch et al., 2018; Saintilan et al., 2020).

Our review goes beyond coastal protection and ecosystem restoration of existing areas in the short-term, by examining potential options that may not have been originally conceived for newly-claimed seascapes. We examine whether 'repurposing' could be conceptually expanded and added to existing adaptation frameworks as an ecosystem-based management approach (Forst, 2009; Long et al., 2015).

2. Methods

We conducted a systematic literature review to identify potential options for newly-claimed seascapes following the PRISMA approach (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (Liberati et al., 2009). We searched CAB Abstracts, Scopus, Springer Link, and Nature between 13 October and 9 November 2022. Our search was inclusive of both peer-reviewed and 'grey' literature. The search was confined to publications from 1 January 2000–13 October 2022.

2.1. Individual database search parameters

CAB ABSTRACTS - search was conducted using the 'Topic' search function.

SCOPUS - search was conducted using the 'Article title, Abstract, Keywords' search function. The search on SCOPUS had to be refined further as there were irrelevant results. We limited the database subject areas to only search within: Earth and Planetary Sciences, Environmental Science, Agricultural and Biological Sciences, Arts and Humanities, Engineering, Social Sciences, Multidisciplinary, Energy, Materials Sciences, and Decision Sciences.

Springer Link and *Nature* – searches were conducted using the basic search function as the advanced search function was not appropriate for the search string.

2.2. Search process

Our search process is set out in Fig. 1. A pilot search was conducted which captured many articles not relevant to the research aim. Papers were first screened by title only, and if deemed potentially relevant, then screened by abstract. The search terms were iteratively refined for relevance to coastal processes and/or coastal hazards associated with SLR (Table 1).

The terms were divided into three lists; List A: Coastal processes and/or hazards, List B: Options, and List C: Qualifiers; and defined as follows:

List A: Common terms associated with the coastal processes or hazards resulting from SLR (Table 1).

List B: Potential options that could be associated with the coastal area (Table 1). Structures which predominately prevent flooding and erosion were excluded (e.g., dykes, sea walls, locks, and levees).

List C: Terms that could eliminate ambiguity when reviewing the article abstracts (Table 1). Not all articles met the conditions of List C; hence, there was an element of subjectivity to the search where, in some cases, a decision on relevance was made after careful reading of the abstract. For example, through reading "Sea-level driven land conversion and the formation of ghost forests" (Kirwan and Gedan, 2019), we noted that ghost forests could provide future habitat for coastal species after inundation.

Any papers retained were read in full and, if relevant, manually coded using the NVivo software (www.lumivero.com) to facilitate a systematic and rigorous approach to reading the articles. Coding was approached inductively using focused coding and memoing following Lofland (2006). Future seascape options were coded using the wording in the article. Any commentary on the type of conditions (e.g., environmental, socio, socio-environmental, or political, etc.) that may be required to enable the option was also coded along with examples. The final coding applied was to identify any potential resulting benefits or drawbacks from the implementation of each option.

Our focus was on gradual SLR, so we excluded abrupt SLR from tectonic-induced subsidence. We also excluded the concept of restoration from the search terms. This may seem counter-intuitive, however, restoration implies a return to a previous or notional baseline state for existing and not newly-created seascapes.

Successful restoration may imply recovery of ecological functioning over time to deliver a range of ecosystem services. The options for newly-claimed seascapes may mean that the functionality for some spaces is different in the future. Therefore, restoration may not be an appropriate or available response for all areas that become inundated. However, restoration still featured in the search results and was included when used in the context of extending the historical ecosystem boundary. Our approach enabled restoration options such as afforestation and other nature-based solutions to be identified for evaluation after screening.

We identified 15,136 papers for initial screening: 730 from the pilot search, and 14,389 using the final search terms in Table 1. Following the methods used by Greenhalgh and Peacock (2005), an additional 17 papers for screening came through 'snowballing' and existing 'personal knowledge'. A total of 14,920 papers were discarded based on their title, and 125 after studying the abstracts, and 16 papers due to either duplication or not being in English. This left 75 papers remaining which were read in full and of those, 22 papers were eliminated as being not relevant to our research aim. Following the completion of the filtering process, 53 papers were kept for options analysis.

3. Results

Twenty-nine potential options were identified in the systematic review from 53 papers (Table 2). We grouped the options into eight broad categories as 'option groups' as a heuristic. The categories were assigned to either an overarching 'Anthropogenic Group' or a 'Nature-based Solution Group' from our reading of the primary focus of the article. We retained the original terms used to describe options, with minor modifications to align with more frequently used terms in the literature. We note that some options were similar, and some could fit under more than one category (e.g., seaweed can be both a nature-based solution and an economic activity). Each category reflected the grouping of options that had similar features or spatial characteristics.

The common themes in the literature were nature-based solutions for responding to SLR, which included increasing carbon sequestration as 'blue carbon' (e.g., de Paula Costa et al., 2022; Macreadie et al., 2022), and hazard and risk reduction, often as an alternative or complementary means of providing coastal defences or protection to communities and their associated infrastructure (e.g., Hill, 2015; Morris et al., 2021). Conservation and restoration of existing ecosystems, and the creation of new ecosystems, were also suggested (e.g., Powell et al. (2019); Van Coppenolle and Temmerman (2019).

In our review, we did not identify any studies that specifically centred solely on developing a range of options for repurposing inundated areas when responding to SLR. Therefore, we took a broad approach and searched for options that could potentially be reconceptualised and used

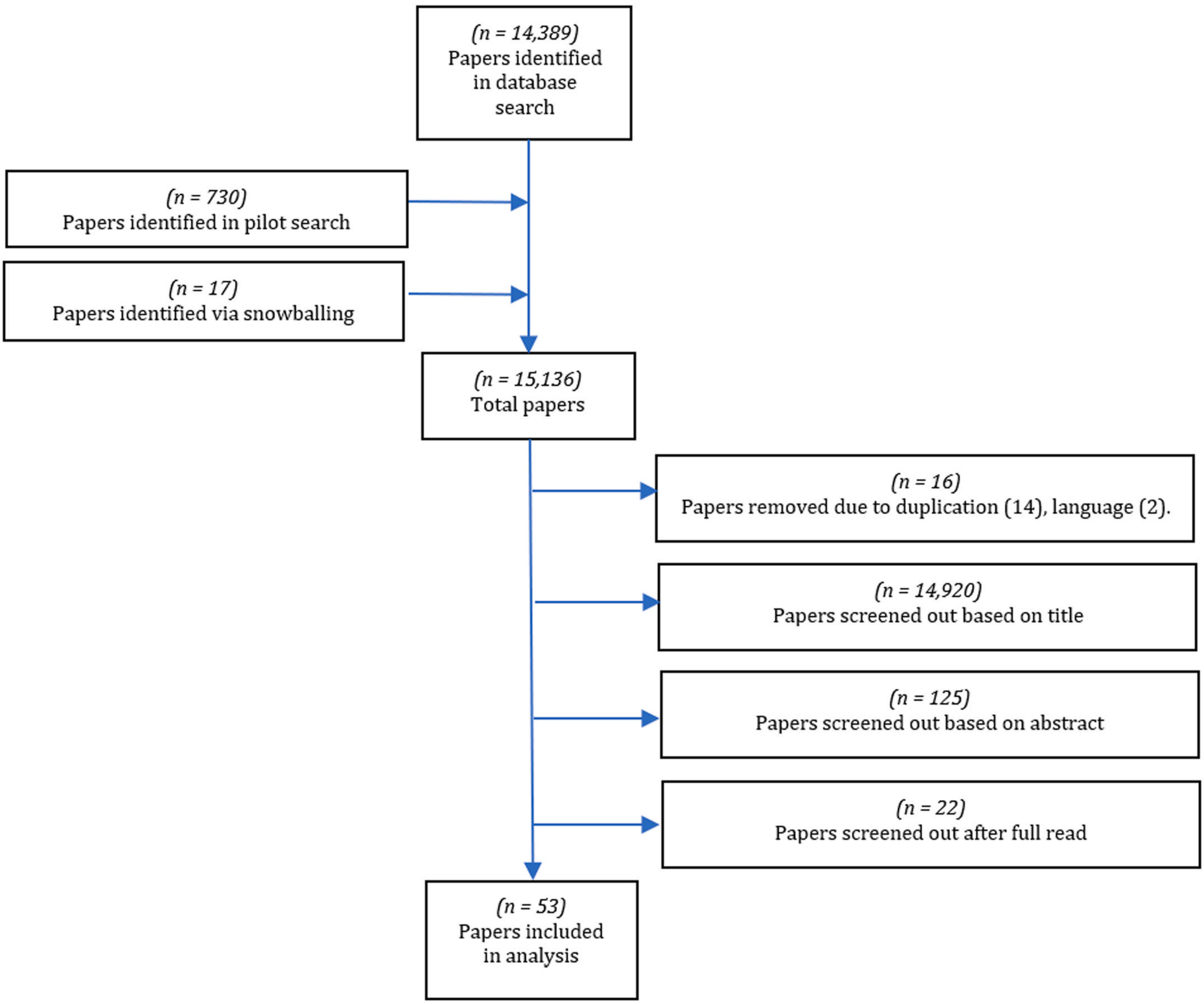

Fig. 1. Summary of screening process for the systematic literature review conducted on the CAB Abstracts, Scopus, SpringerLink and Nature databases between October and November 2022.

Table 1
List of the final search terms used for our systematic literature review. For each item in List A, the set of terms was used in conjunction with every item from List B. List A are terms associated with coastal processes and hazards resulting from SLR. List B are potential options for newly-claimed seascapes that were already known. Terms from List C were used to determine the relevance of articles if there was ambiguity.

List A: Coastal Processes &/or Hazards	List B: Options	List C: Qualifiers
1. (''coastal squeeze'' OR ''coastal inundation'')	a. Eco* tourism	Restore/ation
2. ''Inland wetland migration''	b. Seaweed carbon	Repurpose
3. ''seascap* OR ''sea scap* ''	c. Blue carbon	Reuse
4. ''sea level rise'' OR ''managed retreat'' OR ''storm surge''	d. Blue economy	Rehabilitate
	e. Aquaculture	Decontamination
	f. Marina development	Remediation
	g. Wetlands	Future
	h. Habitat creation	Protection
	i. Estuar*	Resilience
	j. Recreation	Artificial
	k. Reef	Conversion
	l. Energy	Restore/ation
	m. Surf*	
	n. Beach*	

Table 2
Twenty-nine potential options identified for newly-claimed seascapes from a systematic literature review (n= 53). The two main groupings are used for heuristic purposes to group broadly similar options, accepting that there may be somewhat arbitrary distinctions between some options within different groups, and some options could encompass more than one option group.

Anthropocentric Grouping	Specific Option	Citation
Aquatic infrastructure	Artificial lagoons / tidal lakes	Burt and Bartholomew (2019), Frihy (2009), May et al. (2006) & Waltham and Connolly (2013)
	Artificial waterways	Burt and Bartholomew (2019) & Scott et al. (2015)
Land reclamation	Afforestation	Boori et al. (2012), Kleint et al. (2001), Onat et al. (2018) & Powell et al. (2019)
	Artificial islands	Steenbergen and Van Bemmelen (2011) & Powell et al. (2019)
	City construction	Jones et al. (2012)
	Causeway	Erftemeijer et al. (2020)
	Sand bar	Hill (2015)
Land management and modification	Coastal border* (buffer zone)	Akbar et al. (2019)
	House elevation	Onat et al. (2018)
	Light infrastructure (moveable buildings on stilts)	Fouqueray et al. (2018)
	Shoreline realignment	Ausden (2014), Berry et al. (2013), Davis et al. (2019), Hadley (2009), Hodge and Johnson (2007), Mander et al. (2007), May et al. (2006), Scott et al. (2015), Powell et al. (2019), Rupp-Armstrong and Nicholls (2007)
Marine farming, tourism and recreation	Aquaculture farms	Fabinyi et al. (2022) & Zhu et al. (2020)
	Artificial swimming pools	Frihy (2009)
	Coastal grazing marsh	May et al. (2006)
	Ecotourism (shrimp farms)	Trang and Loc (2022)
	Marinas	Frihy (2009)
	Rice cultivation	Sapkota and White (2020)
	Seaweed cultivation	Fabinyi et al. (2022), Hehre and Meeuwig (2015) & Nuryadi et al. (2017)
Nature-based Solutions Grouping	**Specific Option**	**Citation**
Intertidal and subtidal	Mangroves	Akbar et al. (2019), Erftemeijer et al. (2020), de Paula Costa et al., 2022, Hu et al. (2020), Locatelli et al. (2014), López-Medellín et al. (2011), Macreadie et al. (2022), Morris et al. (2021), Powell et al. (2019), Sutton-Grier and Moore (2016), Ward et al. (2021) & Winata et al. (2020)
	Seagrass	de Paula Costa et al., 2022, Macreadie et al. (2022), Morris et al. (2021), Sapkota and White (2020), Sutton-Grier and Moore (2016) & Ward et al. (2021)
	Seaweed	Morris et al. (2021), Ocean Visions and Monterey Bay Aquarium Research Institute (2022) & Ryu (2021)
Reefs	Artificial reefs	Charlier and De Meyer (2000) & Onat et al. (2018)
	Bivalve reefs	Hossain et al. (2013), Morris et al. (2021), Powell et al. (2019) & Ridge et al. (2017)
	Coral reefs	Morris et al. (2021) & Powell et al. (2019)
	Living breakwaters	Hill (2015)
Terrestrial Margins	Dune creation and beach nourishment[a]	Bolt et al. (2019), Boori et al. (2012), Charlier and De Meyer (2000), Hill (2015), Kleint et al. (2001), Morris et al. (2021), Onat et al. (2018), Rogers et al. (2019), & Spencer et al. (2022)
Wetlands	Tidal marsh / saltmarsh[b]	Ausden (2014), de Paula Costa et al., 2022, Gedan et al. (2020), Hill (2015), Macreadie et al. (2022), May et al. (2006), Mitchell et al. (2020), Morris et al. (2021), Orchard and Schiel (2021), Powell et al. (2019), Ridge et al. (2017), Sapkota and White (2020), Sutton-Grier and Moore (2016), Waltham et al. (2021) & Ward et al. (2021)
	Wetland creation & restoration	Boori et al. (2012), Kleint et al. (2001), Kirwan and Gedan (2019), Mander et al. (2007), Powell et al. (2019), Ryu (2021), Sudol et al. (2020) & Van Coppenolle and Temmerman (2019)
	Wetland elevation by sediment addition	Rogers et al. (2019) & Stagg and Mendelssohn (2011)

* Coastal border – "a vacant or vegetated buffer zone used in the context of coastal protection for coastal infrastructure and residential areas" (Akbar et al., 2019 p. 5). This could be reconceptualised to enable inland migration of the sea.
[a] Dune creation could occur with sea-level rise to enable these ecosystems to be retained on the margin of inundated areas.
[b] Tidal marsh and saltmarsh were not distinguished here.

Table 3
Potential opportunities, barriers and implementation factors for options where the objective is primarily for an anthropocentric purpose (from Table 2).

Anthropocentric	Potential Opportunities	Potential Implementation Barriers
Aquatic Infrastructure	- Habitat provisioning (natural) (Waltham and Connolly, 2013)	- Downstream erosion and effects on hydrology - When linked with urban intensification may negatively impact natural habitats - Water circulation required to avoid hypoxic conditions - Climate extremes may hinder biological success - Salinity - Higher wave energy needed to increase species diversity and abundance (Waltham and Connolly, 2013; Burt and Bartholomew, 2019)
Land creation	- Ability to mitigate erosion and storm damage - Habitat provisioning (human & natural) - Inundation protection - Low maintenance - Nursery and refuge habitat - Protection for tourism industry and related employment (Steenbergen and Van Bemmelen, 2011; Jones et al., 2012; Hill, 2015; Bolt et al., 2019; Powell et al., 2019; Spencer et al., 2022)	- Unpredictable behaviour of subsoil during and after construction - Geomorphological characteristics and beach processes - Ongoing maintenance - Pre-existing contamination of sourced sediment - Continued sediment supply - Unpredictable changes to sediment transportation and beach profiling - Construction can cause physical changes negatively affecting natural habitat - Loss of coastal access - Loss of local food gathering - River-bank instability - Decline in species abundances - Noise pollution (Charlier and De Meyer, 2000; Steenbergen and Van Bemmelen, 2011; Onat et al., 2018; Morris et al., 2021)
Land management & modification	- Flood mitigation and protection - Habitat provision (natural) - Nutrient cycling & carbon sequestration - Recreation provision - Wastewater treatment (May et al., 2006; Mander et al., 2007; Hadley, 2009; Ausden, 2014; Davis et al., 2019)	- Conflict from competing land ownership, use and existing values - Unintended erosion - Socio-economic constraints - Politico/legal constraints - Accommodation space - Changes to inundation and flood risk - Archaeology and/or cultural heritage - Present habitat condition - Proximity to seed sources (Hodge and Johnson, 2007; Rupp-Armstrong and Nicholls, 2007; Hadley, 2009)
Marine farming and tourism	- Economic provisioning - Food provisioning - Increase in resilience of local community (Sapkota and White, 2020; Zhu et al., 2020; Trang and Loc, 2022)	- Sewage and waste disposal contamination - Displacement of local communities - Loss of coastal access - Loss of local food gathering - Unjust and uneven social and economic outcomes - Small tidal ranges may offer conditions for intertidal farming - Seaweed farming can cause changes to natural habitat, result in trampling, shading, and siltation of the surrounding area (Hehre and Meeuwig, 2015; Zhu et al., 2020; Fabinyi et al., 2022)

to address the preparation and management of 'newly-claimed seascapes'. Any paper that presented potential options for newly-claimed seascapes was considered as we did not attempt to determine the feasibility of any option, given local variability in social-ecological and biophysical contexts.

A range of potential opportunities were identified for each option group (Tables 3 and 4). Habitat provision with the associated ecological functions of nutrient cycling and carbon sequestration emerged as a likely benefit common to the two overarching option groups (e.g., Powell et al., 2019). Potential economic opportunities were identified in the form of new space for aquaculture farms, food provision, recreation, and tourism (Table 3) (e.g., Trang and Loc, 2022). Nature-based solutions also provide the benefits of buffering storm surge, reducing wave energy, and stabilising shorelines, in addition to facilitating blue carbon sequestration and providing ecosystem services (Table 4) (e.g., Locatelli et al., 2014).

Potential implementation barriers were also recognised in the literature (Tables 3 and 4). These included legal, political, socio-economic and cultural considerations such as existing regulations, land ownership, financial resources, and protection of archaeological and heritage values (e.g., Hodge and Johnson, 2007; Fabinyi et al., 2022). Biophysical constraints that were identified included: compounding and synergistic effects from the accelerating rate of SLR; mobilisation of pre-existing land contamination; and the influence of local hydrodynamics, such as wave exposure, fetch, tidal range, and current speeds.

4. Discussion

Sea-level rise (SLR) is unstoppable (IPCC, 2021) and much of the research and policy focus has appropriately been on adaptation and protection of communities and infrastructure (Haasnoot et al., 2013; Haasnoot et al., 2021; Mallette et al., 2021). This study has expanded that future-focused approach to look at potential options for spaces claimed by the sea. The purpose is not to substitute for, or divert attention away from investment in short- to medium-term management priorities. Rather, this study offers a signal for policymakers and communities to consider whether imminently- or newly-inundated spaces could be reimagined and transitioned in some areas. As such, it may extend the solution space beyond the point of SLR impact where the biophysical and socio-economic contexts are favourable. This recognises the temporal dimension in dynamic and reflexive planning for adaptation to SLR (Haasnoot et al., 2013; Fincher et al., 2014; Glavovic et al., 2015).

The concept of temporarily repurposing areas before permanent inundation has previously been suggested (Haasnoot et al., 2021). This would involve land rehabilitation and removal of structures that could contain contaminants if released into the marine environment and/or be impediments to future navigation. However, the progressive repurposing and long-term planning for newly-claimed areas may also require thorough scoping and feasibility analyses. Our review, therefore, goes beyond coastal protection and ecosystem restoration of existing areas in the short-term by examining potential options that may not have been

Table 4
Potential opportunities, barriers and implementation factors for options where the objective is primarily for a nature-based or ecological purpose (from Table 2).

Nature-based Solutions	Potential Opportunities	Potential Implementation Barriers
Intertidal & subtidal	- Mitigate storm damage and erosion - Shoreline stabilisation - Wave energy reduction - Protection against seawater intrusion - Capacity to adapt to SLR - Food provision - Habitat provision (natural) - Nursery and refuge habitat - Nutrient cycling & carbon sequestration - Cultural services provision - Water purification (López-Medellín et al., 2011; Jones et al., 2012; Locatelli et al., 2014; Hehre and Meeuwig, 2015; Hill, 2015; Kirwan and Gedan, 2019; Powell et al., 2019; Hu et al., 2020; Winata et al., 2020; Zhu et al., 2020; Morris et al., 2021; Ryu, 2021; Ward et al., 2021; Fabinyi et al., 2022; Macreadie et al., 2022; Ocean Visions and Monterey Bay Aquarium Research Institute, 2022)	- Dependent on coastal geomorphology - Requires area with adequate inundation and drainage - Excessive pollutants can inhibit growth - Colonisation may be impacted by slope steepness - Succession may be affected by rainfall - Sediment dynamics - Soil oxygen content - Light availability - Salinity - Nutrient availability - Site selection requires appropriate height in relation to MSL - Suitable substrata - Temperature dependent - Wave exposure (López-Medellín et al., 2011; Powell et al., 2019; Rogers et al., 2019; Erftemeijer et al., 2020; Hu et al., 2020; Morris et al., 2021; Ryu, 2021)
Reefs	- Mitigate storm damage and erosion - Shoreline stabilisation - Wave energy reduction - Capacity to adapt to SLR - Food provision - Habitat provision (natural) - Nursery and refuge habitat - Nutrient cycling & carbon sequestration - Water purification (Steenbergen and Van Bemmelen, 2011; Hossain et al., 2013; Hehre and Meeuwig, 2015; Onat et al., 2018; Powell et al., 2019; Zhu et al., 2020; Morris et al., 2021)	- Can be expensive compared to other options - Unfavourable impacts on down drift beaches and shorelines - Ocean acidification - Sufficient plankton - Dissolved oxygen - Temperature - Nutrient availability - Salinity - Sedimentation - Suitability of substrata - Tidal current and elevation - Water clarity (light and turbidity) - Water pollution - Wave exposure (Charlier and De Meyer, 2000; Hossain et al., 2013; Morris et al., 2021)
Terrestrial margins	- Mitigate storm damage & erosion - Wave energy reduction - Habitat provision (natural) - Recreation provision - Support habitat migration (Hill, 2015; Bolt et al., 2019; Morris et al., 2021; Spencer et al., 2022)	- Biogeochemical components - Hydrology conditions - Geomorphological conditions - Reduced wave energy or protection from high wave energy - Requires area with adequate accommodation space for habitat migration (Charlier and De Meyer, 2000; Osswald et al., 2019; Morris et al., 2021)
Wetlands	- Ability to mitigate erosion - Carbon sequestration - Capacity to adapt to SLR - Flood mitigation - Habitat connectivity - Habitat provision (natural) - Nursery and refuge habitat - Provisioning of organic matter to wider seascape - Water purification (May et al., 2006; Steenbergen and Van Bemmelen, 2011; Jones et al., 2012; Ridge et al., 2017; Davis et al., 2019; Kirwan and Gedan, 2019; Powell et al., 2019; Van Coppenolle and Temmerman, 2019; Morris et al., 2021; Waltham et al., 2021; Ward et al., 2021; Macreadie et al., 2022)	- Land management, use, & practices (e.g., timber harvest) - Upland land cover - Nutrient availability - Hydrodynamics - Tidal regime - Wave energy - Salinity - Rainfall - Temperature - Rhizosphere microbial community and soil temperature (Ridge et al., 2017; Davis et al., 2019; Van Coppenolle and Temmerman, 2019; Gedan et al., 2020; Morris et al., 2021; Orchard and Schiel, 2021; Waltham et al., 2021)

originally conceived for newly-claimed seascapes. The resultant typology is intended to facilitate discussion and options for local communities and policymakers as relationships with coastal areas are redefined.

This study adds to recent thinking around repurposing as a global tool for areas and ecosystems that have, or are, undergoing profound shifts in use. For example, agricultural land abandoned due to rural depopulation and other factors has been identified as potentially important for biodiversity recovery, by repurposing to become conservation areas (Daskalova and Kamp, 2023). Repurposing may be a valuable tool for adaptive management as climate change and biodiversity loss drive dynamic changes to socio-ecological systems (Voulvoulis et al., 2022). Our results suggest that, at least in some areas, human relations with the coast can potentially be reframed to positively influence the trajectory of system changes induced by SLR.

In many jurisdictions the policy focus for coastal management and adaptation to SLR has been guided by the 'PARA framework' (Protect, Accommodate, Retreat, Avoid) (Mallette et al., 2021). We suggest that Repurposing could be added to the framework, i.e., PARA(R). Whether that is a realistic option in the short-term is debatable, and perhaps unlikely in jurisdictions with limited resources to even deal effectively with the PARA components. Nevertheless, repurposing may have immediate benefits as a new consideration, if only to widen the scope of possibilities in certain situations beyond abandonment and loss. For example, structures that have been decontaminated before inundation could become new reefs and fish nurseries that benefit inshore fisheries (Paxton et al., 2022). Repurposing can therefore fit within an adaptive and relational ecosystem-based management approach to the coastal-ocean interface (Macpherson et al., 2021). It may also expand the solution space to include potential options and long-term solutions to SLR.

Declaration of Competing Interest

The authors state that they have no conflicts of interest.

Data availability

Data will be made available on request.

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