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Article

Land–Sea Interactions: A Spatial Planning Perspective

Alberto Innocenti [1,2,*] and Francesco Musco [2]

[1] Department of Technology and Innovation, University of Southern Denmark, 5230 Odense, Denmark
[2] Department of Architecture and Arts, University Iuav of Venice, 30135 Venice, Italy
* Correspondence: alinn@iti.sdu.dk

Abstract: Coastal areas are the most populated areas on the planet and are the most attractive areas due to the richness of the biodiversity, natural resources, and trading reasons. Coastal cities are enlarging their boundaries fast by reclaiming land to place new growing economic sectors such as tourism, oil and gas, aquaculture, and fishery. These processes will put an extra strain on the interactions between land and sea. A crucial initiative regarding Land–Sea Interactions comes from the European Union through Directive 2014/89/EU. The directive pays special attention to the discourse surrounding Land–Sea Interactions. This study aims to analyze the existing research on Land–Sea Interactions to develop a base knowledge to determine elements and interactions with a spatial planning perspective. The research is based on a double literature review, a systematic literature review based on an open-source database, and a bibliographic search based on a key Land–Sea Interactions paper. The results identify economic sectors, natural elements, and their functions in the discourse of Land–Sea Interaction. Furthermore, this study identifies shared features and terminologies to define Land–Sea Interactions clearly. The main conclusion is that Land–Sea Interactions are human-induced and, in most cases, happen from land to sea, not vice versa. The other crucial conclusion is that specific types of natural elements can decrease the negative impact that those interactions can have either on the environment or among other human activities.

Keywords: Land–Sea Interactions; coastal planning; source-to-sea; marine spatial planning; LSI; Land–Ocean Interactions; coastal interactions; coastal zone; MSP

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1. Introduction

Historically, coastal areas have been the most attractive places to develop settlements and communities due to the richness of the biodiversity, the extraordinary natural resources, and logistical reasons—coastal areas offer strategic advantages for trading [1]. These are some reasons why the world's most developed cities and megacities are located in coastal areas. Nearly 2.4 billion people (40% of the world's population) live within 100 km of the coast [2]. If we only look at Europe, more than 206 million citizens currently live near coastlines, stretching from the northeast Atlantic and the Baltic to the Mediterranean and the Black Sea [3]. Pressure on coastal and marine environments continues to increase, putting an unsustainable strain on coastal resources and biodiversity [4,5]. The global population is projected to reach more than 9 billion people by 2050, with a consequential increase in pressure on marine and coastal resources [2,6]. If we assume that 2% of the urbanized areas have been developed on coastlines that are less than 10 m above sea level and 13% of the world's population is living in these areas [7], we can conclude that coastal communities and settlements are also among the most vulnerable to climate change (sea level rise and storm surge) [5,6,8–10]. Coastal cities are growing fast and often reclaim land to expand and increase economic sectors such as tourism, oil and gas, aquaculture, and fishery [4,9,11]. These processes will put an extra strain on an environment already adversely affected by human activity [5,6,9,12].

A crucial initiative regarding Land–Sea Interactions (LSI) comes from the European Union through the Directive 2014/89/EU, which established a Maritime Spatial Planning

(MSP) framework by which the EU member states are committed to developing their own maritime spatial plan [13]. The directive puts forward a plan to manage the discourse surrounding Land–Sea Interactions carefully [13]. This is a key point in the Directive 2014/89/EU for different reasons. First, land and maritime planning systems are not working according to a common framework, and coastal dynamics are not managed in an integrated way [12]. Secondly, administrative boundaries cannot delimit Land–Sea Interactions, because there is no recognized standard spatial dimension [12]. The maritime spatial process works across borders and sectors to ensure that human activities at sea take place in an efficient, safe, and sustainable way [13]. Many have devoted attention to blue growth, a long-term strategy to support sustainable growth in the marine sectors as a whole. A lot of activities and sectors that operate at sea are known to affect conditions on land and vice versa [12,13].

Furthermore, in the last two decades, research on coastal zones, planning processes, and tools has attempted to manage the diverse human activities that have led to the deterioration of coastal environments. From a scientific perspective, different international research programs (e.g., Future Earth) and agencies (e.g., United Nations, European Union, UNESCO-IOC) [14,15] have explicitly focused on research on coastal zones. One example is the Future Earth Coasts Program (from Future Earth), which is involved in a large number of research studies of coastal areas to support sustainability and help coastal zones adapt to global change [6,10,16–18]. In particular, crucial for this research is a world-renowned article on Land–Sea Interactions called "Land-Ocean Interactions in the Coastal Zone: Past, present & future" [16], which details all the work carried out on Land–Sea Interactions by Future Earth researchers under the auspices of the International Geosphere-Biosphere Program (IGBP). The main goal of these studies is to strengthen the science–policy interface and contribute to securing sustainable coastal futures in the Anthropocene epoch, which refers to the human impact on earth's geology and ecosystems [16]. However, both research (e.g., Future Earth and academia) and policy (e.g., European Commission and UNESCO-IOC) [14,15] did not share a common definition of Land–Sea Interactions; this can lead to misunderstanding and can create ambiguity about what is and what is not Land–Sea Interactions [19–21].

The lack of a clear definition for Land–Sea Interactions in spatial planning is recognized by the scientific community as a whole, which also brings awareness to the fact that the discourse on LSI has been researched from a vast number of research fields' studies that have not been systematized yet in the planning field [12,19].

For these reasons, it is essential to establish a base knowledge on the Land–Sea Interactions discourse to support and manage the coastal and maritime spatial planning processes. Such an approach will contribute to dealing with the increasing pressure on both the sea and coastal areas by improving synergies and reducing conflicts. Moreover, as mentioned above, the issue of climate change is inextricably linked with coastal zones and their own interactions.

This study analyzes the research available on Land–Sea Interactions and creates and organizes the comprehensive knowledge that already exists on coastal areas by drawing on facts and information from other fields of research on coastal area issues into a spatial planning perspective. The research is based on a double literature review: one is a systematic literature review based on an open-source database, and the second one reviews the bibliography of a world-known article on LSI [16]. Moreover, the principal results identify economic sectors and natural elements and their functions in the discourse of Land–Sea Interaction. The research also identifies typologies and distinguishes shared features and terminologies to determine a clear definition of Land–Sea Interactions.

This paper is structured as follows: in Section 2, the literature reviews methodology and visualization tool is presented. Next, the results are presented in Section 3, divided into land and sea anthropic uses and environmental and climate issues. Finally, the discussion is presented in Section 4.

2. Literature Reviews Methodology and Visualization Tool

Carrying out a double literature review of the Land–Sea Interactions discourse was fundamental for several reasons. First, it was essential to build a complete but not exhaustive picture of all the academic fields that have contributed directly and indirectly to the research on this topic. Secondly, it was essential to have a deep immersion in the subject of Land–Sea Interactions to integrate new knowledge and different perspectives and reveal the complexity and heterogeneity of coastal areas. Finally, it was crucial to put together a general frame of references on the topic and to marshal the considerable amount of information about Land–Sea Interactions in a clear and comprehensible form. The following paragraphs will outline the methodology used for both literature reviews and the visualization tool.

The literature reviews followed Pittway, who highlights the importance to observe a clearly defined protocol stated before the review is conducted. Furthermore, it is a comprehensive, transparent search conducted over multiple databases that can be replicated and reproduced by other researchers [22].

2.1. Systematic Literature Review

The systematic literature review (Figure 1) was conducted with the aim of finding relevant studies on Land–Sea Interaction. The only search criterion was that all articles should be scientific; therefore, an open-source academic database was used (Scopus). The methodology was structured according to a four-stage review process: (a) *criteria settings*, (b) *literature search*, (c) *literature refinement*, and (d) *analysis of selected articles*.

(a) *Criteria settings*. In this first stage, the set of criteria chosen included only English-language, peer-reviewed academic journals, while books, conference papers, and dissertations were excluded. The key search terms used were: “landsea”, “land-ocean”, “interact*”, “land interact*”, “ocean interact*”, “sea interact*”, “lsi”, “loicz”, “coast*”, and “planning”.

(b) *Literature search*. To cover the whole spectrum of disciplines contributing to such a complex topic, the Scopus database was chosen, as it is made up of a massive number of peer-reviewed journals covering all the relevant subject fields: life, social, physical, and health sciences. Using the terms mentioned above, the search of titles, keywords, and abstracts was conducted. The terms were used in a combination of three strings: the first one was TITLE-ABS-KEY (“land-sea” OR “land-ocean” OR “interact*”), the second one was TITLE-ABS-KEY (“land interact*” OR “ocean interact*” OR “sea interact*”), and the third one was TITLE-ABS-KEY (“lsi” OR “loicz” OR “coast*” OR “planning”). Each string resulted in a different number of articles found: 4,214,228, 12,739, and 1,574,484, respectively. The next step was to refine the results from the three strings in this final query; this refinement is made automatically with Scopus by setting the final query. The output of the final query is the articles that are at the same time containing at least one of each search term of the three strings. This is the final query: [TITLE-ABS-KEY (“land-sea” OR “land-ocean” OR “interact*”)] AND [(TITLE-ABSKEY (“land interact*” OR “ocean interact*” OR “sea interact*”)] AND [TITLE-ABS-KEY (“lsi” OR “loicz” OR “coast*” OR “planning”)]. The aim here was to limit the search to articles that contained at least one of each of the string terms. This resulted in 2,536 papers containing at least three terms. The last step of this stage was an extra “filtering”; in this stage, the search was limiting the articles found to final publication status, open access, and published between 1997 and 2021. This extra filter yielded 243 papers.

(c) *Literature refinement*. The aim of this stage was to further refine the search by skimming the academic articles. Even though the search method was well defined by the terms and the criteria used, there was still a margin of error from the Scopus database. In this step, a further refinement was made through checking manually the titles and key words and reading through all the abstracts of the sampled articles; more specifically, the articles were manually checked to establish if they contained any of the key terms used, such as if they were present in the title and keywords, and the abstracts were read to see if they were relevant to the topic (relevance on the Land—Sea Interaction thematic and/or relevance to spatial planning). From the original 243 articles, a final selection of 39 was made.

(d) *Analysis of selected articles*. In the last stage, the 39 selected articles were analyzed by reading them in full. This made it possible to choose the definitive 18 papers to be used for the Land–Sea Interactions literature review. An Excel table was set up to collate all the information gathered for the outcoming fluxes scheme (visible at the end of the results chapter).

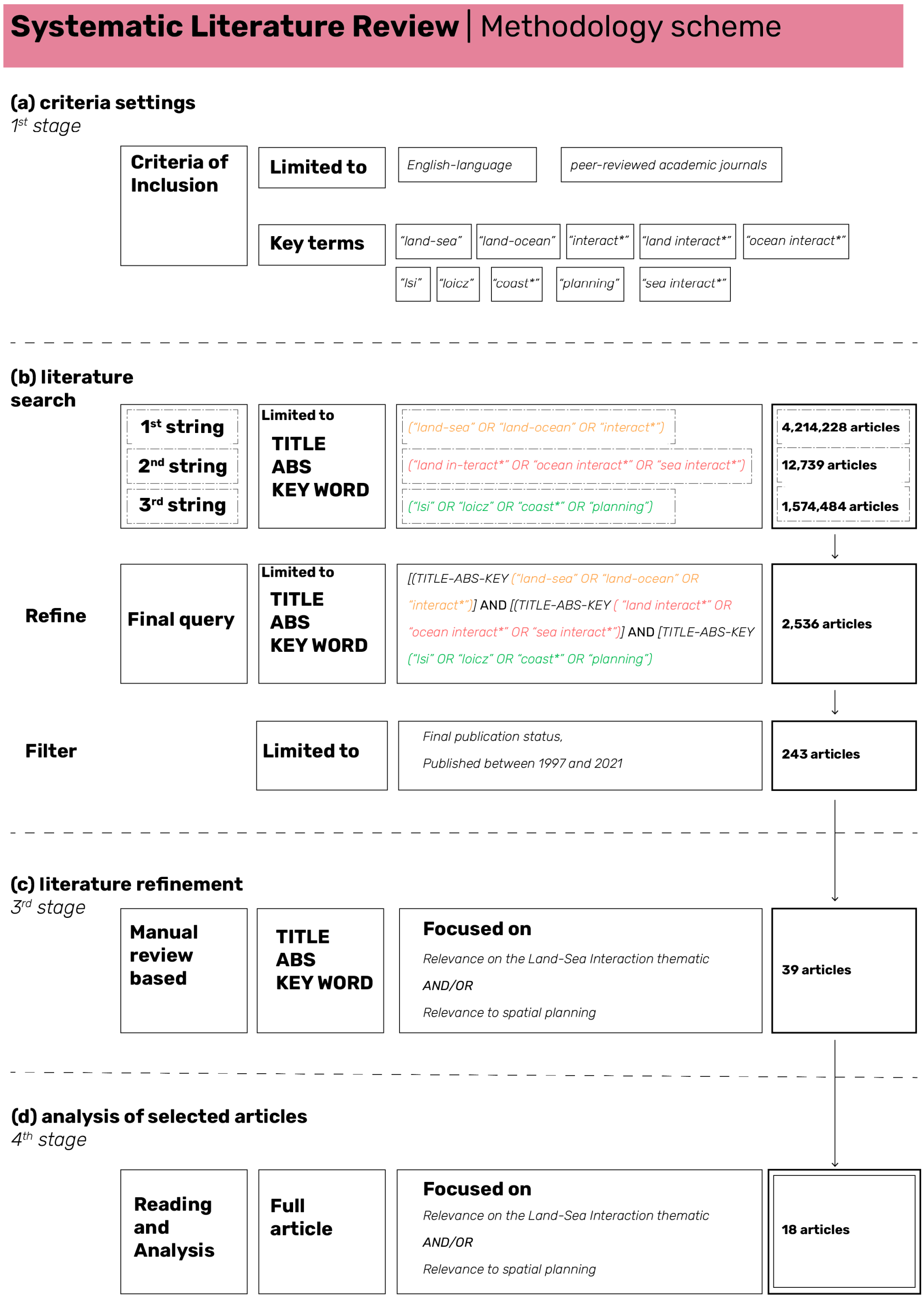

Figure 1. Methodology scheme of the systematic literature review applied in the paper.

2.2. Bibliographic Search of Key Land–Sea Interactions Paper

Despite all the information acquired from the systematic literature review, we performed a further analysis on a central research paper called "Land-Ocean Interactions in the Coastal Zone: Past, present & future" [16] in order to enrich the research and have a solid base from which to investigate Land–Sea Interactions. This paper gave invaluable knowledge and understanding of the topic. The literature review was based on the scientific articles that make up the bibliography of the "Land-Ocean Interactions in the Coastal Zone: Past, present & future" paper. The search followed a shorter three-stage review process: (a) criteria settings, (b) literature refinement, and (c) analysis of selected articles (Figure 2).

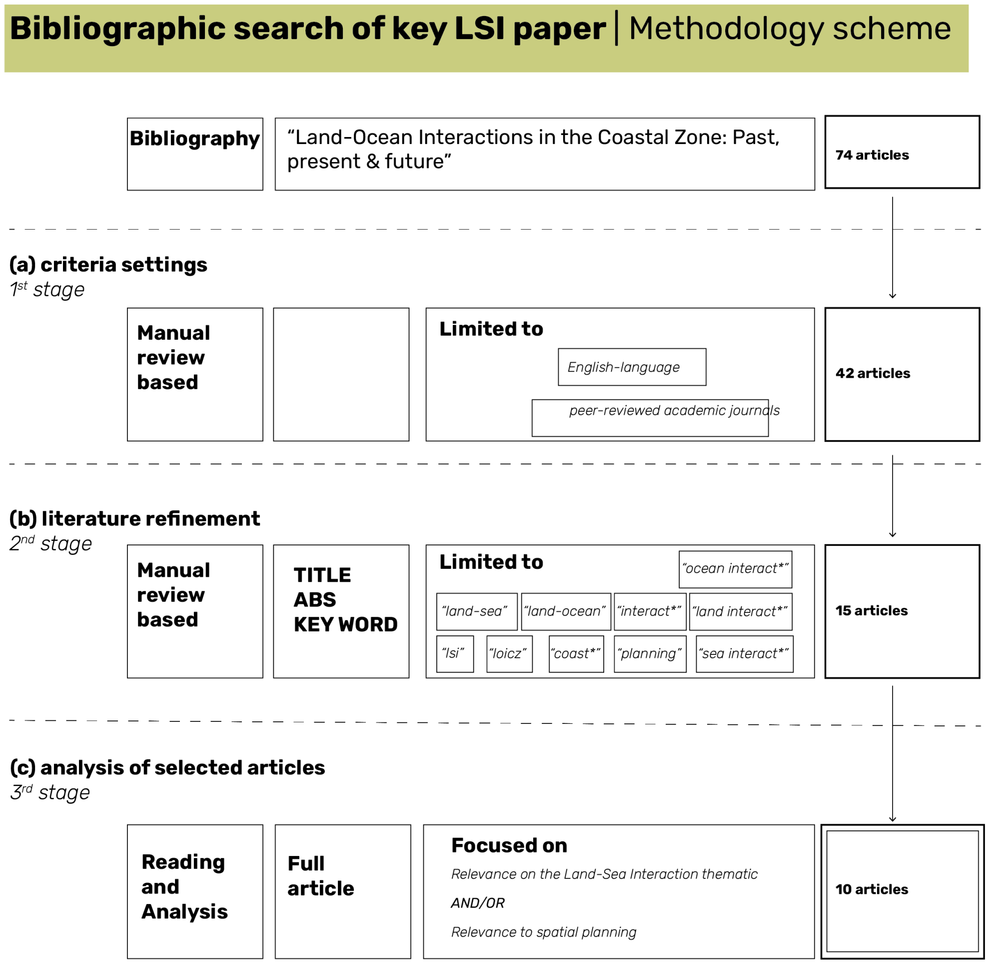

Figure 2. Methodology scheme of the bibliographic search of key LSI paper applied in the research.

(a) Criteria settings. The bibliography of the "Land-Ocean Interactions in the Coastal Zone: Past, present & future" article is composed of 74 articles. The aim of the first stage was to discard all the papers that were not peer-reviewed, since the criteria set was based only on English-language, peer-reviewed academic journals.

(b) Literature refinement. At this point, a search of all the peer-reviewed articles from the bibliography was carried out using the same search terms as in the previous literature review, i.e., "land-sea", "land-ocean", "interact*", "land interact*", "ocean interact*", "sea interact*", "lsi", "loicz", "coast*", "planning". This step consisted of checking all terms listed in the title, abstract, and keywords of each selected article.

(c) Analysis of selected articles. After the second refinement stage, it was possible to carry out the last stage, which consisted of reading all the 15 selected papers in full, in order to select the definitive articles which could be used for the Land–Sea Interactions literature analysis. This last stage resulted in the final 10 papers on which the Land–Sea Interactions literature review was based. An Excel table was also set up to collate all the information acquired from this stage.

2.3. Excel Table and Information Collecting

All the information acquired from both literature reviews was collected systematically using an Excel file (Figure 3). These files kept track of all the information gleaned from each article. The Excel file was made up of two sections, each divided into columns. One section contained the Land–Sea Interactions information gathered from the literature review, and the second one contained the details of the related article (author, article title, journal, year, field, pages, and case studies locations). The composition of the columns of the first section was defined after collecting the information from the first three articles and was structured as follows: land activities, land sector, interaction causes, first driver, second driver, interaction consequences, sea sector, and sea activities. One of the main outputs of collecting systematically the information found in the analyzed papers allowed the differentiation of LSI categories and enabled the identification of the components of Land–Sea Interactions and their functions.

Land — Sea

Activities	Sector	Interaction cause	First driver	Second driver	Interaction consequence	Sector	Activities
	Agriculture	Pollutions (N + P)	River		Habitats loss, biodiversity loss	Marine ecosystems	
Sewage sources	Urbanization	Sewage pollution	River		Habitats loss, biodiversity loss	Marine ecosystems	
Sewage sources	Industry	Sewage pollution	River		Habitats loss, biodiversity loss	Marine ecosystems	
Dams	Infrastructures	Change hydro morphology	River		Habitats loss, biodiversity loss	Marine ecosystems	
Animal rearing	Agriculture	Pollutions (N + P)	River		Habitats loss, biodiversity loss	Marine ecosystems	
WW treatment plants	Industry	Pollutions	River	Bay	Habitats loss, biodiversity loss economic loss	Aquaculture	
	Urbanization	Pollutions	Surface runoff	Bay	Habitats loss, biodiversity loss economic loss	Sea tourism	
Refineries	Industry	Heavy chemicals Pollution	River	Bay	Habitats loss, biodiversity loss economic loss	Aquaculture	
Harbor	Maritime transport	Pollutions (Chemicals + N + P)	River	Bay	Habitats loss, biodiversity loss economic loss	Aquaculture	
	Inland tourism	Pollutions (N + P)	River	Bay	Habitats loss, biodiversity loss economic loss	Marine ecosystems	

Authors	Title article	Journal	Year	Field	Page	Case study	Coordinate
Xu, H. Et al	The fate of phosphorus in the Yangtze (Changjiang) Estuary, China, under multistressors: Hindsight and forecast	Estuarine, Coastal and Shelf Science	2015	Estuarine, Coastal and Shelf Science	1 1 3 5	Yangtze River (China)	31.735650 121.123524
Sekovski, I. Et al	Megacities in the coastal zone: Using a driver pressure-state-impact-response framework to address complex environmental problems	Estuarine, Coastal and Shelf Science	2012	Estuarine, Coastal and Shelf Science	1 2 3 4 5 6		

Figure 3. Example of extract of the Excel table. The first section contains all the information collected about Land–Sea Interactions and is divided as follows: land activities, land sector, interaction causes, first driver, second driver, interaction consequences, sea sector, sea activities.

2.4. Sankey Matic Tool: A Way to Visualize the Complexity

This research on LSI also has identified patterns in the information gathered and presented the results in a more easily readable format by using the diagram builder Sankey Matic.

The Sankey Matic is an online open-source tool that depicts information flows, where the width of each flow pictured is based on the amount of input. Sankey diagrams are very effective at showing particular kinds of complex information, for example, flows of energy from source to destination and goods from place to place. Land–Sea Interactions flows in the diagram are built on strings based on a pair of nodes (A to B, from B to C, and so on). Since the tool works in pairs of nodes, all the Land–Sea Interactions collected through the literature reviews were systematized into an Excel file. The logic underlying the categorization process was based on the structure flow of Land–Sea Interactions detected from the literature review analysis.

3. Results

The literature reviews highlighted the complexity of Land–Sea Interactions as a research topic both in terms of the thematic itself and since it has been researched from many disciplines. What was discovered during the literature reviews is the massive number of studies and amount of material about Land–Sea Interactions that are not systematized in any way. Most papers analyzed contained relevant information to contribute to the discourse on Land–Sea Interactions into a spatial planning perspective. Studies ranged from microbial ecology through marine science and biology to geochemistry which, from a nonexpert perspective, could easily result in a chaotic and incoherent body of information, even though all the studies did refer to coastal areas (Figure 4).

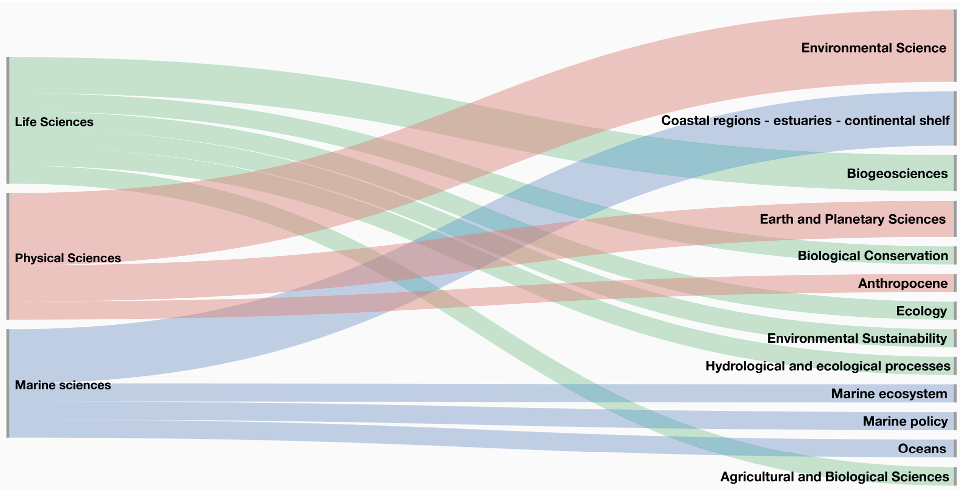

Figure 4. This figure shows the diversity of the research fields of the article analyzed in the double literature reviews.

Almost all the research papers in both literature reviews are based on case studies. Of the 18 articles selected from the systematic literature review, 14 were based on case studies; in the LOICZ literature review, only 5 out of 9 articles were based on case studies. Of the total of 28 articles from both literature reviews, 21 were based on case studies, for a total of 35 case studies. The articles from the database literature review have case studies in the United States on both the west and east coasts. In the second literature review, the case studies referred to in the articles that make up the bibliography of "Land-Ocean Interactions in the Coastal Zone: Past, present & future" are mainly located in Europe, both in the north and the south, and in some sporadic cases in countries on the Indian and the Pacific oceans (Figure 5).

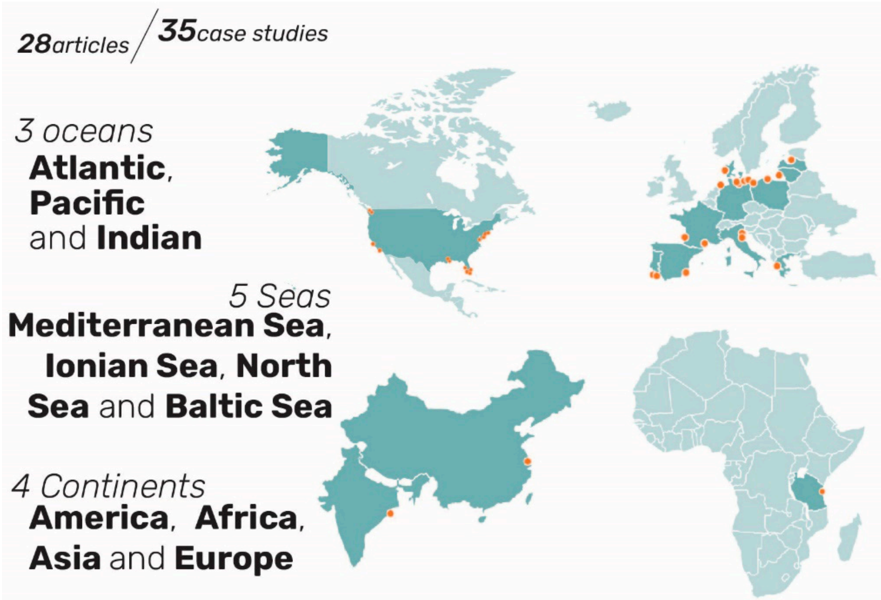

Figure 5. This figure shows the distribution of the case studies of the 21 articles reviewed.

The mix of research fields enriched the discourse on Land–Sea Interactions, not only by more accurately defining the interaction between land and sea but also by adding important insight through detailing the human activities that interact with both natural processes and other anthropic activities. Other significant findings cover the positive and negative impacts of the externalities on these interactions, the way pollutants interact with the ecosystem, and the multiple benefits of specific natural elements in coastal areas that can help counteract climate change's effects.

3.1. Classification and Categories

For the sake of clarity, it was chosen to adopt the following classifications, as explained below. One of the common threads that ran through all the analyzed papers was how authors recognized sectors and (human) activities on both land and at sea. More specifically, the prevailing assumption seems to be that, in most cases, the interaction flows between land and sea are generated from inland human activities. How these activities impact coasts and marine ecosystems was also clearly described. The sectors identified on land are agriculture, industry, urbanization, tourism, maritime transport, and infrastructure; at sea, the sectors are the marine ecosystems, fishing, aquaculture, tourism, maritime transport, and coastal ecosystems. Here, a few things about the sectors need to be clarified: for example, with agriculture, we are referring to a specific typology of intensive agricultural practices that aims to maximize yields through the heavy use of pesticides and chemical fertilizers; with urbanization, we are referring to a vector of many human activities. Clarification is also needed for the marine ecosystem, which means a community of living organisms in conjunction with the non-living components of their environment, interacting as a system. For some of these sectors, precise activities were identified. For example, in agriculture, one activity is the branch concerned with raising animals intensively for meat, milk, eggs, and other products. For the industry sector, the activities identified in the review that produced interactions are wastewater treatment plants, refineries, and power generation plants. In the review, urbanization was referred to more generally as a sector. The activities mentioned are sewage source systems, land reclamation, and development in coastal areas. In the maritime sector, marine ecosystems were mostly referred to in a general way, and only in a few studies were fish nurseries and spawning specified as distinct activities. The fishing sector covers commercial fishing. The aquaculture sector includes shellfish and bivalve farming. The tourism activities are recreational fishing, boating, and other water activities.

3.1.1. Agriculture

From the literature review, it emerged that the agricultural sector is one of the most likely generators of interaction. Although agricultural activities can be located far inside a coastal area, the pollutants (nutrients and fertilizers) that are discharged can reach the sea, impacting negatively on both the marine ecosystem and human activities situated in and/or on the sea [23,24]. An example of this is the case of the Mississippi River in an article by Hurst, White and Baustian, 2016 [25]. The case describes the effects of adopting only a short-term view of agricultural development, which resulted in the destruction of almost 80% of the bottomland hardwood forests on land adjoining the Mississippi River. Despite the positive effect that bottomland hardwood forests could have had on nutrient removal, the decision was made to chop them down and convert the land into agricultural fields. This change in land use consequently increased the discharge of NO_3 (nitrates) into the Gulf of Mexico [25]. This type of issue is also happening in Europe. According to Newton et al., the agricultural sector is putting enormous pressure on European semi-enclosed coastal systems, including lagoons and transitional waters [26]. Overexploitation of agricultural fields and intensive production can lead to waterways transporting not only freshwater, but also a range of anthropogenic chemicals into the sea [27,28]. In another case study, located on the east side of Florida facing the Atlantic Ocean, researchers showed how agriculture and urbanization expansion seriously affected the watershed of the St. Lucie Estuary. These sectors modified the natural wetlands system into a series of sub-basins that created changes in flow, salinity, and water quality by increasing the amount of algae blooms [29,30]. One of the activities of the agricultural sector is raising animals (animal breeding) that discharge large amounts of pollution and is, therefore, also a generator of interactions. Too frequently, mixed pollutants from machinery, nitrogen, phosphorus, and nitrates are released into local water systems [23,27]. A case illustrating this is the paper by Kinney and Valiela, who reported on duck farms that dumped nitrogen pollution in Moriches Bay (on the New York coast). The paper showed how high quantities of nitrogen in the bay generated eutrophication which induced an excessive growth of algae [31]. Despite this, there are also examples among the articles which show marine ecosystems functioning as cleaners of nitrogen entering the bay, as in the Feng article. This paper describes how the nitrogen disappeared due to natural denitrification and fishing harvests, with the residue being transported out into the open sea [32]. From these studies, it is clear how intensive agriculture and farming production generate pollutants that can contaminate watersheds, rivers, creeks, wetlands, and lagoons, affecting marine ecosystem cycles [26]. As seen, a small number of nutrients, primarily nitrogen and phosphorus, are vital for maintaining a healthy marine ecosystem. However, an oversupply of nutrients can cause eutrophication in estuaries and bays because marine ecosystems are also under considerable pressure from other anthropic activities. The consequences of this, apart from polluting the marine environment, have led to eutrophication, decreasing water quality, and loss of biodiversity, directly affecting spawning and nursery mechanisms [8,33]. At the same time, such pollution affects anthropic sectors based on the sea, such as tourism (recreational fishing), commercial fishing, and aquaculture activities, as these are based on the biodiversity and quality of water in the marine environment [25] (Figure 6).

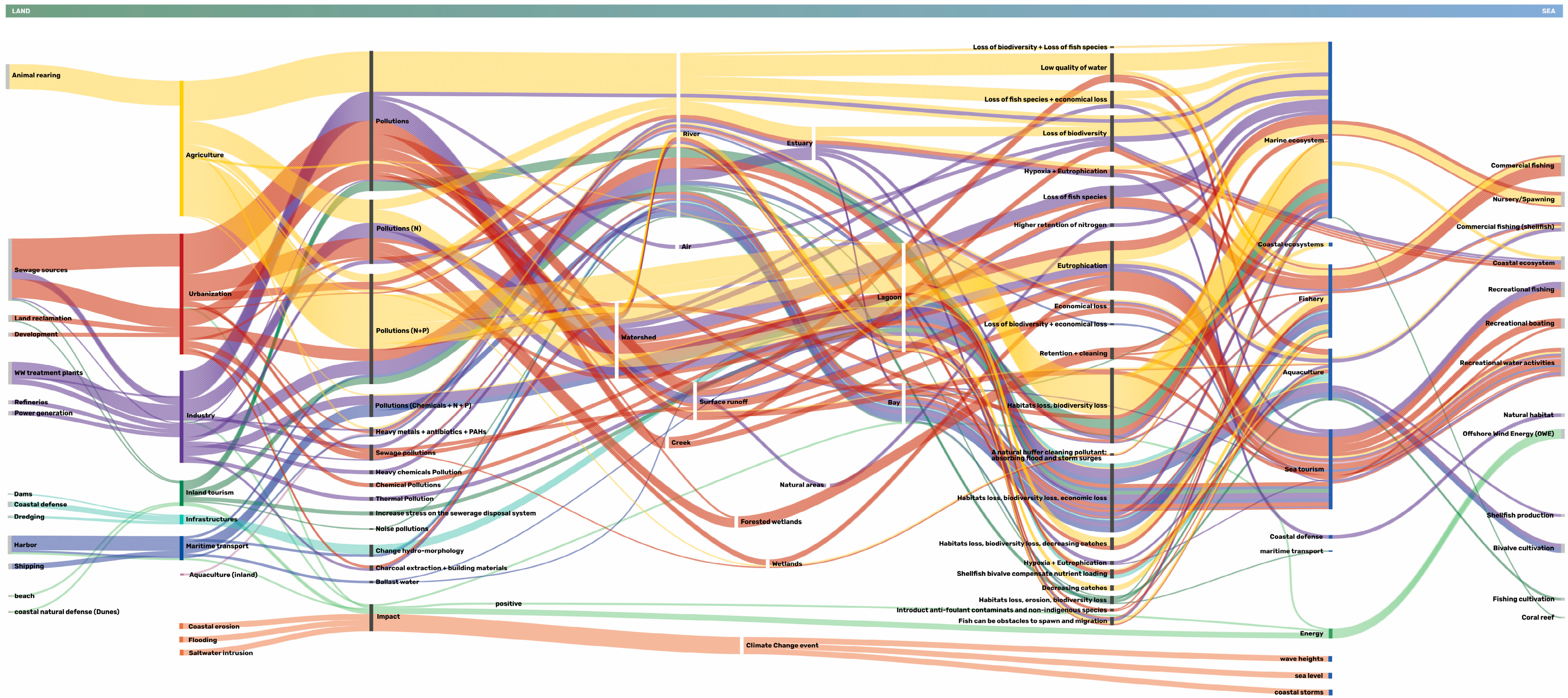

Figure 6. This figure shows the Land–Sea Interactions fluxes determined from the double literature reviews. This representation highlights the LSI analyzed in the literature reviews and specifically, the sectors and activities involved in LSI (categories), the causes of LSi and the typologies of consequences on other sectors, activities, and ecosystems.

3.1.2. Industry

Another prominent sector that generates interactions in coastal areas in several ways is industry. However, industry differs from agriculture, where pollutants typically derive from across a wide area; in the industrial sector, interactions tend to take place in a more precise location, and the source of contaminants is more easily identifiable [27,34]. Therefore, it is easier to pinpoint where industrial pollution—direct or indirect—originates. As many industrial areas have a high percentage of impervious surfaces, sometimes up to 75%, if the area is located close to a river or a coastal area, it will increase the chances of pollutants entering the water system as the result of indirect surface runoff. Samhouri and Levin's case study of Puget Sound, in Washington state, demonstrates the increasing level of risk associated with industrial toxic contaminant loadings, leading to the loss of several species of fish, including Pacific herring and canary rockfish, as well as the Dungeness crab and a number of marine mammals [34]. According to Kinney and Valiela, it has been recognized that one of the most invasive activities in the industry sector is wastewater treatment plants. From their study on the Great South Bay, on the New York coast, it appears that wastewater treatment plants are directly responsible for dumping large amounts of nitrogen into watersheds —and consequently into the sea [31], leading to a significant loss of water quality. However, several studies have analyzed coastal megacities all over the world that lack minimal infrastructure, such as wastewater treatment plants, resulting in feces and pollutants being discharged directly into the sea [8]. Specific activities identified by analyzing the two literature reviews are industrial processes such as food, paper, chemical industries, power generation, and refineries. For example, food and paper products can directly result in eutrophication from the discharge of nutrients and organic matter into watersheds or the sea [26]. Newton's case studies show that many lagoons and wetlands are threatened by human activity, for example, by industries in Porto Maghera, near Venice (Italy), the industrial complexes near Marismas de Odiel in Spain, and the industries centered on Aveiro in Portugal.

In most cases, the factories generate interactions with other ecosystems and activities. Newton's case study in Etang de Berre, on the Mediterranean coast of France, describes how the power plant activity produces direct externalities by altering the temperature of the sea (thermal pollution), changing the salinity and resulting in the loss of fish species and fishing activities [26]. Last but not least, according to Sekovski, Newton and Dennison's and Gao's articles, some land-based industrial activities (such as refineries and municipal waste processing plants) have a negative effect on coastal and marine habitats through accidental discharges [35,36] (Figure 6).

3.1.3. Urbanization

The third sector located on land is urbanization. As already indicated, it is not considered to be a 'sector' because coastal urbanization plays a number of different roles in the discourse on Land–Sea Interactions. The continuous exponential growth of coastal cities has led to a series of problems related to Land–Sea Interactions. Coastal cities worldwide are growing and expanding and, therefore, continually need new land to expand their borders. Rivers, deltas, forest clearings, wetlands, salt marshes, mangroves, and seagrass meadows are all threatened by this exponential growth, which is often implicated in the destruction of important coastal habitats [35]. Another problem with the densification of cities is the subsequent loss of urban green spaces, which has led to an increase in the percentage of imperviousness in those areas. The expanding number of impervious surfaces increases the pollutants runoff into rivers and their catchment areas; furthermore, this type of city has a reduced ability to react quickly to the effects of climate change, making it much less resilient [35,37]. The constant expansion of cities leads to the exploitation of natural resources and the deforestation of adjacent areas. The main consequence is a decreased capacity for retaining the extra nitrogen human activities produce [38]. In poorer overpopulated coastal regions, such as in India and Bangladesh, many priority habitats, such as mangroves, are exploited for charcoal, fuel wood and salt production, threatening the estuarine environment, which is also a resource for other anthropic activities such as fishing and tourism [39]. Apart from poor coastal regions, the coast remains one of the most attractive areas for economic growth. In general, developing resorts and marinas for tourism purposes results in the overexploitation of coastlines. This endangers not only inland priority habitats, such as wetlands, marshes, and lagoons, but also affects marine habitats such as seagrass meadows and coral reefs, which are essential for the spawning and nursery activities of many types of fish, with a consequent loss of biodiversity and possible adverse repercussions for the fishing industry [23,24,26,27]. Moreover, some studies in the literature review regarded sewage sources as the major pollution source when discussing urbanization. According to Oleson, pathogens from sewage can exacerbate coral disease, with cascading effects on fish abundance and biodiversity [24]. In his paper, Miller outlines the close relationship between urbanization and the environmental loading of fecal sewage. According to Miller, this externality can affect the quality of coastal waters, coastal habitats, and biodiversity. At the same time, he considers sewage pollution to function in a way that somehow defines the borders of these specific interactions. More precisely, the study explains how there is a lower risk of sewage pollution if sites are more than 5 km away from the sea, and pollution increases dramatically if sites are less than 5 km away from the sea [40]. The literature review shows that the role of urbanization is multi-faceted. Urbanized coastal areas can be seen as a hotspot for generating interactions because many socio-economic dynamics shape the urbanization, such as expanding some coastal regions and their boundaries for economic, tourism, or commercial or productive purposes. These interactions increase the pressure on coastal environments resulting from human activity that affects other linked activities and priority habitats (Figure 6).

3.1.4. Coastal and Marine Ecosystems

The "sectors" identified as marine and coastal ecosystems are clearly not economic sectors in themselves. However, they are under serious threat from human activities both on land and on or in the sea. In most of the cases in the articles, marine ecosystems were referred to in a general sense; only in a few of the papers the components of the interaction were specified as linked to how human activities on land and on sea directly affect marine ecosystems by decreasing the environmental quality of the sea with the consequential loss of natural coastal and marine habitats that are the spawning and nursery sites for many species of fish [12,26]. For example, in their case study, Samhouri and Levin discovered that on the Puget Sound on the northwest coast of the United States, some fish species that relied heavily upon the nearshore for nursery or spawning reasons were expected to experience serious adverse effects from coastal developments and human activities [34]. Similar observations were made by Hurst, White, and Baustian in their research on the Gulf of Mexico, in which the over-contamination of organic matter in the Gulf of Mexico impacted spawning and migration habitats. Furthermore, it affects the benthos and has repercussions for some human activities that take place on the gulf, such as recreational and commercial fishing [25] (Figure 6).

3.1.5. Aquaculture

Aquaculture is one of the fastest-growing economic sectors based on anthropic activity located at sea. The sector can be divided into two main activities: mollusks and fish farming. Aquaculture production in the sea is open, with water flowing freely through the cages; this openness makes the system vulnerable to external influences. For fish farming to be profitable requires intensive production, with a higher quantity of fish kept in the same cages that need to be fed and given antibiotics. As mentioned above, intensive production can lead to problems, and the increase in intensive fish farming has been identified as having a negative environmental effect, contributing to, for example, mangrove and wetlands loss [26,27,35]. Intensive production can lead to introducing and transferring invasive species, spreading parasites and diseases, and releasing chemicals, nutrients, and waste in general [35,41]. It produces its own externalities and, together with pressure from other anthropic activity, can result in the loss of coastal and marine habitats such as seagrass meadows, and have direct consequences for lower primary production, reduced sediment stabilization and nutrient traps, and loss of fish and shellfish nurseries [35]. Several studies from the literature review also highlight the fact that, very often, pollutants discharged inland can have a detrimental impact on the aquaculture sector, especially fish aquaculture, and lead to economic losses. Regarding mollusk farming, specifically bivalves, several studies have demonstrated that they have a substantial role in protecting marine ecosystems from pollutants. Furthermore, shellfish farming (mollusks) is considered a possible way to compensate for nutrient loading, which effectively removes nitrogen from the system, thus providing a valuable ecosystem service [26] (Figure 6).

3.1.6. Fishing

In the discourse on Land–Sea Interactions, the fishing sector is indirectly impacted by many inland anthropic activities such as tourism, industry, urbanization, and agriculture [34,41]. The pollution produced from these activities directly affects marine ecosystems by decreasing the environmental quality of the sea with the consequential loss of natural coastal and marine habitats that are the spawning and nursery sites for many species of fish [26]. Another consequence of the discharge of chemicals, fertilizers, and nutrients is the increasing eutrophication in estuaries. If pollutants spread to coastal waters, this can lead to a loss of fish species and a reduction in harvestable fish and shellfish, resulting in significant economic losses [26] (Figure 6).

3.1.7. Tourism

The tourism sector is closely interconnected with the inherent attractiveness of natural resources and natural landscapes. However, if the massive growth in tourism in coastal cities and areas is not well managed, it will inevitably lead to a deterioration of resources, habitats, and coastal landscapes. Tourism has a direct and indirect impact on the environment, affecting, for example, priority habitats and leading to a loss in biodiversity, primarily due to land reclamation in coastal zones used to build tourist resorts, marinas, beaches, and even airports [26,34,35]. Another aspect of the tourism sector that adversely impacts the environment is the seasonal peak in population size that leads to increased production of waste, overburdening urban wastewater treatment plants and leading to increased stress on sewage disposal systems that can cause severe problems in coastal areas [24,26]. Tourism puts direct pressure on a city's infrastructure and natural systems. The coastal and sea tourism sectors include a wide range of activities such as recreational fishing, sailing, water sports, and ecotourism that, if not well regulated, can directly increase the pressure on marine ecosystems. The growth of boat transportation and recreational water activities also increases pollution levels, contributing to the destruction of numerous habitats [26,42] (Figure 6).

3.1.8. Infrastructure

A sector connected with urbanization was identified through the literature analysis: infrastructure. When cities and territories grow and expand their boundaries, they exploit areas all along the coast; to protect these new urbanized areas, it is often necessary to build dams and dykes. These types of constructions are typically made with hard surfaces, which have a profound impact on the hydro-morphology, leading to a number of changes in the sedimentation process, an increase in the amount of pollutants deposited in rivers, changes in water flux that increase coastal erosion, and impact on natural processes such as the migration of eels, salmon, and trout for spawning [26]. Generally, human activity requires the constant construction of infrastructures such as irrigation channels in agricultural fields, dykes, dams, road networks, highways, airports, and harbors. These infrastructures change the landscape dramatically, albeit with the aim of improving conditions for the city's population, but at the same time, by disrupting ecological corridors, natural streams, and sediment flows in coastal areas, they cause a lot of environmental problems [35].

Other types of infrastructure, such as dams, breakwaters, and seawalls, are located in coastal zones and, according to Xu, since they are built specifically on the shore or in the sea, they contribute significantly to changing sea currents by altering natural marine processes [43] (Figure 6).

3.1.9. Marine Transport

This is a strategic economic sector worth billions but, at the same time, one that has an enormous impact on natural ecosystems. The main area of activity for maritime transport is harbors, mainly because of their key roles in the network between land and sea and their strategic locations on coasts. For these reasons, the harbor can be identified as a potential hotspot of interactions. Many inland industrial activities are closely linked to collateral harbor activities, such as refineries, chemical production, etc. [27]. Similarly, maritime activities such as energy plants and hydrocarbon platforms are also linked with harbors. All these activities create a larger network because all goods move from land to sea and vice versa through the harbor. From the literature review analysis, it is clear that harbors put an enormous amount of pressure on the environment, from pollutant discharges, oil spills, and the introduction of alien species through ballast water discharges that cause the proliferation of algal blooms and subsequent loss of habitats [26]. Oil spills are mainly caused by accidental discharges from ships inside the harbor or outside the landing zones [35]. In European coastal areas, there is a high risk of producing externalities when estuaries are turned into harbors by constructing navigational channels or straightening, widening, and dredging existing ones to provide passage for big ships. These developments result in hydrological and sediment changes and fluxes that impact different migratory fish species. One example is the lagoon in Venice, where more and more channels are being built, putting even more pressure on the lagoon's ecosystem. One additional interaction generated by one of the activities in the maritime transport sector is that from ballast water. This is a regular procedure for large cruise ships, tankers, and bulk container ships, which involves them loading a large amount of water from the place of departure to increase stability and maneuverability during transit. This ballast water is then unloaded at the next harbor and typically contains a variety of biological organisms, including plants, marine species, and bacteria. These organisms often include non-native and exotic species that can cause extensive ecological and economic damage to marine ecosystems [35,44] (Figure 6).

3.1.10. Energy

The last sector identified is energy; the specific activity is offshore wind energy (OWE). The energy sector is one of the crucial sectors that is growing at sea. According to Abramic, offshore wind energy can contribute positively to creating clean energy at sea and will avoid any conflicts, if well planned [45]. In this perspective, it defines a minimum distance between OWE and other uses. For example, OWE should be planned at least 3 km from port areas to avoid issues with maritime traffic [45]. Furthermore, OWE should be located between 3 to 10 km from the coast for proper maintenance operations.

In the article, Abramic also specifies the negative impact on the landscape that OWE could generate in coastal urban areas if planned too close to the coast. If farther than 10 km, it will have a low conflict (visual impact) with coastal urban areas [45]. OWE and coastal industrial areas were included as a positive interaction [45] (Figure 6).

3.1.11. Role of Watersheds and Rivers

All the analyzed articles clearly describe the crucial role of streams and water bodies in the discourse of the Land–Sea Interactions as drivers of contaminants discharged from inland anthropic activities. Moreover, water streams, or watersheds, constitute the land feature where water networks converge and where most human sectors, such as agriculture, urbanization, and industrial areas, are located; therefore, watersheds are the 'motorway' for the flow of pollutants from land to sea. Watersheds and rivers do not, however, always cause pollutants and nutrients to flow into the sea, which does not mean that they become unimportant, but rather that the situation is more complex and dependent on a great many different factors. For example, in a case study of the Baltic Sea carried out by Winder et al., the land–sea patterns produced by watersheds changed considerably depending on the use of the area. In the case study, the number of nutrients found in the northern part of the Baltic Sea was lower than that in the south since the south is an agricultural area [46]. Other studies have also shown that watersheds and rivers can retain nitrogen and pollutants generated inland, but often they are overwhelmed by excessive pressure from anthropic activities. Several papers pointed out that significant increases in nutrient and pollutant transportation from land to sea have been caused by human activities ever since pre-industrial times [47]. This makes it possible to identify areas with specific characteristics, such as very intensive agriculture or densely urbanized areas adjacent to rivers, making them prime candidates for creating an interaction between land and sea. At the same time, we can never be completely certain. Therefore, it is helpful to utilize instruments such as buoy systems to monitor autonomous water quality in bays close to estuaries [37] (Figure 6).

3.1.12. Role of Natural Elements

One of the most interesting observations from the literature review analyzed is the crucial role played by some of the natural elements present in coastal areas. These natural elements, such as wetlands, salt marshes, bottomland hardwood forests, and lagoons, shape coastal zones and are recognized as forming an interface between land and sea with a high concentration of bio-diverse and valuable ecological areas providing at least 40% of the value of the world's ecosystem services and avian habitats. These areas are economically important for tourism, agriculture, aquaculture, and fishing [16,26,46]. According to the literature, most of these natural elements function as recyclers and retainers in fixing nitrogen and other nutrients discharged into rivers and groundwater [25,31,47,48]. Taking a closer look at coastal areas, we can see that in addition to salt marshes and fresh and salt wetlands, bottomland hardwood forests, forests, and green cover also function as natural basins helping retain and clean pollutants. In addition, some of these elements can work to counteract climate change events such as storms and flooding [16]. For example, according to Costanza: Coastal wetlands function as valuable, self-maintaining "horizontal levees" for storm protection, and also provide a host of other ecosystem services that vertical levees do not [49]. These natural elements are part of the complex patchwork of systems including anthropic activities and urbanized areas present between the land and sea continuum. According to Hurst et al., their role in, for example, reducing nitrates (NO3), has long been recognized. This is the case with the Mississippi River, where bottomland hardwood forests along the river and its tributaries were instrumental in reducing nitrate deposits in the Gulf of Mexico [25]. However, even though the bottomland hardwood forests positively impacted nutrient removal, they were replaced by new field crops because of growing pressure from the agricultural sector. Historically, the forests on the Mississippi River floodplain have played a significant role in reducing nitrates during spring flooding events since the types of soil associated with these forests tend to have higher denitrification rates than agricultural land. Nowadays, however, the water carried by the river flows directly into the Gulf of Mexico, transporting an enormous quantity of building sediment, nutrients, and pollutants straight into the sea [25]. These natural elements, therefore, have multiple roles and are crucial to keeping our coastal environments healthy. As the exponential growth of coastal cities continues to be at the expense of natural habitats, it is clear, as Kinney and Valiela point out, that we need to take steps to preserve the natural environment, such as forests, marshes, and wetlands, to increase the capacity of watersheds to retain nitrogen [31] and to conserve these crucial areas of biodiversity. The continuous exploitation of natural coastal elements for production purposes and the transformation of coastal sites into new urban areas will make the environment much more impervious. These changes will adversely affect the Land–Sea Interactions by increasing the surface runoff of pollutants; simultaneously, it will become increasingly difficult to recover these areas and reduce their capacity to counteract extreme climate events. These studies show how important it is to preserve these natural elements that are so crucial for ensuring positive Land–Sea Interactions and addressing climate change challenges (Figure 6).

3.1.13. Role of Climate Change

Several studies in the literature review describe climate change's profound effects on coastal areas and Land–Sea Interactions. It has been recognized that "coastal habitats are affected by a changing climate from both terrestrial and marine sources", and that this occurs in different ways depending on the climate change-related event. According to Newton: "coastal regions are hotspots of global change and vulnerable to environmental, economic and social pressures, especially when associated with river mouth systems" [26] (p. 2). Coastal areas and their hinterlands are being affected by climate change events as a result of the general increase in temperature that leads to heat island events and an increasing amount and frequency of heavy precipitation. These extreme events produce significant changes in the soil moisture, the hydrology network, the runoff from watersheds, and the salinity of estuaries. From the marine side, the major short-term threats are the increasing number of coastal storm surges, the rising effect of coastal erosion, and coastal flooding. The exploitation of natural habitats on the coast has significantly affected the functionality of coastal ecosystems and thus made them more vulnerable to climate change impact. From a longer-term perspective, changes in sea level, saltwater intrusion, and the warming up of the sea all present potential dangers [50]. These extreme events in coastal areas can, directly and indirectly, affect the interactions between land and sea. In general, they tend to exacerbate the effects of externalities on interactions. Therefore, in the discourse on Land–Sea Interactions, climate change plays a role as an external driver that increases both the number and magnitude of such interactions. As noted above, natural elements in coastal areas have a dual role in building more resilient coastal landscapes: firstly, by reducing the externalities of human activity on the environment, and secondly, by counteracting some of the extreme climate events, such as coastal flooding, erosion, storm surges, and saltwater intrusion (Figure 6).

4. Discussion

The literature reviews show that the discourse on Land–Sea Interactions has its own distinct structure and hierarchy in the spatialization of the land–sea continuum. These interactions are generated by human activity and not by natural processes; in fact, natural processes exist with or without the interference of any human activity, with human activity generating externalities that interact with natural processes.

The literature identified both land and sea "families" of economic sectors and their activities that generate these interactions. Regarding the sectors and activities at sea, similarities can be noted with the uses (activities) identified in Maritime Spatial Planning (MSP). The activities and, more generally, the sector, need a conductor to activate the interaction process between land and sea; from the literature, these catalysts can be identified in watersheds, individual rivers, and creeks. The literature also describes another anthropic element that acts as a conductor: the imperviousness of soils that works as surface runoff, which is the anthropic transporter of pollutants, indirectly via the hydrographic networks or directly into the sea, as is typical of coastal cities. The imperviousness and consequently surface runoff, as already described, is an externality of the densification of urbanized areas and the increased waterproofing of the soil.

Anthropic activities interact with both land and sea, impacting natural processes to the extent that creates conflict with other anthropic activities [33]. A classic example of Land–Sea Interactions that create a conflict is the intensive production of field crops, where the excessive use of chemicals and fertilizers often results in the discharge of these substances into watersheds, groundwater, and rivers. In many cases, the water networks are unable to absorb and metabolize all the released substances and therefore transport the pollutants to the sea, contaminating the marine ecosystems. This adversely affects natural processes and, at the same time, conflicts with other anthropic activities located at seas, such as aquaculture or recreational water activities (tourism). From the case studies analyzed in the literature, we can see that the majority of the interactions have some type of pollution component, which affects the quality of the natural environment and impacts other activities. It is worth noting that almost all the interactions are generated on land and end up in the sea; only a small percentage are created at sea, which then affects the land. In fact, in the literature analyzed, only a few sea-land interactions were found, namely fish farming and offshore wind energy. In the first case, antibiotics and chemicals are used to stop the spread of parasites and diseases between the breed fishes, which then affected the marine and coastal ecosystems, resulting in significant losses of mangroves [35]. In the second case, the possibility of conflicts can be reduced if the infrastructure is well planned. This review examined important maritime transport activities (e.g., harbor and shipping) whose actions occur on the exact interface between land and sea. At the same time, harbors involve significant logistical and production components both on land and at sea, creating a land–sea continuum. As anticipated, a great deal of information from the analyzed articles looked at the role of water basins, rivers, and canals as conductors of interactions. The articles stressed the close relationship between drivers (streams and rivers) and specific natural elements that play a fundamental role in maintaining the balance of nutrients released into nature by human activities.

A crucial finding from the literature is the role played by many natural elements in maintaining a balance between externalities produced by human activity and natural processes. These natural elements perform a number of functions in reducing the number of pollutants and, in many cases, may provide a remedy to some of the effects of climate change. The natural coastal elements already highlighted previously, such as lagoons, estuaries, deltas, marshes, and wetlands, are not only recognized for their high environmental value and as biodiversity boosters: these elements also play an essential role in maintaining a balance between nutrients released in nature and pollutants produced from human activities [26,33]. At the same time, according to Costanza: Coastal wetlands function as valuable, self-maintaining “horizontal levees” for storm protection, and also provide a host of other ecosystem services that vertical levees do not [49]. Furthermore, they are typically areas of high environmental value, with exceptional biodiversity and landscape significance. Consequently, it is clear that far greater efforts are needed to preserve and protect these elements. The pressures caused by anthropic activities are proving challenging for these natural environments, which have often been reclaimed in order to widen urban boundaries in coastal areas.

Another point that is worth mentioning from this review regards hard infrastructures, such as dams and coastal defense systems, that interact with the environment by altering natural processes in coastal areas [26]. Furthermore, with the increased frequency of extreme climatic events, the externalities generated from infrastructures, cities, and other anthropic activities can exacerbate Land–Sea Interactions.

A remarking point from the literature reviews is that interactions are similar to fluxes that can move either from land to sea or vice versa. This categorization can be seen in the diagrams (Figure 7) since it divides the fluxes into five components: stressors, interactional causes, drivers and/or buffers, interaction consequences, and receivers. The stressors are all the economic sectors and their activities that generate an interaction. The interactional causes are the externalities produced by the stressors. The drivers are both natural (watersheds, rivers) and anthropic (impervious surfaces) components, where externalities converge and result in the interaction. The buffers are natural elements (wetlands, forested wetlands, marshes, and mangroves) which have a key role as cleaners and retainers. The interaction consequences show the effects of the externality. Finally, the receivers are the environment, all economic sectors, and activities that directly or indirectly interact with the stressors (Figure 7).

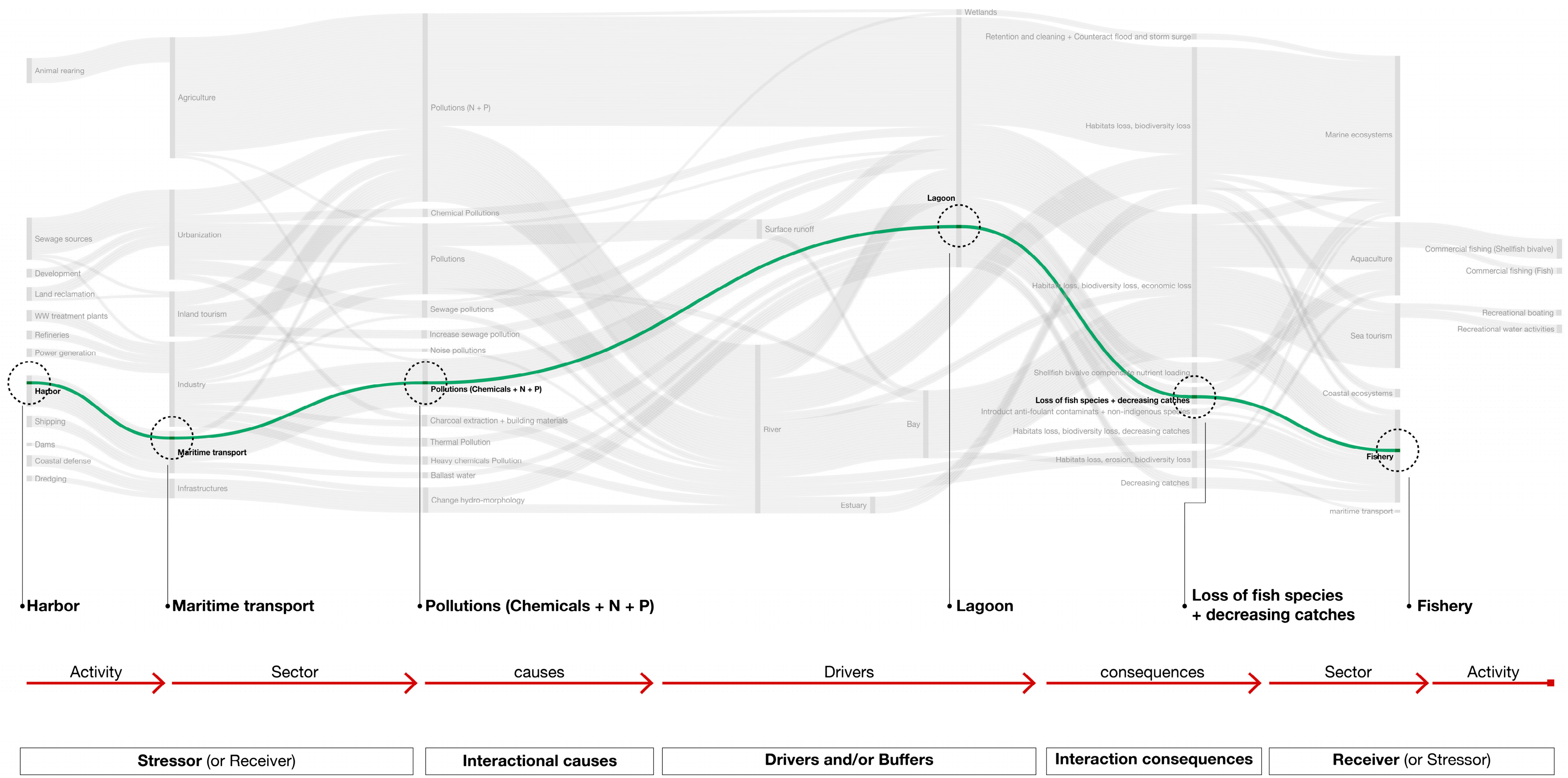

Figure 7. This figure shows the Land–Sea Interactions elements, structure, and function.

Summing up, from inception to the endpoint, Land–Sea Interactions are composed of STRESSORS, which are the generators of interactions; DRIVERS, which can be both natural (rivers) or anthropic (surface runoff), and which function as conductors of the interaction; RECEIVERS, which are affected by the consequences of the interactions. In addition, natural elements can function as BUFFERS, which retain and clean, decreasing the damage caused by the interactions. BUFFERS also function as natural solutions to counteract extreme climate events (Figure 7).

As it is a very complex phenomenon, it is also necessary to consider uncertainty in the discourse about Land–Sea Interactions. The literature reviews show that climate change (or natural and human catastrophes) is an important external driver. These drivers should be considered in a Land–Sea Interactions understanding because they can exacerbate the interactions or severely impact the area. The last outcome of the literature reviews is a comprehensive elaboration of a definition of Land–Sea Interactions as a complex set of dynamics, across the land–sea interface involving the impact of anthropic activities on and at sea affecting the natural environment and its bio-geo-chemical processes. External drivers, such as climate change or human disasters, should be incorporated since they can exacerbate the already existing interactions on the coastal zone.

It is worth underlining the limits of the research. Specifically, in the systematic literature review conducted, there are limitations from methodological and results perspectives. Starting from the methodology, it must be highlighted that the terms used in the systematic literature review were selected rather arbitrarily with the only criteria of relevance to the topic researched; changing these terms would also have produced different types of articles and maybe different results. In order to try to avoid this problem, a second literature review was conducted based on a bibliographic search of a key Land–Sea Interactions paper [15]. Albeit the possible limitation of the first systematic literature review, it appears that both literature reviews' results were aligned. The results of the double literature reviews should be seen as an initial ground base that builds a spatial planning knowledge of LSI, not as a definitive set of conclusions on Land–Sea Interactions. Thus, it constitutes an attempt to describe and interpret the state of the art of LSI from a spatial planning perspective, which although not exhaustive, is still significant as a first tentative step in moving towards a broader perspective of the topic. However, we still need to learn a lot about the topic, so this study should be seen more as an exploratory investigation into a very complex topic involving a wide spectrum of different fields.

5. Conclusions

These literature reviews prove that knowledge about Land–Sea Interactions and coastal areas draws on a wide range of scientific fields and that spatial planners should integrate this knowledge into their practice. Thus, a holistic approach is necessary if we want to find better solutions and answers to the challenges that coastal areas are facing and will have to face so that we maintain a realistic and effective perspective on the anthropic and natural processes that shape coastal territories. In conclusion, it seems that to build up a complete picture of Land–Sea Interactions, it is necessary to consider a territory and its socio-economic and ecological dynamics in a holistic and integrated way in order to be able to respond more effectively to diverse issues, such as climate change and other unforeseen events. As well as examining information from different research fields, therefore, we need to find organic ways to integrate and synthesize these results to make them more comprehensible for both scientists and policymakers. Useful methods for achieving this included mapping and the visualization of information in various forms, which, in addition to making the information more accessible, also make evidence of non-noticeable information. Finally, these reviews showed the role of spatial planning, not only as a discipline for designing and planning cities and territories but also the role it has in linking diverse disciplines to better comprehend coastal territories. The limitations and unexpected results of a study should only sometimes be seen as problems, as they can often be turned into opportunities. As mentioned above, this is an exploratory study that does not in any way claim to be definitive or conclusive. It would be valuable and interesting to follow up and expand on the knowledge developed in this study by carrying out individual literature reviews for each sector and activities outlined from the literature reviews. This would yield new information that would make it possible to enhance the discourse on Land–Sea Interactions in the spatial planning field and in the Maritime Spatial Planning perspective. Furthermore, this research is opening a new perspective on a thematic not yet developed in the spatial planning field. The double literature review built a base knowledge about LSI in the specifics of the categorizations, elements of LSI, interactions between uses, and uses of the environment; regarding these specifics, there is much work to develop. The spatial planning field can further expand on the analysis and mapping perspective in order to identify the spatialization of the LSI and to overcome conflicts in the management of the land–sea continuum. Another interesting area for further research would be to forge even more links between the framework of knowledge developed in this study and the relation with the European Union existing regulation that can positively affect LSI, to establish how particular coastal issues are already being tackled. Ultimately, the unexpected results paved the way for tackling a crucial issue coastal territories face today: their resilience. As the research showed, natural elements play a number of crucial roles: enhancing biodiversity, decreasing the externalities produced by human activities and, finally, providing natural solutions for coastal cities and areas to adapt to the land–sea continuum.

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