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Regulating human interventions in Colombian coastal areas: Implications for the environmental licensing procedure in middle-income countries

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ABSTRACT

Although anthropogenic impacts could be assessed in any environment, coastal areas pose a particular challenge because of their special nature as the interface between land and sea. Therefore, this study evaluates the environmental regulatory framework for coastal interventions in Colombia, as an archetype of medium income countries (MICs), to derive implications for the environmental licensing procedure (ELP). The methods comprised two simultaneous pathways: a. An inventory of human interventions at the large scale area of the Colombian Caribbean Coast, with an estimation of the overall environmental impact; b. An analysis of the ELP in Colombia during the last 25 years. The study evidences several weaknesses, such as a consistent reduction in the number of works and activities covered in each new legislative. Moreover, the Colombian ELP currently regulates only four of the ten types of interventions with greater effect in its coastal zones. The discussions highlight some policy implications for the ELP in MICs, mainly based on how the impact of a type of intervention can be magnified in proportion to its frequency of occurrence, and the need to articulate instruments of environmental management and territorial planning. At last, the need to evolve the impact assessment of human interventions from environmental factors toward socio-natural processes is evidenced and further addressed, by the introduction of a susceptibility approach inspired on geomorphological processes. Overall, this study highlights important gaps of the Colombian ELP for coastal environments, which entails valuable lessons for MICs.

1. Introduction

Although the environmental impact assessment (EIA) is the main governmental tool for environmental control, its application in coastal zones poses substantial challenges because of their special nature as the interface between land and sea (Frihy, 2001; Fuentes-Bargues, 2014; Nordhaus et al., 2018). In addition, EIA legislation plays a decisive role in the generalized weak performance of the environmental management at middle income countries (MICs), often associated to the political context and unclear or too ambitious regulatory frameworks (Ahmad and Wood, 2002; Kabir and Momtaz, 2013; Kolhoff et al., 2016, 2018). As an archetype of MICs, Colombia reflects this pattern of weak procedural performance at the environmental management of human interventions, mostly due to the limited compliance of EIA best practices regarding screening, scoping, alternative analysis, and unclear coastal delimitations (Pereira et al., 2018). Therefore, it becomes pertinent to analyze the regulatory framework applicable to coastal areas in MICs, with the aim of improving conceptual and methodological approaches that impregnate environmental management instruments with technical robustness. Such upgrading process, based on the transfer of scientific knowledge into management practices, contributes to overcome the effectiveness complains about EIA systems in the control of human impact.

A primary source for the problem statement relies on coastal regulatory frameworks and policies. From the legal perspective, Milanes (2018) revealed that technical terms and corresponding policies for coastal boundaries in several countries are backed by their respective coastal laws. For instance, the regulatory framework of Cuba exhibits a high level of awareness for coastal environments when evaluating the impact of human interventions (Pereira et al., 2018; Milanes et al., 2019). As another example, the national government of the UK has separately transposed EIA directives by marine and terrestrial projects through the Marine Work Regulation and the Town and Country Planning Act, respectively (Lonsdale et al., 2017). Colombia has three

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coastal zones adjoining the Caribbean Sea (continental and insular) and the Pacific Ocean. This is a unique feature since the country is neither an island nor a peninsula. The state ought to recognize this and accord special care for its coastal environment (Avella et al., 2009). However, Colombia has no coastal law or similar high-level regulations, and its legal code for coastal matters relies on a few specific decrees and two nonbinding policies with limited national implementation (Botero and Marin, 2018; CCO, 2017; MMA, 2000).

In this context, the only regulatory framework covering coastal interventions in an integrated manner relies on the two nonbinding ocean and coastal policies. The oldest policy, formulated by the Ministry of Environment in 2000 (MMA, 2000), includes a specific program to promote the sustainability of economic sectors, which emphasizes the following: 1. fisheries and aquaculture, 2. agro-livestock and agro-industry, 3. mines and energy, 4. ports and maritime transport, 5. coastal infrastructure, 6. industry and trade, and 7. tourism and recreation. Thereafter, the Colombian Oceanic Commission approved a National Coastal and Oceanic Policy in 2007, which proposes actions to prevent and control the environmental impacts of certain economic activities (CCO, 2007). However, the updated version of this policy in 2017 (CCO, 2017) only mentions environmental implications within economic development actions, without any explicit strategy or program to manage the associated impacts.

Regarding environmental management of anthropogenic impacts, several countries have adopted environmental licenses as a policy instrument, where the government legally intervenes in activities of public or private interest that may cause environmental degradation (Burgel et al., 2017; Jaskoski, 2014; Monteiro and da Silva, 2018). According to the study of nine Latin American countries performed by Villarroya et al. (2014), the approval of environmental licenses depends on the predicted mitigation of negative impacts and/or fulfillment of additional requirements set by the licensing authority. Therefore, the environmental licensing procedure (ELP) is considered to be the legal and administrative protocol to bind and legitimate the EIA in a given country, where a petitioner is entitled with a permit to execute a project, work, or activity according to the outcome of the environmental assessment. Despite being a bureaucratic action, the ELP operate on technical principles of EIA best practices, regarding the protocol for screening the types of intervention requiring an impact assessment, scoping the environmental study, examining project alternatives, approving or denying licenses, or following up on approved licenses (IAIA and IEA, 1999; Pereira et al., 2018). Therefore, the ELP correspond to the legal action, whereas the EIA involves the activities that provide the technical input for the decision-making process.

In Colombia, the ELP presents flaws in coastal delimitations during the impact assessment and lacks a screening stage for certain interventions that may require a robust valuation of their impacts over natural processes (Pereira et al., 2018). Recognizing the context and evolution that have created this lax environmental regulatory framework contributes to derive ELP implications on the management of coastal areas in countries with similar contextual factors. Therefore, this paper compares the environmental impact of interventions on the gross scale of the Caribbean Coast of Colombia (CCC) against the ELP regulatory evolution in the country. Section 2 describes why Colombia could be a valid example of MICs. Section 3 describes the methodology used to estimate the environmental impact of coastal interventions and the ELP evolution in the case study, while Section 4 synthesize the corresponding results. Based on the findings, Section 5 discusses the environmental regulatory framework and the policy implications of ELP within the context of the MICs, and finalize with the introduction of the susceptibility concepts as a technical aid for ELP. Lastly, Section 6 synthesize the conclusions of the study.

2. Colombia as a case study of ELP in middle-income countries

According to the World Bank, middle-income countries are defined by "having a per capita gross national income of US$1,026 to $12,475", comprising a group of 103 nations that includes Colombia (The World Bank Group, 2019). Although few authors from the field of environmental sciences had focused on this economic classification (i.e. Kolhoff et al., 2018), several researches analyze the ELP in MICs from different perspectives (i.e. Ahmad and Wood, 2002; Kabir and Momtaz, 2013; Kolhoff et al., 2016; Marara et al., 2011). The findings of these studies are usually similar, which allows comparing the ELP among them. In Kenya, Marara et al. (2011) conclude that EIAs are only used as the frontage of national commitments to international conventions and laws. Meanwhile Ahmad and Wood (2002) recommend the preparation of user-specific guidelines for Egypt, Turkey, and Tunisia, based on the EIA recommendations of the Organization for Economic Cooperation and Development (OCDE). On the other hand, Kabir and Momtaz (2013) recognize that countries such as Bangladesh, China, Brazil, Taiwan, Sri Lanka, Sudan, and India had various deficiencies when the EIA legislation was first introduced. Another similarity between MICs is related to the link between their early EIA regulations and the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro, Brazil, between 3 and 14 June 1992 (Kabir and Momtaz, 2013; Kolhoff et al., 2016). In Kenya, the Environmental Management and Coordination Act that gave legal status to EIA was approved in 1999, further complemented in 2002 by the release of Environmental Impact Assessment Guidelines and Administrative Procedures, and ratified by the Environmental Impact Assessment and Audit Regulations of 2003 (Marara et al., 2011). In Bangladesh, the government formally introduced the EIA in 1995 under the Environmental Conservation Act (Kabir and Momtaz, 2013), soon after Turkey (Executive amendment in1997 to the Environment Act 2872 of 1983) and soon before Egypt (Law No. 4 on Environmental Protection in 1994) and Tunisia (Law No. 88 of 1991 and Decree No. 3621991) (Ahmad and Wood, 2002).

In the case of Colombia, the environmental licensing was conceptually conceived since 1974 (Decree 2811), but it was enshrined by law only after the recognition given to EIA practices at the UNCED. In this sense, the law 99 of 1993 introduces the country to the path followed by other MICs in the assessment and control of the human impacts on the environment. Ever since, the institutional competences and further dispositions of the ELP have evolved through six different decrees (Decree 1753 of 1994, Decree1728 of 2002, Decree 1180 of 2003, Decree1220 of 2005, Decree2820 of 2010 and Decree 2041 of 2014).

Additionally, as part of the ELP, the Ministry of Environment had established guidelines for the preparation and submission of environmental studies, commonly called terms of reference (ToR). These documents tackle the planning of gross projects on the account of the environmental policy, risk assessment, administrative law, and public order, with the aim of informing decision makers on the effects and benefits of such human interventions over the national sustainable development (Joseph et al., 2015). The regulation of EIA based on ToR is a frequent practice within MICs, such as reported Marara et al. (2011) about Kenya, Pereira et al. (2018) about Cuba, Ahmad and Wood (2002) about Egypt, Turkey and Tunisia, and Kabir and Momtaz (2013) about Bangladesh in a lesser extent. In Colombia, > 40 ToR have been created by the Ministry of Environment since 2006, 84% of which refer to the elaboration of environmental impact studies, other 11% for the environmental diagnosis of alternatives and the remaining 5% for management plans. If the ToR for a given project or activity has not been issued yet, the competent environmental authority in Colombia is entitled to formulate specific ToR for each case. Therefore, these guidelines are conceived to ensure that environmental impact statements of human interventions contain relevant information to motivate the approval or denial of an environmental license from the corresponding authority.

Nevertheless, almost none study has analyzed the EIA regulation on a particular territory or environment, such as coastal or oceanic areas. According to Vallega (1999), the concept of coastal zones integrates

bio-physical elements with socioeconomic issues from a geographic approach. Although coastal ecosystems are independent of the economic development of the countries, the human impact over them is highly influenced by economic drivers (Barragán and de Andrés, 2015). Colombia is not an exception to this pattern, because its highly diverse coastal zones have very different levels of human development (Avella et al., 2009). Although the country has three coastal zones, this study was focused on the Colombian Caribbean Coast, in which deltaic plains and low coasts alternate with high coasts of mountainous segments along approximately 1700 km of shoreline, (Correa and Pereira, 2019).

In addition, the national statistics (DANE, 2012a, 2012b) report large areas with socioeconomic development based on the primary economic sector in the CCC, which includes the basic activities of farming, poultry, and livestock. The industries and the third economic sector activity are highly concentrated in the densest areas between the cities of Cartagena and Santa Marta, and represent less than one-third of the coastline (see Fig. 3). Furthermore, the most populated cities (i.e., Barranquilla, Cartagena, Santa Marta, Cienaga, and Riohacha) represent one-sixth of the most populated cities in the country, which comprise a little > 6% of the total national population (DANE, 2012a). This data suggests that Colombia has two relevant features for the ELP analysis in MICs with coastal areas: 1. Its recent economic behavior has the same path than MICs (see Fig. 1); 2. the CCC has almost all levels of human development and tropical ecosystems of coastal areas (Avella et al., 2009).

3. Methods

The research was developed in three methodological stages, which lead to the synthesis of policy implications of ELP for MICs (Fig. 2). First, an inventory of human interventions was done on the whole CCC, from the structure of coastal uses and activities proposed by Barragan (2003) and adapted by Botero et al. (2014). This list of human interventions defined > 50 types of activities related with land transformation, infrastructure, or joint facilities, whose placement could disturb the natural processes influencing the coastal morphology (Pereira et al., 2018). To cover > 3400 km^2 of the coastal area, human interventions were identified by observing free access satellite imagery; the majority of the images was from Google Earth, but alternative services were also canvased, such as Nokia, Bing, and ESRI. Therefore, each human intervention was marked on the virtual map the of Google Earth® platform, and included in a database with its coordinates, type of activity and imagery provider. Additionally, the register of this inventory was segregated by the five gross areas defined by the environmental policy of coastal environments for the Colombian Caribbean, under the label of an Environmental Coastal Unit (ECU); the boundaries of these units in the CCC are depicted in Fig. 3.

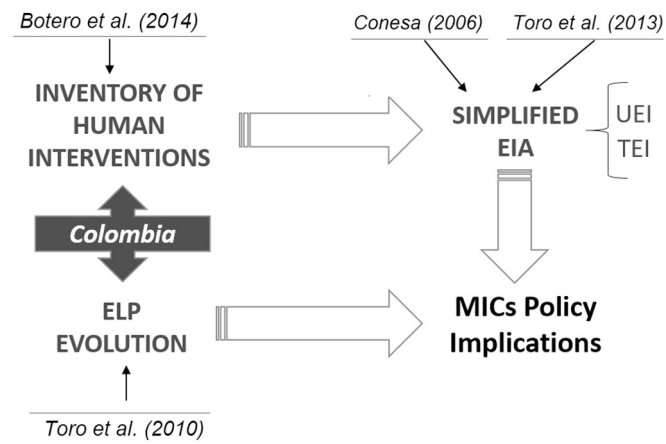

Fig. 2. Methodological stages.

After observing and cataloging the human interventions at the gross scale of the study area, a simplified EIA was performed on each intervention identified through the estimation of two parameters: the unitary environmental impact (UEI) and the total environmental impact (TEI). The former was based on four attributes defining by Conesa (2006) in his methodology to assess environmental impacts, namely extension, intensity, reversibility, and persistence, which are further explained by Toro et al. (2013). Each attribute was graded from 1 to 4, with extra values for attributes of extension and intensity, according to the qualitative method of Conesa (2006). Secondly, the number of interventions was accounted at the study area to obtain the frequency of occurrence per typology and organize them from the most to the least frequent. Finally, TEI values derived from multiplying the UEI of each typology with its respective frequency of occurrence on the CCC. Therefore, UEI value means the environmental impact caused by a single human intervention identified and TEI value represents the sum of every intervention within the same typology in the whole study area.

Simultaneously, a thorough review of the ELP evolution in Colombia was performed by referring to the previous diagnosis of Toro et al. (2010). Each intervention typology for the study area was highlighted from the legal framework approved by the Ministry of Environment in the last 25 years, supplementary material of this article (Appendix) contains a brief description of the five decrees that have regulated project, work, and activity governed by the ELP in Colombia, namely Decree 1753 of 1994, Decree 1728 of 2002, Decree 1180 of 2003, Decree 1220 of 2005, and Decree 2041 of 2014. Although several projects, works, and activities regulated by these decrees are not specific to coastal areas, the codes assigned to the human interventions during the inventory in the CCC were used to highlight the equivalent

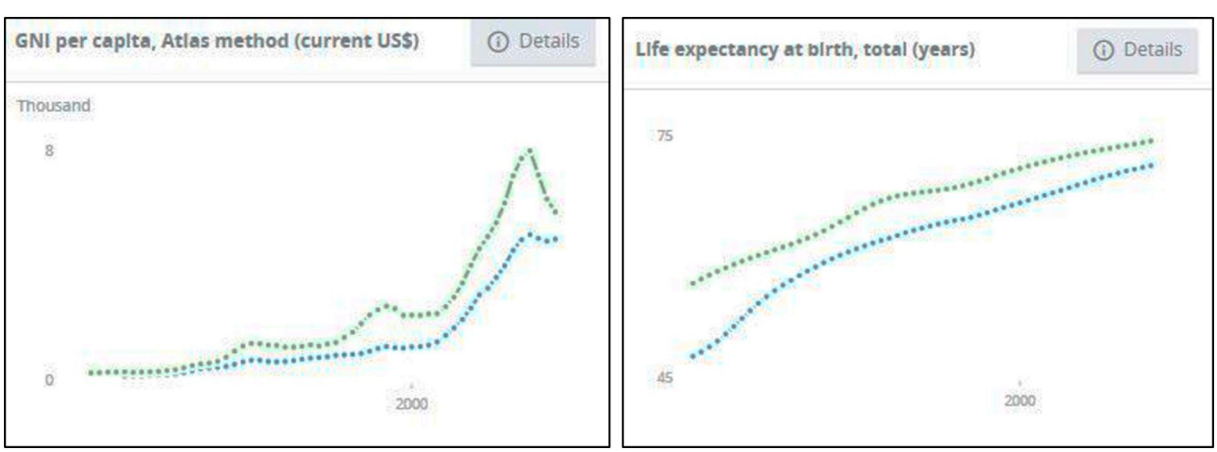

Fig. 1. MICs trends in comparison with Colombian case from the World Bank Data consulted in March 2019. Blue represents MICs and green represents Colombia.

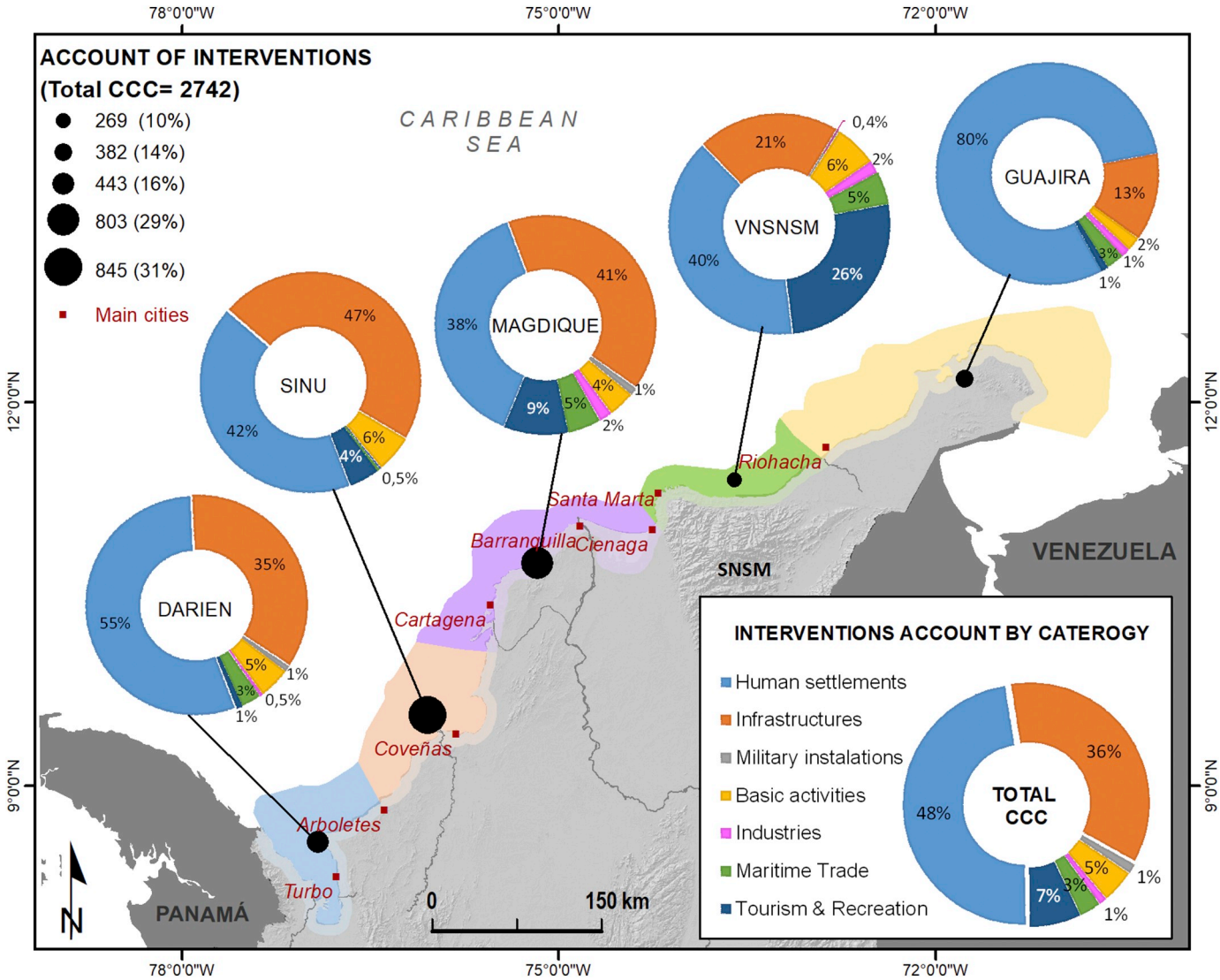

Fig. 3. Geographic distribution of human interventions within the five ECUs of the CCC (SNSM stands for the Sierra Nevada de Santa Marta massif).

interventions conceived in the regulatory record. Lastly, the integration of the simplified EIA with the ELP evolution in Colombia allowed to extrapolate some policy implications for MICs, and propose an innovative improvement for ELP based on the concept of susceptibility.

4. Results

4.1. Interventions with a greater effect on Colombian coastal zones

The inventory allowed to identify a total of 2742 individual human interventions affecting the coastal zone, which demonstrate the heterogeneity of the CCC. The geographic distribution of these results is synthesized in Fig. 3, including seven gross categories of human uses and activities that gather 29 different types of interventions. As a consequence, two of the regions with the highest proportion of interventions were recorded for the ECUs SINU and MAGDIQUE, with a representation of 31% and 29% respectively. Medium quantity of interventions was accounted within the units at the two geographical borders of the study area, namely GUAJIRA and DARIEN, with 14% and 16% of the total account of interventions respectively. Lastly, the one ECU with the lowest proportion of interventions was VNSNSM, which faces the highest coastal mountain in the world (Correa and Morton, 2003). In the main, this data stresses that human interventions are not uniformly distributed in coastal areas, neither by the number of occurrences nor by typological diversity.

For instance, GUAJIRA unit comprises the fewest typologies and second fewest interventions accounted, while MAGDIQUE presents the highest proportion of typologies and high accounts of individual interventions within all ECUs. The lowest account of interventions in VNSNSM is mostly due to the reduced extension of the coastal zone left by the natural boundaries of the Sierra Nevada de Santa Marta massive. Nonetheless, this unit presents the second highest diversity of intervention typologies within the study area, with a substantial representation of tourism and recreation facilities. Overall, the biggest proportion of interventions correspond to four different types of human settlements and eight types of public infrastructure, such as roads and shore protection structures (see Table 1).

Regarding the estimation of environmental impacts, Table 1 also summarizes the results of the most relevant types of interventions in terms of frequency, UEI, and TEI. The values regarding the frequency represent the number of occurrences of each intervention typology, the proportion it comprises in the total account of interventions in the study area, and the occurrences' order from the most to least frequent. In the respective segments for the UEI and TEI, the first column presents the estimated values, the second column presents the proportion of the environmental impact estimated within the sum of all identified

Table 1
Top 10 human interventions impacting the CCC and geographic distribution of the overall TEI.

Category	Typology	Code	Frequency			UEI			TEI			Regulated by ELP
			Accounts	%	ORD	Value	%	ORD	Value	%	ORD	
Human settlement	Low-density settlements	AHB	971	35.4%	1st	0.16	1.4%	28th	15.7	18.4%	2nd	No
Infrastructure	Groins	CYP	738	26.9%	2nd	0.41	3.6%	13th	299.8	36.3%	1st	Yes
Human settlement	Luxury settlement with pier	AHM	188	6.9%	3rd	0.38	3.3%	14th	70.5	8.5%	3rd	No
Human settlement	Luxury settlements	AHU	145	5.3%	4th	0.34	3.1%	17th	49.84	6%	4th	No
Tourism & recreation	Nature tourism	EDN	99	3.6%	5th	0.13	1.1%	29th	12.38	1.5%	14th	No
Infrastructure	Road infrastructure	CAP	62	2.3%	6th	0.5	4.4%	4th	31	3.8%	5th	Yes
Basic activity	Farming and livestock	UAG	62	2.3%	7th	0.28	2.5%	21st	17.44	2.1%	11th	No
Basic activity	Aquaculture	GRA	61	2.2%	8th	0.38	3.3%	15th	22.88	2.8%	7th	Yes
Tourism & recreation	Sun, sea and sand tourism	EDF	57	2.1%	9th	0.34	3.1%	18th	19.59	2.4%	10th	No
Infrastructure	Breakwaters	ROM	56	2%	10th	0.47	4.2%	10th	26.25	3.2%	6th	Yes
Sum				89%			30%			85%		Yes (40%)
ECU	DARIEN		SINU			MAGDIQUE			VNSNSM			GUAJIRA
Overall TEI	15.5%		29.7%			33.5%				10.7%		10.5%

Note that ORD stands for the order or rank within all the typologies in the respective variable.

interventions, and the third column presents the rank of each typology within all 29 interventions. The last column of Table 1 set the typologies of interventions regulated by the Colombian ELP, according to the latest regulation (Decree 2041 of 2014).

The data states that most frequent human interventions in the study were low-density settlements (AHB), which describe a scattered pattern. This is consistent with the demographic distribution in Colombia, where < 30% of the population lives in coastal areas, with the main cities and towns (*high-density settlements*) located at interior mountainous areas (Avella et al., 2009). Therefore, although this intervention typology had almost the lowest UEI (28th), it had the second biggest TEI in the study area, indicating the importance of the geographic recurrence of such occupations on the environmental assessment for a broad territory. Conversely, interventions with highest UEI values, such as inlet navigation channels (1st UEI; 14th Freq), mining (3rd UEI; 25th Freq) and ports (7th UEI; 18th Freq), were not included in Table 1 because their frequencies of occurrence were lower than those of the top 10 TEI values. Interventions linked to nature tourism had high frequencies in the study area, but their UEI was the lowest within the identified human interventions and, consequently, had a medium TEI (14th).

Notably, the data indicate that the majority of interventions with high TEI are also those with a high frequency of occurrences, however, two groups of typologies are remarkable. On the one hand, there are groins (2nd Freq; 13th UEI and 1st TEI) and breakwaters (10th Freq; 10th UEI; and 6th TEI), which correspond to rigid structures for shore protection. The relevance of these types of infrastructure has been largely established by scientific literature as high-impact activities for coastal areas (Williams et al., 2018). On the other hand, luxury settlements have received the opposite scientific attention, that is, the negative effects of this infrastructure over coastal processes and the deepest impacts of those edifications with their own piers (3rd Freq; 14th UEI; 3rd TEI) have rarely been studied. This invisibility has transcended to the environmental regulation because none of the typologies of human settlements is considered in the current ELP legal framework (see the last column of Table 1). Within the five intervention typologies with highest TEI, only groins (2nd TEI) and roads (5th TEI) are regulated through the ELP; the remaining unregulated typologies (AHB, AHM, and AHU) total 32.9% of the overall environmental impact on the CCC.

4.2. Regulation of human intervention in the CCC

Although previous publications have already registered the evolution of the regulatory framework of the Colombian ELP, no studies have analyzed the human interventions affecting the coast. For instance, Toro et al. (2010) presented a detailed list of sectors and economic activities requiring an environmental impact study according to the decrees enacted for the national environmental system from 1994 to 2007. As an updating exercise, Table 2 contains the list of projects, works, and activities under environmental licensing in Colombia presented by Toro et al. (2010), with two additional columns: one column for Decree 2041 of 2014 (currently in force) and the other column for the codes representing the interventions that affected the coastal areas.

Looking at the top ten interventions of Table 1, the typologies of human settlements (AHB, AHM, and AHU) stand out because they were once included in the legal code for the ELP. The construction of blocks of flats and housing were under the ELP within decrees of 1994, 2002, and 2003, but it was excluded from the decree of 2005 and successive. Other typologies with a similar normative regression are within the category of tourism and recreation (EDN and EDF) because the construction and operation of tourist resorts and leisure/sports premises were under the ELP by the decrees of 1994 and 2003 but excluded from the decree of 2005 and successive. This activity may also comprise the typologies of luxury settlements if considered as second residencies, which is a variant of the 3S tourism (Barragán and de Andrés, 2015).

The most impacting typologies within the category of basic activities (UAG and GRA) were once regulated in the decrees of 1994 and 2002. Both regulations include livestock, fish, and poultry farming, as well as intensive flower cultivation. The only economic activity related to this category of basic activities in the decree of 2014 refers to irrigation systems, which imply hydrological modifications to supply water for cultivation purposes. Although this intervention was also under the decrees of 1994 and 2005, they still fail to represent the geochemical and morphological disturbance of the landscape due to farming and livestock. The remaining types of interventions with the greatest impact, regarding shore protection structures (CYP and ROM) and linear infrastructure (CAP), are considered in the current decree of 2014, as well as in the decrees of 1994 and 2005. Therefore, Colombia currently regulates only four of the ten types of interventions with greater effect in the Colombian coastal zones: two types of shore protection structures (CYP and ROM), the basic activity of aquaculture (GRA), and the road infrastructure (CAP).

Regarding the institutional structure of the ELP in Colombia, the pattern or distribution of the ToR indicates suggest that environmental goals are subdued by economic development. Since 2006, the Ministry of Environment have created and updated 43 ToR, which distribute among six economic sectors, namely infrastructure ($N = 14$), energy ($N = 10$), oil industry ($N = 8$), mining ($N = 1$), pesticides ($N = 7$) and flora and fauna ($N = 3$) (ANLA, 2017; Toro et al., 2010). In addition, the updating process of those guidelines has only responded to the regulatory and technological evolution of each regulated sector, and to

Table 2
Evolution of the prescriptive character of the environmental licensing of projects, works, and activities in Colombia, with emphasis on coastal areas. Updated and complemented from the study by Toro et al. (2010).

	Activities governed by EIA	Decree 1753 (1994)	Decree 1728 (2002)	Decree 1180 (2003)	Decree 1220 (2005)	Decree 2041 (2014)[a,b]	CODE[d]
1	Cemetery construction	X[c]	X	X[c]			–
2	Construction of premises for storage and distribution of food	X	X	X[c]			–
3	Construction of blocks of flats and housing premises	X[c]	X	X[c]			AHB AHM AHU
4	Hospital construction	X [c]	X	X[c]			–
5	Dam and reservoir construction	X	X		X		–
6	Construction of water supply line systems	X	X				–
7	Construction of mass transport systems	X [c]	X	X[c]			–
8	Construction and operation of wastewater treatment systems (> 200,000 users)	X			X	X	–
9	Construction, modification, fitting and operation of terminals for ground transportation of passengers and goods	X [c]	X	X[c]			–
10	Construction and operation of tourist resorts and leisure and sport premises	X		X[c]			EDN AHU AHM
11	Construction and operation of electrical power stations; exploration and use of polluting alternative energies; cable laying of transmission lines	X			X	X	–
12	Construction and operation of irrigation and/or drainage systems	X			X	X	UAG
13	Construction and operation of premises for storage, treatment, and/or final disposal of dangerous waste.	X			X	X	–
14	Storage of dangerous substances with the exception of hydrocarbons	X			X	X	–
15	Construction and operation of sanitary landfills.	X			X	X	–
16	Maritime and port sector: Construction, extension, and operation of seaports; Deepening dredging; Construction of breakwaters, channels, and hydraulic fills; beach stabilization and coastal waterways; Artificial creation of beaches and dunes	X			X	X	ROM CYP
17	Construction, modification, and operation of airports	X			X	X	CAP
18	Commercial game and establishment of wild animal farms	X			X	X	–
19	Introduction of foreign species, subspecies, breeds and wild varieties of flora and fauna	X			X	X	UAG GRA
20	Livestock, fish and poultry farming	X	X				
21	Genetic manipulation and production of microorganisms	X	X				–
22	Intensive flower cultivation	X	X				UAG
23	Design and establishment of shopping centers and leisure areas.	X	X				–
24	Service stations, and fuel deposits and packaging centers	X	X				–
25	Generation of nuclear energy	X			X	X	–
26	Timber and furniture manufacture	X	X				–
27	Paper manufacturing, printing shops, and publishing houses	X	X				–
28	Manufacture of foodstuffs	X	X				–
29	Manufacture of metallic products, machinery, and equipment	X	X				–
30	Textile manufacture, garments, and leather	X	X				–
31	Manufacture of basic metals	X	X				–
32	Public works in the railway network.	X			X	X	–
33	Public works in the national waterway network: Construction of ports; Closing of active wetlands; Deepening dredging in navigable channels and delta areas; Construction of breakwaters	X			X	X	ROM
34	Road network projects: Construction of roads; Construction of minor roads; Construction of tunnels and their approach roads	X			X	X	CAP
35	Pesticide importation and production	X			X	X	–
36	Forest exploitation projects	X					–
37	Reforestation and forestry	X					–
38	Project affecting National Natural Parks	X			X	X	–
39	Mining, exploitation: Coal; construction materials; metals and precious stones; other minerals	X	X		X	X	–
40	Hydrocarbon sector: Seismic exploration; exploratory drilling; hydrocarbon exploitation, transport, and piping; delivery terminals and transfer stations; construction and operation of oil refineries	X			X	X	–
41	Basic chemical industrial sector: Manufacture of basic mineral-based chemical substances; manufacture of alcohols; manufacture of inorganic acids and their oxygenated compounds; manufacture of explosives, gunpowder, and fireworks	X			X	X	–
42	Projects requiring water transfer between hydrographic basins	X			X	X	–
43	Construction and operation of facilities for the storage, treatment, use (recovery/recycling) and/or final disposal of Waste Electrical and Electronic Equipment (WEEE) and waste batteries and/or accumulators					X	–
44	Construction and operation of facilities for the storage, use, recovery and/or final disposal of waste or hazardous waste, and the construction and operation of security landfills for hospital waste					X	–

[a] This decree contains the same list of sectors and economic activities under ELP as the previous update (Decree 2820 of 2010).
[b] Compiled in the Unique Environmental Decree 1076 of 2015.
[c] Environmental license is not required when the land-use plan approves the project location.
[d] Based only on the top 10 typologies presented in Table 1.

the increased demand for environmental licenses for certain projects within the corresponding sectors. For example, with the issuance of Law 1682 of 2013 (commonly called "the Infrastructure Law"), a general update of all ToR for the infrastructure sector was enforced according to the new guidelines. Consequently, the ToR have been influenced by the regulatory developments of economic sectors rather than the necessity to protect a certain area of environmental importance or a critical natural process.

Nonetheless, the generic character of this guidelines remains as the main weakness of the ELP, such as in other MICs (Ahmad and Wood, 2002; Kabir and Momtaz, 2013; Marara et al., 2011). Indeed, the information requirements of the ToR lack substantial specificity in the type of intervention, despite being formulated by sector or economic activities (Pereira et al., 2018; Toro et al., 2010). For example, although over 60 roads have been placed within the study area (see CAP in Table 1), the ToR for the alternative diagnosis of linear infrastructure formulated in 2006 makes no distinction regarding coastal settings (Resolution 1275 of 2006). Similarly, the ToR formulated in 2013 for environmental impact studies of road construction added requirements of analysis for management protocols; however, no instructions are given regarding particular types of environments. The subsequent update of this type of ToR in 2015, referred to roads and tunnels, integrated a caption about marine coastal water quality within the technical requirements on the abiotic component (Resolution 0751 of 2015). Nonetheless, the representation of coastal processes remains obtuse for characterizing the influence area of roads in the littoral environment and their eventual follow-up.

5. Discussion

5.1. The involution of the environmental regulatory framework in Colombia

Overall, the results above presented reveal how the regulatory framework in Colombia has reduced considerably the restrictive character over economic activities inducing environmental damage, especially during the extremely unrestrictive period from 2002 to 2005. The first decree in 1994 included > 42 economic sectors or activities under ELP, which could be interpreted as a response to the international environmental boom triggered by the UNCED in 1992. By the following update of the ELP Decree in 2002, the number of economic sectors and activities was reduced to 22, and the lowest number (7) was reached in the Decree of 2003. The updated decree in 2005 increased the amount of sector or activities to 21, and the currently enforced regulation has maintained a similar figure since 2014, although not exactly the same interventions. Along with the revision conducted in this study, no public document was found to support these legal reforms. This corroborates the previous conclusion about the lack of technical studies supporting the decision to include or remove economic activities or sectors from consecutive ELP regulations in Colombia (Toro et al., 2010), which resembles the pattern of other MCIs (Kolhoff et al., 2018; Marara et al., 2011). Therefore, the consistent reduction on the number of economic activities and sectors under environmental licensing rest on changes of government politics and international agendas, rather than technical arguments.

Another pattern worth noticing from the Colombia case, as an archetype for MICs, is the pressure to become part of multilateral organizations (Ahmad and Wood, 2002; Marara et al., 2011). Indeed, the reduced coverage of activities in the Colombian ELP raised concern at international levels, including the Organization for Economic Cooperation and Development. Within the conditions set by this international organism to grant Colombia a membership, there was a thorough revision of the national regulatory framework that could lead to adjustments for articulating the Colombian ELP with the standards and good practices of OECD (Government of Colombia, 2019). This conjuncture has led to the first technical study ever performed to support a regulatory reform in the country, which corresponds to the consultancy work of the Environmental Studies Institute of the National University (IDEA, 2018). The normative outcome of this effort has yet to be submitted to the Colombian legislative apparatus for effective application. Therefore, the historical evolution and owning regulatory pattern depicted by the Colombian case shows the challenges that a medium income country has to face in the advance of its economic development path.

As a consequence of these contextual factors, some of the eliminated economic sectors over the years are currently generating most of the environmental impacts. For instance, farming and all types of livestock are currently excluded from the Colombian ELP regulation, despite being among the 10 most impactful interventions in the gross geographical scale of the study area (see the codes UAG and GRA in Table 2). These results agree with the early environmental evaluation of economic sectors performed by IDEA (2018), who recommends the agricultural sector within the human activities that must be included in the ELP regulatory framework. Similarly, this national diagnosis includes the same typologies of infrastructure registered in Table 1 within the list of projects that must keep a prescriptive character for the licensing procedure, namely shore-protection structures and varieties of roads (see codes CYP, ROM and CAP). However, this assessment approach by economic sectors disregards nearly 50% of the interventions with effect on coastal environments, such as highly impacting facilities linked to tourism and navigation (see codes EDF and AHM in Table 1). Therefore, despite adding the missing technical criterion to the environmental regulatory evolution in Colombia, the assessments of potential impacts from economic sectors still unaware the locative particularities governed by geomorphological processes at distinctive kinds of environments, such as the coastal zone.

Furthermore, several overlapping competencies remain within the institutional framework in MICs (Kolhoff et al., 2018). As an example, scattered human settlements comprise the largest proportion of human interventions with substantial effects on the dynamic equilibrium of Colombian coastal environments (see the codes AHB, AHU, and AHM in Table 1). Even though these sorts of human occupation are unregulated by the ELP, they are under the regimen of uses and activities admitted by the respective territorial planning instrument. In addition, the particular case of luxury housing with piers is the kind of intervention that would require a positive concept from the maritime authority, because they occupy the public domain defined in the Decree-law 2324 of 1984. A big concern in this matter relies on the lightweight of the environmental pronouncement of competent authorities involved in permits and concessions for this types of land use (Botero et al., 2016; Milanes et al., 2017). Although such types of interventions may be considered negligible out of the context of the regional inventory conducted on the study area of the Colombian Caribbean, their scattered nature and high occurrences are worth attention for managing anthropogenic impacts. Therefore, recognizing how proliferous are these human developments and its derivative effects would call for a more articulated strategy for territorial planning and environmental management.

In the main, the lax pattern on the ELP regulatory framework of Colombia illustrates the pressing contribution of the contextual factor on the substantive performance of environmental management instruments in MICs. The shifting political agenda of consecutive governments have ruled arbitrarily on the environmental regulatory framework of Colombia, which reinforces the subjectivity complains of EIA practices due to ethical issues associated with private interests and/or corruption (Bragagnolo et al., 2017; Castley et al., 2003; Enríquez-de-Salamanca, 2018; Williams and Dupuy, 2017). This situation exemplifies one of the factors influencing low EIA performance in MICs because the achievement of environmental standards is threatened by short-term objectives of decision making over environmental protection issues (Kolhoff et al., 2018). Although no country is identical to another, the eroded environmental regulatory framework depicted by the Colombian case allows inferring the typical evolution of countries improving their practices (Pereira et al., 2018). This situation stresses the

role of technical criteria and methodological approaches in the improvement of the substantive performance of environmental management instruments in MICs, such as ELP and land and marine spatial planning.

5.2. Policy implications of ELP in coastal MICs

Even though EIA application in coastal environments have been analyzed in several countries, such as Cuba, Portugal, Spain, Sri Lanka, New Zealand, and Egypt (Enríquez-de-Salamanca et al., 2016; Frihy, 2001; Fuentes-Bargues, 2014; Guerra et al., 2015; Hapuarachchi et al., 2016; Pereira et al., 2018), the policy implications of this management tool have not been studied in depth. In a broad sense, certain policy implications for MICs with coastal zones can derive from the large scale environmental impact assessment of the Colombian Caribbean described in Section 4.1.

Initially, the contrasting numbers depicted in Fig. 3, about intervention's account in the study area, describe a geographical diversity of human uses and activities. For instance, the pattern at GUAJIRA unit correlates with one of the lowest human development indexes reported in Colombia, together with the largest indigenous population of the CCC (DANE, 2012a). Such configuration and character of human settlements imply fewer human interventions and more pristine landscapes; however, indigenous territories in other MCIs are also excluded from the ELP (Marara et al., 2011). Meanwhile, MAGDIQUE unit registers the highest concentration of human population, industrial infrastructure, and active commerce within the CCC, but the most degraded coastal environment (CGR, 2017). These examples demonstrate how anthropogenic impacts may differentiate the state of development and natural integrity among the coastal regions of a single country. Therefore, the future evolution of the ELP should consider the regional particularities of human interventions on distinctive kinds of environments, which outstand from performing a similar inventory to the one presented in this study.

Another implication for coastal policies is observed regarding how the impact of a type of intervention can be magnified in proportion to its frequency of occurrence. The relevance of the TEI, rather than the UEI, suggests that each coastal region may estimate its territorial carrying capacity for the more frequent coastal interventions. This estimation was already suggested for marine and coastal environments in the EIA regulatory frameworks of Spain and Italy (Pereira et al., 2018). Although methods for estimating the territorial carrying capacity in the EIA context exist (Loro et al., 2014), these methods have yet to discriminate the type of environments being disturbed by human interventions and their ecosystem processes. In the Colombian case, this situation becomes highly critical, where two national policies are related to coastal management but not one mention the concept of territorial carrying capacity.

A third policy implication stems from countries with renown coastal regulation, such as Cuba. Such referents suggest that environmental licensing must validate and be validated by territorial planning instruments, such as land-use planning, integrated coastal management, watershed management, and marine spatial planning (Botero et al., 2016; Pereira et al., 2018). Nevertheless, land use and watershed management plans in Colombia exclude coastal areas, while the majority of the integrated coastal management plans are still in formulation stages and marine spatial plans are inexistent (Botero, 2019). Moreover, none of those four planning instruments has a direct and strong link with ELP, although all of them are formulated and/or approved by the local environmental authorities. Therefore, the government of MICs should ensure the coherence between ELP with the territorial plans comprising the coastal area. Additionally, a novel approach of integrated coastal management should conceive the territorial planning evolution in accordance with the concurrent reality of the types of interventions ruling the overall environmental impact.

Consequently, the TEI estimated for each intervention's typology in each coastal unit can be considered to be a useful approach to integrate coastal interventions within the land and marine planning instruments. The identification of typologies with high TEI can feature which of them require a differentiated level of administrative control, according to the results of each coastal unit or region. Given the frequency and spatial distribution of the types of interventions representing high values in the overall TEI, their environmental regulation can be integrated into territorial planning instruments and other administrative procedures (i.e., concessions or environmental management plans) instead of following individual ELPs. Additionally, medium TEI values would represent restriction levels that territorial authorities would have to enforce. A periodic diagnosis of the overall environmental impact in a given country through an exhaustive inventory of interventions, such as in this research, would provide technical criteria to formulate and update the territorial planning instruments.

5.3. The susceptibility concept as a technical aid for ELPs

The analysis of the Colombian environmental regulatory framework of previous sections provides a compelling argument regarding the need to make a transition in the traditional and global approach of EIA practices. First, by fragmenting the environment into abiotic, biotic and socioeconomic components the structure of the ToR fails to capture the holistic principle of nature. According to this approach, the flow of matter and energy along a kind of environment are better represented by processes than by segregated environmental factors, such as air quality, water quality or land use changes (Pereira et al., 2018). A further conceptual inconsistency in the management of anthropogenic impacts can be stressed from the conventional operation of environmental licensing because these procedures circle around economic activities instead of kinds of environments. Such traditional approach takes advantage of weak technical criteria in EIA practices to pursue economic development over environmental management goals, which better harmonize with an ecosystem services approach (Downs and Booth, 2011; Enriquez-Acevedo et al., 2018; Goudie, 2018). In the main, the results analyzed in this study stresses the need for a changing approach in the structure of environmental regulations and management, where the natural processes shaping a type of environment are faced with the most frequent and probable interventions therein. Such a novel approach can be defined as the susceptibility to the effect of human interventions.

To determine a customized definition of this susceptibility concept requires the consideration of related terms, such as vulnerability and risk associated variables. In terms of environmental impact, the concept of vulnerability has been used to describe the physical, biotic and social susceptibility of natural systems to damages or threats by the construction, operation or decommissioning of projects, built structures or activities (Toro et al., 2012). However, technical criteria framing these environmental assessments hardly consider the particularities of the interaction man-environment that discriminate the different spheres of susceptibility (Pereira et al., 2018; Zhang et al., 2013). In a general context, the susceptibility is the tendency of a system to be affected or experience damage (Emrich and Cutter, 2011; Paul, 2013). In addition, the susceptibility is directly related to the resilience of the environmental factors and the intrinsic and independent character of the event triggering the changes in the system (Fitton et al., 2016; Mcfadden, 2010; Toro et al., 2012). Turning these conceptions into the purposes of the impact assessment, the *susceptibility* can be defined *as the predisposition of an environmental unit to experience changes or affectation due to the introduction of human interventions*. In this concept, the environmental unit is understood as any socio-natural system subject to management through an environmental license.

The methodological component of this conceptual approach of susceptibility is inspired by the role of geomorphology in environmental management issues. According to Cendrero et al. (2001), geomorphological processes can be recognized as the backbone that

describes the relationship between man and environment. According to this reference, processes are evaluated as active hazards to human developments, but they are also responsible for configuring the landscapes or passive assets under threat by anthropogenic activity. In this context, geomorphological processes play a central role in estimating the predisposition of an environment to undergo changes due to human activity. In addition, the processes have differentiated importance over the type of morphological configuration under study and, at the same time, they are receptors of man introduced disturbances. To deduct the level of susceptibility of an 'x' configuration with respect to a 'y' intervention, process importance and process affectation need to be combined as two perturbation variables in a cross matrix.

Finally, this study only drafts a conceptual approach of susceptibility, in which the human-nature interaction is customized for a particular type of environment. For example, in marine-coastal environments the highest proportion of geomorphological processes are within the geological category, followed by climatic and hydrodynamic processes, and to a lesser extent, biogenic, geochemical and eolic processes. In other kinds of environments, the diversity and quantity of processes within these same or different categories may vary, implying that the concept of susceptibility discriminates types of environments, as well as types of human interventions. In other words, improving the ELP with the susceptibility approach would mean to customize the technical guidelines or ToR according to the type of environment to be perturbed. The novelty of this conceptual approach of susceptibility relies upon its potential application as the technical criteria for supporting the instruments of environmental management of anthropogenic impacts. The illustration of this approach in the coastal environment would recognize the particularities of the coastal landform and the varying characteristics of the human affectations. In addition, the application of this approach of geomorphological susceptibility to the variety of ecosystems in MICs, such as Colombia, would set the path for a successful transition of EIA systems from the current anthropocentric and fragmented-oriented conception toward an ecosystem-based management approach.

6. Conclusions

The review of the EIA regulatory framework in Colombia confirms several of the weakness identified in other middle-income countries. Firstly, the inventory of human interventions at the gross regional scale highlights the limited reach of the ELP on the most relevant human interventions affecting the coastal zone, as well as its disarticulation with territorial planning instruments and policies. Secondly, the assessment of the unitary and total environmental impact of more than two thousand interventions in the CCC evidence the importance of regulating human interventions based on their frequency of occurrence and type of affectation, instead of the merely economic sectors defining by the political agenda. Indeed, the Colombian ELP leaves 6 of the 10 most frequent and impactful types of interventions inventoried without guidelines, including varieties of human settlements, farming activities, and tourism developments. Additionally, a loss of restrictiveness was evidenced during the governments that ruled from 2002 to 2014, which implied that several human uses and activities were approved without an impact assessment. Thirdly, the Colombian case describes a typical EIA practice, where the environmental licensing of coastal interventions is sorely dictated by the type of intervention regulated, leaving aside the consistency of this evaluation with the natural processes influencing the coast.

On the other side, the compared results here presented states that strict controls should be applied to specific human interventions with high frequency, such as low-density settlements and hard shore protection structure, either by rigorous licensing instruments and/or by comprehensive territorial planning instruments. Therefore, small scale human developments need an improved environmental regulatory framework to limit admissible activities and/or minimum restrictive conditions to allow its implementation. The coastal environmental policies and regulations should widen their scopes and integrate all types of interventions. The ELP instruments, such as the impact assessment and ToR, should be complemented with environmental planning instruments. This study highlighted that territorial carrying capacity and coastal and marine planning are core instruments to control the environmental impact of several small but frequent coastal interventions from a precautionary approach. Accordingly, the environmental coastal regulation in MICs, such as Colombia, should move from the perspective of single and insolated intervention or sector to multiple, simultaneous, and diverse interventions at a regional scale. This novel approach requires an assessment of the susceptibility of littoral environments to the effect of all potential human activities. This proposal also implies that MICs may benefit from adjusting its ELP to effectively include such environmental susceptibility estimation as a tool within the coastal and marine policy cycle.

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Appendix A. Supplementary data

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