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Regional Plan against Coastal Erosion: A Conceptual Model for Sicily

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Abstract: Over the last few decades, Sicily has faced both erosion-related difficulties and limited Integrated Coastal Zone Management (ICZM). In particular, a lack of synergy between regional bodies, an absence of information exchange between scientific and administrative communities, the application of not-updated national and international best practices and the misrepresentation of environmental laws, have resulted in a system focused on risk erosion rather than on coastal area development. Following years without planning, in 2006 the *Regione Siciliana* launched PAI-*coste* (Hydro-Geological Asset Plan. It is interesting to note that in Italy, the "risk" known worldwide as geological or hydraulic or geomorphological is commonly denoted as "hydro-geological", creating a pseudo-neologism correctly related to the groundwater circulation and not to surficial movements.), based on a diachronic comparison between cartographies and territorial qualitative information. However, it has proved to be static and obsolete and thus requires updating in order to determine the focal points for further planning and to shift it from an e-static to e-dynamic process via the GIS and WEBGIS tools. Sicilian legislation holds all the laws necessary for the creation of a continuous flow of information between local administrations and the regional government. The aim of this paper is to determine a regional management plan for the central government against coastal erosion with the inclusion of a seasonal monitoring program carried out by the local administration as a part of the Strategic Environmental Assessment (SEA), which is in turn linked to the Plan for the Administrations of Maritime State Property (PUDM; Italian acronym). The plan will be managed at the regional level and will take into account problems and particular features at a higher rather than local level. A key outcome should be the Regional Plan against Coastal Erosion, containing constant feedback from the local administration, stakeholders and citizen groups.

Keywords: integrated coastal zone management (ICZM); coastal erosion; resilience; Strategic Environmental Assessment (SEA)

1. Introduction

From a conceptual point of view, coastal erosion (CE) is a key factor of integrated coastal zone management (ICZM) [1], and is thus important in the whole coastal planning process. Anthropogenic plans and infrastructures are both causes of and threatened by erosion processes due to the increasing occupation of coastal areas. ICZM was introduced into the global techno-political context by the United Nations Conference on Environment and Development (UNCED) in 1992 and, in 1993, into the scientific one by CICIN-SAIN [2], by whom a greater integration of coastal and ocean resource management programs was recommended. Ten years later, the Johannesburg declaration re-affirmed the importance of ICZM. The role of ICZM was defined by CICIN-SAIN and BELFIORE [3] as a necessary tool

in coastal and marine areas for the following key applications: (1) the sustainable development of coastal and marine areas; (2) the reduction in the vulnerability of coastal areas and their inhabitants to natural hazards; and (3) maintaining essential ecological processes, life support systems and biological diversity. Essentially, ICZM is a dynamic, continuous and interactive process aimed at promoting the sustainable arrangement of coastal areas by establishing a balance between anthropogenic activity, economic development and nature conservation [4]. In theory, the word 'integrated' refers to a synergy of policies, administrations and relevant experts of both terrestrial and marine disciplines. The word 'management' in its broadest meaning includes a strategic development of local policies, with the collaboration of all members involved, rather than a sectorial planning system.

Relating to this, the European Union Council resolution 94/C 135/02 (6 May 1994), underlined "once more the need for a community strategy for the integrated management and development of coastal zones, based on the principles of sustainability and sound ecological and environmental practice". Furthermore, ICZM incorporates principles important for coastal erosion management, such as the involvement of all relevant parties, local specifications and the application of long-term management plans. In order to tackle coastal erosion, an integrated approach should be employed, including practical measures (e.g., maintaining beach width, preserving dune strength, controlling cliff retreats) as well as the elaboration of management plans. From 1996 to 1999, the European Commission for the Environment put into practice a demonstration plan for ICZM by developing approximately 35 demonstration programs and 6 thematic studies. This resulted in the delivery of two documents in 1999: "Better Management for Coastal Resources" [5] and "Lessons Learnt from EU Demonstration Programmes" [6]. Following on from this, with the aim of developing coastal erosion policy recommendations, the General Directorate Environment of the European Commission launched EUROSION in January 2002, and in 2004, presented mandatory principles for effective coastal management [7]. More specifically, the following recommendations were proposed:

1. Increase coastal resilience by restoring the sediment balance and providing space for coastal processes. In the light of climate change, it is recommended that coastal resilience is enhanced by:
   a. restoring the sediment balance;
   b. allocating the space necessary to accommodate natural erosion and coastal sediment processes;
   c. and identifying strategic sediment reservoirs.
2. Internalise coastal erosion costs and risks in planning and investment decisions. The impact in terms of costs and risks of human-induced coastal erosion should be controlled through a better internalization of coastal erosion concerns in planning and investment decisions.
3. Coastal erosion management should move away from piecemeal solutions and adopt a planned approach based upon accountability principles. This will help to optimise investment costs against risk, increase the social acceptability of actions and maintain options open for the future.
4. Strengthen the knowledge base of coastal erosion management and planning through the development of information governance strategies.

These recommendations should be taken as the starting point in order to determine a proactive approach to data and information management for institutional leadership on a regional level, with the incorporation of information on 'best practice' (including learning from failures).

Several EU member states have demonstrated "strong" forward-looking responses to coastal erosion, such as the planned retreat practices in Denmark. Similarly, the French Ministry for Ecological Transition is developing a new legislation for coastal zone adaptation to the effects of climate change. Moreover, in Spain, the Ley de Costas is promoting the demolition of buildings that invade maritime and coastal state property.

There is an urgent need for Italy to manage the urban areas highly affected by the morphology of its territory, dominated by the Alpine and Apennine ridges that over the years have forced the population to move towards the coastal areas which have a total length of 7546 km, the second longest in Europe after Greece.

Numerous Italian regions have offered interesting management plans, focusing on the holistic needs of the coastal areas [8–10]. In Sicily, however, there is a lack of coastal planning, just focused on local or sectorial erosional rates, which had previously caused severe damage to the natural and archaeological-cultural heritage.

It is important to note that, until 2019 (in the pre-COVID-19 era), about three quarters of the Sicilian surface was used for agricultural use, the tourism industry accounted for 15% of the regional GDP, with about 5 million arrivals and 14 million people as an annual presence (Piano Regionale di Propaganda Turistica, 2018 [11]); also, the fishing industry plays an important role in Sicily: about 20% of the fish yield in Italy is caught in the waters around Sicily. Nevertheless, unemployment in 2019 stood at around 22.3% of the population (data from National Institute of Statistic—ISTAT [12]).

The failure of previous regional plans for coastal management can be due to the following conceptual observation:

1. The lack of synergy, both among the different regional organisms and between regional and local authorities.
2. The absence of updated data and information exchange between the scientific community and the administrative system.
3. Copying both national and international best practices without adapting them to the local context.
4. Lack of public sharing and transparency procedures of decisions and administrative acts.
5. Excessive misrepresentation of the laws, particularly those referring to city planning and the environment.

In the current paper, we provide a conceptual road map to configure a regional plan for coastal erosion, overcoming the current limitations and integrating local aims with strategic goals.

In this way, the aim is to create a regional management plan against coastal erosion with the inclusion of a seasonal monitoring program carried out by local administration as part of the Strategic Environmental Assessment (SEA), which is in turn linked to the Plan for the Administrations of Maritime State Property (PUDM, Italian acronym).

The plan will be managed by a "control room" at the regional level and will take into account problems and particular features at a higher rather than local level. A key outcome is the Regional Plan against Coastal Erosion, containing constant feedback from the local administration, stakeholders and citizen groups.

The proposed planning policy must include regional databases and takes into account local needs, framing them in a wider and clearer territorial context based on geography, cultural and touristic potential, and economic interest. Furthermore, extensive investment should not be required, and a new legal framework should be avoided. The technical costs should be distributed over as many bodies as possible, and full use of the available information from different authorities should be made.

2. Materials and Methods

The new regional plan against coastal erosion, rather than simply defining the areas at greatest risk of erosion, will have to provide a suitable tool for safeguarding and enhancing the huge natural, archaeological, cultural, infrastructural and economic heritage of Sicily. In fact, the correct planning and the correct implementation of the interventions to mitigate erosion phenomena requires the identification and adoption of adequate decision support tools, which favor a broad participation of local communities in strategic choices, and their sharing. structural or non-structural interventions to be carried out. For this reason, it is necessary to use, as a data and information management tool, a WebGIS platform which, as is known, allows access to all the information relating to the Sicilian coasts of an environmental, urban and territorial nature currently held by various public administrations.

The plan must also be drawn upon the basis of the "National guidelines for the defense of the coast from erosion and the effects of climate change", elaborated by the National Table on Coastal Erosion (TNEC) - MATTM - Regions, with technical coordination ISPRA.

The specific objective is to create a dynamic tool that allows the integration of defense interventions in a plan logic, through the implementation on a regional scale of coastal enhancement criteria with a view, as already mentioned, of sustainable development and environmental protection.

Geographical Framework of Study Area

Sicily, with its 1623 km of coastline (Figure 1), occupies an intermediate position in the European chart for linear coastal development, after Estonia and before Holland [13], and this shows in the extraordinary variability of geo-diversity [14].

Figure 1. Sicily in the European contest.

Using 3 × 3 m resolution satellite imagery, provided by the Sicilian Region for the new coastal plan, the perimeter of Sicily was estimated, combining lithological and morphological observations. A total of 24% of the coastline is composed of rocks in the form of low carbonate platforms (such as those in the areas of Ragusa and Trapani) and headlands (carbonate in Agrigento, metamorphic in Messina and columnar basalt in Catania). The remaining 69% is composed of bays (primarily sandy or pebbly beaches), of which more than 400 km (27%) exhibits major or minor erosion problems. More than 110 km (7%) encompasses port facilities, embankments and riverbanks (Table 1).

The principle Sicilian cities, such as Palermo, Catania, Messina, Syracuse and Trapani, are located on the coast, as well as other 129 municipalities (126 in Sicily and 7 in the minor islands). These areas are associated with the breakdown of coastal erosion management. Furthermore, the spread in the construction of second homes has favored the hyper-urbanization of the 300 m Sicilian coastal belt. This phenomenon began in the early 1970s as a consequence of the economic boom affecting the island during the 1960s and the subsequent extension of small fishing villages on the coast. During this period, the coastal area was transformed from a resilient system with occasional interruptions to a

continuous, rigid environment. The destruction of the dune line marked the initiation of the first erosion events of beaches that had previously been stable.

Table 1. Variability of coastal facies both in percentage and kilometers (including minor islands).

	Coastal Facies	*Length*	*Percentage*	*Total*
Coastal Perimeter of Sicily	Cliffs	392.4 km	24.2%	93%
	Beaches	1117 km	68.8%	
	Artificial coasts	113.6 km	3.0%	7%
			4.0%	
	Advancing coasts	324.6 km	20.0%	96%
	Stable coasts	795.3 km	49.0%	
	Eroding coasts	438.2 km	27.0%	
	Not valuable	64.9 km	4.0%	

In Sicily, using the same satellite imageries as above, 1348 anthropic works, going from an 18-armed river mouth to 162 ports and thus passing through 1168 rigid defense structures: practically a defense works every 1.39 km was detected.

3. Discussion

3.1. Existing Plan

Coastal erosion becomes a socially relevant issue for municipalities and local authorities when a storm surge erodes a local beach, demolishes a promenade or affects seaside houses and public services. Furthermore, the concerns of environmentally aware groups are raised when natural coastal parks come under threat from erosion. During the 1980s and 1990s, erosion-related problems were tackled by employing extreme measures of high urgency with hard engineering methods (e.g., seawalls, breakwaters and groynes) upon the request of local authorities. These measures were able to protect the land located behind coastal areas, yet the erosive process was shifted down-drift.

The "Funding Program within Measure 1.2.4—Integrated Safeguard of Coastal Areas", P.O.R. Sicilia 2000–2006, introduced several forward-looking guidelines for coastal planning. These include "sandy coasts defense projects" based on respecting the coastal environment and eliminating the causes of erosion. Within this programme, 17 initial interventions were performed, followed by several other "soft" engineering methods that were funded for the defense of sandy–pebbly beaches. However, these efforts included limited beach nourishment in terms of volume, with the absence of maintenance and monitoring activities. Furthermore, the beaches were protected by hard structures, which were generally costly and located under water. The interventions failed to counteract the causes of erosion. After several years, the projects lost their effectiveness because of the small quantity of sand fill and the absence of refilling and monitoring. Meanwhile, the implementation of a real management plan, which was essentially lacking before, began to be necessary for the EU.

Thus, in 2006, the *Regione Siciliana* launched PAI-*coste* (Hydro-geological Asset Plan) [15], based on a diachronic comparison between the cartographies and territorial qualitative information (from the media and occasional personal communication with technical staff). Although PAI-*coste* undoubtedly allows for a greater understanding of the regional coastal system, it holds the several basic conceptual problems:

1. The dimension of each physiographic unit (sedimentological cell) is too large (64.4 km on average for each of the 26 physiographic units (PU), divided by 123 municipalities, including minor islands); they include too many municipalities that complicate any synergise among them.

2. The plan is based solely on cartographical updating (the last of which dates back to 2006). Thus, it does not take into account any kind of regular implementation and only considers the surficial evolution over time. The latter is strongly affected by basic errors such as cartographic distortion.
3. The beach sediment characteristics are not clearly defined, with just a vague indication of shoreline seasonal variability, and cliffs are completely ignored.
4. The wind/waves analysis is insufficient and does not include the monitoring of data or extreme events.
5. The plan only considers local erosion, overlooking other crucial requirements for effective coastal planning, including: (a) the potential impact in a wider territorial context; (b) the cost–benefits valuation and (c) the socio-economic and touristic framework reflecting the island's development opportunities and (d) and the effects of human structures as ports or defense structures.

Furthermore, PAI-*coste* employs a coast-classification methodology based solely on the danger-risk postulate using a 1-to-4 risk scale, without considering the specific value of different areas in terms of economy, environment and tourism. In particular, it focuses on local critical areas while omitting the causes of the crises and fails to provide indications regarding management and development techniques.

PAI-*coste* is locally implemented upon the request of city councils observing a specific erosive process in their territory. Thus, by upgrading the local risk level (e.g., from 3 to 4), the city council in question can request an emergency defensive measure. Such a system, in fact, has resulted in a fragmented relationship between the central government and local administrations. In addition, the lack of a (continuously implemented) dynamic plan that can be shared online prevents the flow of information among stakeholders and citizens, who consequently remain distanced from any decision processes.

Currently, new EU-funded items focus on counteracting geological hazards, such as landslides, alluvial floods and coastal erosion. However, it is unlikely that these interventions, which are based on planning made back on 2006 cartography and projects which are often old and based on the particular needs of clients, can fulfil expectations. Any sustainable coastal defense policies should consider both environmental needs and those of the local population, and should be based on the constant management of the existing situation, rather than on expensive emergency measures. That is, local administrations should constantly monitor the shoreline evolution in order to allow for soft sand maintenance work, thus avoiding severe erosive processes that require heavy structural works.

3.2. Towards a New Planning Vision

In 2019, the system started to change and the President of the region, using the structure of the Commissar for the hydro-geological emergencies in Sicily, introduced the Coastal Contract for some homogeneous part of the territory which had separately received funds for coastal protection intervention. In the framework of the Coastal Contract, the Commissar re-drew the strategy for the intervention in a synergic vision, at least avoiding an upsurge of downdrift erosion effects. This action was applied to two areas of the region where specific erosion problems were present.

The Coastal Contract consists of the stipulation of an agreement among coastal municipalities, belonging to a homogeneous area, in putting together the funds previously obtained by the National Government, for the defense against erosion, and to undertake together a cognitive and management plan to create a synergy of actions, such as not to create damage downdrift.

This form of collaboration, managed in a very streamlined and fluid way at the regional level, is less automatic at the local level so that in the two areas identified, one in the north-central sector of the island and the other in the extreme south-eastern sector, it has not yet brought about a real result (areas highlighted in Figure 1).

With the aim to continue on the footsteps of these first positive results and not wanting to disperse the information however acquired with the *PAI-coste*, a first step in the Regional Plan Against the Coastal Erosion has been to define a more structured hierarchy of the coastal areas, following the Linee

Guida del Tavolo Nazionale contro l'ErosioneCostiera (TNEC) to analyze the shoreface evolution and the sediment movement at different scales, above all under pressure of both direct anthropogenic activity and the preliminary effects of Climate Changes.

For these reasons, three orders of territorial sectors were identified, considering also the archipelagos and isolated islands around Sicily (Figure 2):

1. Physiographic units, in the strict sense, I order, delimitated by natural structures (capes, promontories), resuming those ones identified by the Geoportale Nazionale: 10 sectors;
2. Macro-cells, II order, identified by capes, promontories and larger ports such the physiographic units considered *PAI-coste* of Sicilian Region (2006): 26 sectors;
3. Management units, III order, specifically identified for the Regional Plan Against the Coastal Erosion considering capes, promontories, also minor ports and isolated points: 58 sectors.

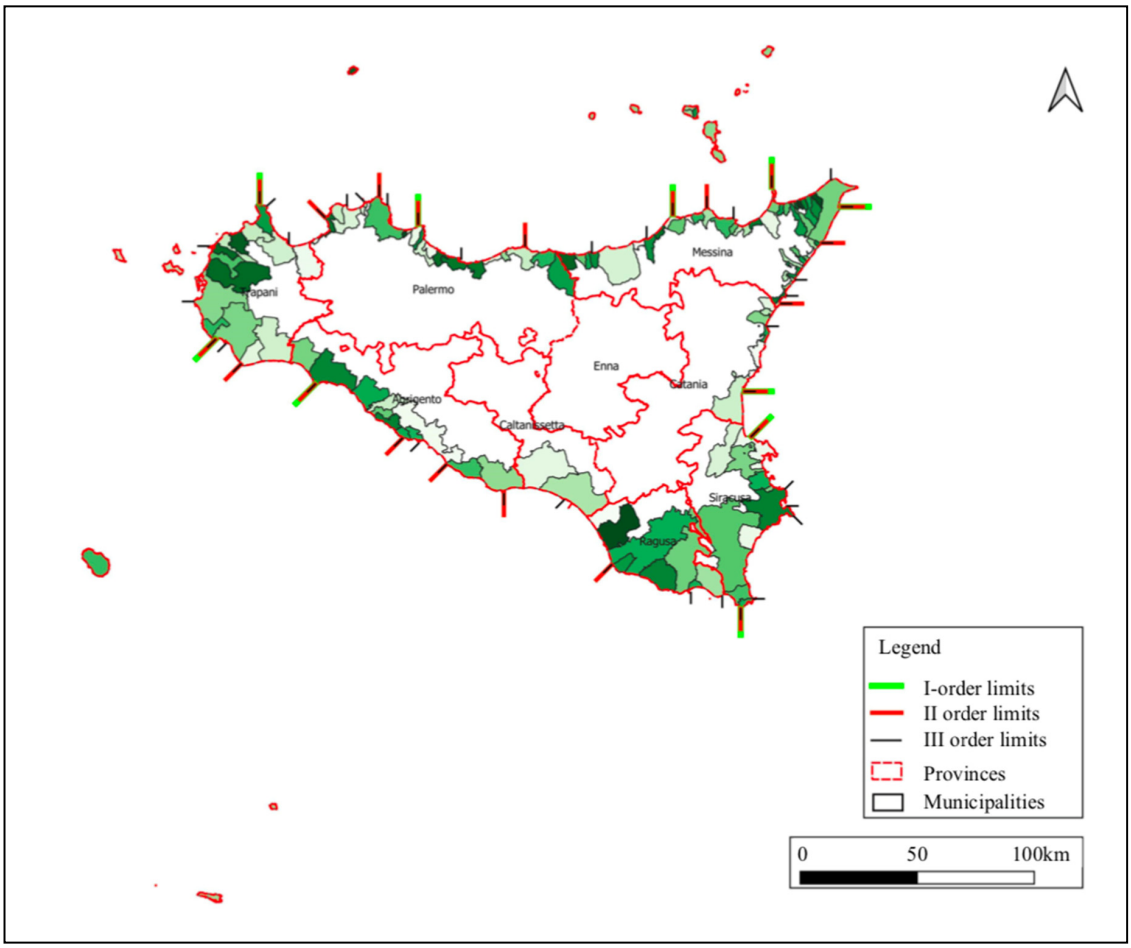

Figure 2. The proposed physiographic unit (PU) partition to create a better interaction among bordering administrations. For each archipelago, there is coincidence between I and II PU order, while each island is a III order PU.

In the first order, the main driving forces such as winds, waves and currents should be considered; the second order needs to monitor coastal evolution and sediment drift, while the third one needs to coordinate the different local administration towards a common effort.

Because of that, it is necessary to draft a plan to collect information from the local grassroots level and convey this information to higher levels, extending it to a wider context (from management units to macro-cells and to physiographic units). In addition, the needs of specific areas should not be neglected, particularly in such a physically diverse territory with varying administrative systems.

To ensure a faster transposition to the new coastal plan in Sicily, it should be based either on existing techno-legal tools or on the implementation of the existing plan.

At the local level, public administrations must draft information on their own coastal space in order to build the Plan for the Utilization of Maritime State Property (PUDM, Italian acronym) for the management of different activities along the shore. Following the assignment of the PUDM, performing a Strategic Environmental Assessment (SEA) will provide the necessary local information for the regional authority to obtain a draft a plan for the whole island, taking into account the optimum physiographic setting and marine climatic features.

The PUDM is drafted in order to respond to specific legal demands, but, at the same time, it is promoted by City Councils in order to enhance and redevelop the entire coastline. This combines the need for maritime state property safeguards and protection with the requirement to strengthen city identities and tourism potential. In particular, the latter should be undertaken with clear projects that include investment in infrastructure within the applicable urban and environmental legislation. Furthermore, the Strategic Environmental Assessment (SEA) initially assesses the environmental context quality, accounting for the local population's approval of the council's choice, and subsequently monitors the environmental evolution.

PUDM is not merely a beach plan, as it accounts for the eco-systemic development goals of the local administrations. The PUDM and SEA are regulations that form part of the regional legislative framework and are considered as simple administrative steps (rather than technical instruments) with great potential in improving the coastal system management. The correct use of these regulations will guarantee, from a technical point of view, the correct flow of information between local administrations and the region due to the updating and dynamic planning of the document.

The creation of a bottom-up plan, supported by a monitoring system and integrated into an existing legislative framework, can overcome these bottlenecks.

Therefore, the introduction of a dynamic planning process for coastal areas is urgently required, with the maximum involvement of local administrations and stakeholders. The decision process needs to be reversed from "top to bottom" to "bottom to top", giving the regional level the right to coordinate and manage real information related to real territorial needs.

We outline a local reference framework based on the correct application of the laws and the PUDM and SEA drafts as follows:

1. Direct awareness of the coastline and local management plans (PUDM).
2. Environmental report (SEA), providing the geomorphological, sedimentological, and environmental framework.
3. Approval by the local population, after public consultation (SEA).
4. Long-term seasonal verification, based on the monitoring phase of the SEA.

As the starting point, (time "0"), from the technical point of view, the new coastal plan should be based on the last available PAI cartography (currently the 2006 version with some local implementation), re-drawing the new order of PUs, according to the Coastal Erosion at National Level [16] indications.

The plan must be updated to 2020.

The diachronic evolution of the coastal system until the 2006 PAI cartography can be implemented using high-resolution satellite images in order to monitor the shoreline evolution and to evaluate the land use changes of inland areas. To consider also the seasonal physiologic evolution both the spring–summer and fall–winter coverture must be used. The double yearly acquisition represents the rate of data acquisition that the plan must respect in order to keep fit and functional.

Sedimentological data, from EU projects (EUROSION, BESS, M.E.S.S.I.N.A.), local monitoring plans (Ragusa [17,18] end Messina [19]) and private, local administration and scientific documents, can be used to implement knowledge on the dimension, color and composition of beach sediments. The acquisition of these data should fill up the lack of synergy between regional bodies and scientific community.

The sedimentological dataset should be completed with the definition of the borrow material deposits for beach nourishments (marine, coastal, fluvial, dams and occasionally) and their compatibility with the sediments of the beaches.

Cliffs, which were completely ignored in the previous PAI, should be included as a separate section in the plan. Cliffs represent an important risk item, particularly due to the touristic importance of numerous locations that contain cliffs (e.g., Scala dei Turchi, close to Agrigento, and the Bay of Isola Bella under Taormina; Figure 3).

(**a**) (**b**)

Figure 3. Spectacular cliff views by drone: at (**a**) Scala dei Turchi and at (**b**) Taormina Bay (with the snowy Etna volcano on background).

In addition, the plan should provide, for the first time for Sicily and perhaps among the first examples in Italy and in Europe, an in-depth study on the local scale of wave action. The wave data for all first-order PUs were defined at the −20 m isobaths, and therefore for each second-order PU, the approach to land was proposed, taking into account the slope of the submerged beach between 0 and −10 m to define at the local level (third-order PUs) the littoral drift.

The data collected on the aforementioned variables can be combined in the form of GIS layers, representing a new tool for the regional government with an interactive planning process that involves the feeding and implementation of data by the local government. The technical-administrative process required to support a new conceptual plan should start at the local level with the development of the PUDM and SEA. The results of these planning instruments will guarantee the collection and updating of GIS data which will subsequently be used to create a WEBGIS tool for politicians, stakeholders and the general population (Figure 4).

From a strictly technical point of view, with regards to seasonal monitoring, topo-bathymetric, geomorphological, sedimentological and environmental parameters should be collected in order to evaluate the evolution of the local territorial context from different perspectives. At present, the use of drones with high-resolution cameras and laser scanners, allows for the rapid and low-cost monitoring of beach volume, length and shape. This information can be integrated with a continuous monitoring system via remote cameras positioned on lampposts that film the beach at regular intervals. Such a technique can provide data on variations due to wave direction and intensity [20,21].

Sediment analysis performed with seasonal samples helps to highlight the "thickening" or "thinning" phenomena, or the compositional variation of sediments. This provides information on the evolutional trend of deposits. Furthermore, data derived from high-resolution satellite imagery can determine the presence/absence of marine phanerogams, with an indication of limits and depth, if present. The images can be validated with ground control surveys (e.g., baseline bathymetric survey extended to the closure depth) [22].

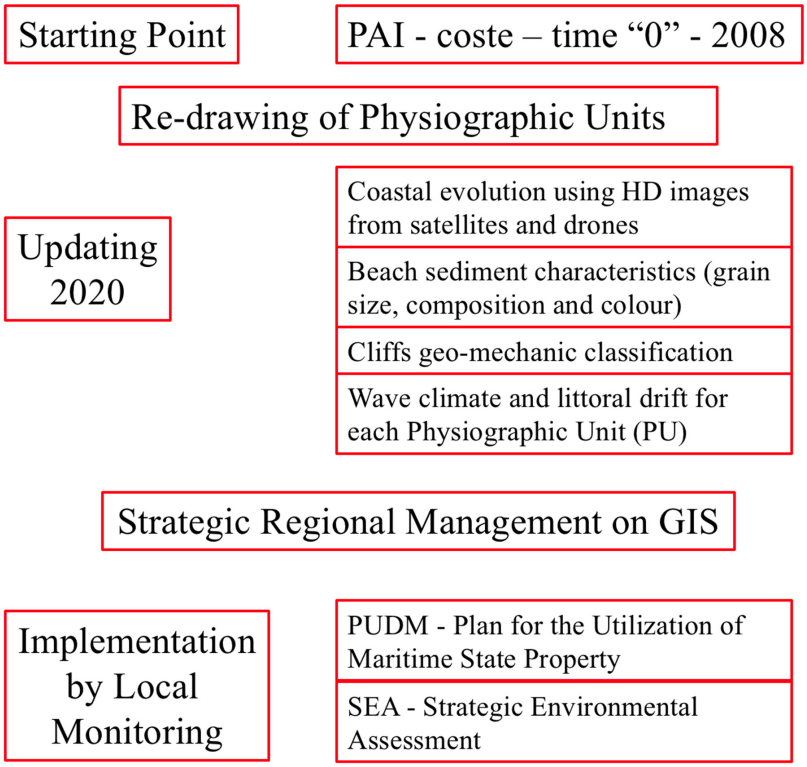

Figure 4. Flow chart of the proposed coastal plan against coastal erosion.

The use of GIS is of fundamental importance in the study of coastal management, in fact by exploiting the main capabilities of the tool it is possible to represent the individual parameters that fall within the regional planning phase and therefore create a database with all the coastal monitoring data.

In the GIS, any represented element is equipped with a symbol, with spatial coordinates that represent it and with a series of numerical and/or alphanumeric information attached through a shapefile.

The possibility of superimposing different layers of data, in order to obtain a unitary view or choose a comparison between two or more layers, allows to extrapolate more information and achieve better information awareness (Figure 5).

The local population should be maintained informed about the processes and the plans drafted by their local administration. Individuals should have access to WEBGIS and eventually to plan's non-technical summary, with further information provided via the internet, press and television. Once the population has been informed and understands the processes and plans, they should be able to make their views heard. The regional level authorities will therefore be aware of the population's needs and wishes.

At the regional level, all data acquired locally must be managed and contextualized according to true regional development needs in order to create a realistic, verifiable and implementable planning tool. This data will be added to the territorial socio-economic context of the area and integrated with the marine climatic and territorial dataset of the Physiographic Units.

The regional management of coastal areas will allow the development of territories via targeted and diversified investment and synergic measures which will not necessarily aim in building new structures but at eliminating the structural causes of erosion. Moreover, central management will determine the appropriate data using locally-derived information and by considering the socio-economical characteristics and development of the territory. Politically relevant areas will be separated from touristic areas with a high economic potential and hotels with a gross domestic product originating from outside the island.

Shoreline	Definition of contour "0" and local administrative limits: municipalities and provinces	
Physiographic Units:	I order II order III order	
Coastal Sediment	Date; XYZ; Mean Size, Standard Deviation, Skewness, Kurtosis, Mode, Φ50; Composition (%): Light and Heavy minerals, Calcite, Shell fragments, Phoraminiphera, Spicule sponge; Fragments of Carbonates, Vulcanite, Metamorphic, Sedimentary; Micha and Aggregates.	
Monitoring sections	1663 orthogonal sections from -1m to the limit of the beach; 1 for beach 300m length, 3 for beaches from 300 to 1,000 m length, 1 section each 500m for beaches longer than 1,000m.	
Beaches	To define and code the 774 beaches (about).	
Coastal Type	Rocky	High Low
	Artificial (lined channel river mouth)	
	Ports	
	Mobile shoreline (beaches)	Natural Urban Pocket Beaches Protected
Hydro-Geological Asset Plan (PAI)	GIS layers from PAI (2006) to include in the GIS project	
Sic e Zps	Delimitation of both Site of Community Importance (Directive Habitat 92/43/CEE) and Special Protected Zones (Directive Birds 79/409/CEE).	
Land use	From 1990 European Union produces, each 6 years (about), a 44 classes land use map of the whole territory. For the GIS 2018 Corine Land Cover (1) upgrade can be used	
***Posidonia Oceanica* and coralligenous**	Two different sources can be acquired: 1) 1999 - 2002 monitoring provided by the Service for the Sea Defense of the Ministry for Environment and 2) 2014 - 2018 monitoring provided the Regional Agency for Environment Protection (ARPA, Italian acronym) within the Marine Strategy Directive (2008/56/CE).	
Hazard	Stretches of coast under erosion have been classified in terms of hazards on a 4 levels scale, using: erosion trend, waves and morphology (the valuation method is under improvement).	
Wave Analysis	Offshore Waves at the I order Physiographic Unit and Coastal Waves at the III order Physiographic. In both case it should be possible to visualize the results linking each single sector trough dedicated layers.	
Coastal Works	On the 3x3 meter resolution satellite imageries, list of: armed river mouth, stone islands, mixed works, emerged "T" groynes, oblique emerged groynes, oblique submerged groynes, emerged orthogonal groynes, submerged orthogonal groynes, seawalls, continuous breakwaters, breakwaters, continuous submerged breakwaters, submerges, ports and peers.	
Brief Records	For each of the 126 municipalities of Sicily and on for each minor islands.	

Figure 5. Concise record of the GIS structure. (1) "Technical Guidelines" (EEA, 2017) [23] based on CLC2006 Technical guidelines (EEA Technical Report No 17/2007) [24] with the CLC2012 Addendum to the CLC2006 Technical guidelines (ETC/SIA report) [25].

Previous interventions were expensive hard structures that gave rise to the need for further construction. The availability of a widely-diffused and implemented knowledge of the territory will allow for the employment of low cost and low action targeted actions, including:

1. Restoring of beach resilience.
2. Identifying local strategies to re-establish the local sedimentary budget:
    - management of harbour sediments;
    - repositioning of wind-transported sediments;

- re-naturalization of river solid load;
- redistribution of sediments along the same beach;
- self-nourishment, using small quantities of sediments deposited in the area during the winter season.

3. Defining strategic deposits of borrow sediments for beach nourishments:
   - submerged relict deposits;
   - fluvial overflows;
   - dam infilled sediments.
4. Limiting the damage due to coastal erosion with small and continuous management interventions, for example, covering beaches with permeable nets, *Posidonia Oceanica* leaves, and accumulating sediments in the back-beach.
5. Protecting the equilibrium of naturally protected areas.
6. Defining the borders in order to grant concessions for mining deep sediment deposits.

Such technical information, which is acquired locally, would subsequently have to be conveyed centrally to be applied to wider Physiographic Units via the integration with marine climatic features, port presence or interference and hospitality/tourism potential. Thus, the local logic of emergency measures is abandoned, and the proposed strategies can be framed within a wider context, limiting the negative down-drift effects, and obtaining a planning system that takes into account not only a single beach but the entire region's economic growth. A dedicated Central Coastal Office within the Regional Ministry for Territory and the Environment (ARTA) will manage this bureaucratic technical path based on the existing legislation.

Replacing a static and centralist planning phase allows us to abandon an old way of thinking and an outdated development pattern based on evident limitations that not only affect costal planning, but also the economic, social and political spheres that are sensitive to the current global metamorphosis. The new democratic vision, based on the stay-connected principle, allows for a continuously evolving planning system that undergoes constant monitoring. Informed public participation cannot be avoided any longer as it is now authorised by the present legislation in Sicily.

4. Conclusions

In order to meet the needs of the management, the predictive elements of the coastal management plan are applied to implement low-level maintenance work at the beginning of the erosive process. This is done by modifying the original causes of erosion and limiting its effects. For example, the removal of old constructions which are now useless and obsolete, the reshaping of coastal morphological elements, and redesigning external profiles of such structures (e.g., seafront walls and coastal roads), would favour an improved balance of the coastal system.

The correct planning of coastal areas based on objective data and framed within a context that takes into account both the relevant physiographic unit features and their touristic appeal is indispensable for planning systems. In particular, touristic appeal includes the sun and sea, historical, archaeological, naturalistic, cultural (e.g., food, wine and cinematography) resources and hospitality potential.

In the past, both Sicily and southern Italy in general have demonstrated a tendency towards underdeveloped well-defined plans. Instead, a programmatic vision was followed, allowing the requests of local administrations to be met. In the last two decades, following the spirit and the rules of the European Union, an organizational plan has been drawn up prior to the realization of any intervention. However, this plan proved to be rigid and soon became obsolete.

A regional plan against coastal erosion should be a dynamic and easy to implement process for interventions framed at the correct scale, overcoming administrative borders and exhibiting a resilient spirit. The proposed coastal plan, together with the local plans (PUDM and SEA), will permit the seasonal implementation of the geomorphological and sedimentary datasets, and will increase the environmental knowledge of the different areas.

Furthermore, the GIS dataset will permit the execution of the dynamic process necessary to implement the coastal plan. The application of WEBGIS to translate the GIS information into an online database will result in constant feedback from stakeholders, environmental groups and citizens who will consequently feel more involved because of the transparency of the planning activities.

The trigger of this virtuous circle of "bottom–up territory" should focus the management proposal towards a resilient route and attract more attention from local citizens, who will become increasingly aware of their rights and the ability to defend them via the internet.

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