Adaptation Plan for Banco Mula di Muggia

Final Version of 30/11/2021

Deliverable Number 5.5.2

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Summary

1 Foreword

This document has been produced in the framework of the INTERREG Italy – Croatia CHANGE WE CARE Project. CHANGE WE CARE fosters concerted and coordinated climate adaptation actions at transboundary level, tested in specific and representative pilot sites, exploring climate risks faced by coastal and transitional areas contributing to a better understanding of the impact of climate variability and change on water regimes, salt intrusion, tourism, biodiversity and agro-ecosystems affecting the cooperation area. The main goal of the Project is to deliver integrated, ecosystem-based and shared planning options for different problems related to climate change (CC), together with adaptation measures for vulnerable areas, to decision makers and coastal communities. Additional information and updates on the CHANGE WE CARE can be found at https://www.italy-croatia.eu/web/changewecare.

2 Aims and content of the document

This document is the guideline for Adaptation plan in the Banco Mula di Muggia pilot Area and corresponds to the Deliverable 5.5.2 indicated in the Application Form. It represents the synthesis of adaptation/management Plans for the Pilot Sites, where the shared knowledge base on the present and expected dynamics of coastal systems in the cooperation area and Pilot sites, built in WP3 and WP4, is conveyed. The definition of such Plans is foreseen to be pursued by means of participatory processes (cf. Deliverable 5.5.1) determined in order to get all information available, shared decision and consensus by the stakeholders to make the Plan effectively implementable in a collaborative way by all subjects and decision makers involved. The Adaptation Plans will be developed taking into account outcomes of WP3, WP4 and of the Participatory process itself, including shared vision, objectives, measures/ actions/ interventions.

3 General site description

The study area, entirely included in the Municipality of Grado (Friuli Venezia Giulia Autonomous Region) is located between the Grado inlet and the mouth of the Isonzo River, in the Gulf of Trieste, northern Adriatic, Italy (Figure 3-24) (13°24'36" - 13°28'15" East and "45°21'17" - 45°39'30" North. It represents the easternmost part of the system of barrier islands bordering the Grado Lagoon and is nearly entirely devoted to tourism and agriculture. Here, the coastal area has undergone significant changes in historical times due to natural processes but also to anthropic actions i.e. land reclamation and tourism development.

Grado is a tourist town with approximately 8,000 inhabitants, which more than triples during the summer season; the number of nights spent in tourist accommodation is ca. 1.4 million per year (2017). Grado Pineta is a touristic district of Grado having several hotels, restaurants, second houses, and a small marina (Punta Barbacale). Four big camping-resorts with fully equipped beaches are located in the eastern part, between Grado Pineta and the Primero inlet. Most of the beaches are equipped, with services for tourists.

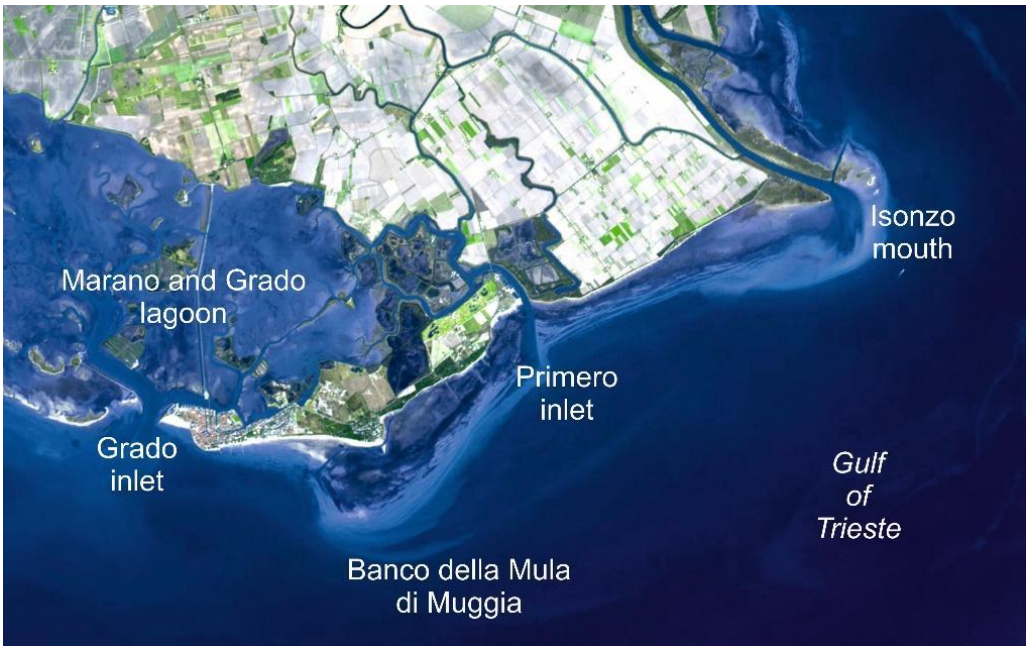

Figure 3-24 Overview of the study area.

The area is well connected by land, air and sea. Two regional routes connect Grado to the highway A4 and Trieste is about 1 hour of trip by car. The Trieste airport is about 20 km and railway stations are at the

same distance. A seasonal service connects by boat Grado to Trieste and an efficient cycling network connects the site to the mainland.

The tidal magnitude is unusual for the Mediterranean Sea, with semidiurnal mean and spring tidal ranges of 65 and 105 cm respectively. The passage of atmospheric low pressure systems is able to amplify tidal water levels up to 160 cm: the so called “acqua alta”. Climate is temperate, influenced by ENE (Bora) and SE (Scirocco) winds.

The banco della Mula di Muggia is a system of active and relict sand banks, which extends up to 2 km seawards. It can be divided in two parts with arcuate triangular shape divided by the tidal inlet of Primero: the Banco della Mula di Muggia s.s. and the delta complex of the Isonzo River. The Banco Mula di Muggia can be considered as a barrier-island system i.e. an elongate accumulations of unconsolidated sediment that separate the open sea from a landward restricted basin (Figure 3-25). The main sediment source is the Isonzo River, which represent the eastern limit of the study area.

The succession of sandy bars (between -2 m and -5 m) if the Mula di Muggia is arranged in the form of an arc and represents the outer limit of a wide muddy intertidal area partially covered by seagrass (Figure 3-26). Historical data document the presence of the bank morphologies since 1822, long time before the urban development of the area. The present Isonzo delta consists of a delta structure stretched out along the mouth of Sdobba, which became the only distributary channel after the occlusion of the Quarantia branch in 1937. It has a typical river-dominated form, with a single elongate distributary, about 1300 m wide at the base, and 700 m wide at the mouth, extending ca. 1 km in NNW-SSE direction. A series of sandy bars characterize the delta front.

Figure 3-25 Aerial view of the Banco Mula di Muggia.

Figure 3-26 The western part of the Banco Mula di Muggia: the sandy bars and the muddy intertidal zone.

In the pilot site two areas are designated in the Natura 2000 network (Figure 3-27): SPA Valle Cavanata e banco della Mula di Muggia IT3330006 and SPA Foce dell'Isonzo - Isola della Cona IT3330005, both designated also as SAC.

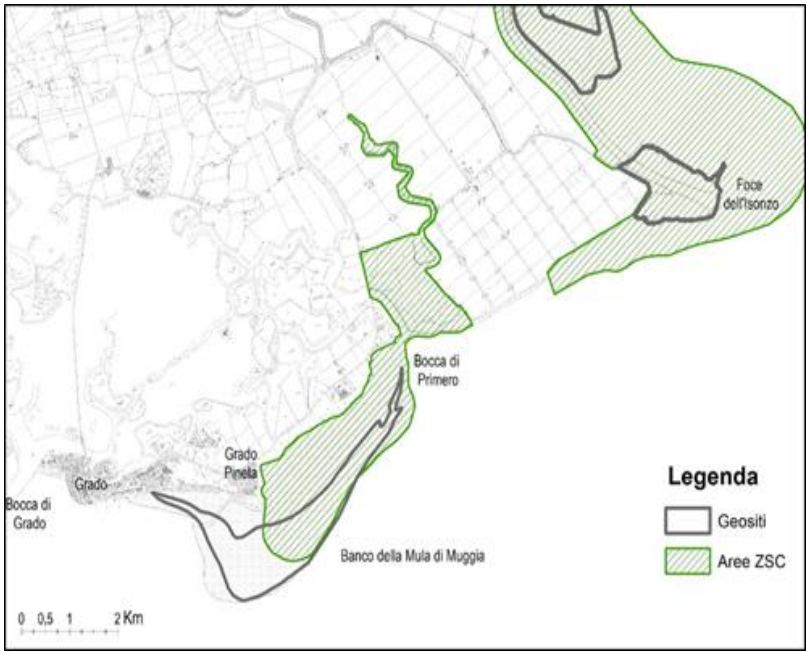

Figure 3-27 Natura 2000 site and geosite perimeter.

4 A statement of the pilot sites managing authorities

Most of the offshore area is designed as the Special Area of Conservation IT 3330006, managed by the Regional Administration (Regional Law 07/2008). The offshore area is property of the Italian State, most of the beaches are managed as private properties under state concession. The Regional Law 11/2015 confirms to the Regional Administration the soil protection function for the realization of the defence and conservation interventions of the coasts with the exception of the inhabited areas, where the task is assigned to the Municipalities.

The Municipality of Grado is the managing authority for the onshore area. The municipal general regulatory plan (PRGC) regulates the activities and incorporates all the constraints deriving from other higher-level plans.

4.1 Management plan of Natura 2000 network

In the pilot site, two areas are designated in the Natura 2000 network (*Figure 4-1*):

- SPA **Valle Cavanata e banco della Mula di Muggia** IT3330006 (National legal reference of designation DGR n. 435 del 25/02/2000), designated also as SAC (National legal reference of designation DM 21/10/2013 - G.U. 262 del 8-11-2013). Includes a former "fish farm", remnant of the eastern portion of the Lagoon of Grado, which after agricultural reclamation has been completely dammed and equipped with adjustable locks communicating with the open sea. Over half of the total 860 hectares of the site are at sea and involve part of the shallow waters of the Mula di Muggia Bank, with vast areas of tidal flats and periodically emerging sandy bars. The conservation measures are reported in DGR 546 del 28.03.2013 “Misure di conservazione di 28 SIC della regione biogeografica continentale del Friuli Venezia Giulia”, 1° supplemento ordinario N. 15,10 aprile 2013 al BUR n. 15,10 aprile 2013 http://bur.regione.fvg.it/newbur/visionaBUR?bnum=2013/04/10/15_1
- **SPA Foce dell'Isonzo - Isola della Cona IT3330005 (**National legal reference of designation DGR n. 435 del 25/02/2000), designated also as SAC (National legal reference of designation DM 21/10/2013 - G.U. 262 del 8-11-2013). The site includes (for a total of 2668 ha) the terminal part of the course of the Isonzo River with the adjacent floodplain areas, the mouth area of the river and a coastal marine area that expands both north and south from the mouth. The perimeter only partially coincides with that of the Regional nature reserve (Riserva naturale regionale). The conservation measures are reported in the *Piano di gestione della ZSC e ZPS IT3330005 Foce dell’Isonzo (Approved by DGR n. 429 del 15.03.2019 e DPReg 46 del 22.03.2019, 1° supplemento ordinario N. 10, 3 aprile 2019 al BUR n. 14, 3 aprile 2019.* For those parts of the ZSC SPA belong also to the Regional Nature Reserve of the same name, the rules of the management plan are integrated with those of the Conservation and Development Plan (DPReg. 11 marzo 2008 n. 077/Pres., published on BUR n. 13 26.03.2008; modified by l DPReg. 29.11.2012, n. 0243/Pres. published on the 1° supplemento ordinario n. 35 del 12.12.2012 al BUR n. 50 del 12.12.2012

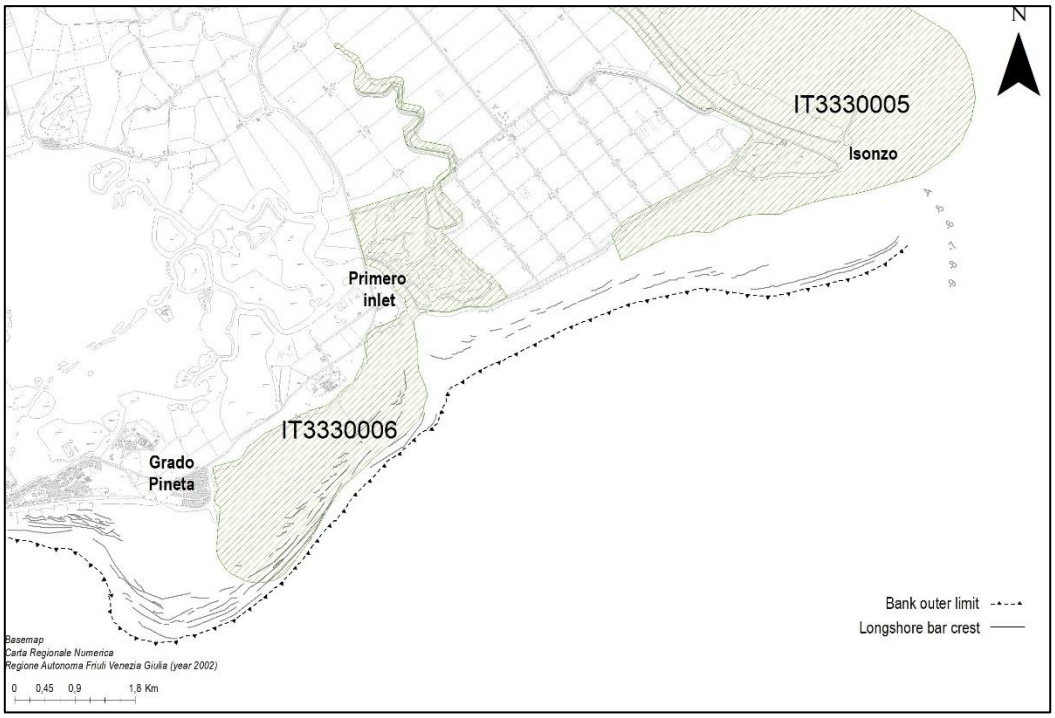

Figure 4-1-Perimeter of the Natura 2000 sites in the pilot site.

4.2 The Municipal General Regulatory Plan (PRGC)

Every Italian municipality is required by law to have a municipal general regulation plan (PRGC), which is an urban planning instrument that controls building activity within the municipality's boundaries. It incorporates all the constraints deriving from other higher-level plans, such as landscape plans, hydrogeological plans, natural protected area, etc.
The PRGC of Grado define the whole inland as area for marine tourism development, only the wooded area between the Camping and Grado Pineta has a lover anthropic pressure and it is identified as an ecological corridor (Figure 4-2).

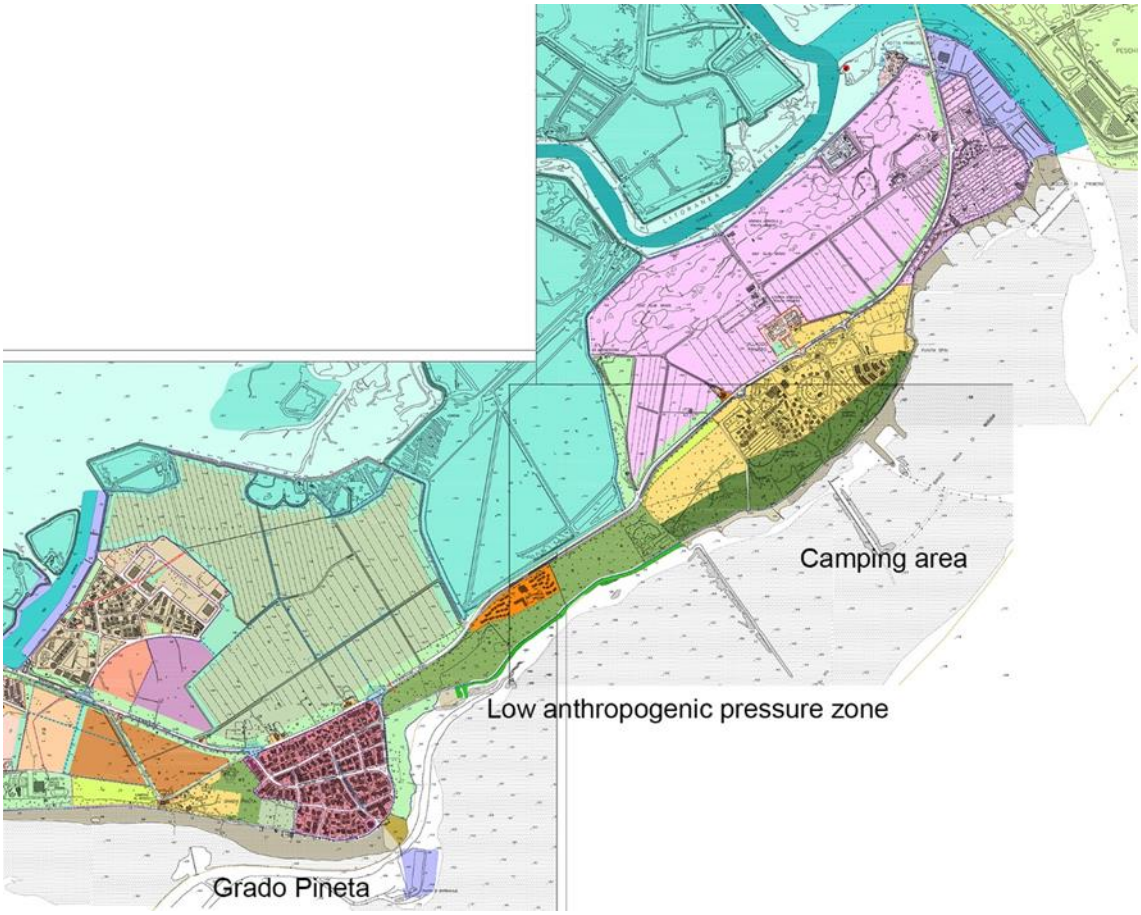

Figure 4-2 Extract from the Municipal Master Plan of Grado, the three different pressure zone are visible; from left, can be distinguished the Grado Pineta district, the low pressure wooded area and the Camping area (Municipality of Grado).

Actually, the PRGC foresees for the area close to the Banco Mula di Muggia:

- the enhancement of the "light" tourist offer, integrated with nature;
- to integrate the tourist offer with proposals and structures aimed at seasonal adjustment;
- the enhancement of the agricultural landscape and the food and wine and fish offer.

4.3 The Hydrogeological Plan (PAI) and The Flood Risk Management Plan

The Hydrogeological Plan (or PAI) is a fundamental tool of the land use planning policy outlined by Italian law 183/89. The PAI has the value of a Sector Territorial Plan and is the cognitive, regulatory and technical-operational tool through which actions, interventions and rules of use are planned and programmed, concerning the defence against the hydrogeological risk of the territory.

The Plan for the hydrogeological structure of hydrographic sub-basins of regional interest of the Autonomous Region of Friuli Venezia Giulia (hereinafter PAIR) defines the hydraulic structure and hydrogeological of the territory belonging to the regional catchment areas through identification, perimeter and classification of areas with hydraulic and geological hazard for safety of people, for functional damage to buildings and infrastructures, for the interruption of functionality of socio-economic structures (*Figure 4-3*).

The Plan also has the objective of promoting soil and soil maintenance interventions defence works, as essential elements to ensure the progressive improvement of conditions of safety and environmental quality of the territory, as well as to promote actions and interventions necessary to let the best hydraulic and environmental conditions of the hydrographic network, eliminating obstacles to the outflow of floods, good hydrogeological conditions and environmental aspects of the slopes, the full functionality of the defence works essential for hydraulic and hydrogeological safety. The Plan implements rules to the use of the territory according to the natural hazards encountered.

In implementation of the EU Directive 2000/60, at the end of December 2021 the Flood Risk Management Plan of the Eastern Alps District came into force and the Hydrogeological Plan (or PAI) is no longer in effect.

The Flood Risk Management Plan has the value of a territorial plan for the sector and is the cognitive, technical and operational tool regulatory that:

- identifies and perimeters the areas with hydraulic hazard, the areas of attention, the river areas, the areas at risk, planning and scheduling actions and rules of use based on the characteristics physical and environmental aspects of the area concerned (*Figure 4-4*, *Figure 4-5*);

- coordinates the discipline envisaged by the other basin planning tools present in the district hydrographic map of the Eastern Alps.

It is the fundamental tool for identifying and planning the actions necessary to reduce the negative consequences of floods for human health, the territory, assets, the environment, cultural heritage and economic and social activities.

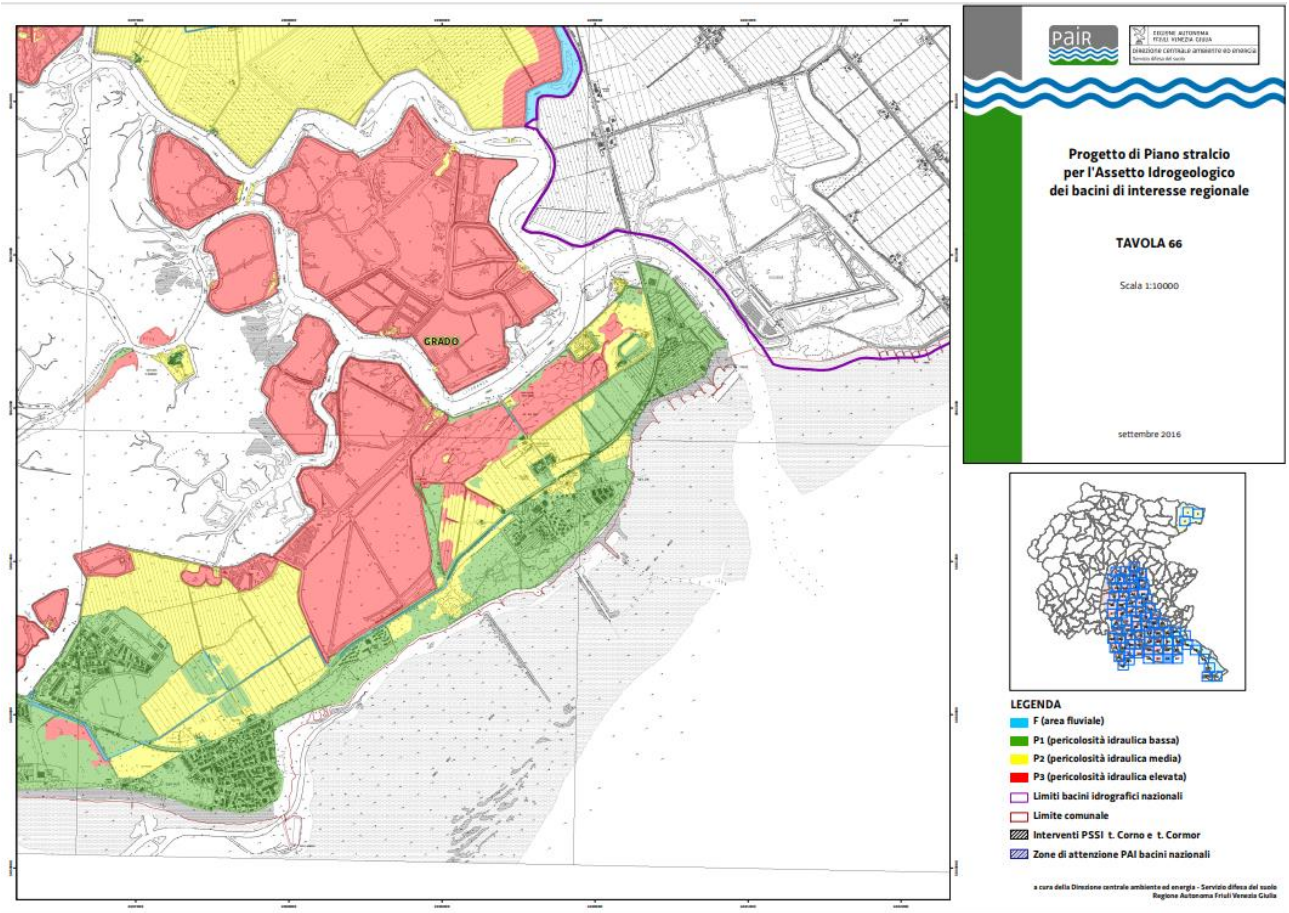

Figure 4-3 Map of the hydraulic hazard from the Hydrogeological Plan (or PAI), no longer in effect.

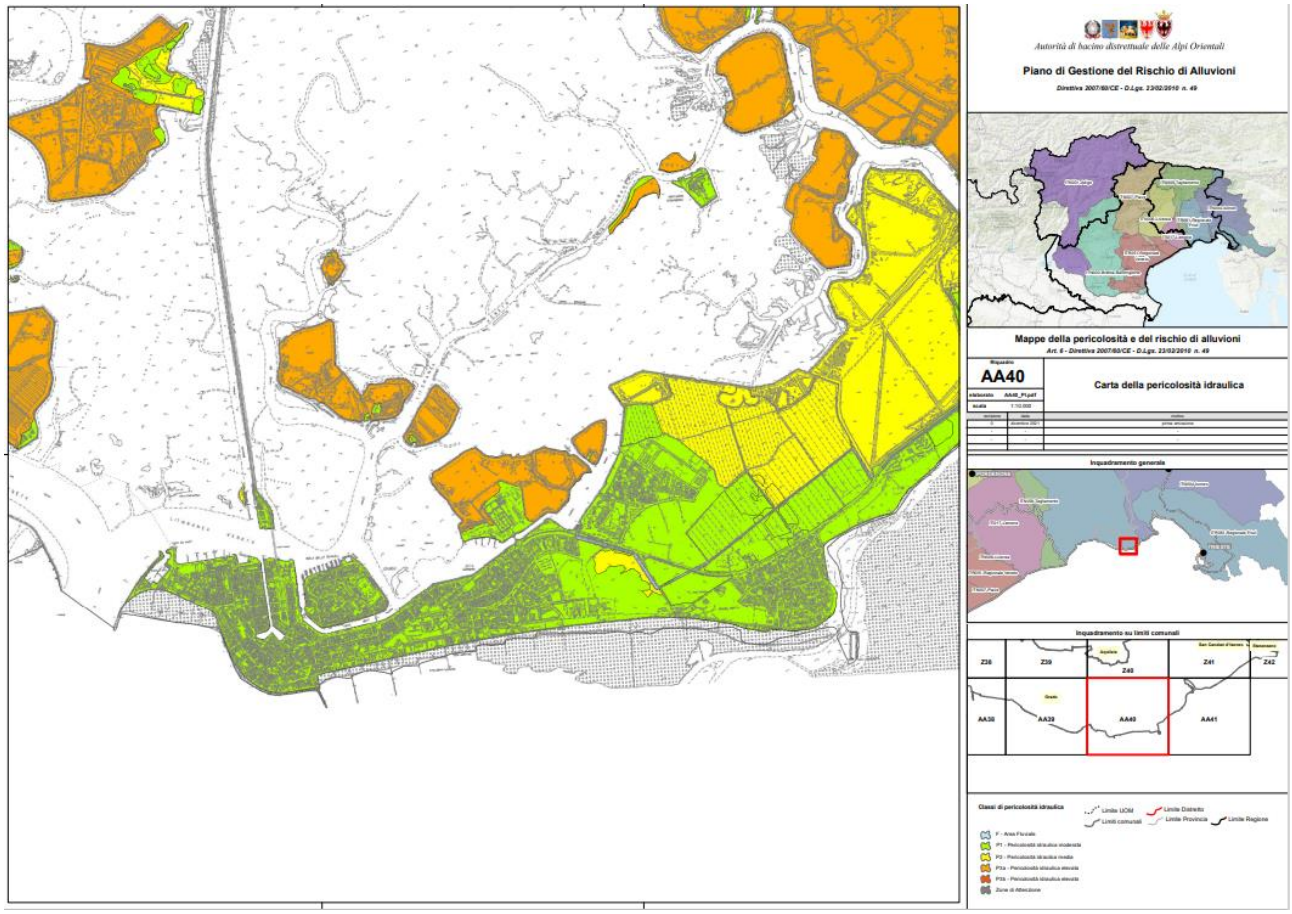

Figure 4-4 Map of the hydraulic hazard from the Flood Risk Management Plan of the Eastern Alps District.

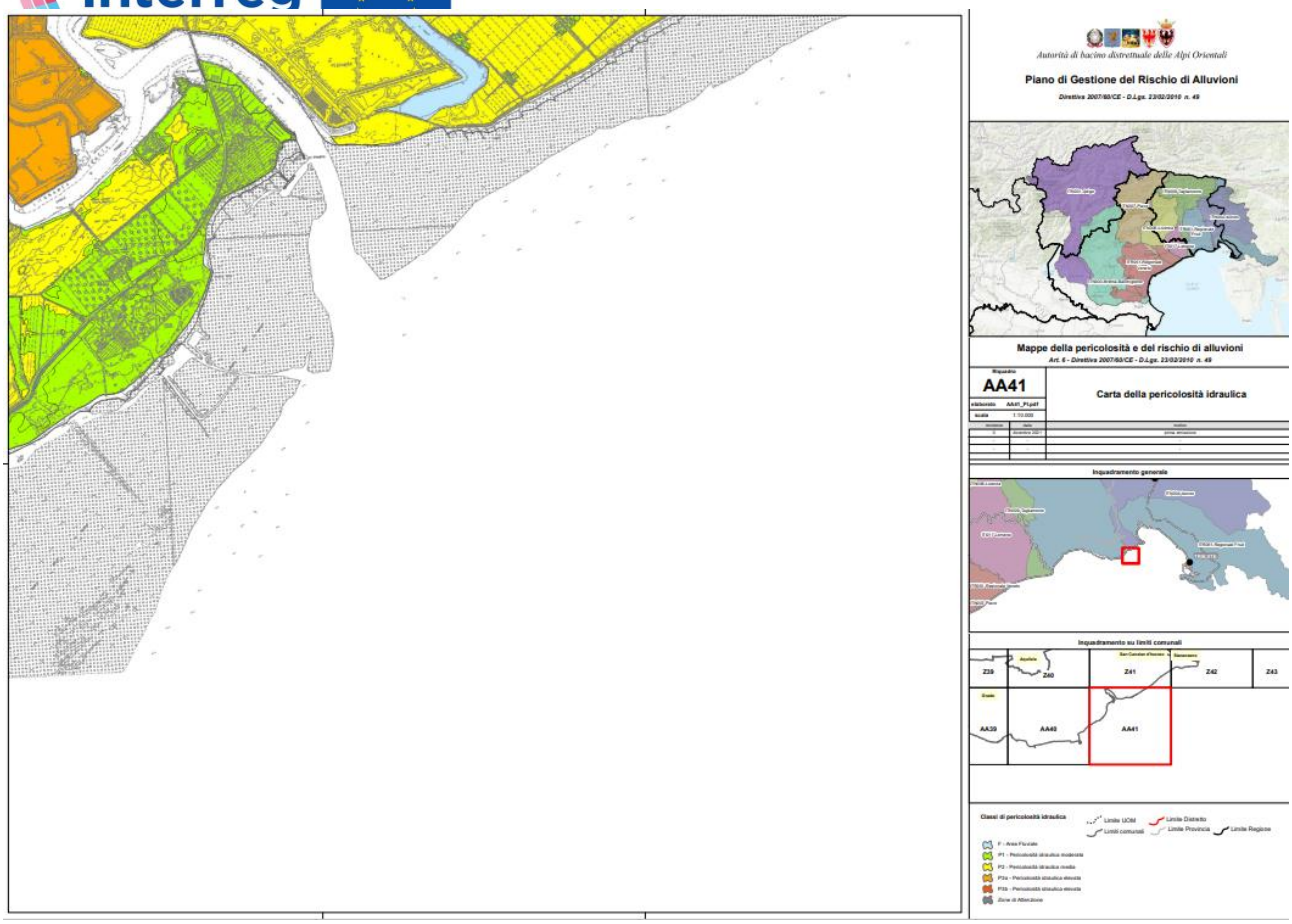

Figure 4-5 Map of the hydraulic hazard from the Flood Risk Management Plan of the Eastern Alps District.

4.4 Corine Land Cover

The CORINE Land Cover (CLC) inventory defines three different classes of land use for the area (Figure 4-6): Code 331 (beaches, dunes, sand), Code 112 (discontinuous urban fabric) and Code 311 (broad leaved forest). The information is not sufficient for the definition of the area where the tourist settlements are present, because part of the camping and touristic villages are classified as code 311, as they are low impact tourist facilities.

The imperviousness products of the Copernicus land service (Figure 4-7) capture the percentage of soil sealing and it is an important information about the anthropogenic pressure. It is the indicator of land consumption. Built-up areas are characterized by the substitution of the original (semi-) natural land cover or water surface with an artificial, often impervious cover.

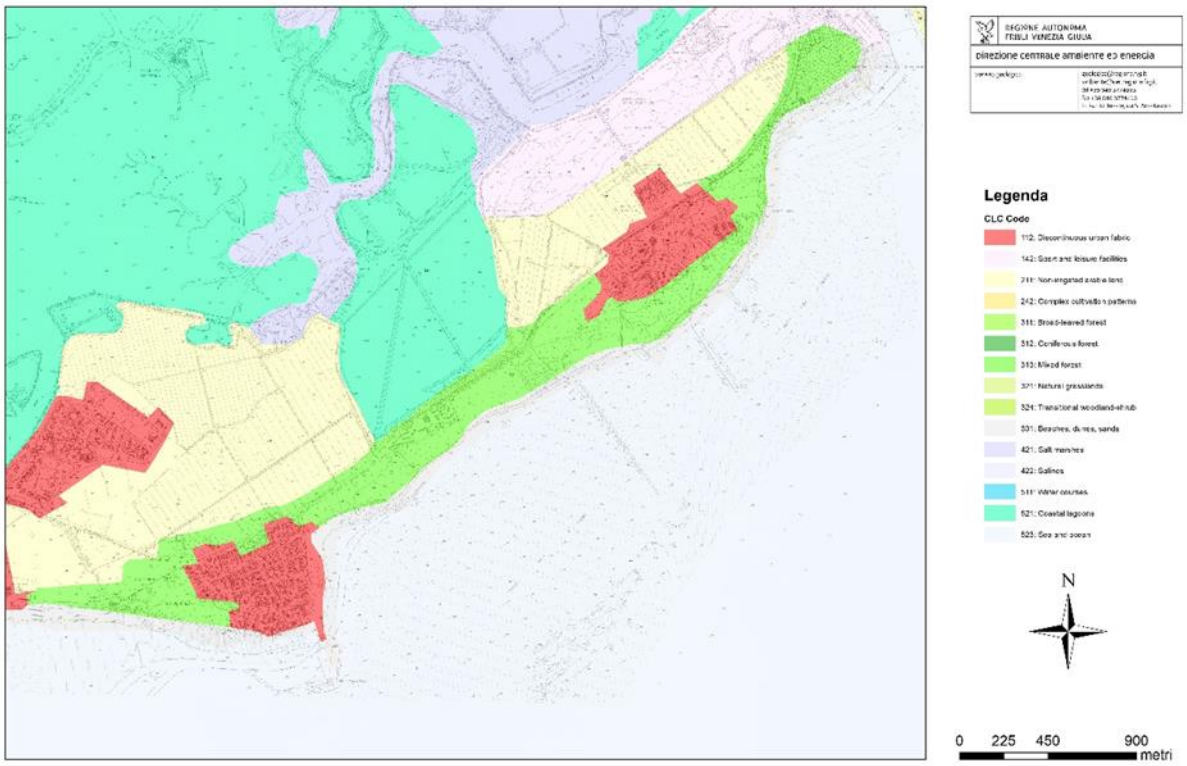

Figure 4-6 Map of land use from CORINE Land Cover (CLC) inventory (land.copernicus.eu).

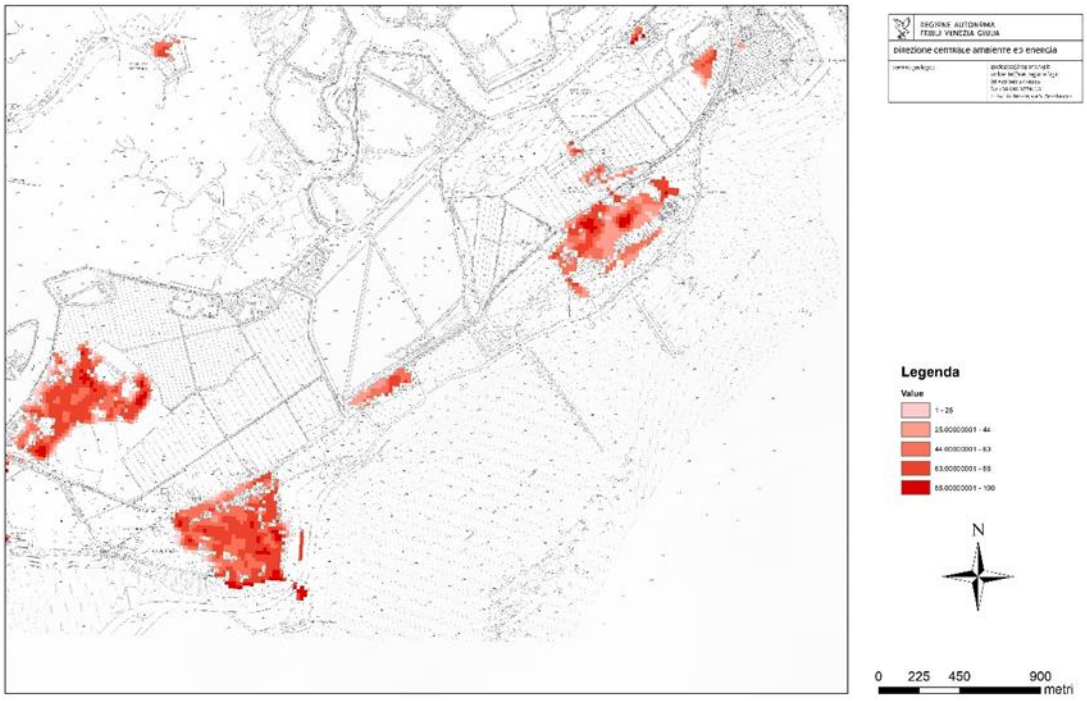

Figure 4-7 Imperviousness map (land.copernicus.eu).

5 An overall description of the Pilot Site state-of-art and the main results

The vast majority of the coastal territory between Grado and the Primero inlet, was rapidly urbanized in two phases, the first towards the end of the 19th century and the second in the 1960s, with the aim of promoting tourism growth. According to historical archives, new beaches were formed artificially using replenishment sands obtained from the neighboring seabed (De Grassi & De Grassi, 1957). The rest of the area, from Primero to Isonzo, was largely utilized for agricultural purposes. As a result of this rapid coastal development, a strong backshore defense "keep the line" policy has developed, leading in a rigid system with no degrees of freedom in terms of possible beach migration to the hinterland. Despite the touristic development, many of the coastal area's natural elements have been preserved, leading to the implementation of a conservation program that includes the creation of Natura 2000 protected areas. Consequently, the Grado coastline needs to be managed for multipurpose use (McLahlan et al. 2013), combining the needs of tourism and nature protection.

5.1 Morphosedimentary elements

The sedimentological, bathymetric and morphological data allow us identifying and mapping areas with different morpho-sedimentary characteristics, which can be considered as a basis for future management and planning (*Figure 5-1*).

The different morpho-sedimentary areas can be briefly described as follow:

- Back-barrier area: characterized by shallow water and silting up, with a high prevalence of fine sediments, due to the shelter conditions against wave action.
- Emerged sandy bank: recent sandy accumulation areas, which are developing above mean sea level.
- Sandy accumulation area: submerged bar and trough zone with strong sandy accumulation.
- Longshore migrating sandy bars: submerged sandy bar and trough zone where the sedimentary budget is substantially balanced through strong longshore transport from east to west.
- External area: from the bank outer limit to the closure depth within the range -2 -2.5 m and -5.4 m, it appears interested both by accumulation and erosion processes. Morphological features suggest that the transport is directed towards N-E, that is, opposite to the direction of migration of the Banco.
- Nourished beach: touristic beach, which needs periodically nourishment interventions.
- Open beach: sandy beach expose to wave action.
- Protected beach: sandy beach protected against wave action.

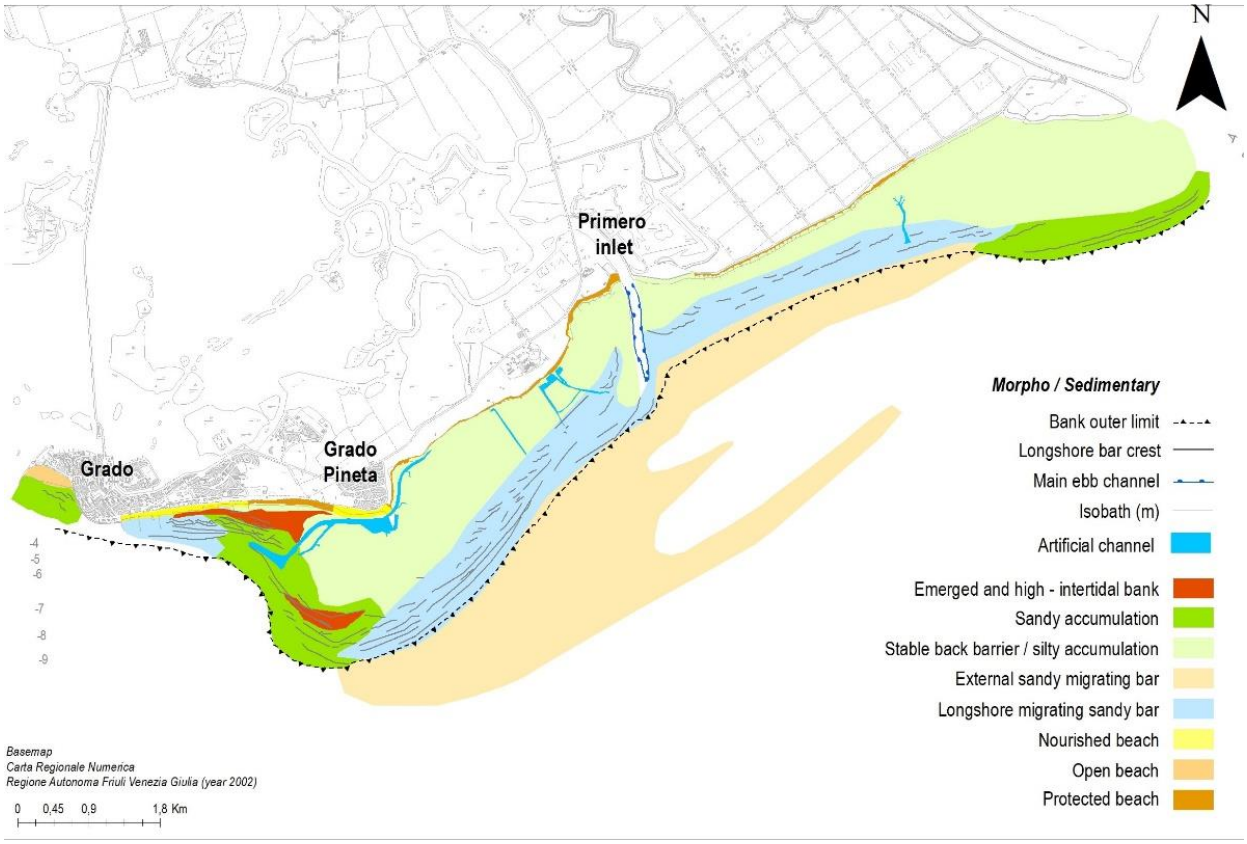

Figure 5-1 - Simplified morpho-sedimentary representation of areas with different characteristics in the pilot site.

5.2 Tourism

Regarding the tourism, some remarks have be obtain from the municipal general regulatory plan (PRGC) (https://www.comunegrado.it/area-urbanistica-patrimonio-edilizia-privata-attivita-economiche/servizio-urbanistica/piano-regolatore-generale-comunale-prgc).

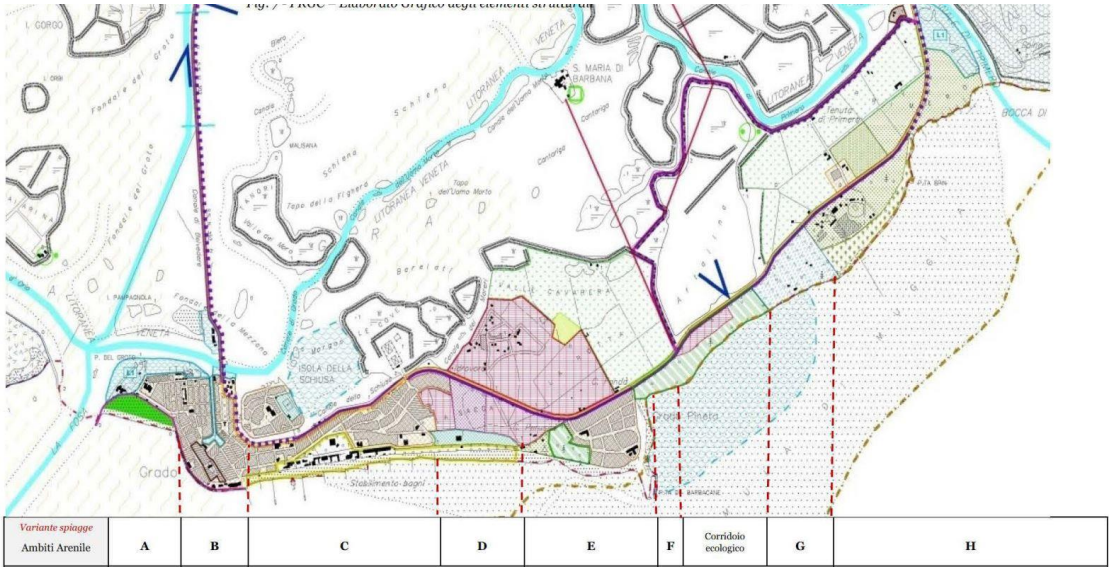

Figure 5-2 The touristic beaches of Grado

Local coastal tourism is primarily focused on beaches that are managed as private properties under state concession and are fully equipped with numerous facilities (walkways, beach umbrellas, toilets, showers, and kiosks), leaving little space for free and natural areas.

The touristic beaches of Grado are about 6,140 m long (*Figure 5-2*) and have different characteristics:

- (A) The beach Costa Azzurra that has about 1,500 umbrellas.
- (C) The main beach of the municipality, it is the historical beach of Grado managed by GIT, which has about 4,000 umbrellas and has around 600,000 entries per year.
- (D) The Sacca dei Moreri is currently characterized by two types of organization. In the western part it is under state concession, while the eastern is free, without facilities.
- (E) The beaches of the Camping al Bosco and Grado Pineta, part under concession and part free.
- (F) Little artificial beach utilized by the resort Ca'Laguna.
- (G) Very narrow beach, it is currently non-utilised for touristic use.
- (H) On the easternmost part of the coastal tract between Grado Pineta and Primero the camping resorts have little beaches with facilities, walkways, small docks and artificial channels

Grado's region is distinguished by its nautical vocation. There are nearly 4,000 berths in the area, distributed throughout the sea and the lagoon, in marinas and ports. The modest marina at Punta Barbacale with 100 berths, in the backbarrier of the Mula di Muggia has a sinuous access channel that is gradually restricted by the movement of the sandy banks. A larger marina (270 berths) is located inside the Primero inlet, with access via the Primero main channel, the distal part of which requires frequent dredging to maintain navigability.

Finally, kitesurfing has grown in popularity. The beaches and backbarrier areas from Grado Pineta to Primero channel are the most popular, as the wind conditions and shallow, protected waters are excellent for practicing this technique. In certain periods kite surfers reach even 300-350 at the same time in water.

At the moment it is still a spontaneous activity, carried out by young people who require few services and move in total autonomy.

5.3 Nature protection

Some parts of the Grado coast have high natural and environmental significance, officially designated as Natura 2000 protected areas, as mentioned in Par. 5.1.1.

The marine habitats are as follows: 1110 - Sandbanks slightly covered by sea water all the time with colonies of *Cymodocea marina, Zostera marina* and more rarely *Zostera nolti* and 1140 - Mudflats and sandflats not covered by seawater at low tide; These latter include blue algae and diatom cover, as well as, colonies of *Zostera noltii* and *Zostera marina*.

The most important component is the avifauna, whose populations tend to cluster along the Friuli Venezia Giulia shore. The Mula di Muggia Bank area is one of Italy's most important wintering habitat for *Anas penelope*, *Numenius arquata*, *Calidris alpina, Pluvialis squatarola*, and *Limosa lapponica*.

As for the ichthyofauna, it is interesting the presence of eurialine species such as *Aphanius fasciatus, Knipowitschia panizzae and Pomatoschistus canestrinii*; the latter two are endemic to the Upper Adriatic. On the seabed at *Cymodocea nodosa* there is a dense population of *Pinna nobilis* and at the limits of the site there are some stations of *Branchiostoma lanceolatum,* typical of the sandy seabed with bottom currents.

The roost and feeding areas for Anatidae and limicolous are indicated in the Management Plan of IT3330006 (*Figure 5-3*) and IT3330005 site, as well as the most significant pressures and interferences due to human activities (hunt, kitesurf).

As evidenced by the management plan, the ANSER project (Anser, 2008) and IWC data (Zenatello et al. 2014), the Mula di Muggia sand bars, even outside the protected area, represent an extremely important area for its role as roost at high tide during the winter season (from mid-September to the end of April). In particular, the most important is the western part of the Bank with the two emerged sandy bars (*Figure 5-4*).

Figure 5-3 - Map of the most important sites for birdlife: the red dots indicate "roost areas and feeding for Anatidae and limicolous; the blue polygon indicates the Marine Habitats of the fine sand or muddy.

Figure 5-4 The two emerged sandy bars in the western part of the Bank are extremely important for their role as a bird roost during the winter season (from mid-September to the end of April)

5.4 Multipurpose management

Thanks to the historical analysis and more recent data collection, areas with varied morphosedimentary characteristics and with distinct tourist-recreational, ecological, and conservation values have been identified on a map (Figure 5-5).

The aim of this zoning is to synthesize natural dynamics, uses and conflicts and furnish a base for future management guidelines. The map emphasizes how coastal areas have been developed without considering their inherent characteristics, in the absence of ICZM or coordinated coastline management guidelines. In the Table 5-1, each of the area of the map is briefly described and its main morphodynamic, ecologic and socioeconomic issues are reported.

The building of beach resorts and facilities occurred even in unsuitable areas located on fetch-limited beaches faced by very shallow waters and a silty seabed (backbarrier area). Despite the sheltered position during heavy storms and “acqua alta”, some of these beaches are being eroded, and in the absence of post-storm natural constructive processes, they require periodic sand replenishment.

Local coastal tourism is primarily focused on beaches that are managed as private properties under state concession and are fully equipped with numerous facilities (walkways, beach umbrellas, toilets, showers, cabanas, kiosks), leaving little space for free and natural areas. This model implies a lack of acceptance of the specific characteristics of the sites (particularly the backbarrier area) among stakeholders and fosters conflict.

The backbarrier area represent a stable area having conflicts between touristic use (presence of touristic beaches, little docks for boats and kitesurfing) and conservation needs (silty seabed with seagrass meadow, tidal flats used as feeding area from birds).

However, in some locations, the large size and dynamism of natural landforms have grown prominent in relation to the needs of seaside tourism, raising serious concerns for the future of these areas. The westernmost part of the migrating bars, in particular, is viewed as a threat to touristic activities due to the ongoing rapid extension toward the west of the shallow water with silty deposition in the nearshore and the current infilling of the navigation canal towards the little marina of Punta Barbacale. At the same time, longshore migrating sandy bars are being frequented by unorganized but intense tourist use (bathing, recreational fishing of edible bivalves and kitesurfing).

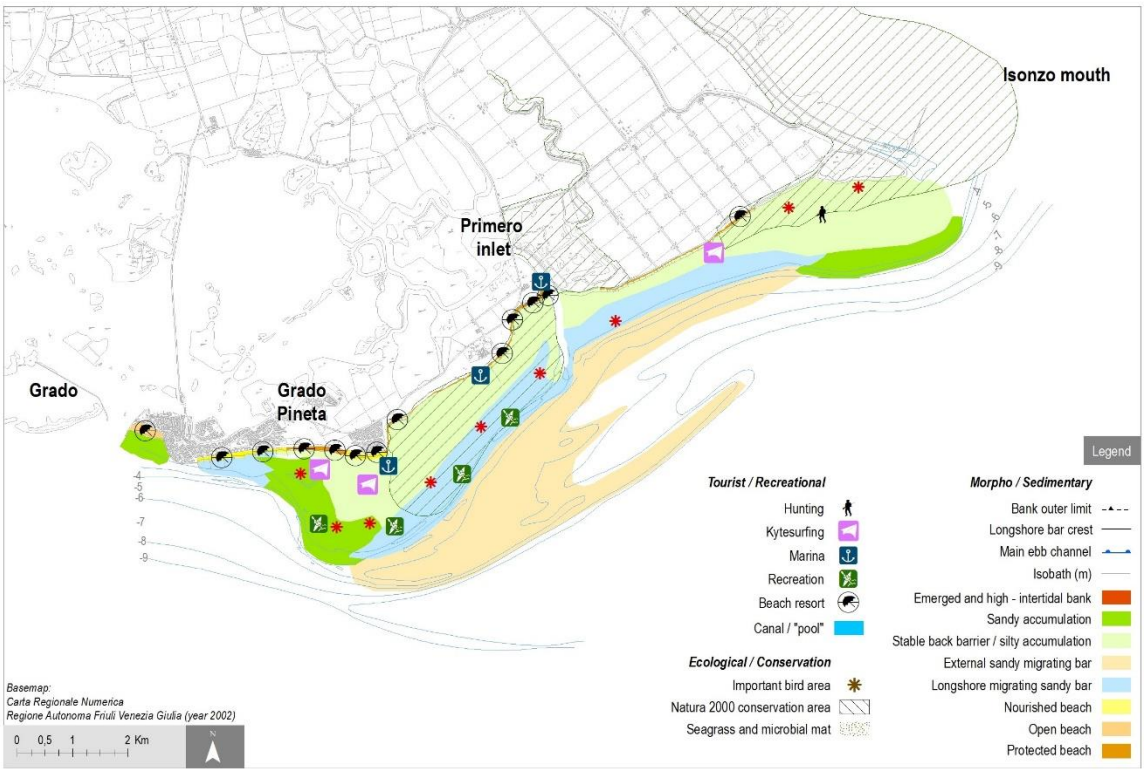

Figure 5-5 Multipurpose zoning map

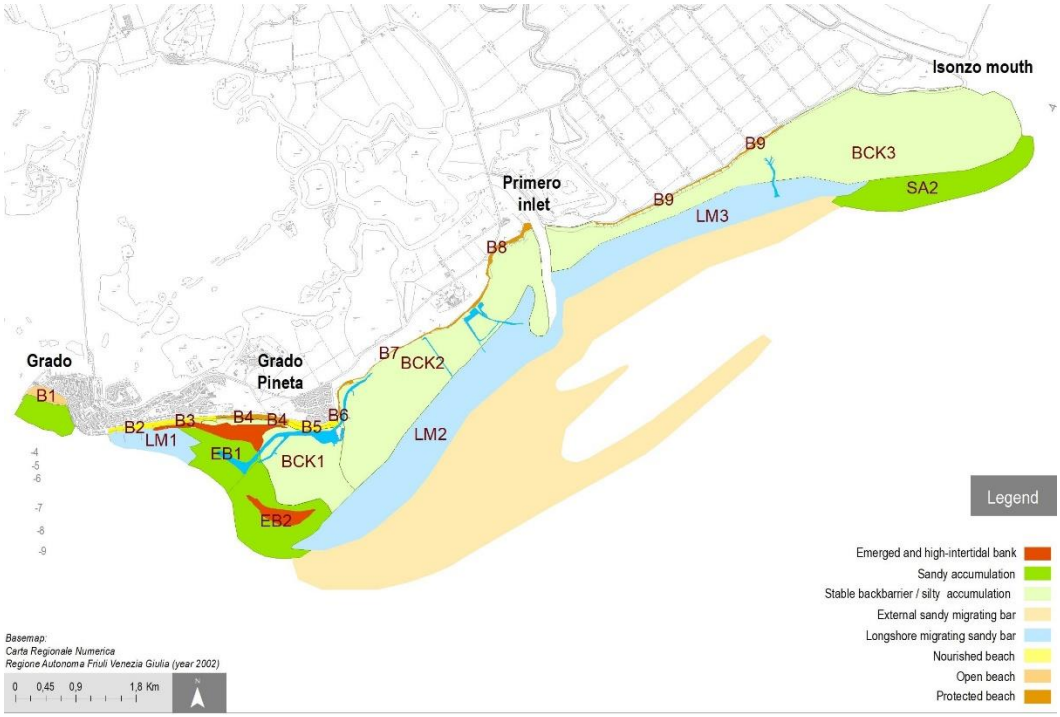

Figure 5-6 Multipurpose zoning map, the specific zones are identified by a CODE (see table 1 for the description).

Table 5-1 A brief description of each area on the map is provided, along with its significant morphodynamic, ecological, and socioeconomic concerns.

code	Zone	Morphodynamic (physical environment)	Ecological	Socio-economic
B1	Open beach (Grado Costa Azzurra)	High dynamism, sand supply, shoreline advance		Beach resorts with infrastructures and facilities for intensive recreation
B2	Open beach (Grado GIT)	High dynamism, sand supply during calm weather, shoreline erosion during storms		Beach resorts with infrastructures and facilities for intensive recreation
B3	Protected beach with need of post -storm nourishment	Low energy, sheltered beach, subject to high water with sand loss, large quantities of stranded seagrass litter		Beach resorts, with infrastructures and facilities for intensive recreation
B4	Protected beach	Low energy, sheltered beach, large quantities of stranded seagrass litter		
B5	Protected beach with need of post -storm nourishment (Grado Pineta)	Low energy, sheltered beach, subject to high water with sand loss, large quantities of stranded seagrass litter	Seagrass in the nearshore	Beach resorts, with infrastructures and facilities for intensive recreation

B6	Protected beach	Low energy, sheltered beach, large quantities of stranded seagrass litter	Seagrass in the nearshore	
B7	Very narrow protected beach	Low energy, sheltered beach	Seagrass in the nearshore	
B8	Protected beach with need of post -storm nourishment	Low energy, sheltered beach, subject to high water with sand loss, large quantities of stranded seagrass litter	Seagrass in the nearshore	Camping resorts with infrastructures and facilities on the beach for intensive recreation
B9	Very narrow protected beach	Low energy, sheltered beach	Seagrass in the nearshore	
BCK 1	Back barrier (Grado Pineta)	Stable backbarrier / silty accumulation	Species of conservation interest (seagrass, Pinna nobilis), bird roost and feeding areas.	Marina, bathing hollow, little navigation channels. Recreational fishery of edible bivalve, kitesurf.
BCK 2	Back barrier Camping	stable backbarrier / silty accumulation	Natura 2000 site, species of conservation interest (seagrass, Pinna nobilis), bird roost and feeding areas.	Little marinas, bathing hollows, little navigation channels. Recreational fishery of edible bivalve, kitesurf (outside the rules).
BCK 3	Backbarrier Fossalon	stable backbarrier / silty accumulation	Natura 2000 site, bird roost and feeding areas	Recreational fishery of edible bivalve, kitesurf (outside the rules).
LM1	Longshore migrating sandy bars (Grado)	High dynamism, sand supply	Bird feeding areas	Beach resorts, with infrastructures and facilities for intensive recreation.
LM2	Longshore migrating sandy bars (from Primero inlet to the Bank apex)	High dynamism, sand supply	Natura 2000 site, bird feeding areas	Recreational use, clam fishery, hunt, fishery.
LM3	Longshore migrating sandy bars (Fossalon)	High dynamism, sand supply	Seagrass, bird roost and feeding areas.	Recreational use, clam fishery, hunt, fishery.
EB1	Sandy accumulation zone with emerged sandy banks (camping al Bosco)	High dynamism, sand supply	Bird roost.	Recreational use, kitesurf.
EB2	Sandy accumulation zone with emerged sandy banks (banco apex)	High dynamism, sand supply	Bird roost.	Recreational use, clam fishery
SA1	Sandy accumulation zone (Costa Azzurra)	High dynamism, sand supply		Beach resorts, with infrastructures and facilities for intensive recreation
SA2	Sandy accumulation zone (Mula Muggia Bank)	High dynamism, sand supply	Bird roost and feeding areas.	Recreational use, clam fishery
SA2	Sandy accumulation zone (Isonzo mouth)	High dynamism, sand supply	Bird roost and feeding areas.	Recreational use, clam fishery

The analysis, as well as the map shown in Figure 5-5 and Figure 5-6, can be used as a basis to guide future planning of the Grado coastal area, in order to reduce sea level rise (SLR) impact and minimise or eliminate the major conflict that exists between coastal morphodynamics, tourist/recreational beach use, and conservation needs.

6 Description of expected scenarios

The most recent research on global climate change has warned governments about the risk posed by rising sea levels, which appears to be the most significant climate change concern for coastal communities.

Furthermore, natural or man-made coastal subsidence can be a critical factor in accelerating change, with differences exceeding 30% greater than the global average.

As elaborated in the WP4.2 report, the relative sea level rise (RSLR) scenarios to 2100 are presented in the Table 6-1a, b for the study area.. The different components of the relative earth - sea movement, in particular, are evaluated according to the most recent scientific literature. The Global sea level rise (GSLR) is derived from the IPCC projections (Oppenheimer et al. 2019), for six predictive scenarios depending on the different climate change reduction hypotheses. The long-term vertical movement (geological subsidence) and the glacio-hydro-isostasy are estimated from geological data. Finally, in the last column, the resulting expected values of total RSLR for the study area are reported.

More severe (high-end) sea level scenarios form literature are proposed in table 5.2b according to Rahmstorf (2007) and Thiéblemont et al. (2019).

Besides sea level rise, wave climate and its variations can play an important role in controlling coastal dynamics and possibly affecting the stability of the coasts and the safety of the infrastructures. At the present state of the art, a local assessment of the future wind wave regime in the nearshore is not available. Nevertheless, some important indications can be obtained from Der 4.1, which includes an analysis of the effects of climate change on hydrodynamic processes at the Adriatic basin scale and offshore of the Pilot Site of Mula di Muggia.

Table 6-1 - Relative sea level scenario projected up to 2100. According to the update scientific literature, the different components of the relative earth - sea movement are presented and, in the last column, the resulting expected total relative sea level rise for the study area

a)

2100 scenario	GSLR (cm)		long term land vertical movements		glacio-hydro-isostasy		total RSLR to 2100
	GSLR (cm)	SLR IGM 42 (cm)	rate (mm/y)	change (cm)	rate (mm/y)	change (cm)	(cm)
IPCC 2013 RCP 2,6 min	29	24.7	0.4	3.3	0.125	1.0	29.0
IPCC 2013 RCP 2,6 average	43	38.7	0.4	3.3	0.125	1.0	43.0
IPCC 2013 RCP 2,6 max	59	54.7	0.4	3.3	0.125	1.0	59.0
IPCC 2013 RCP 8,5 min	61	56.7	0.4	3.3	0.125	1.0	61.0
IPCC 2013 RCP 8,5 average	84	79.7	0.4	3.3	0.125	1.0	84.0
IPCC 2013 RCP 8,5 max	110	105.7	0.4	3.3	0.125	1.0	110.0

b)

2100 high-end scenario	GSLR (cm)
Rahmstorf, 2007 max	140
Thiéblemont et al., 2019	180

7 Shared vision overall strategy intervention option and priorities

7.1 Developing conditions for the sustainable growth in the Mediterranean coastal areas

The Protocol on Integrated Coastal Zone Management in the Mediterranean, (ICZM Protocol) was adopted in 2008 and entered into force in 2011.

The ICZM Protocol provides the legal framework for the integrated management of the Mediterranean coastal zone. Under the Protocol, Parties are called to take the necessary measures to strengthen regional cooperation in order to meet the objectives of integrated coastal zone management. Such measures include those aimed at protecting the characteristics of specific coastal ecosystems (e.g. wetlands and estuaries, marine habitats, coastal forests and woods and dunes), those aimed at ensuring the sustainable use of the coastal zone, and those aimed at ensuring that the coastal and maritime economy is adapted to the fragile nature of coastal zones.

The general Objective of the Joint Action Plan of the "Bologna Charter 2012" (EUROPEAN REGIONS CHARTER FOR THE PROMOTION OF A COMMON FRAMEWORK FOR STRATEGIC ACTIONS AIMED AT THE PROTECTION AND SUSTAINABLE DEVELOPMENT OF THE MEDITERRANEAN COASTAL AREAS) is to protect the Mediterranean coasts from coastal erosion and enhance the resilience of coastal areas to climate change.

This will be accomplished through 3 pillars:

- knowledge, research and monitoring the status of Mediterranean coastal areas;
- integrated Coastal and Maritime spatial planning for the sustainable development of coastal and marine areas;
- studies and works answering to the Climate Change adaptation needs along the Mediterranean coasts.

The Bologna Charter promotes an integrated land-sea approach which directly feeds into the objectives and principles of the EU MSP Directive (2014/89/EU) and ICZM Protocol (Barcelona Convention).

The integrated management of the coastal zone for the Mediterranean establishes an approach, principles and "behavioural indications" for Public Administrations, economic entities, businesses, stakeholders, citizens, in order to achieve a good degree of sustainability of coastal zone development, through an integrated planning process. The sustainability of development in a coastal zone means that the coasts themselves should be:

Resilient: able to adapt to future uncertainties of climate change, including rising sea levels, warming and drought; resilient to climate variability, such as extreme storms, floods, waves, etc; resilient to earthquakes and erosion; resilient to the negative impacts of human processes, including the pressure of tourism and urban development on the coast.

Productive: financially productive in traditional, modern and future economic sectors; able to support the economic aspirations of the coastal community, to provide a competitive asset for the local economy with a high content of natural and economic values, to increase well-being and reduce poverty.

Diversified: ecologically varied, a mosaic of marine and terrestrial ecosystems, of different rural and urban landscapes, old and new; a varied economy, able to guarantee an open society and a great variety of social groups, with a distinct Mediterranean character.

Distinctive: maintaining the cultural specificity of coastal areas, including architecture, customs and landscapes.

Attractive: maintaining the attractiveness of the coast, not only for visitors, but also for the local population and for investors, to promote a self-sustaining cycle of sustainable growth.

Healthy: free from pollution from terrestrial and marine sources, with clean air and fresh and marine waters, with a healthy environment for people, for natural resources such as fishing, and for wildlife.

This is a "check-list" to help set up an integrated management plan, strategy or program. Even in a coastal erosion or climate change adaptation management plan, these criteria should be considered in a balanced way, which maximizes mutual benefits and minimizes the risk of negative consequences, for the coast, for the environment. and for the human activities related to it.

Some key messages:

- The development of Coastal & Maritime tourism is accompanied by significant challenges (Coastal systems over exploitation, Biodiversity loss, Energy consumption and GHG -greenhouse gas- emission, Waste management, Water and other resources consumption, Cultural-historical heritage preservation and management, etc.), so the highest attention to sustainability is a must.
- Demand of “greening”, sustainable, tourism is more and more increasing;
- The development of a sustainable and more diversified Coastal & Maritime tourism has the potential to create new qualified and decent jobs;
- Investing in sustainable and diversified tourism can bring new economic opportunities for local operators and communities and for territorial-cultural valorisation;
- The private sector, local stakeholders and communities can and must be mobilized to support the development of integrated, alternative, new tourism proposals and offers;

- The vision and the lead role of competent Authorities is fundamental and pre-conditions to make possible the development of a diversified, inclusive and sustainable Coastal & Maritime tourism in local destinations.

7.2 The Participatory Process

The activation of a Participatory Processes at local level is an excellent way to identify and co-design options and solution to be developed in the future.

PP4 designed a dedicated participatory process in relation to the issues to be tackled, the nature and characteristics of the Banco Mula di Muggia pilot site test. The participatory process, initially designed as a restricted process with selected stakeholders, is divided in two sections:

- The extended consultation, set to an online survey translated into three languages.
- The restricted participatory process, set on two different webinars.

Three sections characterize the online survey: the first is about the type of respondent, the second is focused on the Mula di Muggia Pilot area, the third on climate changes and their effects.

The free Google-Module tool was used for the online survey, which received 375 responses. This contribution is important to understand what people know and perceive about some morpho- ecological characteristics of the pilot site area and about the effects of the climate change.

The restricted stakeholders are technicians of Municipality of Grado (GO) as regards policy maker, tourist operator having an economic relevance on the pilot site test, researchers of University of Trieste as regard the environmental aspects and technicians from Autonomous Region of Friuli Venezia Giulia as regards fishing and Natura 2000 network.

Two non-technical reports, prepared for the webinars with the stakeholders, contributed to the discussion.

To summarize the results of the participatory process, it is clear that the “living with nature” is a solution driven by natural trends, as a fundamental guideline for a correct human use, thus forcing us to a responsible and sustainable development. This permits to limit possible impacts of definitive choices, as those following hard engineering philosophy. Configuration regimes aimed at beach nourishment or morphological reshaping should be possible options. The strategies for the future of the Grado area should focus on the monitoring and evolution of the Bank area, on the adaptation of the infrastructures and use to the natural evolution and eventual implementation of light interventions that can adapt to natural evolution.

7.3 Intervention

The results of the studies and the consequent zoning map reported in Figure 5-5 and Figure 5-6, can be used to guide future planning, in order to undo or limit the major conflict between coastal morphodynamics, tourism-recreational beach use and conservation needs.

Among the options systematized in the Eurosion 1 Report, which should be taken into account in the decision-making process behind any planning, coastal management and adaptation strategy, or program of interventions there is the option "limited intervention". It is planned to proceed with, non-invasive interventions, working with natural processes in reducing risks and allowing natural coastal changes.

This option may include a range of measures: slowing down or stopping erosion and beach retreat, through maintenance nourishments; measures for the safety of exposed people and natural or man-made elements (flood warning systems, maintenance or restoration of dunes, forests and coastal wetlands, restriction of coastal development, etc.).

The following are a series of indications for the pilot site that can be associated with this management approach.

7.3.1 Preservation of the Bank system

The preservation of coastal natural ecosystems matches the goals of the Green Deal, which calls for a rethinking of the concept of sustainability in order to look to the future of the economy and society. It must be considered as an opportunity to increase the efficiency of the blue economy while maintaining the natural resources essential to human well-being.

The abundance of sediments represents both a source of great wealth and a tangible possibility for mitigating the SLR threat. While erosion and loss of sand are worldwide a major problem for the tourism industry, the rapid morphological changes and the management of important quantities of moving sediments represent the challenge – as well the opportunity - in the pilot site area.

The backbarrier area and the longshore migrating sandbars have a natural ability to protect human settlements and infrastructures, as well as offer a series of natural co-benefits such as fishery habitat, carbon sequestration, tourism opportunities, education, and research.

7.3.2 Preservation of sediment sources and sediment longshore transport

The most important issue is to preserve the sediment source (the Isonzo river) and the natural ability of the longshore transport to distribute the sand along the littoral toward west. Monitoring the river's sediment supply will be required, as will obtaining up-to-date data on sediment mining in the river bed. It is essential to preserve the hydrological conditions of the river through the control on hydraulic interventions in the drainage basin as indicated in the *Piano Regionale di Tutela delle Acque* by the Regione Autonoma Friuli Venezia Giulia (*Decreto del Presidente della Regione n. 074/Pres dd. 20 marzo 2018*, https://www.regione.fvg.it/rafvg/cms/RAFVG/ambiente-territorio/pianificazione-gestione-territorio/FOGLIA20/FOGLIA22/).

Moreover, natural sediment transport to the west, along the system of longshore bars that border the entire Bank structure, provides a natural supply of sand, reaching and bypassing the mouth of Grado up

to feed the external sand banks of the Grado lagoon, up to Porto Buso. This natural "conveyor belt's" dynamism must be ensured by avoiding any structural interventions that can change the dynamics.

7.3.3 Coastal defences

The use of hard defense structures should be avoided in particular the shore – normal ones, if not limited to reinforcing those already in place to defend the hinterland.

The vulnerability analysis has highlighted some elements of weakness of the coastal system with respect to the sea ingression in its projection to 2100. For the areas identified (camping al Bosco, east side Punta Barbacale) as likely points of water penetration an analysis and a design integration of the defences must be made. The interventions must to be possibly of "soft" type with the use of naturalistic engineering techniques that consider the ecological and morphological characteristics and tend to their improvement.

In general, it is advisable to check punctually the existing defensive works in the backshore with verification of the possibility of closing the gates with movable bulkheads.

7.3.4 Nature protection

The widespread use of kitesurfing, which affects many areas both within and outside the boundaries of the Natura 2000 site, appears to have a significant impact on aquatic birds from mid-September to the end of April, as evidenced by the international scientific literature (Krueger, 2016).

In particular, recent sand accumulation zones, which are developing above the mean sea level (indicated in the map as "recent emerging or intertidal banks") represent an extremely valuable habitat for the aquatic birdlife refuge during high tide (roost areas). For these reason, there is a need to harmonise bird protection with the protection standards already given by Natura 2000 management plans in areas that are close to the perimeter of Natura 2000 sites but not included.

Kitesurfing's impact during the non-bathing season should be reduced by establishing alternative locations for this activity. The utilisation of the latter, which are located in more populous regions and can provide services, can also help to extend the tourist season.

7.3.5 Nourishment

In a dynamic environment characterised by significant natural and landscape features, sand nourishment appears to be the most appropriate and low-impact coastal intervention measure.

In particular, the presence of large areas of sandy accumulation favours the application of a coastal cell approach. Once the compatibility of sediments is established, the overabundant sediments in the accumulation areas can be managed as a temporary reservoir for the nourishment of adjacent beaches, with the adoption of periodic and programmed dredging/nourishment intervention. Several criteria favour this approach: (i) the small size of the deficit areas, (ii) their benefits as protected beaches, thus conservative, and (iii) the requirement to dredge some navigable canals of access to the lagoon on a regular basis (port of Grado, mouth of Primero).

According on the available data on prior interventions (from 2005 to 2019), a quantity of sand equivalent to 10,000 mc/year is estimated for nourishment of the beaches. In addition, new sand deposits can be

provided (as already mentioned in Natura 2000 management plans as possible intervention option) for the reinforcement or elevation of localised landforms in order to encourage the presence of the aquatic avifauna.

As indicated in *Figure 7-1*, sands can be transferred from a source location to a storage area (nourishment) either in the direction of natural transport dynamics along the coast (bypass principle) or in the opposite direction, slowing natural migration processes. In the first case the likely source / sink locations are: (1) from the accumulation area of the Banco Mula di Muggia to the GIT beach, (2) from the ebb-tidal delta of Primero to the camping resort beaches, (3) from the ebb-tidal delta of Primero to the longshore bars in the Natura 2000 site.

In the second case the likely pathways are: (1) From the ebb-tidal delta of the Grado inlet to the GIT beach (2) from the accumulation area of the Banco Mula di Muggia to the Grado Pineta beach, (3) from the accumulation area of the Banco Mula di Muggia to the longshore bars in the Natura 2000 site.

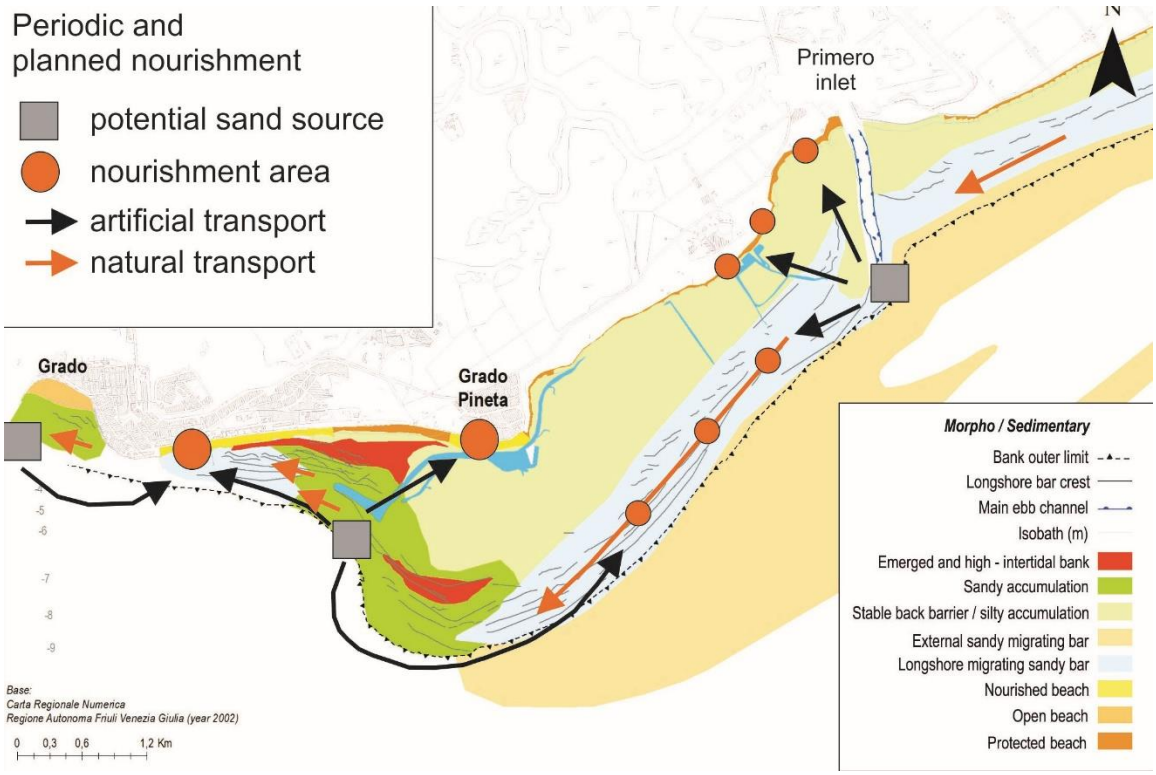

Figure 7-1 Hypothesis of periodic and planned interventions with indication of the likely source and nourishment locations.

A more complex alternative hypothesis would be a sand bypass systems. A Sand Bypass System is a permanent solution usually applied to sand erosion and littoral drift problems affecting river mouths and navigation channels worldwide. It can be described as the artificial transport of littoral drift across tidal

entrances to help prevent accretion, on the updrift side, control downdrift erosion and maintain navigation channels (http://www.coastalwiki.org/wiki/Sand_by-pass_systems).

Solutions of this kind to ensure the renewal of the beaches of Grado are hardly applicable due to the characteristics and arrangement of the possible are as source - sink.

7.3.6 Limitation of the natural dynamism

The active morphodynamics caused by waves and currents becomes prominent characteristics in migrating sandy bar areas and accumulation zones. Because of its rapid westward extension, the westernmost part of the Mula di Muggia bank is considered as a threat to tourist activity on the most important tourist beaches.

It also complicates the access to the little marina next to the headland of Grado Pineta (known as Punta Barbacale) (Figure 7-2). Structural interventions are not feasible, due to the great complexity of coastal dynamics as well as the need to preserve the bank system and the natural transport of sediments to the west. The sedimentary flow could be reduced by dredging modest amounts of sand in specific areas and utilising it for beach nourishment (*Figure 7-2*).

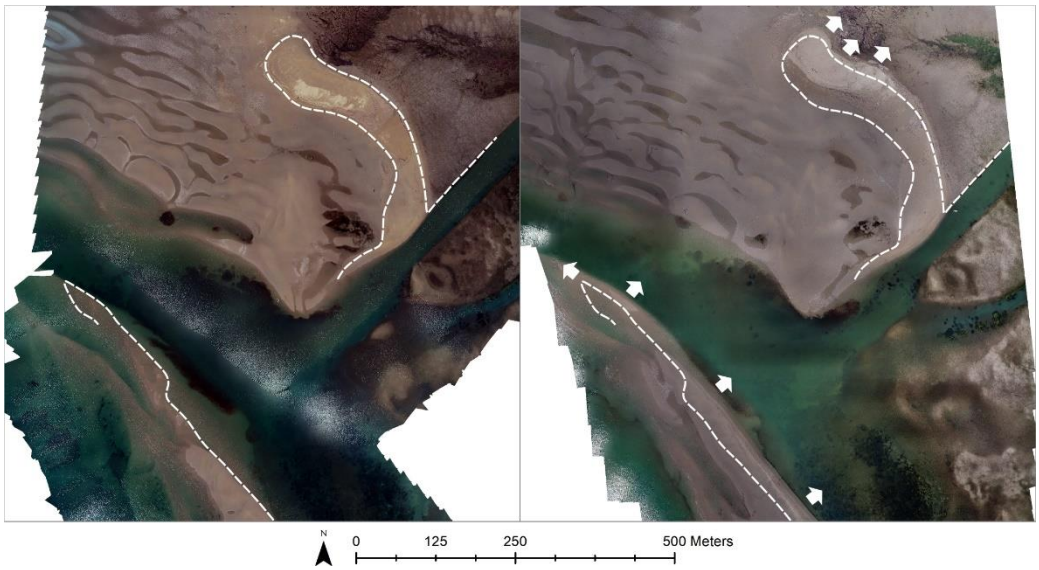

Figure 7-2 Two orthophoto obtained by UAV surveys in April 2019 (left) and in April 2021 (right). The progressive occlusion of the canal due to the extent toward west of the longshore sandy bar in front of Camping al Bosco (area EB1 in the map of Figure 5-6) is clearly visible. The orange rectangle indicates a likely zone of sand dredging.

7.3.7 Little canals, bathing hollows and little marinas

Grado Pineta's small marina, located in the shallow water of the back-barrier area, lacks a suitable canal of access, and the current canal causes conflicts with bathing areas..

Managers of camping resorts express the need to excavate "natural pools" and access channels for micro – port in order to improve tourist fruition of protected beaches located in back-barrier muddy areas (BK2).

At the moment, some jetties and berths for temporary mooring, as well as small "bathing hollows," represent an unorganized fact with many limits to fruition.

The implementation of digs is not currently planned within the Natura 2000 perimeter. The possibility of intervening in this direction has to be regulated and reviewed by the VAS (Environment Impact Assessment) procedure, with appropriate indications and compensatory measures. These interventions must be small and close to the shore, must not interfere with hydrodynamics, must not damage seagrass, and must be used in accordance with Natura 2000 site management requirements.

7.3.8 Tourism education and communication

Local coastal tourism is mostly focused on equipped beaches, with extensive use of infrastructures, and scarcity of free natural areas. This model implies a lack of acceptance of the peculiar characteristics of the sites by the stakeholders and promotes conflicts.

The acknowledgement of natural and environmental values (via the Natura 2000 network) is expressed in the confirmation of a specific and unequivocal priority: the protection of natural values and biodiversity. At the same time, the natural morpho-sedimentary resilience of the coastal area is prioritised due to climate change uncertainty.

Tourist must be provided with knowledge elements that lead him not only to accept the natural elements of the place, but also to appreciate them as factors of value and to appreciate the possibility of living with these, attributing to this perspective an added value compared to others that he already recognises in the locality he frequents.

To attain this goal, efforts such as training, awareness-raising, and promotion are required. In the medium to long-term, more ecologically responsible types of tourism can contribute to the conservation of the tourist resource itself, and at this time scale, the economic benefits of information and education projects can be appreciated.

Guided tours, museums, brochures, public lectures, newspapers, signage, are just a few of the devices that figure importantly in the educational processes linked to coastal tourism. Products and strategies have to be finalized to people education to change its behaviour. The importance of education (and of overlapping fields such as communication, journalism, and environmental and science reporting by the media) is wide recognized by the scientific world.

8 Action plan

8.1 The rules for beach management

The Regional Maritime State Use Plan (P.U.D.) governs the administrative functions in matter of assets belonging to the maritime state property for tourist-recreational purposes, conferred to the Autonomous

Region of Friuli Venezia Giulia in implementation of the decrees of the President of the Republic 24 July 1977, n. 616 (art. 59) and 15 January 1987, n. 469 and subsequently devolved to the Municipalities according to the Regional Law of 13 November2006, n. 22.

In 2016, the Municipality of Grado upgrade its Municipal General Regulatory Plan (PRGC) with a special plan named “Beaches”. The basic principles identified for the "BEACHES" plan are the following:

1. To ensure a future in Grado as a seaside city, avoiding costly and demanding nourishment but restoring bathing and rethinking relations with the Natura 2000 area in front in terms of opportunities.

2. Reperimetration of the Mula di Muggia on the beach side and its expansion towards the sea allowing the creation of a body of water suitable for bathing.

3. Integration of the beach area with the spaces and functions behind it.

The beach is an important part of Grado's tourist offer, but it must be able to relate with the entire municipal area, with the urban space and with the natural space both at sea, inland and in the lagoon.

8.2 Technical indications for sediments, the mercury

As regards the interventions of restoration, stabilization or advancement of the shoreline, the technical indications expressed by ICRAM (Nicoletti et al., 2006) and by APAT-ICRAM (APAT -ICRAM, 2007) while, pending the new national regulation soon to be approved, the sediment handling activity for the nourishment of both the emerged and submerged beaches is governed by the D.M. 24/01/1996. As regards the quality of the sediment, the reference is to the D.M. MATT 260/2010. This is especially true for the interventions of medium or high entity, for which specific design documentation is required for the authorizations, in particular as regards the excavation areas. In principle, the interventions of nourishment and stabilization must take place according to a coordinated intervention plan (which takes account of the sedimentological and evolutionary characteristics of the entire coastal area) and monitoring which also includes the assessment of any critical chemical concentrations or evidence of ecotoxicity.

From a geochemical point of view, several analysis campaigns have characterized the sediments of the Gulf of Trieste defining, in particular, the presence of metals, also with regard to priority hazardous substances, and of organic contaminants. Referring to one of the most recent series of geochemical analysis performed in the Gulf of Trieste (Covelli et al., 2001), it appears that the sediments are characterized by high percentages of mercury (Hg) with concentrations ranging from 6.3 mg / kg to 13.50 mg / kg offshore and between 0.3 and 2.8 mg / kg near the coast, values that are also found in the marine area in front of Grado with the highest values in the more sector east between Grado Pineta and Canale Primero (Figure 8-1). For comparison, the average background value of the Mediterranean is 0.1 mg / kg, the limit value for soils is equal to 1 mg / kg according to Legislative Decree 152/2006 and subsequent amendments, of 0.3 mg / kg according to the D.M. 367/2003 and the D.M. 260/2010 while the Istituto Superiore di Sanità, in its opinion no. 14741 AMPP.IA.12 of 20125, indicates a limit value in sediments of 0.8 mg / kg for shellfish and fish farming and of 2.0 mg / kg s.s. for clam farming. In the sediment the predominant component of mercury is the sulfur form (HgS). The origin of the metal is to be found in the mining activity of Idrija in Slovenian territory (completed in 1996 but active since the 40s of the last century) which emitted mainly into the air large quantities of the metal in the form of vapours and

particles, transported by the Isonzo river and accumulated in the sediments of the Gulf of Trieste, in particular in silty and clayey ones. The distribution of mercury in the Gulf has a prevalent component towards SW.

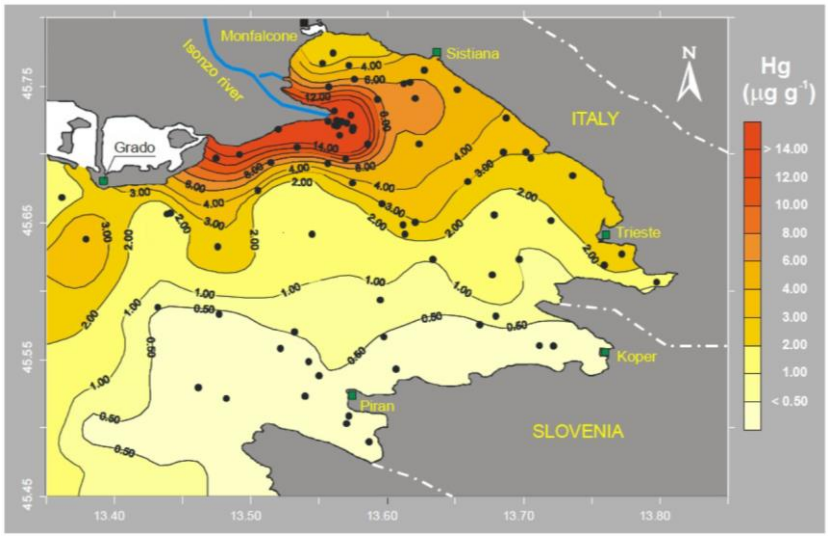

Figure 8-1 Areal distribution of mercury (Hg) concentrations in the sediments of the Gulf of Trieste (Covelli et al., 2001).

Actually, the presence of mercury (Hg) is the main problem for the interventions of restoration, stabilization or nourishment .

9 Monitoring plan

9.1 Introduction

The project's activities, particularly the compilation of a database including all past data, have highlighted the pilot site's chronic lack of systematic surveys. There can be no adaptive planning or management without basic understanding and a constant and adequate monitoring of coastal changes. Continuous, accurate monitoring of meteo-climatic conditions and morpho-bathymetric changes over time is the basis for correct comprehension of local coastal morphodynamics and must be ensured in order to plan actions and possibly re-direct them over time.

At the same time, the extreme natural events that affect the coasts, such as storms, high tides, river floods can induce significant morphological changes within a few hours such as retreat of the shoreline, erosion of beaches and barrier islands, sand bank migration, sand overwash, large amounts of stranded deposits and habitat destruction.

To address the consequences of these phenomena it is useful to adopt a rapid assessment methodology (Rapid Environmental Assessment, REA) of the changes occurred as a result of the event. Using methods

and technologies for prompt surveys of the post-event state (starting from recent past data) it is possible to have a quantification of the modification and damage suffered. In the current climate context of increasing extreme phenomena, an approach of REA is strongly encouraged by the European Union and at national level and is certainly the most appropriate means, if activated in a short time close to the event, in order to reach rapid solutions of intervention. This type of approach is also very useful for understanding the dynamics of extreme events in relation to the long-term dynamics of the ordinary events. The outcome of such assessments must be part of the coastal planning and management process.

Monitoring should therefore be carried out on more than one topic:

- monitoring of coastal morphology and dynamics

- weather and sea climate

- river and coastal solid transport

- subsidence.

9.2 Monitoring of coastal morphology and dynamics

The topo-bathymetric survey is extremely complex in the pilot site due to the rather articulate morphology and the vastness of the intertidal or shallow waters, many of which are affected by extremely soft seabed and dense seagrass meadows. Because of the project's experience, it is possible to provide a series of specific indications, which are reported below.

A periodic survey must be planned with periodicity of minimum 5 years and the integration of different methodologies of surveys must be considered:

9.2.1 Methodologies:

(a) High resolution aerial -photographs and LIDAR survey
The national and regional institutional flights are of sufficient quality and resolution to detect sub-aerial and intertidal forms, the latter in the case of shooting at low tide. But, it is necessary to highlight the fact that the most recent flights are cut, excluding the area of the Mula di Muggia Bank (Figure 9-1). The flight specifications would need to be reviewed, to include the area of interest and plan the flight at low water conditions.

The Lidar survey can be very useful, especially if it is performed in very low tidal conditions, and even for aerial photos associated with it that are of extremely high resolution.

Figure 9-1 Coverage of AGEA orthophoto of 2014 in the pilot sit, the lack of the most of the Bank is evident

(b) Topo -bathymetric survey.

The topo-bathymetric survey must be accurate and carried out with a geomorphological approach. A double approach is considered appropriate: linear and geometrically distributed surveys are integrated by additional surveys in order to detect specific lanforms (Figure 9-2). The detail of survey but also the instrumentation used must vary according to the morphological variability (presence of bars, channels, variable orientation of morphologies). Bathymetric surveys can be conducted using either multi-beam or single-beam instrumentation. It is obvious that multi-beam surveys provide better spatial information, but given the vastness of the area involved, a careful cost/benefit analysis is required. The shallow seabed, on the other hand, necessitates very close routes of survey, resulting in suboptimal multibeam performance.

About the single-beam, in terms of spacing, the greater the spatial variability of the morphology, the closer the routes are required. In this case, the lines provided in the Change We Care “ad hoc” survey (2019) must be guaranteed as a minimum (Figure 9-2).

The widespread presence of shallow waters (depth less than 1m) with dense seagrass necessitates a point survey using a GNSS system, on foot or with the assistance of a boat with a very low draught. At low tide, intertidal areas can be detected using lidar or UAV flights supported by adequate Ground Control Point coverage (Figure 9-3).

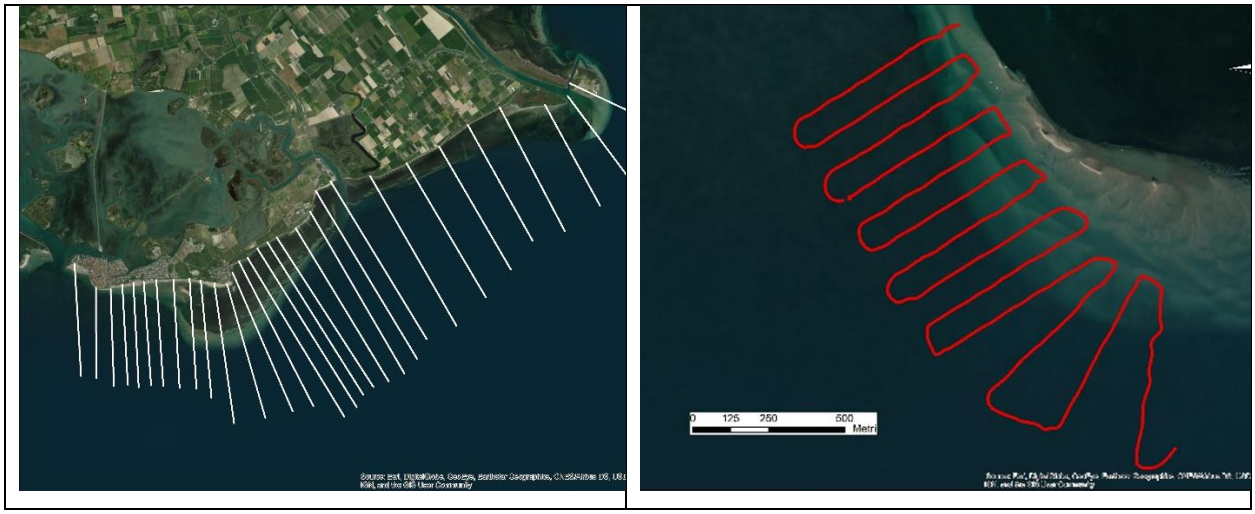

Figure 9-2 Survey pathways for bathymetric data: (left) geometrical approach and (right) additional surveys to detect bars not parallel to the general shoreline arrangement.

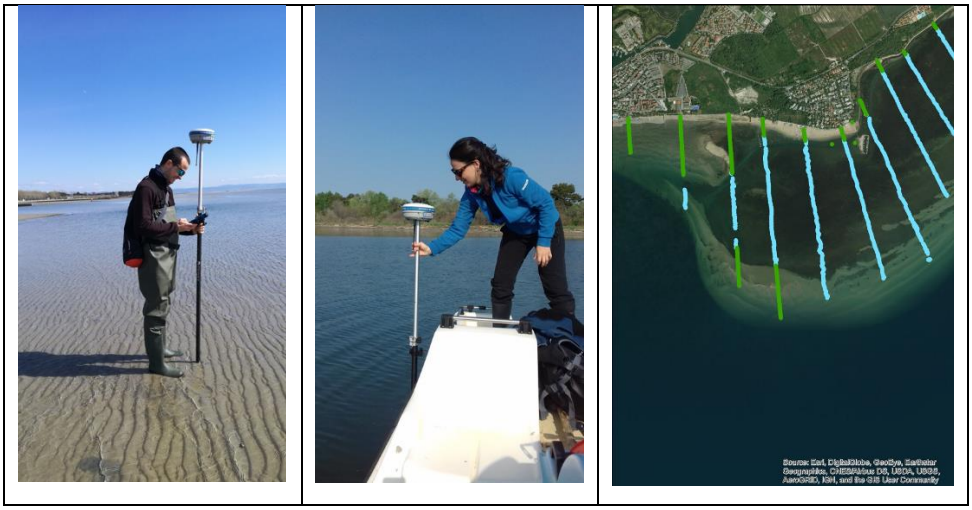

Figure 9-3 Point to point topographic surveys using a GNSS system in 2019: (left) data acquisition, (right) distribution of points in an area of the Bank (in green the points surveyed by feet, in cyan the point surveyed by pedal boat.

Figure 9-4 Single beam bathymetric surveys and UAV survey in 2019: (left) data acquisition, (right) distribution of survey point pathways in an area of the Bank and the ortophoto obtained by UAV (in green the topographic points surveyed by feet, in cyan the topographic point surveyed by pedal boat, in orange the bathymetric pathways).

A survey in focus areas must be planned at closer intervals of time in areas with very rapid morphologic changes. The most important area is ihe westernmost part of the migrating bars, in particular, in front of the Grado beaches, which is viewed as a threat to touristic activities due to the ongoing rapid extension toward the west of the shallow water with silty deposition in the nearshore and the current infilling of the navigation canal. The use of UAV survey, in particular, can be useful to monitoring the rate of bar migration and lengthening (Figure 7-2).

9.2.2 Rapid response

In some focus-- areas, "ad hoc" surveys using a REA approach should be planned, to assess the effects of storm or flood events. The surveys must be carried out shortly after the event and before any anthropic actions that alter the effects of such events (so there must be collaboration between beach managers and who does the monitoring).

9.2.3 Weather and sea climate

The systematic, continuous monitoring of hydrodynamic forces in the marine field (winds, waves, tides and currents) is functional not only to coastal morphodynamics assessment, but also to other sectors such as navigation, fisheries, environmental security, tourism, renewable energy, monitoring of events and impacts: wind, tides, currents, waves offshore and nearshore.

It is also useful to compile a list of extreme events. The collection of observational data must be integrated with appropriate weather-marine modelling in order to develop sea-state forecasts, prediction for alert systems, and event re-analysis.

9.2.4 River solid discharge

Prerequisite for any coastal management activity should be an adequate knowledge of the quantity (and quality) and spatial and temporal distribution of river sedimentary contributions. To that end, knowledge of the river and its drainage basin is required, and so are tools for analyzing and evaluating direct and indirect solid river transport.

Some useful tools for this purpose are:

- Acoustic Doppler Current Profiler (ADCP) on the river bed to measure continuously current, flow rate and turbidity;
- Acoustic Doppler Current Profiler (ADCP) mounted on a vessel used to measure the total water transport by crossing from one bank to another;
- Water and sediment sampling for calibration of solid transport in suspension (bottle samplers) and of solid flow rates to the bottom (with Helly-Smith system, sedimentary traps) to be carried out at a fixed rate and at any flow rate (flood, ordinary, low level).

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