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The COASTAL project: Increasing land-sea synergies and coastal-rural collaboration for a healthy ocean.

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Abstract

Coastal and sea regions not only concentrate populations and intensive economic activity but also environmental stresses and higher levels of pollution. On the other hand, rural hinterlands face depopulation and often economic recession while still environmentally impacting coastal regions. Land-based activities (agriculture, forestry, industries and urbanization) are directly and indirectly impacting land, coastal and sea ecosystems (soil and river pollutions, marine water eutrophication, etc.), the coastal region are the downstream recipient of land use negative practice externalities. At river basin scale, despite the fact that land-based ecosystems are linked to coastal and sea ecosystems through water flows, the understanding of these links remains limited partly due to sectorized and fragmented research and governance practices. At the European policy level, legislations follow these spatial and sectoral approaches, the Water Framework Directive[3] (WFD) and the Marine Strategic Framework Directive[4] (MSFD) which seek to achieve 'Good Environmental Status' of rivers and marine water respectively, but both lack interconnections and common working principles. Although river water flows directly impact coastal and marine waters, neither the Common Agriculture Policy[5] (CAP) nor the

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[3] https://ec.europa.eu/environment/water/water-framework/index_en.html
[4] https://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm
[5] https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/cap-glance_en

Integrate Coastal Zone Management[6] (ICZM) principles sufficiently address the gaps between sea management, coastal management and inland management.

The EU H2020 COASTAL project adopts an innovative source-to-sea approach where at river basin scale, sea, coastal and rural regions are seen as a whole and single ecosystem. The project seeks to improve land-sea synergies in strategic business and policy decision making, and collaborations between coastal and rural stakeholders in order to (1) create connections between land ecosystems and coastal ecosystems, for sustainable use and management of theses ecosystems as well as reaching the Sustainable Development Goals[7] (SDGs) pertaining to the sustainable use of freshwater (SDG 6), seas (SDG14), terrestrial ecosystems (SDG 15) and climate change impacts (SDG13); (2) support sustainable growth in rural, coastal and marine sectors by fostering cross-sectoral collaborations; (3) develop links between EU WFD, MFD and CAP by developing policy alternatives for coastal-rural areas. The COASTAL project adopts a strong participatory multi-actor, bottom-up approach based on collaboration between rural, coastal and sea stakeholders. The methodology and tools used combine local and scientific knowledge to explore and analyse social, environmental and economic land-sea interactions in a collaborative System-Dynamic framework to identify problems and develop practical and robust business road maps and strategic policy guidelines to improve land-sea synergies and coastal-rural collaborations. The project adopts an interactive approach via Multi-Actors Labs (MALs) centered around 6 selected coastal regions (in Belgium, Sweden, Romania, Greece, Spain and France) with both common as well as unique opportunities and challenges.

Introduction

The need to increase land-sea synergies

Coastal areas and rural hinterland

Nearly 40% of the world's population lives within 100 kilometers of the coast. Coastal areas experience higher population density, higher population growth associated to global trend of coastal migration, and higher urbanization (most of the world's megacities are located in the coastal zone cf. Brown et al., 2013) than the hinterland (Small 2003, Smith 2011, McGranahan et al., 2007). Coastal areas are also economically highly dynamic, with a high concentration of activities (on land and at sea), a generally lower unemployment rate (in half of EU coastal regions, unemployment is lower than the national average[8]). Coastal zones are generally driven by a strong tourism industry in constant growth (in regions such as the Mediterranean, tourism activities represent 11% of regional GDP and 11% of total

[6] Aims for the sustainable development of coastal areas approach that respects the limits of natural resources and ecosystems ('ecosystem based approach') cf. https://ec.europa.eu/environment/iczm/index_en.htm

[7] https://sustainabledevelopment.un.org/?menu=1300

[8] Eurostat regional yearbook 2011 – Coastal region, https://ec.europa.eu/eurostat/documents/3217494/5728589/KS-HA-11-001-13-EN.PDF/c0dd33ed-0db2-4d8b-ae03-26d9bf3e57fc?version=1.0

employment[9]). In addition to tourism, coastal areas also benefit from increased maritime activity (shipping, fishing, mining, offshore renewable energies, aquaculture). In contrast, the global phenomena of industrialization and urbanization create lasting impact on rural hinterlands which suffer from depopulation and economic decline (Li Y. et al, 2019). 92% of the EU territory is considered to be rural[10] while only 28% of the EU population lives in this area[11].The main rural sectors (agriculture, forestry and other nature based industries) have constantly increased their capital to labor ratio, leading to a decrease in employment rates; thereby making urban and coastal areas more attractive from an economic standpoint, and pushing rural populations to migrate to these areas. The constant population growth and higher concentration of economic activity in the coastal zones, give rise to an intensification of anthropogenic pressures on the rich but fragile coastal and marine ecosystems. Moreover, poor management and use of the natural resources inland further increases the environmental stresses over these ecosystems.

Inland impacts on coastal and sea regions

The source-to-sea continuum considers the land and the sea as a single component i.e from land to freshwater, delta, estuarine, coastline, near shore and ocean, connected through flows of waters, including sediment, pollutants, materials, biota and related ecosystem services (Granit et al. 2017). The sea, the coastal area and its hinterland form a single, unique, ecosystem. The sea and coastal areas being the natural continuity of inland areas, land-based ecosystems and sea-based ecosystems are intrinsically linked; with one not only benefiting from the other, but also impacting it and vice versa. Today marine and coastal resources are increasingly jeopardized by upstream activities on land and along rivers.

Inside a river basin, land-based activities (agriculture, forestry, heavy industry and urbanization) inevitably impact coastal areas and marine water due to unsustainable land use, soil degradation, pollution of inland freshwater. As such, coastal areas are particularly vulnerable as they are subject to both land-based and marine-based human pressures (Halpern et al., 2008). Land-sourced pollution (high levels of nutrients loads) related to poor agricultural practices and continual urban development (i.e. inadequate urban sewage system) lead to marine ecosystem degradation, harmful algae blooms and eutrophication in coastal water (Howarth et al., 2002, DeGeorges et al. 2010, LeMoal et al. 2019). Waste production inland also has a severe effect on the coast and the sea, in the form of increased marine litter – approximately 8 million tons of plastic enter the ocean from land-based sources annually[12], and constitutes more than 80% of marine litter; modelling the drift patterns of floating marine litter shows that the plastic pollution of almost every country is mainly caused by its own terrestrial sources (Bigagli et al., 2019). Hydraulic infrastructure has resulted in over half of the world's major rivers being severely affected by the alteration

[9] Plan Bleu paper n°17, Tourism, May 2017, http://planbleu.org/sites/default/files/publications/cahier17_tourisme_en_web.pdf
[10] EU strategic guidelines for rural development, https://eur-lex.europa.eu/legal-content/FR/TXT/PDF/?uri=CELEX:32006D0144&from=EN
[11] Statistics on rural areas in the EU, 2017 https://ec.europa.eu/eurostat/statistics-explained/index.php/Statistics_on_rural_areas_in_the_EU
[12] SIWI Policy Brief "Transboundary waters: cooperation from source to sea"

and fragmentation of their flow regimes (Nilsson et al., 2005), with deltas are increasingly vulnerable to flooding and submergence as a result of the combined effects of the trapping of sediment behind dams and sea-level rise due to climate change (Syvitski et al., 2009) and in some cases over-abstraction of groundwater (Erban et al., 2014). In other cases river flows hardly reach the sea thus creating disequilibrium in water, sediment and nutrient supply to coastal ecosystems. Additionally, climate change, and primarily sea-level rise, poses a great threat on land to many coastal regions with populations, economic activities and coastal ecosystems put at risk.

The source-to-sea approach supported by a global policy framework but locally the governance still fragmented

Given the scale of the challenge, the international community has recognized the need for integrated coastal and freshwater management. The UN Environment Programme Global Programme of Action for the Protection of the Marine Environment from Land-based Activitie[13]s (GPA) was adopted in 1995. This was followed by the Manila convention in 2012, which committed "to improve cooperation and coordination at all levels to deal with issues related to oceans, coasts, islands and their associated watersheds, by applying integrated management such as 'ridge to reef' approaches, involving stakeholders and developing innovative solutions to improve or resolve identified problems". The importance of improving fresh and marine water quality, as well as land-based ecosystem is also recognized by several goals within the Agenda 2030 for Sustainable Development (SDG's 6, 14 and 15)[14].

However, in many cases regional and national policies fail to align with the international agenda. At EU level, the Maritime Spatial Planning Directive (MSPD) refers explicitly to the need to account for land-sea interactions for addressing nutrient loads, however the quality and ecosystem status of coastal waters, regulated by the EU Water Framework Directive (WFD), is not yet adequately integrated into the Marine Strategic Framework Directive (MSFD) and the MSPD (Borja et al.).

[13] "The Global Program of Action is designed to be a source of conceptual and practical guidance to be drawn upon by national and/or regional authorities for devising and implementing sustained action to prevent, reduce, control and/or eliminate marine degradation from land-based activities. " cf. https://sustainabledevelopment.un.org/partnership/?p=7432

[14] https://sustainabledevelopment.un.org/?menu=1300

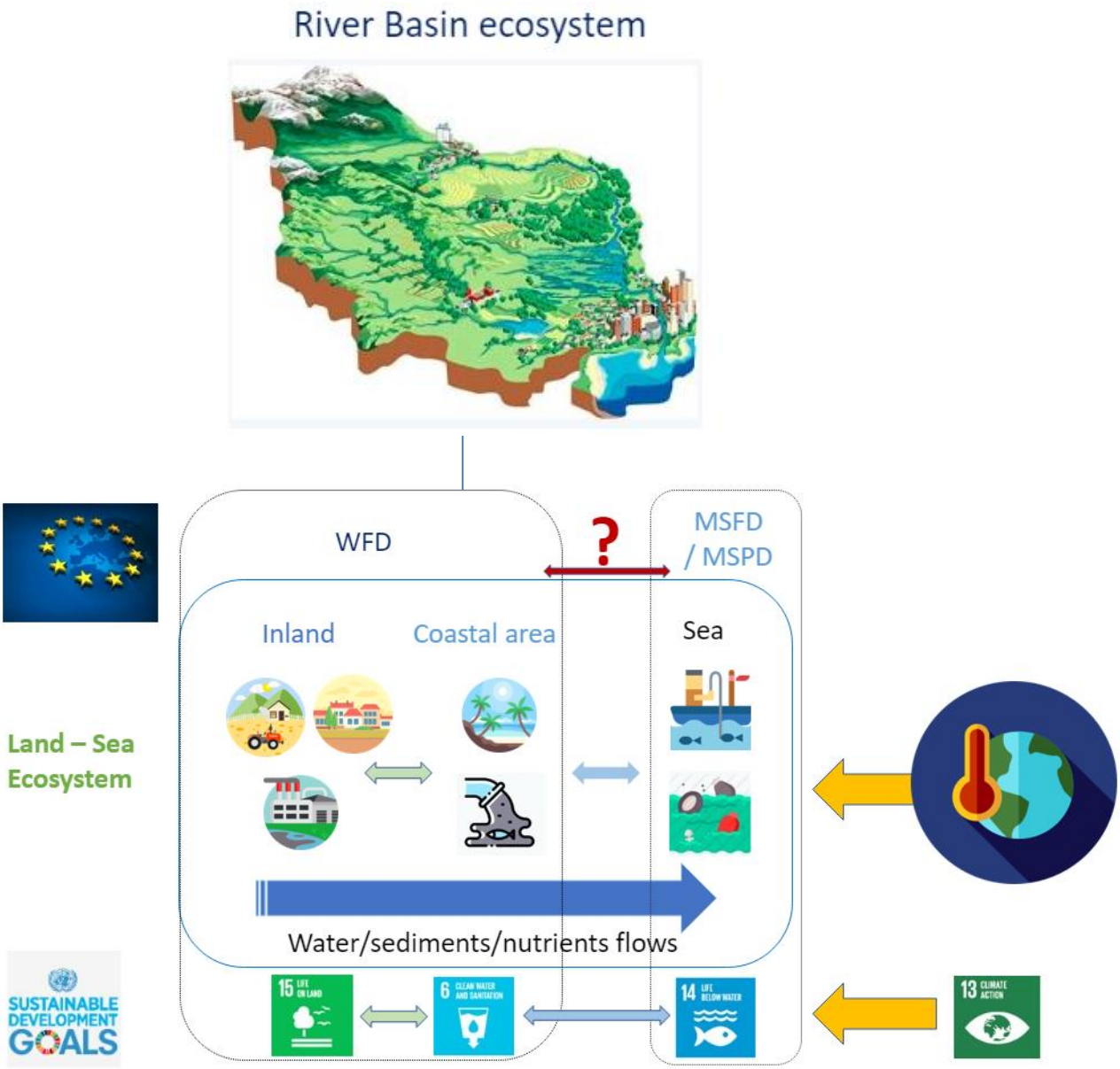

Figure 1: Mapping EU and international policy frameworks onto the source-to-sea continuum [15]

Promoting land-sea synergies to foster the 'source-to-sea' management approach

Bringing together stakeholders from land, coastal and sea regions to create synergies and elaborate innovative approaches to solves common environmental issues in a collaborative way is necessary. Increasing land-sea synergies by creating new business opportunities in the context of the Blue and Green Growth will enable the sustainable development of sea, coastal and rural regions, making the whole land-sea ecosystem more resilient. This requires a paradigm shift at policy level, towards the adoption of source-to-sea concept, in order to ensure that policies such as the MSFD, WFD and the CAP are well connected and truly

[15] Icones from Freepik in Flaticon

represent the Integrated Coastal Zone Management approach as well as supporting rural development and Blue Growth potentials

Working within this context, the EU H2020 COASTAL project seeks to improve land-sea synergies in strategic business and policy decision making, by fostering collaborations between coastal and rural stakeholders in order to:

- support sustainable growth in rural, coastal and marine sectors by cross-sectoral collaborations and the co-design of robust land-sea sustainable strategies.
- create links between EU WFD and MSFD by developing policy alternatives for sea-coastal-rural areas
- highlight the connections between land ecosystems and coastal ecosystems, for a sustainable use and management of theses ecosystems and reach the sustainable development goals.

1. COASTAL project: methodology and tools

The COASTAL project is a unique collaboration of coastal and rural business entrepreneurs, administrations, stakeholders, along with natural and social science experts. Local and scientific knowledge are combined to identify problems and develop practical solutions in the form of robust **business road maps** and strategic **policy guidelines**, aimed at improving land-sea synergy. A multi-actor approach is followed to analyse the social, environmental and economic land-sea interactions in a collaborative **System Dynamics** (SD) framework, taking into consideration the short-, mid- and long-term impacts of decision making and feedback mechanisms on coastal and rural development. The project is organised around participatory **Multi-Actor Labs** (MALs), combining tools and expertise to focus on six case studies representing the major coastal regions in the EU territory. Each MAL consists of local actors and experts who participate in collaborative exercises to analyse problems, causes, propose and discuss solutions, as well as validate and interpret the impacts of simulated business and policy decisions. The MALs are connected via an online platform for collaborative knowledge exchange – the COASTAL Platform. The COASTAL platform and the synergistic tool sets will be further exploited and developed beyond the project life time. The ultimate ambitions of COASTAL are to inspire strategic land-sea planning and contribute to the formulation of integrated coastal-rural regulations at the regional, national and EU level (Tiller R. et al., 2019).

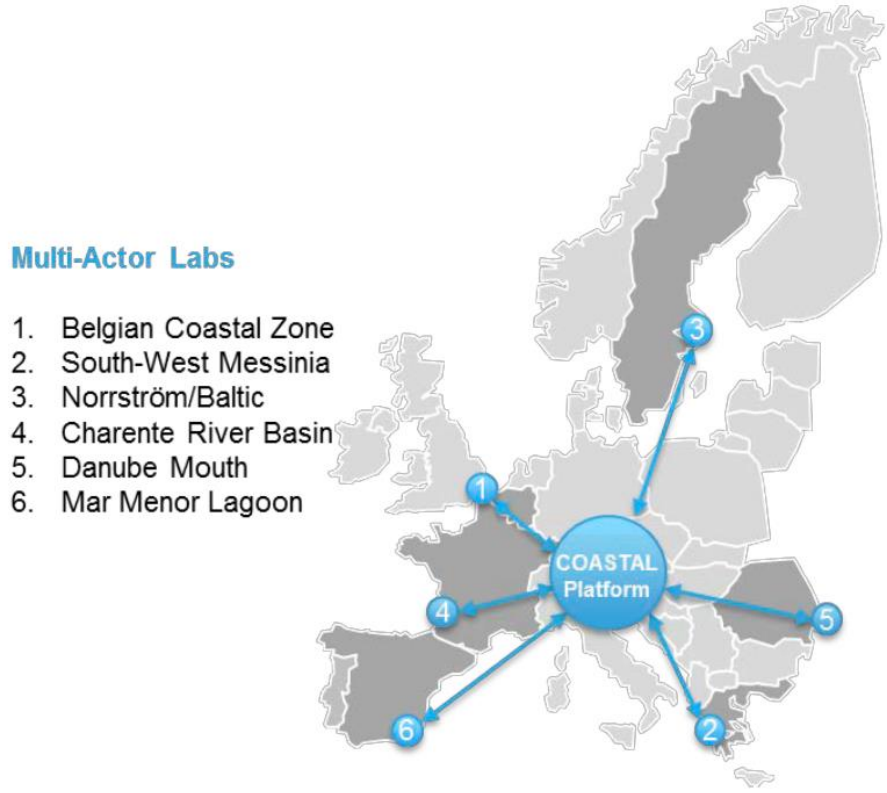

Figure 2: Location of the six COASTAL case studies

COASTAL project case studies[16]

The COASTAL project's six case studies and corresponding MALs differ by problem context, spatial scale, and social-environmental conditions. They are collectively representative of the diversity of European coastal regions with common issues and opportunities as well as local specificities (see table 1).

Belgian Coastal Zone (North Sea Region)

The Belgian coast (60 km length) and hinterland face environmental and economic stresses from intensive multifunctional use of space. Land- and sea-based activities such as agriculture, fisheries, agro-food industry, transport, energy production and recreation are closely interwoven and compete for space. New development opportunities for this densely populated region are created by blue growth; in particular energy production (both on- and off-shore) which creates opportunities for new jobs and strategic specialisation of port activities – this includes innovative production methods using wave and tidal energy. Belgium is world leader in terms of know-how related to offshore energy production and the

[16] All case study descriptions have been developed by local MAL leaders as part as the COASTAL project and are extracted from the project internal documentations (BELGIUM: Jean-Luc de Kok (VITO), Bastiaan Notebaert (VITO); FRANCE: Françoise Vernier (IRSTEA), Jean-Marie Lescot (IRSTEA), ROMANIA: Luminita Lazar (NIMRD); Ruxandra Pop (ICEADR); SWEDEN: Georgia Destouni (SU), Samaneh Seifollahi-Aghmiuni (SU), Zahra Kalantari (SU); GREECE: Giorgos Maneas (SU), Aris Karageorgis, (HCMR), Håkon Berg (SU); SPAIN: Javier Martínez-López (CSIC), Joris de Vente (CSIC);)

first country to implement the multi-purpose use of off-shore wind farms (i.e. combined with shellfish aquaculture). That said, the quality of fresh water resources is under pressure, and land-based emissions of nutrients still exceed the EU-WFD target levels and contribute to coastal eutrophication. In addition, the quantity of fresh water is under pressure during extended periods of drought, as a result of multiple demands from industry, tourism, population and agriculture. A major stressor is the increasing salinization of inland waters, as a result of human waterworks, water management, and sea level rise. A main challenge for this case study is the fragmentation of policy and knowledge for coastal and rural development. A common administrative framework for coastal-rural integration is lacking and policy responsibilities are fragmented at the regional and national level.

South-West Messinia (Eastern Mediterranean Region)

Agriculture (mainly olive farming) and coastal tourism are the two major economic activities in Western Messinia, Greece. Tourism is expanding and goes hand in hand with infrastructure development (hotels, roads and airports) and can provide opportunities for diversified livelihoods, but also increases pressures on the environment and cultural sites. Coastal areas are also affected by agrochemicals, soil erosion, solid waste landfills, and waste water from inland sources. In particular waste products from olive production constitute a threat to surface and coastal water quality. Climate change is expected to increase coastal erosion and decrease the availability of freshwater, with increased risk for saltwater intrusion into coastal wetlands and aquifers. There are also plans for offshore oil and gas exploration that will have implications for the area's rich coastal biodiversity. The study area comprises several important cultural sites and Mediterranean habitats included in the reference list of the Natura 2000 initiative[17]. The MAL will develop a number of alternative strategies for local economic development that will allow a diversification and strengthening of a sustainable local economy while minimizing the impact on the Natura 2000 sites. Long-term planning for sustainable tourism and agriculture will take into account resilience to future climatic changes, exploiting the expertise and experience of local stakeholders.

Norrström river basin – Baltic (Baltic Sea Region)

The Norrström drainage basin (22 000 km²) comprises the major part of the Swedish water management district Northern Baltic Proper. For the case study, economic and environmental issues are considered both at the local scale and that of the Baltic Sea, including environmental and physical interactions between the two scales. The basin is part of the fertile Swedish belt, characterised by extensive agriculture, and includes the Swedish capital Stockholm. An unresolved and well recognised problem for the coastal environment and its sustainable development is the human-driven eutrophication and associated hypoxia with recurring harmful algae blooms, caused by the combined nutrient emissions from households, agriculture, and industry. These impacts occur on the local/regional scale of the Swedish Norrström case and the macro-regional/cross-boundary scale of the whole-Baltic case. Sustainable development solutions must consider the agricultural, urban and industrial activities in the hinterland, the high and increasing population density, tourism development

[17] https://ec.europa.eu/environment/nature/natura2000/index_en.htm

in the coastal zone, on-going and future climate change, and their combined effects on the nutrient loads transported to the coast. The overarching problem, and possibilities for addressing the problem are recognized in strategic planning and development plans at the local and regional scale.

Charente River Basin (Atlantic Coast)

The Charente river basin in SW France is predominantly rural and covers an area of 10 500 km² linked to the sea by the Pertuis Charente River with a large tidal influence. Agriculture represents the main hinterland activity, and major urbanization and industrialization can be found at Port Atlantique-La Rochelle (8.4 million ton per year). The region is characterized by a contrast between the densely populated coastal fringe and the rural territory with a low population density. Industrial activity is dominated by agri-food and wine industry around the cities of Cognac and Angoulême. Tourism in the region is significant. At the river mouth, the Charente river supplies fresh water to the oyster basin of Marennes Oléron. Fresh water is essential for shellfish farming, which depends on a sensitive balance between the temperature, salinity and acidity of coastal waters, inland supply of fresh water and nutrients. The Marennes-Oléron bay is the first European shellfish farming center for spat production and for the number of shellfish companies (SMEs). Charente-Maritime is home to three major marshes, the cultivation of which poses a risk of imbalance, thus endangering the fauna and the flora. There is a high concern for diffuse pollution by nutrients and pesticides of surface water and their influence on the drinking water supply. Most inland watercourses suffer from droughts and periodic low water levels, making water supply a challenge. Thus the main policy issue for the region is the current and future supply and quality of the freshwater for different functions (drinking water, agriculture, industry, and shellfish farming).

Danube Mouth – Black Sea (Black Sea Region)

Due to the semi-enclosed location and size of the contributing catchment area the Black Sea is vulnerable to anthropogenic pressures and pollution sources. The nutrient regime of the Danube has undergone significant changes due to increased economic activity, use of fertilizers, waste water discharges, and use of detergents, leading to changes in the Black Sea ecosystem. Eutrophication results in decreased transparency, higher quantities of organic matter decomposition, and oxygen depletion with bottom waters becoming seasonally hypoxic or even anoxic. Since the early 90s, decreasing nutrient inputs has resulted in signs of recovery. Today, the Black Sea catchment is still under pressure from excess nutrients and contaminants due to emissions from agriculture, tourism, industry and urbanization in the Danube basin. This hampers the achievement of a Good Environmental Status by 2020, as required by the EU-MSFD. The increased rates of eutrophication, pollution and bioaccumulation affect both the biodiversity (including Natura 2000 sites) and fishing sectors. Mass tourism is an important growth sector for the Black Sea and eco-tourism is becoming more important in the region. Approximately 65% of the Romanian coastline is located in the Danube Delta Biosphere Reserve and subject to tourism regulations, resulting in conflicts between nature conservation and economic development. Failing to resolve these conflicts has economic and political impacts.

Mar Menor Coastal Lagoon (Western Mediterranean Sea)

The Mar Menor coastal lagoon (135 km^2) is located in the Region of Murcia (SE Spain). The area is characterized by multiple environmental, socio-cultural and economic interests, often competing for scarce resources, water being the most important. There is a high potential for complementarity, win-win scenarios and development of sustainable business cases based on public-private collaboration, efficient use of water, and innovative farming practices and a transition to sustainable models of tourism and agriculture. The catchment draining into the Mar Menor covers an area of 1.255 km2 and is mainly covered by intensive irrigated agriculture (35%) and tree crops (30%). The intensive and highly profitable irrigated agriculture depends on scarce low quality groundwater and water from inland inter-basin water transfers. Agriculture provides labour and income to the region, but forms a source of excessive nutrient and contamination into the Mar Menor coastal lagoon. The resulting poor water quality affects the ecology of the lagoon with severe implications for its potential function for tourism and fisheries. The coastal lagoon forms part of a Specially Protected Area of Mediterranean Importance (SPAMI). The Mar Menor is one of the hotspots for tourism in the Region of Murcia, with a total number of 346,000 tourists and 1.4 million over-night stays in 2016. Beside international visitors, the Mar Menor has an important touristic function for the regional population (1.5 million inhabitants). The availability of water for irrigation and drinking water for tourism will be further reduced under future climate conditions. As such, the Mar Menor is strongly influenced by interactions between inland agriculture on the one hand, while on the other hand, coastal tourism and fisheries affect natural ecological values and socioeconomic sustainability. The need to move towards sustainable modes of agriculture, fishery and tourism is increasingly recognized and recently revived strongly due to sudden increase in contamination levels resulting in a considerable decline in tourism.

Embedding Stakeholder Perspectives

The general methodology of COASTAL is based on a complete integration of a participatory, multi-actor approach with evidence-based analysis, exploiting local and scientific knowledge and expertise. As such, local stakeholders from coastal and rural areas along with scientists work together to co-design innovative business solutions and policy alternatives to create sustainable, dynamic and resilient European land-sea regions. Stakeholders, entrepreneurs and administration representatives actively and jointly contribute to the design, testing and interpretation of these business and policy solutions.

A Collaborative System Dynamics[18] approach is used to provide a natural framework for describing and analysing the time-dependent development of complex systems such as the land-sea ecosystem, at a strategic level appropriate for business and policy support. The Multi-Actors Labs engage local stakeholders in co-designing metal maps of their regional land-sea interactions during interactive sectoral and cross-sectoral workshops.

[18] System Dynamics modelling is a well-established methodology for analysing the behaviour of complex environmental and social systems, and understanding the counter-intuitive responses to business and policy decisions, resulting from the underlying balancing and reinforcing feedback structures.

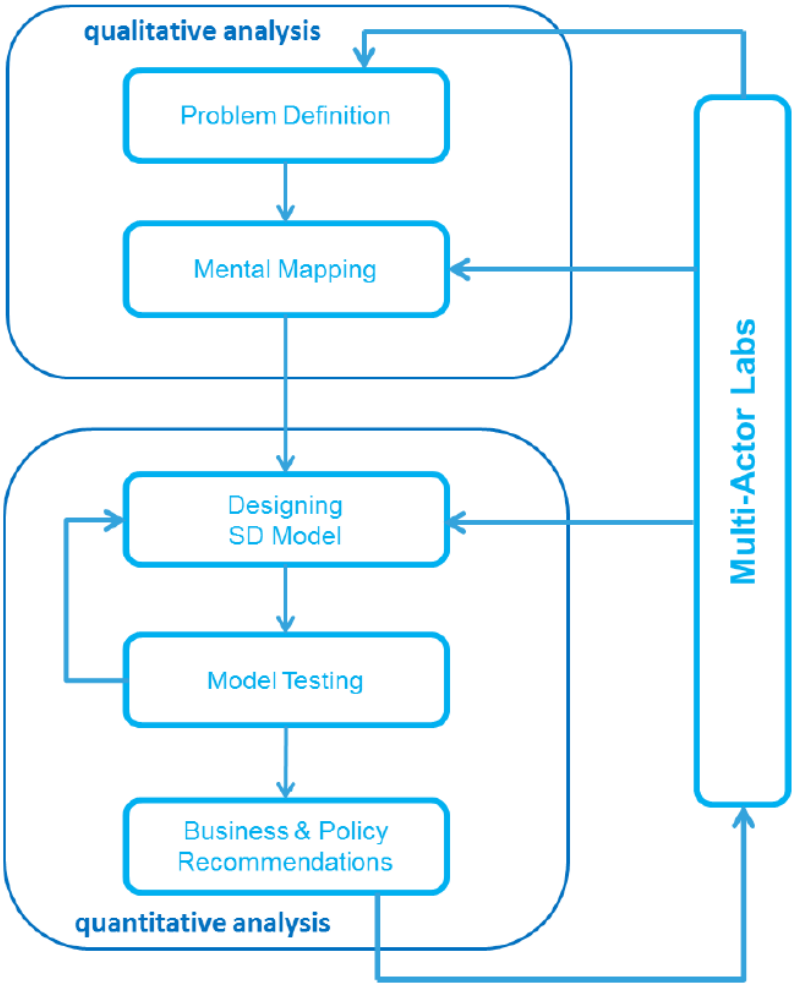

Figure 3: Collaborative System Dynamic modelling in COASTAL[19]

Moreover the MALs have five specific objectives:

- facilitate and coordinate the exchanges between local coastal and rural stakeholders, policy makers, economic actors, and stakeholders, aimed at conceptualising the land-sea interactions and system feedback
- exploit the available scientific knowledge and existing data to quantify the system interactions, using System Dynamics (SD) modelling and Systems Thinking techniques
- contribute to the design, testing and demonstration of generic and reusable tools and key performance indicators for coastal and rural development, and land-sea synergy
- develop practical, feasible and evidence-based business road maps and policy guidelines aimed at improving the land-sea synergy and collaborations between coastal and rural operators
- organise the local dissemination actions, inter-case study exchanges, and contribute to the post-project exploitation of the project outcomes

[19] Cf. COASTAL project

Each local case study organizes 6 sectoral workshops from coastal and rural areas and one multi-sectoral workshop regrouping stakeholders from coastal and rural areas. At the final stage of the project an international workshop will be held, bringing together local stakeholders from each case study. The main purpose of the workshops is to engage stakeholders in an open discussion, aimed at identifying the main issues, opportunities, obstacles and solutions in the context of land-sea interaction and their own sector or field of expertise (tourism, farming, water management, spatial planning). The mental mapping refers to the graphical representation of the issues brought forward by the workshop participants, linking the elements mentioned. Causality between key variables is an important aspect of the mental maps (sometimes referred to as 'mind maps') (Tiller R., 2019). Additionally local stakeholders give feedback on potential business opportunities and best practices applied with success in other coastal-rural regions and are engaged in the co-construction of scenarios and transition pathways to reach sustainability in the context of their respective case study areas.

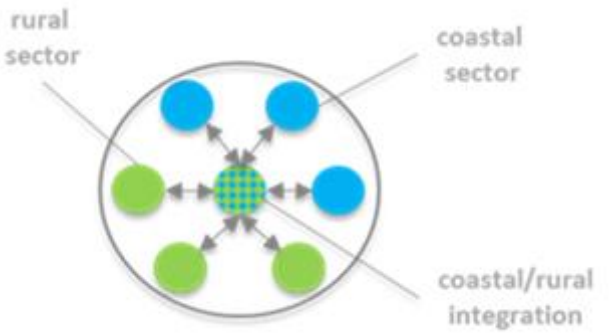

Figure 4: COASTAL Multi-Actor Labs

Fostering land/sea synergies: Initial findings from the COASTAL project

Following the sectoral workshops, the main issues facing the different coastal-rural stakeholders were identified. Despite the diversity of the case studies, it was possible to distil several common issues that need to be addressed.

Table 1: Issues highlight in COASTAL local sectoral workshops[20],[21]

Issues identified for COASTAL case's study	Belgian Coastal Zone and Hinterland	Charente Basin (France)	Mar Menor (Spain)	SW Messinia (Greece)	Danube Mouth and Black Sea (Romania)	Norrstrom and Baltic (Sweden)
Water quality (and eutrophication)						
Water quantity						
Flood Risk and Coastal defence						

[20] Icons made by Freepik , itim2101, Eucalyp, Icon Pond, Roundicons, from www.flaticon.com
[21] COASTAL Deliverable 03: Sectoral Analysis of Coastal and Rural Development; Direct contributions from MAL leaders following interim consultation

Soil quality (and soil's salinization)						
Beach erosion						
Stakeholders conflicts / lack of cooperation						
Lack of Information / Education regarding environmental issues and policies						
Public awareness and lifestyle (including food habits)						
Waste management (inland, beach and marine litters)						
Biodiversity loss						
Natural protected area and other Policy and management related issues management						
Nature conservation						
Cultural conservation						
Traffic congestion / transport network issues						
Land price/ land availability / increase urbanisation						
Climate change						
Sustainable growth						
Seasonal population variability						
Social challenges						
Historic legacy sources of nutrients and pollutants						
Lack of infrastructures for further development						
Taxation issue						
the need of improved renewable energy						
Spatial planning						

As presented in Table 1, issues related to the water resource (regarding the quality and the scarcity of the resource), land availability, as well as the lack of cooperation and conflicts between stakeholders, are common to all case studies. In most of the COASTAL case studies areas, the natural environment and its biodiversity are under threat and local authorities face difficulties related to the protection and the management of these natural areas. The degradation of soil quality often related to salinization is another concern. Finally these regions have to deal with issues related to the seasonality of tourism activity, waste management and coastal risk management (sea-level rise, flood risk, coastal erosion). Climate change is identified in all COASTAL case studies as a serious concern with the potential to exacerbate these issues and create additional impacts on all sectors.

This begs the question: how can developing land/sea synergies provide solutions to rural-coastal-sea issues? As demonstrated by the philosophy of the source-to-sea concept, stakeholders from land and sea regions share the same natural resources; mismanagement of inland natural ecosystems will inevitably affect ecosystem and human activities related to these resources on the coast and at sea. Actors within agriculture, energy, fisheries, cities, infrastructure, and water management must all be collectively engaged as stakeholders in planning, operations, and management from source to sea to protected the natural resources, their related ecosystem services, and ensure a sustainable development of the land-sea regions.

As part of the COASTAL project, an inventory of best practices, successes and lessons learned related to business opportunities and policy alternatives has been compiled. The inventory provides examples from all over Europe and beyond, serves as a reference point for inspiring solutions to increase land-sea synergies and coastal-rural collaborations (Akinsete et al., 2019). However, practices with the main purpose of improving coastal-rural collaborations and land-sea synergies still few and far between, and are not yet common place. In fact, the sector workshops of the COASTAL project are one of the first attempts to identify the opportunities for land-sea synergy, and added value for specifically for rural development. Nevertheless, a few other EU funded projects addressed this particular challenge in a systematic way (for instance with the C-Scope project which aims at achieving an integrate approach to management and planning within the land-sea interface[22]) or for a different domain (the ROBUST project foster the development of rural-urban synergies[23]). The scientific literature when analysing the socio-environmental and economic land-sea interactions, generally take a conceptual and academic approach with little practical examples on how to increase synergies and collaborations. Despite international efforts to promote the idea of a coordinated global approach, local recommendations, practices and projects still generally take a sectoral focus; which at most extends to consider either the rural, coastal or marine issues depending on the sector. Recently, more initiatives have attempted to develop coastal-marine synergies (i.e. development of Pesca tourism[24],

[22] http://www.cscope.eu/en/
[23] http://rural-urban.eu/
[24] Combined activity of tourism and fishery, initially developed in Italy and now spreading in other Mediterranean countries (France, Spain) – cf. TourismMed interreg project https://tourismed.interreg-med.eu/

aquaculture on land[25]), which could provide a potentially inspiring operational framework for the development of coastal-rural synergies. Nevertheless, many initiatives, by working on sustainable tourism, natural conservation and water issues, risk management, local redevelopment, unwittingly create some form of land-sea synergies and coastal-rural collaborations (see further details in Akinsete et al., COASTAL deliverable D09). Following the identification and analysis of the examples of best practice, key business opportunities, lessons learned and policy recommendations are highlighted below.

Combined activities are one of the best examples on how to create synergies between land and sea: Fishery and tourism are so far the best example of successful combined activities in Europe[26], replicable across the continent with the proper legislative adaptation. Inviting tourists on fishing boats at sea, while developing fish markets and valorising fishing culture and heritage on land, fosters sustainable fishing practices and at the same time raises awareness of consumers for a responsible consumption of sea products. These land-sea synergies aid in the protection of the resource at sea while sustaining the entire fishing community on land. Other combined activities can be envisaged, however despite extensive research and promising results (e.g. EU MERMAID, H2OCEAN and TROPOS projects for multi-use of off-shore platforms, COEXIST[27] and MUSE[28] projects for combined activities at sea (i.e between fishery and aquaculture; Energy production and aquaculture or fishery; Aquaculture and environmental protection; Tourism, fishery and environmental protection)), the possibility of other combined activities at sea is still in the prototype stage in most cases and deeply dependant on the local context and legislations.

Ecotourism and agro-tourism based on local natural and cultural heritage can also create coastal-rural collaboration and land-sea synergies. Economic activities, population and tourists are concentrated in the coastal area while the rural hinterland is often neglected but preserved from landscape degradation which in turns makes it attractive for alternative forms of tourism. In collaboration with coastal stakeholders, ecotourism and agro-tourism can create new economic opportunities in rural hinterland. It can also be used as a tool for reducing touristic pressure on the seaside area and extending the touristic season of a coastal-rural region; as such, beneficial for both areas and creating land-sea synergies. In the Algavre region (Portugal), local initiatives promote an alternative tourism based on local products and heritage (establishment of a route of Traditional Salt from the Atlantic, the "KM 0" branding initiative, the Eating Algavre Food tour cf. Akinsete et al. 2019).

The development of renewable energies off-shore, if integrated as part of wider strategic development inland, can foster land-sea synergies as shown in the Renewable Energy Island project[29] of Samsø in Denmark. Through the development of renewable off-shore and inland energies and the direct investment of the local community, the island became 100% self-sufficient in terms of energy production. Local islanders who are shareholders in the different energy production enterprises even generated income. The multiplier effect of the

[25] Cf. Coastal Laboratory in the Netherlands - https://www.kustlaboratorium.nl/aquacultuur

[26] See examples of successful implementation of tourism-fishery combined activities in https://webgate.ec.europa.eu/fpfis/cms/farnet/files/documents/FARNET_Fisheries_and_Tourism-9_EN.pdf

[27] http://www.coexistproject.eu/coexist-results/coexist-case-studies

[28] https://muses-project.com/

[29] Cf. https://energiakademiet.dk/en/

renewable energy strategy has, therefore, been felt throughout the local economy. Moreover the project had positive effects of the quality of air, water and terrestrial environment with significant reductions in emissions of greenhouse gases and airborne particles, which has in turn benefited the provision of ecosystem services. Such an initiative is a perfect example on how the green economy and the needed energy transition towards renewables can create business opportunities, foster collaborations in a coastal-rural community and improve land-sea synergies which will benefit the economy, the environment and the local community. The development of off-shore energy can also boost local port/shipping activities by creating new strands of income generating activity, and thus diversify the local economy as foreseen in the French COASTAL case study for the port of La Rochelle.

Coastal risk management strategies can also create opportunities for renewable energy development; Flood risk and coastal defence systems can be combined with energy production systems at sea with break water-wave energy converters (Emid S., 2014). In the context of climate change, sea-level rise, increase deterioration of weather conditions indicating stronger and more frequent storms along the coasts, increases the risk of major disasters in coastal areas. Technological innovations in the form of breakwaters installed offshore have the ability to reduce the strength of sea waves and keep the sea surge off the coast, thus limiting flood risk and coastal erosion. These breakwaters can be coupled with wave energy converters to take advantage of the wave power and harness the energy for productive purposes. Although this technology is still at the testing phase, it is very promising in terms of coastal risk management and renewable energy development. It is also a good example of how to Green growth and Blue growth may be coupled to foster land-sea synergies.

For coastal defence, **nature-based solutions** are also particularly relevant: beach nourishment[30] compared to conventional options, creates additional co-benefits through increased attractiveness for recreational opportunities. Increasing the width of the beach may provide opportunities for the development of new recreational activities on the beach. It also generally increases the environmental quality, and consequently the number of tourists. Such co-benefits can increase economic activity, generating tax revenue, which in turn leads to leveraging of the overall public investments in the project. As a result of positive environmental and economic positive side-effects outcomes, the beach nourishment solution has become economically more attractive than conventional solutions (De Bel et al., 2018). It is a good example on how a flood risk and coastal defence management project through nature-based solutions became an opportunity for cross-sectoral collaboration and business development.

Besides offering sustainable solutions to anthropogenic pressures, nature-based solutions for environmental issues in coastal and rural areas can also provide additional benefits in terms of landscape restoration, and creating new avenues for recreational activity. In coastal-rural areas, it can create the basis for a circular economy through water recycling and reuse – as an alternative to expensive conventional water treatments, biological treatment using plants to absorb nutrients is for instance highly effective in the tropics

[30] Practice in which sediment is brought onto a beach to replace sediment lost through erosion process

where plants grow year round; however this option is often ignored by sewage designers from temperate zones, where plants only grow part of the year. Scientific findings also point out the advantages of land disposal for secondarily treated sewage effluence and wastewater reuse options. As an alternative to coastal discharges, areas with extensive wetlands could possibly be part of a secondary treatment/overland flow system, with the already nutrient rich wetlands 'treating' the final effluent material. Also, instead of being expensively treated and ejected into the system, waste water could be reused, particularly by the agricultural sector which requires nutrient inputs, or by coastal golf courses which are often in need of nutrient rich effluent waters for irrigation to provide water and fertilizers at lower costs (See details in COASTAL Deliverable D09). A well-designed and planned water recycling and reuse system with nature-based solutions over the whole coastal-inland system (that includes stakeholders from coastal and rural areas in the design process), would reduce the impact of inland polluted water onto the coastal-sea ecosystems; and by extension the impact on activities such as fishery, aquaculture and coastal tourism, which are dependent on good sea-water quality.

Finally, a tool such as a spatial planning management strategy designs above the rural-coastal-marine boundaries can foster land-sea synergies, and improve coastal-rural collaboration by developing a common vision for the whole area from the rural hinterland, to the sea. This will allow the creation of a , and creates a coherent and sustainable development plan for the future by taking into account rural-coastal-marine socio-environmental and economic inter-dependency. Such a strategy should be based on land-sea synergies and stakeholders' collaboration. However the success of such a strategies will depend of the development of a global governance at the EU level, implying a deeper integration of the, still, siloed policies i.e between the WFD, the MSPD, the CAP and the ICZM approach which lack interconnections, as mentioned previously.

Conclusion

Increasing land-sea synergies is necessary in order to protect land and sea ecosystems, create sustainable and resilient coastal and sea regions, and achieve the sustainable development goals. The COASTAL project seeks to increase land-sea synergies via an innovative dual approach using systems dynamics coupled with participatory methods, by involving local stakeholders from representative EU coastal regions to co-design business roads map and policy alternatives. Initial work identifying main issues and business opportunities from representative case studies and the development of an inventory of best practice, successes and lessons learned regarding land-sea synergies and coastal-rural collaborations has yielded preliminary findings which indicate that new, innovative practices such as combined activities, alternative forms of tourism, the development of renewable energies offshore or coastal risk management strategies can play a role in creating a common vision for the development of an interconnected rural-coastal-sea region. Policies are still fragmented but international initiatives (political and scientific) work towards unified, multi-sectoral framework and a better integration of the land and sea ecosystems. The source-to-sea concept highlights the gaps and needs for a better integration,

cooperation and coordination of activities from the rural area until the ocean in order to achieve an harmonized, sustainable development of a land-sea area.

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