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CMCC's Views on the EU Strategy for Coastal Communities

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Executive Summary

The Euro-Mediterranean Center on Climate Change (CMCC) welcomes the European Commission's initiative on an EU Strategy for Coastal Communities.

The Strategy should be anchored in coastal resilience as its central organising principle, addressing a growing gap between the scale of risks and current capacities to manage them.

CMCC identifies **three main interconnected challenges** for EU coastal areas:

1. In the near term, compound extreme events require a shift from reactive emergency management to anticipatory systems built on Multi-Hazard Early Warning and real-time decision support.
2. Over the longer term, systemic pressures such as sea-level rise, ecosystem degradation, and unsustainable development are progressively weakening the foundations of resilience, calling for integrated approaches that combine climate adaptation, ecosystem restoration, and spatial planning.
3. At the same time, a persistent implementation gap, driven by fragmented data, weak coordination, and limited local capacity, continues to prevent available knowledge and tools from delivering effective outcomes on the ground.

While the EU already possesses strong policy frameworks, scientific capabilities, and digital infrastructures (Copernicus, EMODnet, EDITO), the core challenge lies in **integration and operationalisation**. The strategy should therefore function not as an additional policy layer, but as an **enabling framework** that connects existing instruments and translates them into sustained, place-based resilience capabilities.

To achieve this, CMCC identifies **six mutually reinforcing priorities**:

1. strengthening coastal resilience infrastructures and services;
2. scaling ecosystem restoration and nature-based solutions;
3. advancing integrated risk governance and anticipatory planning;
4. ensuring the transition from research to operational uptake;
5. enhancing local capacity through stakeholder engagement and co-design;
6. embedding resilience within the blue economy to safeguard both livelihoods and territorial vitality.

The strategy should operate as a **coordinated, multi-level resilience architecture**, aligning EU-level infrastructures and standards with national implementation

pathways and empowering regional and local actors through co-designed tools and services. In doing so, it should also connect with international initiatives, such as CoastPredict and GlobalCoast, positioning Europe within a broader global system for coastal resilience.

To operationalise this architecture, CMCC proposes the following **measures**:

1. Formalise stakeholder co-design as a structural procedural principle in coastal policy development, ensuring local authorities, civil protection actors, fisheries and aquaculture representatives, and community organisations are engaged early and meaningfully.
2. Establish dedicated science-policy interface mechanisms at local and regional level, including accessible dashboards, boundary organisations, and decision-support services, to translate multi-stressor coastal science into actionable insights for non-specialist decision-makers.
3. Launch a dedicated capacity-enhancement strand covering technical training, preparedness protocols, and peer-learning support, with targeted provision for smaller municipalities, islands, and less-resourced coastal authorities.
4. Encourage Member States and regions to adopt integrated place-based coastal resilience planning frameworks linking climate adaptation, ecosystem restoration, maritime spatial planning, risk reduction, and socio-economic transition within a single territorial logic.
5. Create structured pathways from pilot innovation to long-term operational continuity, with institutional anchoring, service stewardship, and dedicated financing models that break the cycle of repeated demonstration without durable uptake.
6. Align European coastal science infrastructure with internationally endorsed frameworks, in particular CoastPredict and GlobalCoast, to eliminate fragmentation and improve coherence, comparability, and scalability across regions.
7. Mandate interoperability across Copernicus Marine, EMODnet, EDITO, national systems, and local coastal services, enabling coastal actors to access harmonised, high-resolution, and decision-ready information through a unified European coastal intelligence architecture.
8. Establish people-centred Multi-Hazard Early Warning Systems (MHEWS) as a standard resilience capability for coastal territories, integrating observations, impact-based forecasting, uncertainty communication, and locally adapted response protocols.

9. Promote digital scenario-testing environments, built on the European Digital Twin Ocean, as standard planning tools for adaptation pathways, nature-based solutions, spatial planning, and infrastructure investment decisions.
10. Support federated cloud infrastructures for scalable coastal service delivery, enabling modular and secure access to observations, forecasts, simulations, and applications, particularly for authorities without independent technical capacity.
11. Strengthen low-cost and community-deployable observing systems as a complement to institutional monitoring networks, improving data coverage and social ownership of resilience action through citizen science and open standards.
12. Institutionalise cumulative impact assessment and stressor attribution methodologies within coastal planning, restoration, and risk-management frameworks, strengthening the evidence base for prioritisation under compound risk conditions.
13. Establish a structured EU partnership with the UN Ocean Decade CoastPredict / GlobalCoast programme, leveraging existing internationally coordinated standards and pilot experience rather than creating parallel architectures, and anchoring Europe's coastal resilience agenda within a broader global implementation network.

1. Context

Coasts are not peripheral territories. They are among Europe's most strategic and exposed socio-ecological systems, where environmental change, economic activity, critical infrastructure, and human wellbeing interact most directly. EU coastal areas host around 90 million people and concentrate assets that are essential for the European Union's prosperity, security, and territorial cohesion, including ports, fisheries and aquaculture, maritime transport, tourism, energy infrastructure, cultural heritage, and biodiversity-rich ecosystems.

For this reason, coastal resilience must be understood in a broad and integrated sense. It is not only the ability to recover from storms, flooding, or erosion. It is the capacity of coastal territories and communities to anticipate, absorb, adapt to, and transform in response to multiple and compounding pressures while maintaining essential functions, safeguarding livelihoods, protecting ecosystems, and preserving social cohesion. In coastal areas, resilience therefore links climate adaptation, disaster risk reduction, ecosystem health, economic diversification, preparedness, infrastructure robustness, governance capacity, and community wellbeing.

This challenge is becoming more urgent. Climate change is intensifying sea-level rise, coastal erosion, salinisation, flooding, marine heatwaves, and compound extreme events. At the same time, pollution, habitat degradation, and biodiversity loss are weakening the natural protective functions of coastal ecosystems precisely when these buffering capacities are most needed. In many European coastal territories, these environmental pressures interact with socio-economic fragilities such as dependence on a limited number of economic sectors, housing stress, overtourism, accessibility constraints, loss of essential services, ageing populations, and difficulties in attracting and retaining skills and young people. These combined pressures reduce adaptive capacity and make many communities more vulnerable to future shocks.

The key issue is not only coastal exposure, but **the resilience gap between the scale of the challenge and the capacities currently available to address it**. Coastal risks do not follow administrative boundaries or sectoral divisions. They emerge across the land-sea interface and evolve through interactions among ocean dynamics, river catchments, ecosystems, infrastructures, built environments, local economies, and social systems. Yet governance frameworks, data systems, funding instruments, and operational capacities remain too fragmented to support truly integrated resilience planning and action. For many coastal authorities, especially smaller municipalities, island contexts, and remote regions, the problem is not only

a lack of ambition, but a lack of accessible, sustained, and operational support for resilience implementation.

The new EU Strategy for Coastal Communities should therefore place **coastal resilience** at its core, as the integrating principle connecting competitiveness, liveability, sustainability, and preparedness.

In this context, CMCC observes that resilience should be approached as a continuous cycle of risk understanding, prevention, preparedness, response, recovery, adaptation, and long-term transformation. This requires the EU to move beyond fragmented policy uptake and toward place-based coastal resilience frameworks that support local and regional authorities in translating knowledge into action.

A central implication is that **coastal science, observation, forecasting, scenario analysis, and decision-support services must be recognised as essential resilience infrastructures**. Coastal resilience cannot rely only on planning documents or post-disaster interventions. It depends on the ability to observe change early, understand multi-hazard interactions, anticipate impacts, test adaptation options, and support timely decisions before crises escalate. Integrated observing systems, high-resolution forecasting, impact-based warning systems, climate services, and digital twins are therefore not optional research outputs; they are foundational capabilities for resilient coastal governance.

This is where CMCC sees a major strategic opportunity for the European Union. Through its Global Coasts as a New Frontier programme, CMCC is advancing a resilience-oriented vision for coastal areas based on integrated observation, forecasting, digital twins, AI-enabled services, climate downscaling, multi-hazard early warning systems, and science-based support to adaptation and planning. This approach is designed precisely to address the non-linear and compounding nature of coastal risk and to strengthen the capacity of territories to prepare for, respond to, and adapt to change over time.

CMCC also hosts the secretariat of **CoastPredict**, the UN Ocean Decade Programme on observing and predicting the global coastal ocean. CoastPredict promotes the co-design of integrated coastal observing and prediction systems that are globally coordinated but locally implemented, with the explicit aim of delivering fit-for-purpose services for resilience, preparedness, and adaptation. Through its GlobalCoast implementation framework, it supports the development of operational coastal intelligence systems that combine observing networks, AI and models, cloud infrastructures, impact forecasting, digital twins, and stakeholder-oriented

services. This experience is highly relevant to Europe's need for a stronger resilience architecture that can connect scientific excellence to local action.

In parallel, CMCC contributes to the **Decade Collaborative Centre for Coastal Resilience (DCC-CR)**, which reinforces an equally important dimension of resilience: the human and institutional one. Coastal resilience cannot be achieved through technical systems alone. It also requires stakeholder engagement, local ownership, training, community science, social inclusion, and stronger interfaces between knowledge providers, public authorities, and communities. Resilience is most effective when it is co-designed, trusted, and embedded in local governance and practice.

In this context, the new EU initiative on coastal communities is both timely and necessary. Europe has the opportunity to frame coastal resilience not simply as protection against hazards, but as a long-term investment in the capacity of coastal territories to remain safe, adaptive, productive, and liveable under accelerating environmental and socio-economic change. This means supporting adaptation and ecosystem restoration, but also preparedness, operational services, economic transition, social cohesion, as well as the local capacities needed to manage uncertainty and compound risk.

Ultimately, **Europe's coastal communities should be recognised not only as areas of vulnerability, but as frontlines of resilience innovation.** A successful strategy should enable them to become places where climate adaptation, healthy ecosystems, robust infrastructure, operational science, and sustainable blue development are advanced together. From this perspective, coastal resilience is not merely a defensive objective. It is the organising framework through which the EU can secure the long-term vitality, competitiveness, and sustainability of its coastal territories.

1.1 Key challenges and priorities

Coastal resilience in Europe must address pressures that unfold across distinct but interconnected temporal scales. Some challenges materialise suddenly, through acute shocks that threaten lives, infrastructure, and essential services within hours or days. Others accumulate progressively, through long-term environmental, social, and economic changes that steadily erode the adaptive capacity of ecosystems and communities. A resilient EU strategy must therefore be able to respond to both dimensions at once: strengthening immediate preparedness and response, while also addressing the structural drivers of long-term vulnerability.

From CMCC's perspective these challenges can be framed within a set of recurring **coastal resilience priority areas**, in line with those that have emerged across the

GlobalCoast Network of the UN Ocean Decade CoastPredict / GlobalCoast framework:¹ **disaster risk reduction and real-time forecasting of extreme events; climate change impacts on coasts; climate and shorter-term impacts on coastal morphodynamics; pollution impacts; urban oceanography and coastal planning; sustainable food production; maritime operations, safety and search and rescue; integrated coastal zone management and marine spatial planning; and nature-based solutions, restoration, and blue carbon uptake.** This is important because it shows that coastal resilience is not a narrow hazard-management issue, but a broad operational and territorial agenda linking safety, adaptation, ecosystems, livelihoods, spatial planning, and long-term sustainability.

Short-Term Challenge: Compound Coastal Extreme Events

Compound Coastal Extreme Events demand immediate policy attention. CMCC identifies disaster risk reduction and real-time forecasting of extreme events as the first and most recurrent impact area across its pilot-site network, confirming that acute coastal hazards remain one of the most urgent resilience priorities for coastal communities. The rapid onset of storm surges, marine heatwaves (MHWs), and sea-level rise (SLR), especially when interacting with extreme waves, heavy precipitation, river discharge, erosion, and infrastructure exposure, poses acute threats to human life, critical infrastructure, economic activities, and coastal ecosystems. Acute pollution episodes, including oil spills and harmful algal blooms, also require rapid-response governance and operational coordination. In this context, high-resolution Multi-Hazard Early Warning Systems (MHEWS) represent the priority investment to safeguard lives and public assets. From a resilience perspective, this means moving beyond reactive emergency management toward anticipatory capacity built on integrated coastal observing systems, real-time forecasting, impact-based warning services, and locally usable decision-support tools that enable authorities and communities to act before crises escalate.

Long-Term Challenge: Cumulative And Systemic Pressures

Alongside acute shocks, coastal resilience is being undermined by slower but deeper cumulative pressures. CMCC identifies several long-term challenge domains that are directly relevant here: impacts of climate change on coasts, climate and shorter-term impacts on morphodynamics, pollution impacts, and nature-based solutions, restoration, and blue carbon uptake. Together, these areas show that long-term resilience is shaped by the interaction of sea-level rise,

¹ CoastPredict's analysis of 135 pilot-site needs worldwide identifies the following nine main challenge domains that repeatedly shape coastal resilience actions worldwide.

shoreline retreat, saline intrusion, eutrophication, habitat degradation, biodiversity loss, sediment imbalances, and the weakening of the natural systems that protect coastlines.

These trends are compounded by unsustainable coastal and offshore development, land-use change, and infrastructure lock-in, which reduce flexibility and make adaptation more difficult and costly over time. Morphodynamic change is especially relevant because it provides the physical link between climate forcing, sediment transport, erosion, inundation, and the changing exposure of coastal communities. Likewise, pollution impacts and ecosystem degradation reduce both environmental quality and the buffering functions that resilient communities depend upon. In this sense, long-term resilience cannot be achieved without integrating climate adaptation, ecosystem restoration, and risk-informed spatial planning.

Cross-cutting challenge: communities, livelihoods, and coastal governance

As shown through the CoastPredict impact areas, resilience is not only about hazards and ecosystems, but several challenges can be linked directly to the socio-economic and governance dimensions of resilience, including urban oceanography science and planning, sustainable food production, operations at sea, maritime safety and search and rescue, and integrated coastal zone management / marine spatial planning. These categories are particularly relevant for the EU initiative because they link resilience to liveability, economic continuity, food systems, safety at sea, and territorial governance.

This broader framing is important for Europe's coastal communities. It shows that resilience must include the capacity of ports, fisheries, aquaculture systems, maritime operators, local authorities, and coastal cities to function safely under stress, adapt planning and investment choices over time, and maintain the social and economic conditions that allow communities to remain viable and attractive. The inclusion of urban oceanography and sustainable food production among the priority areas is especially relevant, because it demonstrates that resilience must be embedded in everyday coastal development choices, not treated only as a response to exceptional events.

Priority implications for the EU strategy

Taken together, these nine challenge areas provide a useful evidence-based structure for the EU Strategy for Coastal Communities. They show that coastal resilience requires action across four mutually reinforcing fronts: preparedness for extreme events; long-term adaptation to climate and environmental change; support for sustainable coastal economies and safe operations; and integrated governance through planning, restoration, and stakeholder engagement. CoastPredict's broader

framework then links these challenge areas to the operational capacities needed to address them: enhanced coastal observing, cloud-based data infrastructures, short-term forecasting, climate downscaling, decision-support services, and institutional and stakeholder capacity building.

CMCC supports the adoption of a similar logic for the Strategy, thus treating coastal resilience not as a single policy niche, but as a structured agenda that connects hazard reduction, adaptation planning, ecosystem recovery, sustainable blue economy functions, and community preparedness. This is also why CMCC considers coastal science, digital infrastructures, multi-hazard services, and co-designed resilience tools to be essential enabling infrastructures for Europe's coastal future.

1.2 Structural and Operational Constraints

Beyond the immediate hazards and systemic pressures described above, a set of structural and operational constraints continues to limit Europe's ability to generate effective coastal resilience outcomes. These constraints do not primarily stem from a lack of scientific understanding or political ambition. Rather, they arise from the persistent gap between what is increasingly possible in coastal science and what can be implemented, sustained, and used in practice by institutions and communities on the ground. This implementation gap is one of the central barriers the EU Strategy for Coastal Communities must address.

A first constraint concerns the **fragmentation of the coastal knowledge and data landscape**. Coastal resilience depends on the integration of observations, modelling, forecasting, climate information, ecosystem assessments, socio-economic data, and user-oriented services across the land-sea interface. Yet these elements are still too often developed, stored, and delivered through disconnected systems. CoastPredict and GlobalCoast explicitly identify fragmentation, uneven comparability across regions, and the lack of sufficiently integrated observing, prediction, data-management, and risk-management solutions as major barriers to effective coastal implementation. Even where valuable European assets already exist, including large-scale observing and data systems, they do not always provide the harmonised, interoperable, and locally relevant information needed by coastal actors.

A second constraint is the **mismatch between available information and the scale of coastal decision-making**. Many existing products remain too coarse, too generic, or too weakly coupled across domains to support local and regional action in complex coastal environments. CMCC notes that current observation and modelling tools are often fragmented, insufficiently resolved at the coastal scale,

and unable to integrate terrestrial, marine, atmospheric, ecological, and socio-economic dimensions in a way that supports decisions under compound risk. This creates a practical barrier for coastal authorities that need site-specific evidence for planning, preparedness, adaptation pathways, restoration, and infrastructure choices.

A third constraint is the **limited operationalisation of advanced coastal services**. High-resolution forecasting, multi-hazard warning systems, coastal digital twins, adaptation planning tools, and impact-based services are increasingly feasible, but they are not yet consistently embedded in the routine practices of public authorities and coastal managers. Solutions developed within the CoastPredict framework indicate that effective services require not only scientific components, but also cloud-ready infrastructures, application models tailored to specific risks, decision-support systems, uncertainty communication, and mechanisms for multi-platform delivery. Without these enabling conditions, even strong scientific products may remain at pilot stage or fail to reach the actors who need them most.

A fourth constraint concerns **institutional fragmentation and weak coordination across governance levels**. Coastal challenges emerge across administrative and sectoral boundaries, but responsibility is often divided among environment, civil protection, maritime affairs, spatial planning, infrastructure, fisheries, tourism, and regional development authorities. The Commission's call for evidence itself recognises that the strategy is needed to make existing EU policies, funds, and instruments easier to use coherently, especially for smaller Member States and local authorities. In this respect, the problem is not simply whether relevant policies exist, but whether they can be aligned into a coherent place-based implementation framework that supports coastal communities rather than overwhelming them with complexity.

A fifth constraint is the **capacity gap at local and regional level**. Many coastal municipalities, islands, and smaller public authorities do not lack motivation; they lack sustained access to specialised expertise, operational tools, technical staff, and financial continuity. The CMCC considers current support systems as too slow, costly, and compartmentalised for vulnerable coastal regions, while emphasising the need for shared computational resources, standardised approaches, and scalable solutions that can be adapted to different contexts. This suggests that the EU strategy should not assume that local uptake will happen automatically once data or tools exist. Dedicated support for translation, maintenance, and long-term use is required.

A sixth constraint is the still incomplete integration of **stakeholder engagement, trust-building, and community co-design** into operational coastal resilience systems. Actionable coastal resilience requires more than technical excellence. It requires stakeholder mapping, dialogue tools, equitable partnerships, training, community science, and stronger interfaces between knowledge providers and users. Where engagement remains procedural rather than substantive, there is a risk that scientific tools are not trusted, not understood, or not sufficiently aligned with local priorities and values. This weakens uptake and limits the long-term legitimacy and durability of resilience interventions.

A final structural constraint is the **lack of sustained pathways from innovation to continuity**. Coastal resilience cannot depend only on short-term projects or one-off pilots. It requires durable infrastructures for observation, data stewardship, cloud computing, modelling, training, service maintenance, and periodic updating. Federated cloud systems, regional nodes, low-cost observing networks, and training ecosystems are part of the solution, but these elements require long-term institutional anchoring and financing if they are to support resilience at scale. Without continuity, the EU risks generating repeated innovation without durable implementation capacity.

Taken together, these constraints show that the EU coastal challenge is not only one of hazards or environmental pressures, but also one of system readiness. A successful EU Strategy for Coastal Communities should therefore address what coastal communities are exposed to, and at the same time why existing knowledge, infrastructures, and policies are still not translating consistently into effective resilience outcomes. In CMCC's view, this means prioritising interoperability, coastal-scale operational services, vertical coordination, local capacity support, stakeholder co-design, and long-term maintenance of resilience infrastructures as core enabling conditions for implementation.

2. Policy framework

Based on the challenges and structural constraints outlined above, the new EU Strategy for Coastal Communities should not be conceived as an additional standalone policy layer, but as an enabling framework for implementation. Europe already has a broad policy landscape covering marine protection, maritime spatial planning, fisheries and aquaculture, climate adaptation, regional development, water quality, disaster risk reduction, and innovation. However, in CMCC's experience the main barrier is the lack of sufficiently integrated mechanisms to translate available knowledge, infrastructures, and tools into operational resilience outcomes for coastal territories.

From this perspective, the policy framework for coastal communities should be characterised by a stronger focus on **coastal resilience implementation**: integrated observing and prediction systems, multi-hazard warning capacities, digital and cloud infrastructures, adaptation planning tools, ecosystem-based solutions, and the technical and institutional capacities required to sustain them over time. This is also the core logic of CoastPredict and GlobalCoast, which aim to provide fit-for-purpose observing, prediction, and service systems that are globally coordinated but locally implemented and co-designed with users.

2.1 Priority areas A first priority area should be **coastal resilience infrastructures and services**. For CMCC, coastal resilience depends on the ability to treat observing systems, forecasting, impact-based early warning, climate downscaling, digital twins, and decision-support tools as enabling public infrastructures rather than optional research outputs. Resilience services require integrated assets and means for risk identification, forecasting, assessment, communication, and decision support. The strategy should therefore prioritise the deployment and long-term sustainability of operational coastal intelligence systems that can support preparedness, adaptation, and local decision-making.

In this context, the strategy should explicitly build on the European digital and data infrastructures that already underpin operational ocean knowledge. **Copernicus Marine** provides free and open marine data and services, including forecasting and monitoring capacities; **EMODnet** provides harmonised marine data and products across multiple environmental and human-activity themes; and **EDITO**, as the core public infrastructure of the European Digital Twin Ocean, is integrating key service components of Copernicus Marine and EMODnet into a unified digital framework for ocean knowledge and scenario-based use. For a coastal communities strategy, these are not peripheral assets: they are core enabling infrastructures for interoperable coastal intelligence, digital twins, and scalable services.

A second priority area should be **ecosystem restoration and nature-based coastal resilience**. CMCC emphasises that coastal resilience is inseparable from ecosystem health, biodiversity monitoring, restoration planning, and the protection of natural buffering functions. The policy framework should therefore ensure that restoration, blue carbon, habitat monitoring, pollution reduction, and ecosystem-based adaptation are treated as practical resilience investments for coastal communities, not only as environmental objectives in isolation.

A third priority area should be **integrated risk governance and adaptation planning**. By enabling a framework that links short-term forecasting and warning with longer-term adaptation planning, climate assessment, and “what-if”

simulations for planning and restoration the EU strategy would support coastal territories in moving from reactive management toward integrated adaptation pathways informed by scenarios, hazard mapping, and place-based evidence. Maritime spatial planning, coastal zone management, and local development strategies should be more explicitly connected to this resilience planning logic.

A fourth priority area should be **research, innovation, and operational uptake**. CMCC observes that the challenge lies in moving from fragmented pilots to scalable and relocatable operational solutions. The policy framework should therefore support the pathway from innovation to continuity, including cloud-ready architectures, AI-enhanced forecasting, application-specific models, interoperable platforms, and shared digital infrastructures that allow advanced services to be used routinely by coastal authorities and not only demonstrated in projects. In this regard, EDITO is particularly relevant because it is designed as the public infrastructure of the European Digital Twin Ocean and offers a route by which research outputs, modelling advances, and data services can be connected to operational digital environments for decision support.

A fifth priority area should be **capacity enhancement, stakeholder engagement, and co-design**. Resilience cannot be achieved through technical systems alone; it requires empowered stakeholders, technical training, local preparedness guidelines, knowledge exchange, stakeholder dialogue tools, and stronger interaction between researchers, institutions, and communities. The new strategy should therefore make capacity-building and co-design core policy elements, particularly for smaller municipalities, islands, and less-resourced coastal territories.

A sixth priority area should be **place-based blue economy resilience and safe coastal operations**, as coastal resilience also includes sustainable food production, maritime safety, search and rescue, urban oceanography, and sustainable ocean planning. The policy framework should therefore connect coastal resilience with ports, fisheries, aquaculture, maritime operations, and coastal urban systems, ensuring that economic continuity and territorial liveability are part of the resilience agenda rather than separate from it.

2.2 Strengths and weaknesses

The main strength of the current EU landscape is that many of the relevant building blocks for resilient coastal communities already exist. Europe has strong environmental frameworks, marine governance instruments, research and innovation programmes, and data and observation assets. This creates a solid basis on which a coastal communities strategy can build. Further, the EU has strong

scientific capabilities, modelling expertise, marine observation, and the potential to support large-scale interoperable digital infrastructures.

A second strength is the increasing recognition that coastal resilience requires integration across the land-sea interface. Coastal complexity must be addressed by integrating ocean, land, atmosphere, ecosystems, infrastructures, and human systems, especially under non-linear compound risk. The EU strategy can build on this convergence and make it more operational. Moreover, a strength is the increasing availability of European public infrastructures that can support coastal implementation more directly. **Copernicus Marine** already provides open, regular and systematic reference information on ocean state and dynamics; **EMODnet** makes marine data and products easier to access and use across Europe; and **EDITO** is being developed precisely to integrate these components into a common digital framework for the European Digital Twin Ocean. Together, these infrastructures offer the foundations for a more operational, interoperable, and scalable coastal resilience architecture.

The main weakness, however, remains **fragmentation**. Observations, models, forecasts, climate information, socio-economic analysis, stakeholder processes, and decision-support tools are still too often developed and delivered in disconnected ways. This fragmentation weakens operational uptake and limits the ability of coastal communities to act on integrated evidence.

A second weakness is the still limited **translation of innovation into routine public capability**. Advanced services such as multi-hazard early warning systems, digital twins, AI-based forecasting, cloud-based data lakes, and adaptation planning tools are increasingly feasible, but they are not yet consistently embedded in the normal practices of public authorities. Without continuity, maintenance, and user-facing service architectures, the EU risks generating strong innovation with weak long-term uptake.

A third weakness is the insufficient integration of the **human and institutional dimension** of resilience. Actionable knowledge requires stakeholder engagement, equitable partnerships, community science, training, and dialogue frameworks. Where these are absent or weak, even technically advanced systems may fail to gain trust, legitimacy, or practical relevance.

2.3 Governance

The new strategy should complement existing action by acting as a **bridge between policy, science, and implementation**. From a CMCC perspective, governance should not only coordinate sectors; it should also organise the delivery

of resilience capabilities across scales: observing, forecasting, adaptation planning, stakeholder engagement, capacity-building, and service continuity.

European level

At European level, the strategy should focus on those elements where the EU has the greatest added value: interoperability, common standards, support for transboundary and shared infrastructures, and the alignment of policy and innovation instruments. From a CMCC perspective, this includes strengthening the integration of European and national observing systems, supporting operational coastal forecasting and multi-hazard services, promoting federated cloud and data architectures, and enabling coastal digital twins and scenario-testing environments as shared resilience infrastructures. In this respect, Copernicus Marine, EMODnet, and EDITO should be treated as strategic components of the European coastal resilience architecture. For coastal communities, their combined value lies in enabling interoperable coastal data spaces, digital twin applications, scenario testing, and scalable user-oriented services across Europe.

The EU level should also play a central role in ensuring that research and innovation are translated into operational continuity. This means supporting replication, scalability, common service approaches, and links between scientific infrastructures and user-facing public services, so that innovation does not remain confined to temporary pilots.

National level

At national level, Member States should turn European frameworks into coherent implementation pathways for coastal resilience. This includes aligning sectoral responsibilities, strengthening the link between marine, climate, civil protection, and territorial planning authorities, and investing in operational systems that can serve regional and local users. The national levels are also important as potential nodes for shared infrastructures, data stewardship, forecasting services, and technical support mechanisms.

National action should also support technical and human capacity enhancement, including training, disaster preparedness protocols, and long-term maintenance of resilience systems. This reflects the CoastPredict view that resilience requires not only technological assets but also competence, governance, and institutional continuity.

Local level

At local and regional level, the strategy should empower coastal communities as the primary arena of implementation. This includes co-designed services, participatory

planning, local adaptation pathways, nature-based interventions, preparedness arrangements, and stronger access to site-specific evidence and tools. CMCC emphasises that solutions must be fit-for-purpose, trusted, and tailored to local operational needs. For this reason, local implementation should be supported through user-oriented service layers, training programmes, community science, and stakeholder dialogue mechanisms, with a view to embed resilience science and technology in local institutions, communities, and decision processes through meaningful engagement and capacity development.

3. Proposed measures

The EU Strategy for Coastal Communities should deliver a coherent package of measures that helps coastal territories move from fragmented policy ambition to operational resilience implementation. From CMCC's perspective, the most effective measures are those that simultaneously strengthen governance, stakeholder capacity, scientific findings and interoperability, and the practical deployment of coastal services. In line with CMCC's experience, proposed measures should not be treated as isolated interventions, but as mutually reinforcing components of a broader coastal resilience architecture.

3.1. General measures

1. Formalise stakeholder co-design as a structural element of coastal policy development and governance

Effective coastal governance requires the systematic integration of stakeholder knowledge into policy design, implementation, and evaluation. The Strategy should establish co-design as a core procedural principle, ensuring that local authorities, civil protection actors, port authorities, fisheries and aquaculture representatives, civil society, and community actors are involved early and meaningfully in the design of coastal resilience measures.

2. Strengthen Science - Policy interfaces at the Local Level

The translation of complex multi-stressor coastal science into actionable insights for non-specialist decision-makers remains a persistent governance weakness. The Strategy should support dedicated science-policy interface mechanisms at local and regional level, including accessible dashboards, boundary organisations, interface staff, and decision-support services tailored to municipal and regional needs. Science communication and usability should be treated not as optional dissemination, but as a core component of EU coastal resilience infrastructure.

3. Support capacity enhancement for coastal authorities and communities

Many coastal authorities lack sustained access to the expertise, training, and operational support needed to act on available knowledge. The Strategy should therefore include a dedicated capacity strand for technical training, preparedness protocols, peer learning, and community-oriented education, with particular attention to smaller municipalities, islands, and less-resourced regions, including coastal resilience schools.

4. Promote integrated place-based coastal resilience planning

The Strategy should encourage Member States and regions to adopt integrated coastal resilience planning approaches that link adaptation, ecosystem restoration, maritime spatial planning, risk reduction, and socio-economic transition within a single territorial logic. This would help overcome the current fragmentation between environmental, sectoral, and infrastructure planning, and make resilience a practical organising framework for local development choices.

5. Create pathways from pilot projects to long-term continuity

A recurring weakness in coastal innovation is that promising solutions remain confined to short-term projects. The Strategy should therefore support pathways from demonstration to sustained operation, including maintenance arrangements, institutional anchoring, service stewardship, and financing models for continuity.

3.2. Science-Oriented measures

1. Align EU coastal science Infrastructure with international frameworks to eliminate fragmentation

EU-funded coastal science and service platforms remain insufficiently coordinated across observing, forecasting, climate information, risk assessment, and user-facing services. The Strategy should facilitate the alignment of European coastal assets into a more integrated coastal intelligence system and ensure interoperability with internationally endorsed implementation frameworks such as CoastPredict and GlobalCoast. This would strengthen coherence, comparability, and scalability while reducing duplication of effort across regions.

2. Mandate interoperability between international initiatives, Copernicus Marine, EMODnet, EDITO, national systems, and local coastal services

The Strategy should explicitly support interoperability across international initiatives such as CoastPredict and Europe's main ocean data and service infrastructures so that coastal actors can access harmonised, high-resolution, and decision-ready information. International initiatives, such as CoastPredict, together with Copernicus

Marine, EMODnet, and EDITO should be treated as strategic enabling infrastructures for coastal resilience, with stronger connections to national and local systems. This would improve access to integrated data spaces, digital twin applications, and operational coastal services across Europe.

3. Establish people-centred Multi-Hazard Early Warning Systems as a standard coastal resilience capability

Compound coastal extremes require a move beyond hazard-specific systems toward integrated, people-centred multi-hazard warning capacities. The Strategy should support the deployment of MHEWS that combine observations, forecasting, impact-based thresholds, uncertainty communication, and locally adapted response protocols. CMCC emphasizes disaster risk reduction with a focus on people-centred systems integrating sea-level rise, storm surges, harmful algal blooms, and other coastal threats.

4. Develop scenario-testing environments as a standard policy tool for coastal adaptation and restoration

Planning requires tools that allow authorities to test adaptation, restoration, and infrastructure options before implementation. The Strategy should promote the use of digital “what-if” environments, built on the European Digital Twin Ocean and related coastal digital twin approaches, to support adaptation pathways, nature-based solutions, spatial planning, and investment choices. These tools should become standard components of national and regional coastal resilience planning.

5. Support federated cloud infrastructures for scalable coastal intelligence and service delivery

Advanced coastal services require more than models: they require scalable computing, data stewardship, service orchestration, and accessible user interfaces. The Strategy should support federated cloud infrastructures that enable secure, modular, and scalable access to coastal observations, forecasts, simulations, and applications, which would benefit in particular smaller authorities that cannot develop such capacities alone.

6. Strengthen low-cost observing systems and community science as part of coastal resilience infrastructure

The Strategy should support low-cost, community-deployable observing systems as a complement to institutional monitoring networks, especially where official coverage is sparse or local engagement is needed to build trust and awareness. CMCC identifies citizen science and participatory observing as important enablers

of coastal resilience, particularly when supported by open standards, validation protocols, and links to operational systems. This would improve both data availability and social ownership of resilience action.

7. Institutionalise cumulative impact and stressor attribution approaches within coastal assessment frameworks

Coastal communities are affected by interacting stressors whose combined impacts are often poorly represented in traditional assessments. The Strategy should encourage the integration of cumulative impact assessment and stressor attribution methodologies into relevant coastal planning, restoration, and risk-management frameworks. This would improve the evidence base for prioritising interventions and strengthen the link between science and policy decisions in complex coastal environments.

8. Establish a structured EU partnership with UN Ocean Decade CoastPredict / GlobalCoast for coastal observing, prediction, and implementation

As CoastPredict and GlobalCoast already provide a science-based, internationally connected framework for integrated coastal observing, prediction, and service implementation, CMCC observes that the Strategy should leverage this framework through structured cooperation. This would help the EU connect its own coastal priorities with a wider international implementation network, benefiting from shared standards, pilot experiences, and fit-for-purpose service design.

About CMCC Foundation

The CMCC Foundation – Euro-Mediterranean Center on Climate Change (CMCC) is an international, independent, and multidisciplinary research center dedicated to studying the interactions between climate change and society. Its mission is to produce rigorous and policy-relevant scientific knowledge that supports sustainable development, environmental protection, and the formulation of science-based strategies for climate adaptation and mitigation. CMCC conducts advanced climate research and provides multidisciplinary analyses and datasets, integrating state-of-the-art climate modeling with impact assessments and environmental economics. CMCC is one of the institutions selected by the World Meteorological Organization (WMO) to produce seasonal climate forecasts and collaborates with a network of over 700 partner organizations across 71 countries. Since 2006, CMCC has served as Italy's National Focal Point for the Intergovernmental Panel on Climate Change (IPCC).

At a time of extraordinary change, CMCC is doubling down on its commitment to advanced applied research at the nexus of climate science and socio-economic transformation, powered by a wide adoption of advanced machine learning and data science tools. The central question of the next two decades will be how to sustain broad-based economic growth in the face of rapidly changing material conditions, while continuing to transition to a low carbon industrial base.

In particular, CMCC is deepening its scientific focus on global coastal zones, regions that are both increasingly vulnerable to climate change and vital to the global economy. These are highly engineered landscapes, in which environmental stress, high population density, and economic activities intersect. In this context, we intend to build portable AI-enabled digital twins to support dynamic management of all coastal infrastructure, both natural and engineered. Our research priorities are supported by a deep integration of artificial intelligence (AI) and machine learning (ML) methods in all research work to enhance every stage of our modeling and analysis chain, from data assimilation and scenario development to impact forecasting and risk assessments.

Our strategic research framework reinforces CMCC's commitment to producing high-impact science that drives informed decision-making and tackles climate change challenges. By doing so, CMCC continues to shape the critical knowledge needed for a more sustainable, equitable, and resilient future.

For further information about the CMCC and our work, please visit www.cmcc.it.